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Internet of Thinghs with Smart Agriculture

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ABSTRACT

The Internet of Things (IoT) is revolutionizing various industries, and one of the most promising applications is in agriculture. IoT enables real-time monitoring, data collection, and automation, significantly enhancing farming practices. Smart agriculture, powered by IoT technologies, utilizes a network of connected devices, sensors, and actuators to optimize agricultural operations. These IoT-enabled systems can monitor soil moisture, temperature, humidity, crop health, and weather conditions, providing farmers with valuable insights to make data-driven decisions. The integration of IoT in agriculture leads to precision farming, where resources such as water, fertilizers, and pesticides are used more efficiently, reducing waste and environmental impact. In addition, IoT-based automation systems allow for the remote control and monitoring of farm equipment, irrigation systems, and even livestock management. By collecting and analyzing real-time data, IoT can enhance crop yield predictions, improve pest control, and support sustainable farming practices. The use of IoT in agriculture also fosters smarter decision-making through cloud computing and data analytics, enabling farmers to respond quickly to changing conditions and mitigate risks.

Keywords :-Internet of Things , Agriculture Sensors , Cloud Platforms , Wireless Technologies , Hardware Boards , Machine Learning Algorithms.

INTRODUCTION

1.1 GENERAL

The Internet of Things (IoT) refers to a network of physical devices, vehicles, appliances, and other physical objects that are embedded with sensors, software, and network connectivity, allowing them to collect and share data.

IoT devices—also known as “smart objects”—can range from simple “smart home” devices like smart thermostats, to wearables like smartwatches and RFID-enabled clothing, to complex industrial machinery and transportation systems. Technologists are even envisioning entire “smart cities” predicated on IoT technologies.

IoT enables these smart devices to communicate with each other and with other internet-enabled devices. Like smartphones and gateways, creating a vast network of interconnected devices that can exchange data and perform various tasks autonomously. This can include:

- Monitoring Environmental Conditions In Farms
- Managing Traffic Patterns With Smart Cars And Other Smart Automotive Devices
- Controlling Machines And Processes In Factories
- Tracking inventory and shipments in warehouses

The potential applications of IoT are vast and varied, and its impact is already being felt across a wide range of industries, including manufacturing, transportation, healthcare, and agriculture. As the number of internet-connected devices continues to grow, IoT is likely to play an increasingly important role in shaping our world. Transforming the way that we live, work, and interact with each other.

In an enterprise context, IoT devices are used to monitor a wide range of parameters such as temperature, humidity, air quality, energy consumption, and machine performance. This data can be analyzed in real time to identify patterns, trends, and anomalies that can help businesses optimize their operations and improve their bottom line. Let's us look closely at our mobile device which contains GPS Tracking, Mobile Gyroscope, Adaptive brightness, Voice detection, Face detection etc. These components have their own individual features, but what about if these all communicate with each other to provide a better environment? For example, the phone brightness is adjusted based on my GPS location or my direction. Connecting everyday things embedded with electronics, software, and sensors to internet enabling to collect and exchange data without human interaction called as the Internet of Things (IoT).

The term "Things" in the Internet of Things refers to anything and everything in day to day life which is accessed or connected through the internet.

IoT is an advanced automation and analytics system which deals with artificial intelligence, sensor, networking, electronic, cloud messaging etc. to deliver complete systems for the product or services. The system created by IoT has greater transparency, control, and performance.

As we have a platform such as a cloud that contains all the data through which we connect all the things around us. For example, a house, where we can connect our home appliances such as air conditioner, light, etc. through each other and all these things are managed at the same platform.

Since we have a platform, we can connect our car, track its fuel meter, speed level, and also track the location of the car.

If there is a common platform where all these things can connect to each other would be great because based on my preference, I can set the room temperature. For example, if I love the room temperature to to be set at 25 or 26-degree Celsius when I reach back home from my office, then according to my car location, my AC would start before 10 minutes I arrive at home. This can be done through the Internet of Things (IoT).

1.2 Need of IOT in Agriculture

By using IoT devices to automate and optimize processes, businesses can improve efficiency and productivity. For example, IoT sensors can be used to monitor equipment performance and detect or even resolve potential issues before they cause downtime, reducing maintenance costs and improving uptime.

1.2.1 Data-driven decision-making

IoT devices generate vast amounts of data that can be used to make better-informed business decisions and new business models. By analyzing this data, businesses can gain insights into customer behavior, market trends, and operational performance, allowing them to make more informed decisions about strategy, product development, and resource allocation.

1.2.2 Cost-savings

By reducing manual processes and automating repetitive tasks, IoT can help businesses reduce costs and improve profitability. For example, IoT devices can be used to monitor energy usage and optimize consumption, reducing energy costs and improving sustainability.

1.2.3 Enhanced customer experience

By using IoT technology to gather data about customer behavior, businesses can create more personalized and engaging experiences for their customers. For example, retailers can use IoT sensors to track customer movements in stores and deliver personalized offers based on their behavior.

AGRICULTURE IOT

2.1 IoT works

As mentioned before, IoT is a giant network consisting of interconnected devices.

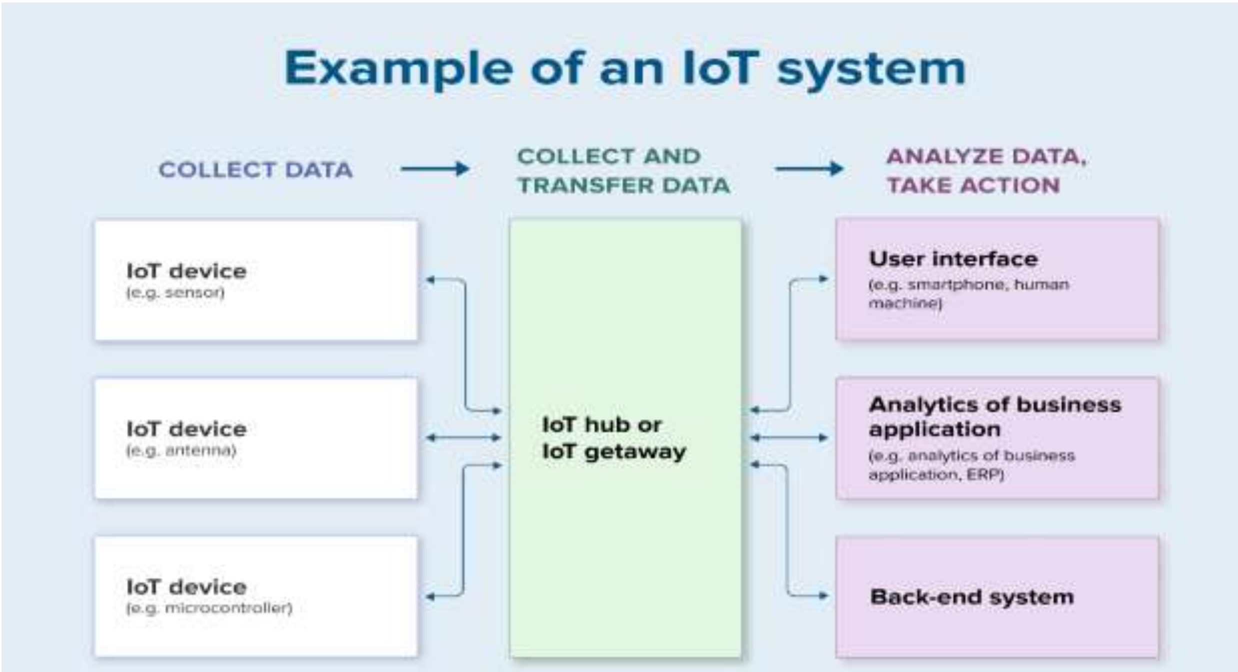

Figure 1 Example of IoT in Agriculture

IoT devices have **sensors embedded** into them. These sensors are capable of sensing their surroundings. The devices store the information in some form of data. These devices include appliances such as mobile phones, coffee machines, microwaves, geysers, fire alarms, Air conditioners, cars and so on.

The sensors embedded in these devices **constantly emit data** about the surrounding and on the working information of these devices. **IoT serves as a platform** to dump all the data collected by these devices.

IoT platform includes **cloud servers and large databases**. The IoT platform acts on the data. It integrates and processes the information. Further, the platform analyses the data thoroughly to gather important details. The platform then sends back instructions based on the data provided.

Finally, the **data aggregation is shared with other devices** for better performance in the future. It is also done for improved user experience.

2.2 Transforming IoT in Agriculture

Internet of things (IoT) is transforming in the agriculture domains like diagnosis of diseases, variable of fertility, water stress, field monitoring, soil erosion, smart data, crop yield analysis and auto spreading as shown in below

2.2.1. Agriculture Crops

In India, these are the major crops for livelihood of farmers. The application of IoT on these crops in the field of agriculture would be discussed below as shown in Table 1 and also Table 2 illustrates agricultural diseases [12].
These are the following ways to monitor the above mentioned crops [15] by using IoT as shown in below Fig. 9

a) Climatic conditions.
b) Agricultural drones.
c) Smart greenhouse.
d) Precision farming.

a.) Climatic conditions

The above mentioned crops have specific climatic conditions. The IoT device has access to control and take the measures to set them in the appropriate conditions as well. For example the crops such as maize and wheat are well grown in clayey and soft soil, When the soil texture changes due to the erosion and the pests which are grown in the soil and

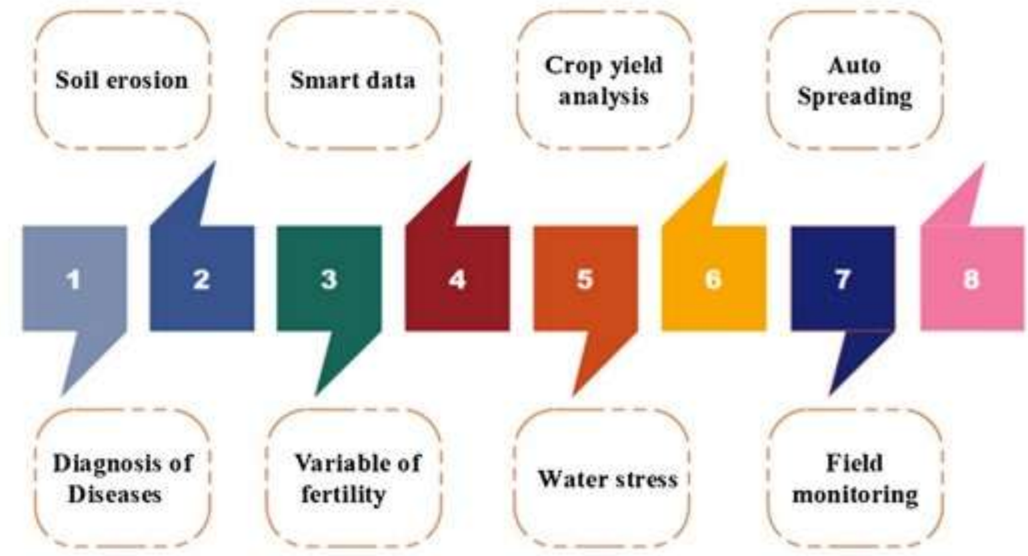

Figure 2 Iot Switching In Smart Agriculture

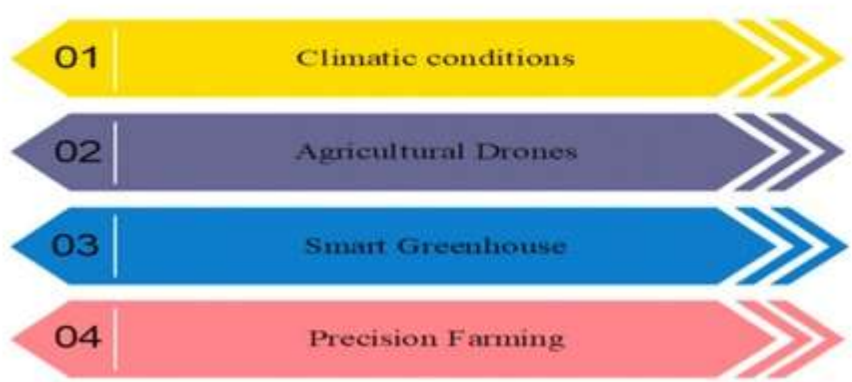

Figure 3 Monitoring ways to crops

due to the production of humus, the sensors which are located around the circumference of the area would release signals and the receiver in the IoT device such as iPad shows the notification through SMS or E-mail. Time and then we can take necessary steps.

b.) Agricultural drones

Technological advancements have almost revolutionized the agricultural operations and the introduction of agricultural drones is the trending disruption. The ground and aerial Drones are used for assessing:

1. Crop health
2. Crop spraying
3. Crop planting and monitoring

The introduction of IoT on this project has implemented the bridge between the quality and quantity of the yield produced. The data which is generated through the sensors and recognized by the device helps to reduce the damage of the crops as an immediate response would be provided from distance communication.

c.) Smart greenhouse

Greenhouse refers to an enclosed area with appropriate climatic conditions for the required crop. Now the recent IoT technologies have developed sensors that automatically change the inner climatic conditions required for the crops. The main advantage is that it is cost-effective and the accuracy would be tremendously increased. Automatic and smart irrigation would be developed by using IoT. The water consumption and the temperature of the greenhouse state would be delivered through SMS and Emails automatically with the help of IoT.

D.) Precision farming

Farming is the most advanced and famous applications of IoT in the field of agriculture. It enables less labor for farming with smart farming techniques such as:

1. Live stock monitoring
2. Vehicle tracing
3. Field observation
4. Inventory monitoring

Farming by using IoT helps the farmers to make quick decisions based on the required conditions. The operational efficiency would be tremendously increased in farming by using IoT.

IOT EMERGING TECHNOLOGIES

3.1 Wireless Technologies

Wireless technologies are systems that enable communication and data transmission without the use of physical wires or cables. They are widely used in various domains such as telecommunication, networking, entertainment, health care, and security. Some of the top wireless technologies are:

3.1.1 Cellular networks (3G/4G/5G)

Cellular networks (3G, 4G, and 5G) are wireless technologies that enable mobile communication over large geographical areas.

Pros:

- Widely available and can be accessed from almost anywhere in the world.
- Fast data transfer speeds, especially with 4G and 5G networks.
- Reliable than Wi-Fi networks because they are not affected by interference from other devices.
- Make phone calls and send text messages.

Cons:

- Expensive, especially if you use a lot of data.
- Slow in areas with poor coverage.
- Affected by weather conditions.
- Less secure than wired networks because they are more vulnerable to hacking.

3.1.2 LPWANs

LPWANs (Low Power Wide Area Networks) are intended for applications with small messages only a few times per hour rather than data-heavy applications like streaming.

Pros:

- Reducing maintenance costs: LPWAN transceivers can run on small, inexpensive batteries for 10–15 years.
- LPWAN's simplified, lightweight protocols reduce complexity in hardware design and lower device costs.
- Using a subscription model allows hardware (the radio chipset) to be cheap while an annual subscription fee is charged for each device connected to the work.

Cons:

- Low data rates cannot be used for high data rates.
- Offers high latency between end-to-end nodes.

3.1.3 mmWave

Millimeter wave (mmWave) is a special class of radar technology that uses short-wavelength electromagnetic waves. By capturing the reflected signal, a radar system can determine the range, velocity and angle of the objects.

Pros:

- High resolution and accuracy: mmWave radar can provide high resolution and accuracy in detecting objects and their features .
- Robustness and reliability: mmWave radar is robust and reliable in various weather and lighting conditions .
- Drastic improvements in network performance: mmWave 5G can provide faster data transmission speeds, higher bandwidth, and dramatic reductions in network latency when compared to sub-6 GHz networks, as well as 4G LTE and LTE Advanced networks.

Cons:

- Cost and complexity: mmWave technology can be costly and complex.
- Coverage and range limitations: electromagnetic waves with higher frequencies cannot travel long distances and are more susceptible to physical obstructions.

3.1.4 LoRaWAN

LoRa is a wireless communication technology developed for long-distance and low-power application scenarios.

Pros:

- Worldwide available: It uses 868 MHz/ 915 MHz ISM bands.
- Wide coverage range: 5 km in urban areas and 15 km in suburban areas.
- Less power and hence battery will last for longer duration.
- Single LoRa Gateway device is designed to take care of 1000s of end devices.

Cons:

- Data rate lower than Wi-Fi or cellular networks.
- Limited number of channels available for transmission.

3.1.5 Radio Frequency (RF)

RF technology allows a set of frequencies to be used in other cells, as long as the cells aren't bordering each other. It is possible for numerous callers in one area to use the same frequency because calls can be switched to the closest base station with that particular frequency.

Pros:

- Transmit data over long distances without the need for wires.
- Can penetrate walls and other obstacles.
- Can be used in other wireless communications, remote controls, and RFID.

Cons:

- Affected by interference from other devices.
- Affected by environmental factors such as weather conditions.
- Expensive.

3.1.6 Zigbee

Zigbee is a wireless protocol that uses mesh networking to connect devices over long distances.

Pros:

- Range up to 100 meters and can support up to 65,000 devices on a single network.
- Low power consumption and can run on batteries for years.

Cons:

- Susceptibility to network interferences due to channel noise and overcrowding.

3.1.7 Satellite communication

Satellite communication is a method of transmitting and receiving data through the use of orbiting satellites.

Pros:

- Global coverage and reliability.
- Can reach areas that traditional terrestrial communication infrastructure cannot.
- Essential tool for remote locations, disaster management, and international communication.
- Can be used for data communication, voice communication, and video communications like phone calls and video calls.

Cons:

- High costs.
- High latency (delays) and slower speeds than cable which interfere with online gaming and real-time stock market trading.
- Some satellite plans also have data restrictions.

3.1.8 Wi-Fi

Wi-Fi is a wireless networking technology that uses radio waves to provide wireless high-speed internet and network connections.

Pros:

- Convenience, portability without a wire, which allows users to be connected only within close proximity to a router.
- High-speed internet access.
- it is very common in networking applications.

Cons:

- Security concerns.
- High latency (delays) and slower speeds than cable which interfere with online gaming and real-time stock market trading.
- Some Wi-Fi plans also have data restrictions.

IOT ARCHITECTURES

4.1 Architecture Of IOT

The 7-layer IoT architectural view, also known as the Open System Interconnection (OSI) model, is a refined representation of the essential IoT architecture layers. This 7-layer architecture of IoT is designed to tackle the increasing challenges of IoT systems by providing a clear structure for data flow, security, and efficiency. Visualizing these layers in an IoT architecture diagram helps illustrate how each layer interacts to create a cohesive and secure IoT environment, optimizing communication, data management, and connectivity in modern technological ecosystems.

The 7 IoT layers in the architecture of IoT, often depicted in an IoT architecture diagram, are grouped into three main categories:

1. Hardware Layers
2. Transport Layer
3. Software Layers

1. Hardware Layers

- **Physical Layer**

The physical layer consists of the devices and transmits data in binary form (as 0s and 1s). It also includes wireless network connections and network components like repeaters, modems, cabling, etc. This layer is crucial in the IoT architecture because it forms the base of the 7-layer architecture of IoT.

- **Data Link Layer**

The data link layer defines the structure in which the data moves in and out of the network entities and corrects errors that may have occurred at the physical layer. The two control protocols that the data link layer uses for security and error control are MACsec (Media Access Control security) and LLC (Logical Link Control). It plays a significant role in maintaining the integrity of the IoT architecture layers.

- **Network Layer**

The network layer is responsible for deciding which path the data packets should take for sending them back and forth between different networks. This layer divides the transport layer into network packets and carries out data transmission with the help of IP addressing, which is essential in ensuring the IoT architecture diagram maintains its efficiency.

2. Transport IoT Layer

The fourth layer in the IoT architecture, known as the Transport Layer, is often considered the heart of OSI. It uses transmission protocols like TCP (Transmission Control Protocol) and UDP (User Datagram Protocol) to ensure reliable data transfer services to the software layers. It is the most crucial layer in the 7-layer architecture of IoT as it facilitates transmission. This IoT architecture layer collects data from the network layer and provides services to the Application Layer while also debugging errors in data transmission and providing an acknowledgment of successful transfer.

3. Software Layers

- **Session Layer**

As the name suggests, the Session Layer opens a session between two systems to communicate with each other. It also determines how long the session will continue and when the session will end. This is vital in establishing robust IoT architecture layers.

- **Presentation Layer**

The Presentation Layer acts as a data translator for the network. It retrieves data from different points and delivers it to the Application Layer. This IoT architecture ensures that data is structured and presented in a usable format for both the Application and Network Layers. The 7-layer architecture of IoT relies on this layer for efficient communication between the lower and upper layers.

- **Application Layer**

The Application Layer is the closest to the end user in an IoT architecture diagram. It collects information from the end user and sends back the desired action. This IoT architecture layer consists of protocols that allow data transmission like HTTP and HTTPS, FTP, DNS, etc., making it essential in the complete IoT architecture.

CONCLUSION

This article delivers complete comprehensive analysis of the idea of IoT especially in the field of agriculture. Years down the lane, agriculture sensors, actuators, and devices will rule the agricultural world by connecting to the internet alongside the basic aim of intercommunication and decision making. By providing innumerable profits to the end user with Thing Speak, a variety of services can be acquired. As we mentioned above the embedded technologies like Raspberry pi interfacing with various sensors and different models are being used to supervise pests, build intelligent seeds, monitor crop yield, weed detection, water management and so on, for improving the result of production in agriculture. By using wireless technologies such as WiFi, Zigbee, Z-Wave, GSM, automation of the controllers like Arduino, Node MCU, and Raspberry Pi helps to improve the crop yield by perfect monitoring and detection of disease affected crops. Hence better usage of automation in agriculture helps to improve the yield of the crops. We hope that this survey is providing the current modernity in IoT for the most extensive and sophisticated research improvements in the agricultural field.

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