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IOT in agriculture at a glance

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Abstract - *Today, one of the main branches that has attracted everyone's attention is the IOT. The IOT has different definitions, applications, and contexts. In this article, we have tried to provide information about the IOT in general and then to introduce the different parts of the IOT in agriculture in a more specific way, so that after reading this article, you can get an overview of the subject. The purpose of writing this article is to write an article that will make everyone familiar with the IOT and the IOT in agriculture.*

Key Words: **IOT, IOUT, IOT in agriculture, IOT architectures, Projects implemented in the IOT**

1.IOT

Although many definitions of IOT have been developed by researchers, there is currently no standard definition for IOT (1,2). The essence of IOT is that everything around us can connect to the Internet and exchange data anywhere, anytime (3,4). The Internet of Things (IOT) was first introduced in 1999 by Kevin Ashton. He described a world in which everything has a digital identity (5,6). According to the Oxford Dictionary, IOT is the interaction of computing devices on a daily basis over the Internet that enables the sending and receiving of useful data (7,8). This structure indicates that the technology consists of two main parts, The first part contains the word things, which refers to the hardware and the physical part where all the sensors and labels are located. The second part, which the term Internet refers to, is related to the communication and interaction of sensors and databases. If we want to describe the Internet of Things briefly and in one sentence, we can say that the Internet of Things means connecting different devices to each other through the Internet to do things and exchange information. (9)

Each component in the IOT has a unique IP address. The Internet of Things can also be defined as a network of information, which enables objects to communicate between objects with objects, humans with objects, and humans with humans using agreed communication devices and protocols (10). The Internet of Things itself is not a separate branch of technology, but a combination of several different technologies that humans use to improve their standard of living. The vast changes that have taken place in the technology and intelligence industry due to the Internet of Things have led to it being referred to as the Third Industrial Revolution (11).

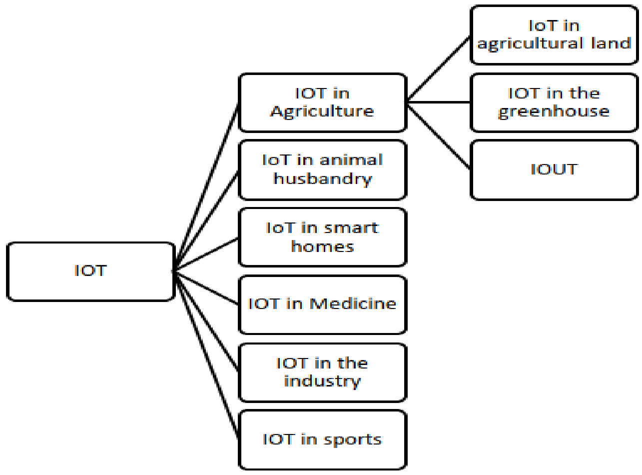

Fig -1: IOT classification

2. IOUT

The part of the Internet of Things that is created due to the need for information on the spot and in real time is called the Internet of underground Things(IOUT). The IOUT represents devices that collect all the information about the earth. It is expected that the use of this branch of the Internet of Things will not only provide on-site monitoring capability, but also by connecting sensors to agricultural machinery, a system completely independent of external factors can be created to manage the target area. In this type of IOT, because all the components are underground, the connection between the components takes place in the soil, and if needed, the data can be sent to the cloud for further processing (12). In IoT, factors such as on-site measurements, wireless communication in challenging areas, connection of field devices, sensors, radios and clouds, real-time decision making, mobility, underground objects (13,14), cloud data storage services Constantly collected, real-time processing of farm conditions, crop decision making, integration with other databases, base stations as gateways for transferring collected data to the cloud (15), and the like Are raised. When using and implementing IoT, the factors raised during the run must be considered.

3. Internet of Things in Agriculture and Greenhouses

Given the increase in population in the coming years and the stability of environmental facilities and even their declining, if the human way of life continues in this way, it will undoubtedly be difficult to provide food. Humans have historically used technology to improve their living conditions. IoT-based smart farming helps farmers reduce waste and increase productivity (16). As mentioned, one of the reasons for using IoT in agriculture is to meet the needs created by population growth. The limited number of usable agricultural lands has added to the importance of greenhouse cultivation. With the transfer of agricultural products from the open air and agricultural lands to greenhouses that are controlled environments, the amount of crop production increases dramatically so that it is possible to increase up to about 12 times per hectare.

In addition to increasing crops, water consumption and soil resources are saved. Among the advantages of smart greenhouses can be the possibility of cultivation in some uncultivable areas, continuous production of crops throughout the year without affecting the existing restrictions, increasing yields, reducing disturbance and damage to cultivation by animals, improving the quality and quantity of crops and increasing The profit of farmers pointed out. In smart greenhouses, all stages of irrigation, fertilization, spraying, pH adjustment, salinity, control of climatic parameters such as soil moisture, relative humidity, temperature, light intensity, carbon dioxide and carbon monoxide are done automatically.

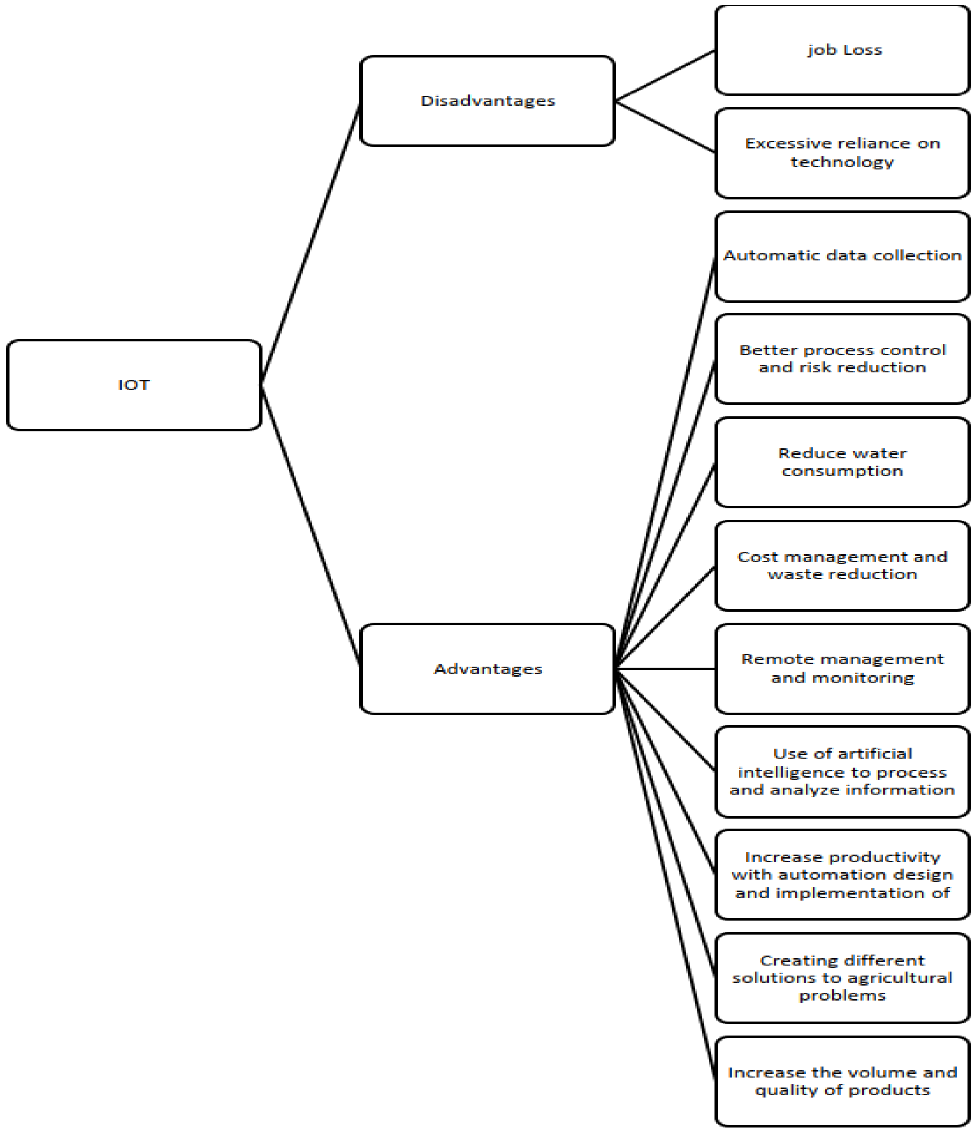

Fig -2: Advantages and disadvantages of IoT

IoT-based smart farming has many advantages and challenges. Among these advantages and challenges are the following (17):

3.1 Advantages

3.1.1 Collection of data from cultivated fields by various sensors

In this method, the necessary information for checking the condition of the land and crops is easily collected and provided to the farmer and the researcher in a completely automatic and systematic way. As a result, information is always fresh and ready to process, helping us to know the general condition of the land, how the staff works, the efficiency of the agricultural equipment, and so on.

3.1.2 Better process control and production risk reduction

Through IoT, by collecting data automatically and processing them, some of the existing and required processes can be planned in such a way that they are fully controlled and monitored. In addition, predicting the production situation and estimating the production volume The product is very useful. By knowing the exact information of the products and their volume, we will no longer face the risk of not selling the products.

3.1.3 Reduce water consumption

Using the Internet of Things, various processes can be automated. One of these processes is irrigation. When irrigated intelligently, only the specified and measured amount of water needed by the plant reaches the plant without wasting.

3.1.4 Cost management and waste Reduction

Using the Internet of Things and intelligent automations, fuel and energy costs and labor are fully controlled and managed; As a result, additional costs are removed from the system and costs are managed in this way. Large losses can be avoided by timely monitoring of anomalies in production at any stage or product health.

3.1.5 Remote management and monitoring

One of the most common systems implemented by the Internet of Things is remote monitoring systems. In this way, you will be able to monitor all existing and running processes completely without the need for physical presence and receive information about the environment.

3.1.6 Use of artificial intelligence to process and analyze information

Data collection from the environment in some cases alone can not be fully and sufficiently efficient, therefore, to make the best use of the collected data, this data is analyzed and processed using artificial intelligence. In this way, the system delivers the required information and warnings to the farmer or the system makes automatic decisions.

3.1.7 Increase productivity by designing and implementing various automations

One of the ways that has become common with the advancement of technology to increase productivity is the design and use of automations. By eliminating unreliable workforce, automations can perform tasks such as irrigation, fertilizing and spraying with more accurately, resulting in the desired result and productivity.

3.1.8-Creating different solutions to agricultural problems

Farmers always face problems in their cultivated area. When data is collected immediately through various sensors and by processing and analyzing information, problems can be fully and quickly identified, and also using artificial intelligence, the solution to these problems can be created as soon as possible.

3.1.9 Increasing the volume and quality of products

One of the results that will seek to control the situation instantly and do things accurately and without error and create ideal conditions through automation and intelligent systems, is to increase the volume and quality of products.

3.2 Disadvantages

3.2.1 Over-reliance on technology

If you rely too much on technology and have complete confidence in the correct operation of the system, you may suffer heavy damages due to errors and unexpected problems.

3.2.2Job loss

Using the Internet of Things and smartening, the activities of existing jobs in agriculture for manpower are eliminated and replaced by intelligent systems. Following the loss of jobs for manpower working in agriculture and greenhouses, new job opportunities will be created for designers and implementers of intelligent systems. Implementable plans and activities that can be implemented in the field of IoT in agriculture can be divided into two categories, which have different parts, which we will describe in the following. In general, it can be said that these two categories are divided in terms of their impact on agricultural products and the environment.

Fig -3: Designs that can be implemented in the Internet of Things

3.3 Intelligent management of factors affecting progress in agriculture

3.3.1 Smart Irrigation [18]

In this type of system, irrigation can be done using a timer at a time set by the farmer, creating intelligent automation or harvesting soil moisture or water infiltration into the soil. Other feasible projects in this field include remote irrigation by the user (farmer) at any time [19].

3.3.2 Intelligent soil quality control

When the land is under cultivation, the soil may lose its fertility due to the plants' use of soil nutrients [20] When this happens, the amount of products produced will be reduced or will not be of sufficient quality. To prevent this from happening, various soil factors such as soil pH, salinity, moisture, nutrients and fertilizer requirements must be monitored. Some of these factors can be directly understood and others can be identified after processing the information collected from the environment [21]. UAVs can also be used in intelligent soil quality control. By preparing accurate three-dimensional maps and rapid soil analysis, drones provide the information needed to design crops and irrigation management patterns and the amount of nutrients (especially Nitrogen) [22].

3.3.3 Intelligent seed management

One way to save money is through seed management. To do this, intelligent robots are designed based on microcontrollers and mobile cameras that, in addition to the ability to plant, plow, fertilize and harvest, also send data related to these operations on the farmer's cellphone (23).

3.3.4 Smart fertilization

Smart fertilization is applicable when a system has the ability to estimate the amount of fertilizer application in the right amount, the right choice of fertilizer type and time of fertilizer application. Together, these factors lead to significant improvements in both harvest volume and quality. Implementations of such systems have been achieved under the name of IoT-based fertilizer management applications. For example, among these applications, we can mention the application for calculating the amount of fertilizer and fertilizer composition.

3.3.5 Intelligent control of agricultural crop growth

Intelligent crop growth control systems have the ability to control different stages of crop growth through various sensors. This will increase the profitability of farmers. The way these systems work is that the sensors collect data from the environment and send it to the main part (database or cloud). The submitted data is then analyzed, processed and processed, and the results are displayed to the farmer through the application, and the farmer is notified if there is a need to make corrections. A similar design has been implemented in China, which shows that farmers have benefited from higher quality crops by spending less and doing less [24]. UAVs help farmers by photographing agricultural environments in near visible and infrared light and reflecting light in multispectral images to better manage crop production, identify pests and assess the health of agricultural products [25].

3.3.6 Intelligent weather management

Intelligent climate management systems are used to control climatic conditions on agricultural land. In this way, by controlling the weather conditions, they can lead to the maximum growth of agricultural products. In these systems, various data such as temperature, relative humidity, light intensity, wind speed and amount of carbon dioxide can be captured and sent to the processing center for processing and receive graphical output [26] .

3.3.7 Intelligent management of agricultural equipment and machinery

One of the factors that has made intelligent agriculture possible is equipping agricultural equipment and machinery with sensors and telecommunication settings that control and track the position and status of agricultural equipment. This system has the ability to control agricultural equipment in any situation [27]. Activities that can be done with this equipment include: plowing and soil preparation, intelligent planting of crops, planting management, intelligent maintenance and harvesting [28].

3.3.8 Efficiency monitoring

Yield monitoring is used in long-term decisions about agricultural operations through the distribution of a place that provides crop yield at the end of the growing season [29,30]. Performance monitoring systems are usually installed on farm equipment and automatically collect performance data at harvest. The collected data are analyzed using GIS tools and international environmental system research tools.

3.3.9 Electrical conductivity and topographic survey

The ability of soil to conduct current is measured by the electrical conductivity of the soil (EC) (31). Along with field topography (altitude and slope), EC data provide insight into product performance. (Through contact and non-contact methods) EC is used to determine nitrogen consumption, water holding capacity and cation exchange, drainage and root depth. EC maps are used to classify the field into different regions.

Then, precise farming methods such as variable rate irrigation, variable rate seeding, nitrogen, yield and drainage management are performed based on zoning. EC mapping is performed using apparent electrical conductivity (ECA) [32] , near-visible infrared reflection spectroscopy (VNIR) (33), and electromagnetic induction (EMI) [34]. There are a number of commercial sensors with GPS available for mapping that are used.

3.3.10 Measurement of soil macronutrients

Macronutrients such as nitrogen, potassium and phosphorus are vital for crop growth. Evaluation of these nutrients helps determine the effect of fertilizer and future applications. Optical spectroscopy based on reflectance spectroscopy is used to measure these micromolecules through reflection and absorption [37,36,35]. A method has been developed to detect the concentration of nitrate and sulfate in natural water sources using planar electromagnetic sensors. This method is used to measure the level of nitrate and sulfate by relating the impedance of the sensor array to the concentration of these contaminants. It has been shown that the impedance of the sensor decreases with increasing concentration of these chemicals. Electrochemical spectroscopy, VIS-NIRS and ATR spectroscopy are the main methods for measuring macro-soil nutrients.

3.3.11 Intelligent sales and market management of agricultural products

By using the Internet of Things in agriculture, information about the production of agricultural products is recorded to a specific standard. Different companies and technologies can use this data to provide better sales services to customers. One of these services is such that the farmer has information about the products sold, factories have information about the products purchased and consumers have all the information about the products and each of them makes appropriate decisions with full knowledge. Also, the information obtained through the Internet of Things can be sent centrally to cooperatives, this information can include information such as production efficiency, water consumption, working hours and .... Using the Internet of Things in agriculture can be used to anticipate the needs of consumers and effectively increase sales opportunities (38). The use of applications related to the market for the sale of agricultural products is another way of intelligent management of agricultural products. To carry out each of these plans and activities, a number of environmental factors must be identified and analyzed. In the following, we will express the factors that can be gained from the environment.

3.4 Harmful factor management

3.4.1 Intelligent control of weeds and plant pests and diseases

One of the ways to deal with plant pests and diseases is to use pesticides. Using this method, in addition to being useful in combating plant pests and diseases, may cause soil contamination and damage to the environment. To deal with the adverse consequences of this process, intelligent pesticide management systems have been designed and implemented. . Smart sprayers are devices used in this activity. These sprayers have the ability to detect the target (39). To perform accurate spraying operations, various sensors and techniques are used, including machine vision, spectral analysis, remote sensing and thermography (40).

3.4.2 Identify population fluctuations of harmful factors

IoT-based systems have been developed to combat plant pests and diseases in the early stages of emergence and even their low population to use the least possible toxins and pesticides to combat plant diseases and pests. One way to deal with pests is to measure the cumulative temperature of trees and plants because when the pests attack the cultivated environment, the ambient temperature rises (41).

Another method used is the use of smart traps;

These traps warn farmers when pests are attacking, and can even track the time and place and patterns of pest activity.

Another method of pest control is weed control, which has three steps and uses herbicides. The first step is to prepare images of the environment, the second step is to process the images and separate the weeds, the third step is to spray the herbicide directly on the grass. At this stage, the imaging operation is performed through the Rasbari camera and the Rasbari itself performs the pest detection operation (42). In addition to the mentioned method, there are also applications for detecting pests and weeds.

Depending on the type of project implemented and the actions to be performed in agriculture, different factors can be harvested from the environment. These factors include soil moisture, soil water infiltration, soil salinity, air humidity, soil nutrients, soil pH, ambient temperature, temperature measurement to detect environmental factors (climate detection systems), imaging He mentioned location for image processing and intelligent decision making, frequency measurements for spectral analysis (for target detection in the spraying system), thermography (a science of infrared imaging), and ambient climate (for pest detection). There are different methods and sensors for measuring each of these factors.

In general, the general trend of IoT in agriculture can be shown as follows:

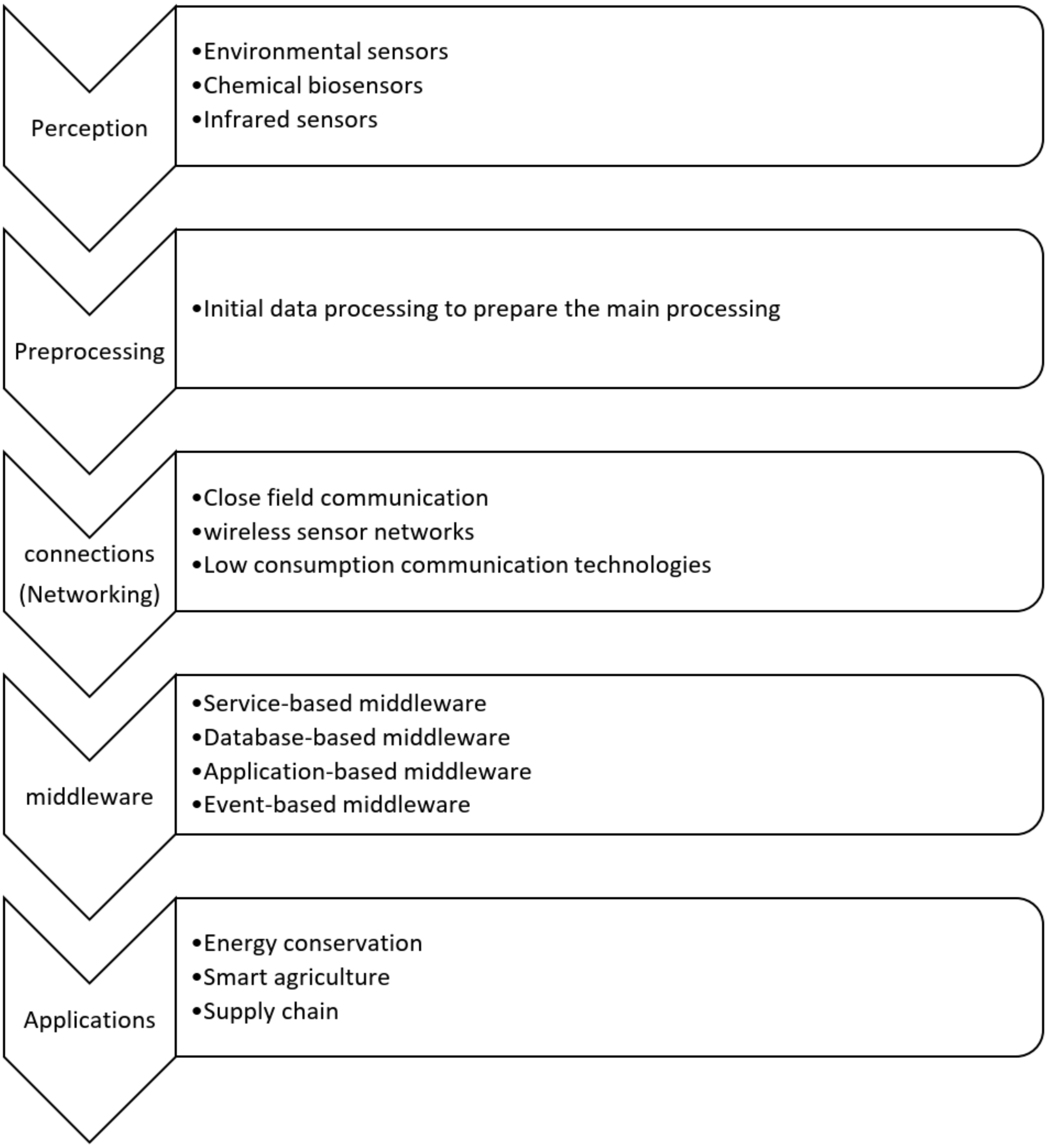

Fig -4: The general trend of the Internet of Things in agriculture

3.4 Architecture

The basic design of systems that are designed and implemented based on the Internet of Things is based on a specific architecture. The various IoT architectural models include the following listed in the table, but in general, IoT architectural models can be divided into three layers (43), four layers, five layers (44) and seven layers. The models listed below sometimes have some layers in common, but they also have differences depending on the type of application and the year of use and release. These different architectural models are often shared in the sensor, network, and application layers. There is no fixed and consensus theory about the main IoT architecture (45), but by referring to the table below, you can get acquainted with the different models of architectures used in the IoT.

Table -1: IoT architectures

Architectural reference	Year	Architecture Stack	Covered issues(IoT challenges)	Used Technique	Security	Privacy
IoT Five-layer Architectures (46)	2008	1. Application Layer 2. Middleware Layer 3. Internet Layer 4. Gateway Layer 5. Edge technology	This architectural model does not address the challenges of the IoT and only describes the main components of the IoT architecture.	-	N	N
IoT Five-layer Architectures (47)	2010	1. Application Layer 2. Middleware Layer 3. Coordination Layer 4. Backbone Network 5. Edge Technology Layer	It considered the issue of packet recognition from different apps and traffic and storage.	Perform tasks in the coordination layer and network layer for restructuring packages and reassembling them to form a unified structure.	N	N
IoT Three-layer Architectures (48)	2010	1. Application Layer 2. Network Layer 3. Perception Layer	It was the accepted three-layer structure of IoT. But it cannot express all of the features and connotation of IoT.	-	N	N
IoT Five-layer Architectures (48)	2010	1. Business Layer 2. Application Layer 3. Processing Layer 4. Transport Layer 5. Perception Layer	It considered data storage and processing issue and it added processing and business layer	Many advanced technologies are used in the processing layer such as: Intelligent processing Cloud computing Ubiquities computing	N	N
General Architecture Of Trusted Security System Based on Io (49)	2011	1. Trusted user module 2. Trusted perception module 3. Trusted network module 4. Trusted terminal module 5. Trusted Agent Module	It considered important features such as integration, management, supervision of many resources of information security.	To achieve security; authentication mechanism, access control mechanism, encryption mechanism, and audit mechanism were used.	Y	N
IoT Architecture Based on Integrated PLC and 3G Communication Networks (50)	2011	1. Application Layer 2. Network Layer 3. Aggregation Layer	It considered scalability issues	Combining two types of complex communication networks: PLC and 3G, which offers low cost, convenience, and more reliable services.	N	N

		4. Perception Layer				
IoT Five-layer Architectures (51)	2012	1. Business Layer 2. Application Layer 3. Middleware Layer 4. Network Layer 5. Perception Layer	It considered the larger traffic and storage needed for data generated by IoT where it focuses on network layer and middleware layer.	Techniques of ubiquities computing, database, information processing, service management, and decision unit are used in the middleware layer.	N	N
Common Architecture for Integrating the Internet of Things with Cloud Computin (52)	2013	1. Cloud Things service platform(IaaS) 2. Cloud Things developer suite(PaaS) 3. Cloud Things operating Portal(SaaS)	It considered integration issue through integrating cloud computing into IoT assist in developing IoT application; it helps to develop, run and deploy Things app online.	Three modules of cloud computing were used: IaaS, PaaS, and SaaS with a set of tools in each module.	N	N
Service oriented Architecture of IoT (53)	2014	1. Sensing Layer 2. Network Layer 3. Service Layer 4. Interface Layer	It considered heterogeneity, interoperability among heterogeneous IoT devices	Service Oriented Architecture (SOA)	N	N
Decentralized Data and Centralized Control IoT architecture (54)	2015	1. Application Layer 2. Control Layer 3. Network Layer 4. Device Layer	It considered security through SDGateway.	SD-Gateway used techniques of: • Firewall • packet encapsulation • Decapsulation	Y	N
				• Network Address Translation (NAT) • Fog computing • Packet forwarding In the application layer, they introduced privacy angement and security management.		
Four-layer of secured IoT architecture (55)	2017	1. Application Layer 2. Support Layer 3. Network Layer 4. Perception Layer	It theoretically discussed security challenges in all IoT layers.	The author suggested using lightweight encryption and protection of sensed data.	Y	N
Four-layer IoT architecture (56)	2017	1. Application Layer 2. Transport Layer 3. Network Layer 4. Perception Layer	It theoretically discussed security issues and solutions in each layer.	The author suggested using Lightweight mobile IPv6 and IPsec to provide security in the network layer. And to use DTLS protocol in the transport layer.	Y	N
A scalable and manageable IoT architecture based on transparent computing (57)	2017	1. Management Layer 2. Server & Storage Layer 3. Core Network Layer 4. Edge Network Layer	It considered scalability and management issues	It used transparent computing by logically splitting the hardware and software of IoT devices	N	N

		5. End-User Layer				
Blockchain meets IoT: an architecture for scalable access management in IoT[68]	2018	1. Wireless Sensor Network 2. Managers 3. Agent Node 4. Smart Contract 5. Blockchain Network 6. Management Hubs	It considered the scalability issue.	Integrating Blockchain in IoT for managing billions of IoT devices through decentralized access control system.	Y	N
5G-IoT architecture[58]	2018	1. Physical Devices Layer 2. Communication Layer 3. Edge Computing 4. Data Storage Layer 5. Management Service Layer 6. Application Layer 7. Collaboration and Processes Layer 8. Security Layer	It considered issues such as scalability, efficacy, security, etc.	New technologies were used such as a device to device communication, 5G-IoT, Machine-Type Communication(MTC), Wireless Network Function virtualization (WNFV), Wireless Software Defined Networks (WSDN), Mobile Edge Computing (MEC), and Mobile Cloud Computing (MCC)	Y	N
IoT Architecture Based on Microservices [59]	2018	1. Consumer devices and application 2. Cloudbased microservices 3. Edge server microservices	It solved issues such as scalability, efficacy, security, etc.	The technology of microservices in the cloud was used in edge server to support computation in sensors and in the cloud to perform services such as	Y	N
				security, virtualization, etc		

As you can see in the table, different IoT models have different number of layers. Most of these models have three, four, five or seven layers. IoT architectural models widely used in agriculture are usually used and implemented with specific layers. In the following, we will give general examples of these models and their layers.

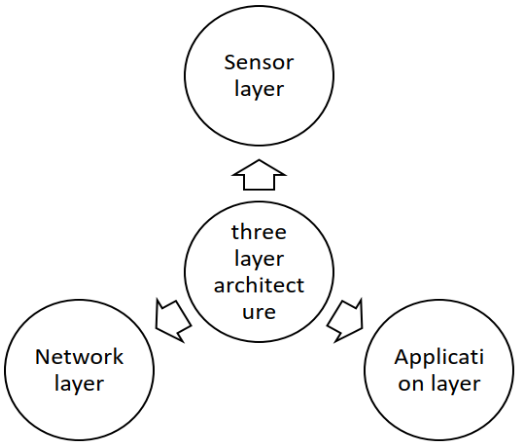

Fig -5: Three-layer architecture

3.4.1 Three-layer architecture [60]

This architecture consists of three layers: sensor, network and application. In the sensor layer, there is integrated hardware through which the required information is collected from the environment. The type of hardware used also varies depending on the context in which the Internet of Things is implemented. The main task of the network layer is to transmit the information obtained in the sensor layer. Key technologies at this layer includes wireless and wired telecommunications protocols, network integration technology, and cloud computing technology for smart data. This layer also has unique addressing and routing capabilities for seamless integration of countless devices into a common network (61). The application layer is actually located between the Internet of Things and the user to process big data and provide effective information using data mining technologies, cloud computing and other intelligent computing technologies. This layer is a combination of IoT and professional software to provide a smart software. The software covers a wide range of industries, including agriculture, water, cities, traffic, and smart homes.

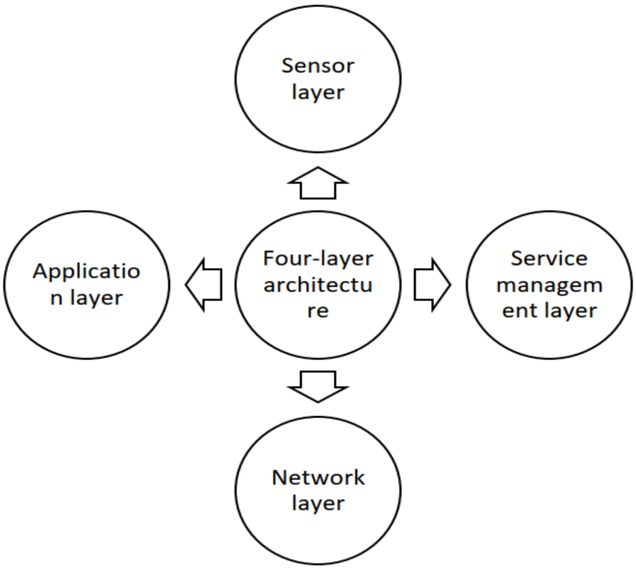

Fig -6: Four-layer architecture

3.4.2 Four-layer architecture [62]

The four-layer architecture, like the three-layer architecture, has sensor, network, and application layers. In addition to these three layers, this architecture also has another layer, the addition of which to the three-layer architecture layers is more supportive. This layer is located between the application layer and the network, known as the service management layer. The technologies used in this new layer include cloud computing, smart computing and fog computing [63, 64, 65].

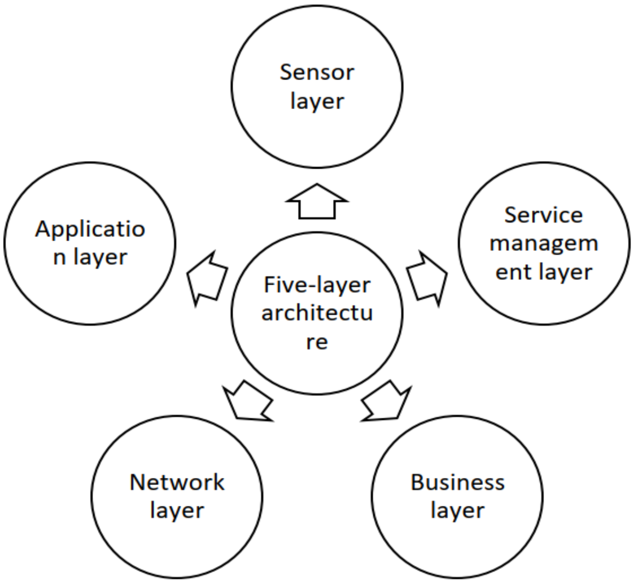

Fig -7: 5-layer architect

3.4.3 Five-layer architecture [66]

The five-layer architecture was designed and presented alongside the four-layer architecture for greater responsiveness and comprehensiveness. In this architectural model, in addition to the previous four layers, the business layer has also been added. The service and business management layer has been designed and added to provide better and more complete services to the user along with the application layer. The business layer represents the business model and the data received from the application layer [61].

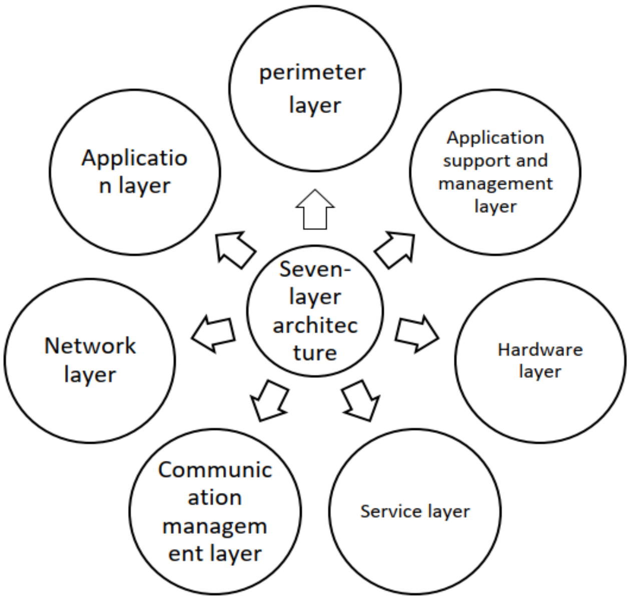

Fig -8: 7-layer architecture

3.4.4 Seven-layer architecture

This architecture includes application layer, application support and management layer, service layer, communication layer, network layer, hardware layer and environment layer. Most of the layers of this architecture are the same as the other architectures mentioned. In the program support and management layer, all actions related to program control, security and management are performed. Other services offered at this layer include Qos management, device management, business process modeling, business process execution, licensing, key exchange and management, trust and credibility, and identity management. Service layer Duty to perform activities such as storage and orchestration of services, combination of services and organization, virtual entity resolution, IoT service, VE service, IoT service resolution, VE and IoT service monitoring, all decisions related to monitoring, storage, organization and Visualize the information received. The next layer is the environment layer. The environment layer contains identifiable objects or places that should be examined through the system. This set of objects includes various categories, among which we can mention moving objects such as cars, humans, and environmental factors such as temperature and humidity (67).

3.5 Ways of communication

As noted in various IoT architecture models, in IoT routines, data must first be collected from the environment and then transmitted for processing or decision making. To transfer data, we must choose one of the different communication channels depending on the type of system implemented and the area covered by the system. The use of wired data transmission methods is very rare due to its cost and various challenges. For this reason, most of the communication channels used are wireless communication channels. The table below outlines some of the most common of these ways.

Table -2: Communication channels

Security	**Power**	**Maximum data speed**	**Maximum range**	**Operating frequency**	**Network type**	**Wireless standard**	**Wireless technology**
WEP,WPA,WPA2	100 mW	-6.75 Gbps 780 Mbps	150 m	900MHz-60GHz	WLAN	IEEE802.11, WLAN2	**WiFi**
Triple DES	2.2-3.6 volts	100 Kbps	100 m	908 MHz	Mesh	Frequency Range	**Z-wave**
128/56 Bit	1 W	1-3 Mbps	100 m	2.402-2.483 GHz	PAN	IEEE802.15.1)	**Bluetooth**
128Bit	1 mW	250 Kbps	100 m	908MHz or 2400-2483 MHz	LAN,MAN, WAN	IEEE802.15.4	**6LowPAN**
N/A	1 mW	10-1000 Bps	2-5 Km	2400-2483 MHz	WPAN	Sigfox	**Sigfox**
N/A	-	50 Kbps	2-15 KM	433-923 MHz	LPWAN	LoRaWAN	**LoRaWAN**
128BitAES	0.01-0.5 W	125 Kbps-1 Mbps-2 Mbps	100 m	2.402-2.483 GHz	WPAN	Bluetooth(Formerly IEEE802.15.1)	**Smart Bluetooth(BLE)**
128Bit	1 mW	250 Kbps	100 m	2400-2483 MHz	WPAN-Mesh	IEEE802.15.4	**ZigBee**
Possible	1-2 mW	424 Kbps	1 m	13.56 MHz	Point to Point	Many standards	**RFID**
Possible	1-2 mW	424 Kbps	0.1 m	13.56 MHz	Point to Point	ISO/IEC13157	**NFC**
GEA2/GEA3/GEA4	-	171 Kbps	10-25 Km	850-1900 MHz	GERAN	3GPP	**GPRS**

4. Conclusion

In this article, we examined the Internet of Things in agriculture at a glance. By studying this article, each person can fully understand the Internet of Things, Internet of underground Things, the Internet of Things in agriculture and greenhouses, the advantages and disadvantages of using the Internet of Things in agriculture, plans that can be implemented in the Internet of Things. Learn about the factors affecting progress in agriculture and the management of harmful factors, the different types of models and architectures that can be used in the Internet of Things, and the means of communication that can be used in the Internet of Things in agriculture. As mentioned, the purpose of writing this article is to write an article that by reading it, everyone will become familiar with the Internet of Things and the Internet of Things in agriculture in general. The next step in this direction will be the design and implementation of a system for monitoring hydroponic greenhouses and controlling various factors in it.

References:

1) T. Gong, H. Huang, P. Li, K. Zhang, and H.Jiang, ―A medical healthcare system for privacy protection based on IoT,‖ in 2015 Seventh International Symposium on Parallel Architectures, Algorithms and Programming (PAAP), 2015, pp. 217–222.

2) M. Wu, T. J. Lu, F. Y. Ling, J. Sun, and H. Y. Du, ―Research on the architecture of Internet of Things,‖ ICACTE 2010 - 2010 3rd Int. Conf. Adv. Comput. Theory Eng. Proc., vol. 5, pp. 484–487, 2010.

3) M. A. Razzaque, M. Milojevic-Jevric, A. Palade, and S. Cla, ―Middleware for internet of things: A survey,‖ IEEE Internet Things J., vol. 3, no. 1, pp. 70–95, 2016.

4) M. Ammar, G. Russello, and B. Crispo, ―Internet of Things: A survey on the security of IoT frameworks,‖ J. Inf. Secur. Appl., vol. 38, pp. 8–27, 2018.

5) W Mingjun, Y Zhen, Z.Wei, D.Xishang, Y.Xiaofei, Chenggang, etal.,A research on experimental system for Internet of Things major and application project, in System Science,Engineering Design and Manufacturing Informatization (ICSEM), 3rd International Conference on, 2012, pp. 261-263.

6) D.Bandyopadhyay and J. Sen, Internet of things: Applications and challenges in technology and standardization, Wireless Personal Communications, vol. 58, pp.4969, 2011.

7) K.Rose, S. Eldridge, and L. Chapin, The Internet of Things (IoT): An Overview–Understanding the Issues and Challenges of a More Connected World, Internet Society, 2015.

8) K.Rose, S. Eldridge, and L. Chapin The internet of things: An overview, The Internet Society (ISOC), pp. 1-50, 2015

9)https://www.elprocus.com/iot-protocols-and-its-architectures/

10) Evans, D., 2015. The internet of things:How the next evolution of the internet is changing everything. Cisco Internet Business Solutions Group (IBSG).

11) Atzori, L., Iera, A. and Morabito, G., 2010.The internet of things: A survey.Computer networks, 54 (15), pp. 2787-2805.

12) Internet of underground things in precision agriculture: Architecture and technology aspects, Mehmet C.Vuran,Abdul Salam,Rigoberto Wong,and Suat Irmak

13) X. Dong, M.C. Vuran, S. Irmak,Autonomous precision agriculture through integration of wireless underground sensor networks with center pivot irrigation systems, Ad Hoc Networks 11 (7) (2013) 1975–1987.

14) Irromesh wireless mesh system, http:/www.irrometer.com/loggers.html#975

15) J. Gutierrez, J.F. Villa-Medina, A. Nieto-Garibay, M.A. Porta-Gandara, Automated irrigation system using a wireless sensor network and gprs module, IEEE Trans. Instrum. Measur. 63 (1) (2014) 166–176, doi: 10.1109/ TIM.2013.2276487

16) https://theiotmagazine.com/iot-in agriculture-why-it-is-a-future-of-connected-farming-world-70b64936627c

17) Patil, V.C., Al-Gaadi, K.A., Biradar, D.P. and Rangaswamy, M., 2012. Internet of things (Iot) and cloud computing for agriculture: An overview. Agro Informatics and Precision Agriculture.

18) Satyanarayana, G.V. and Mazaruddin, S.D., 2013. Wireless sensor based remote monitoring system for agriculture using ZigBee and GPS. In Conference on Advances in Communication and Control Systems, pp. 110-114.

19) Kissoon, D., Deerpaul, H. and Mungur, A., 2017. A Smart Irrigation and Monitoring System. International Journal of Computer Applications, 163 (8), pp. 39- 45

20) Sangtrash, H.M. and Hiremath, A.S., 2017.Review on IoT for Indian Farmers. International Journal of Scientific Research in Computer Science, Engineering and Information Technology, pp. 236-239.

21) Sowmiya,E.and Sivaranjani,S.,2017.Smart system monitoring on soil using internet of things (IoT).International Research Journal of Engineering and Technology, 4, pp. 1070- 1-7217

22) Salih Abdelgader,A.M,2017.Drones and its Application In Agriculture. Presentation in April 2015.

23) Aruna, G.,Ganga Lawanya,G.,Anbu Nivetha,V. and Rajalakshmi,R,2017.Internet of Things Based Innovative Agriculture Automation Using AGRIBOT. SSRG International Journal of Electronics and Communication Engineering, pp.164-166

24) Bing, F., 2012, November. Research on the agriculture intelligent system based on IOT. In Proceedings of the International Conference on Image Analysis and Signal, Hangzhou, China.

25) Salih Abdelgader, A.M, 2017. Drones and its Application in Agriculture. Presentation in April 2015

26) Ram, K.S.S. and Gupta, A.N.P.S., 2016. IoT based Data Logger System for weather monitoring using Wireless sensor networks. International Journal of Engineering Trends and Technology, 32 (2),pp.71-75

27) Krishna, K.L., Silver, O., Malende, W.F. and Anuradha, K., 2017, February. Internet of Things application for implementation of smart agriculture system. In I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC),International Conference on,pp.54-59.

28) Smart equipment for sustainable agriculture precision farming: producing more with less. Agricultural Machinery European, CEMA

29) M.S.Kukal,S.Irmak,Spatialand temporal changes in maize and soybean grain yield, precipitation use efficiency, and crop water productivity in the us great plains, Trans. ASABE 60 (4) (2017) 1189–1208.

30) A. Magri, H.M. Van Es, M.A. Glos, W.J. Cox, Soil test, aerial image and yield data as inputs for site-specific fertility and hybrid management under maize, Precis Agric. 6 (1) (2005) 87–110.

31) E. Lund, C. Christy, P. Drummond, Practical applications of soil electrical conductivity mapping, Precis. Agric. 99 (1999) 771–779

32) H.J. Farahani, R. Khosla, G. Buchleiter, Field EC mapping: A new tool to make better decisions, Crop series. Soil; no. 0.568

33) https://theiotmagazine.com/iot-in-agriculture-why-it-is-a-future-of-connected-farming-world-70b64936627c

34) K.A. Sudduth, N. Kitchen, G. Bollero, D. Bullock, W. Wiebold, Comparison of electromagnetic induction and direct sensing of soil electrical conductivity, Agron. J. 95 (3) (2003) 472–482.

35) H.-J. Kim, K.A. Sudduth, J.W. Hummel, Soil macronutrient sensing for precision agriculture, J. Environ. Monitor. 11 (10) (2009) 1810–1824

36) S. Laskar, S. Mukherjee, Optical sensing methods for assessment of soil macronutrients and other properties for application in precision agriculture: a review, ADBU J. Eng. Technol. 4 (2016).

37) J. Lin, M. Wang, M. Zhang, Y. Zhang, L. Chen, Electrochemical sensors for soil nutrient detection: opportunity and challenge, in: International Conference on Computer and Computing Technologies in Agriculture, Springer, 2007, pp. 1349–1353.

38) A 2015 - Tedyan, M.Sc. H, 1 in Internet Security Objects Research Institute of Communication and Information Technology. Information Technology and Systems Security Group.

39) Song, Y., Sun, H., Li, M. and Zhang, Q., 2015. Technology application of smart spray in agriculture: A review. Intelligent Automation and Soft Computing, 21 (3), pp. 319-333

40) Malavade,V.m.and Akulwar,P.K.,2017.Role of IoT in Agriculture.National Conference

41) Lee,H.,Moon,A.,Moon,K.and Lee,Y.,2017,July.Disease and pest prediction IoT system in orchard:A preliminary study.In Ubiquitous and Future Networks (ICUFN),Ninth International Conference on,pp.525-527

42) Song,Y.,Sun,H.,Li,M.and Zhang,Q.,2015. Technology application of smart spray in agriculture:A review.Intelligent Automation and Soft Computing,21 (3),pp.319-333.

43) I. Mashal, O. Alsaryrah, T.-Y. Chung, C.-Z. Yang, W.-H. Kuo, and D.P.Agrawal,"Choices for interaction with things on Internet and underlying issues," Ad Hoc Networks, vol. 28, pp. 68– 90,2015.

44) M. Wu, T.-J. Lu, F.-Y. Ling, J. Sun, and H.-Y. Du, "Research on the architecture of internet of things," in Proceedings of the 3rd International Conferenceon Advanced Computer Theoryand Engineering (ICACTE '10), vol. 5, pp. V5-484–V5-487, IEEE, Chengdu, China, August 2010.

45) Pallavi Sethiand Smruti R.Sarangi , Internet of Things: Architectures, Protocols, and Applications

46) J. Pereira, ―From autonomous to cooperative distributed monitoring and control: Towards the Internet of smart things,‖ in ERCIM Workshop on eMobility, 2008.

47) Adv. Comput. Theory Eng., pp. V5-376-V5-380, 2010.

48) M. Wu, T. J. Lu, F. Y. Ling, J. Sun, and H. Y. Du, ―Research on the architecture of Internet of Things,‖ ICACTE 2010 - 2010 3rd Int. Conf. Adv. Comput. Theory Eng. Proc., vol. 5, pp. 484–487, 2010.

49) X. Li, Z. Xuan, and L. Wen, ―Research on the architecture of trusted security system based on the internet of things,‖ Proc. - 4th Int. Conf. Intell. Comput. Technol. Autom. ICICTA 2011, vol. 2, pp. 1172–1175, 2011.

50) H. C. Hsieh and C. H. Lai, ―Internet of things architecture based on integrated PLC and 3G communication networks,‖ Proc. Int. Conf. Parallel Distrib. Syst. - ICPADS, pp. 853–856, 2011.

51) R. Khan, S. U. Khan, R. Zaheer, and S. Khan, ―Future internet: The internet of things architecture, possible applications and key challenges,‖ Proc. - 10th Int. Conf. Front. Inf. Technol. FIT 2012, pp. 257–260, 2012.

52) J. Zhou et al., ―CloudThings: A common architecture for integrating the Internet of Things with Cloud Computing,‖ Proc. 2013 IEEE 17th Int. Conf. Comput. Support. Coop. Work Des. CSCWD 2013, pp. 651–657, 2013.

53) S. Li, L. Da Xu, and S. Zhao, ―The internet of things: a survey,‖ Inf. Syst. Front., vol. 17, no. 2, pp. 243–259, 2015.

54) O. Salman, I. Elhajj, A. Kayssi, and A. Chehab, ―An architecture for the Internet of Things with decentralized data and centralized control,‖ Proc. IEEE/ACS Int. Conf. Comput. Syst. Appl. AICCSA, vol. 2016-July, 2016.

55) Y. Yang, L. Wu, G. Yin, L. Li, and H. Zhao, ―A Survey on Security and Privacy Issues in Internet-of-Things,‖ IEEE Internet Things J., vol. 4, no. 5, pp. 1250–1258, 2017.

56) V. Adat and B. B. Gupta, ―Security in Internet of Things: issues, challenges, taxonomy, and architecture,‖ Telecommun. Syst., vol. 67, no. 3, pp. 423–441, 2018.

57) H. Guo, J. Ren, D. Zhang, Y. Zhang, and J. Hu, ―A scalable and manageable IoT architecture based on transparent computing,‖ J. Parallel Distrib. Comput., 2017.

58) H. Rahimi, A. Zibaeenejad, and A. A. Safavi, ―A Novel IoT Architecture based on 5G-IoT and Next Generation Technologies,‖ 2018 IEEE 9th Annu. Inf. Technol. Electron. Mob. Commun. Conf., pp. 81– 88, 2018.

59) S. K. Datta and C. Bonnet, ―Next-Generation, Data Centric and End-toEnd IoT Architecture Based on Microservices,‖ 2018 IEEE Int. Conf. Consum. Electron. - Asia, ICCE-Asia 2018, pp. 206–212, 2018.

60) https://www.researchgate.net/publication/275352749_Architecting_the_Internet_of_Things_State_of_the_Art

61) B. N. Silva, M. Khan, and K. Han, "Internet of Things: A Comprehensive Review of Enabling Technologies, Architecture, and Challenges," IETE Technical Review, pp. 116, 2017.

62) A. H. Ngu, M. Gutierrez, V. Metsis, S. Nepal, and Q. Z. Sheng, "IoT Middleware: A Survey on Issues and Enabling Technologies," IEEE Internet of Things Journal, vol. 4, pp. 1-20, 2017.

63) M. Farooq, M. Waseem, A. Khairi, and S. Mazhar, "A critical analysis on the security concerns of internet of things (IoT)," International Journal of Computer Applications, vol. 111, 2015

64) I. Ali, S. Sabir, and Z. Ullah, "Internet of Things Security, Device Authentication and Access Control: A Review," International Journal of Computer Science and Information Security, vol. 14, p. 456,2016.

65) H. Suo, J. Wan, C. Zou, and J. Liu, "Security in the internet of things: a review," in Computer Science and Electronics Engineering (ICCSEE), 2012 international conference on, 2012, pp. 648-651.

66) K. Zhao and L. Ge, "A survey on the internet of things security," in Computational Intelligence and Security (CIS), 2013 9th International Conference on, 2013, pp. 663667.

67) Rashmi Lecturer in Computer Science JVMGRR College Ch. Dadri, Bhiwani,Haryana, India, IoT (Internet of Things) Concept and Improved Layered Architecture

68) O. Novo, ―Blockchain Meets IoT: An Architecture for Scalable Access Management in IoT,‖ IEEE Internet Things J., vol. 5, no. 2, pp. 1184– 1195, 2018