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Developing an Internet of Things (IoT) Compatibility Framework for Efficient Farming

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The potential for optimising agricultural operations, increasing output, and guaranteeing sustainable resource management via the integration of Internet of Things (IoT) technology in agriculture is considerable. Problems with interoperability arise from the wide variety of Internet of Things (IoT) devices, protocols, and platforms, which makes it difficult to implement IoT solutions on farms. In order to overcome these obstacles and promote effective farming operations, this study suggests creating an Internet of Things (IoT) Compatibility Framework that is designed for the agricultural sector.
This research presents the IoT Compatibility Framework, which is an extensive collection of rules, standards, and protocols for making sure that IoT solutions in farming settings are reliable, scalable, and compatible with each other. Key needs and issues particular to agricultural settings are identified via a comprehensive examination of current IoT frameworks and standards. These contexts include environmental unpredictability, resource limits, and distant deployment.

Keywords: Internet of Things (IoT), protocols, and platforms, Compatibility Framework, scalability, Interoperability.

1. Introduction

In order to increase agricultural output, it is common practice to measure and forecast crop performance across a wide range of soil, irrigation, weather, and fertiliser conditions. The variability in land quality and restrictions may be efficiently shown by productivity, making it a crucial statistic of land conditions. Establishing ideal conditions for seed germination, healthy plant growth, plant production, root development, harvest, and grain formation is the principal objective of agricultural soil management [1].

The drawbacks of conventional farming include the lengthy and difficult process of evaluating crop health reports, the use of inaccurate soil samples, and the length of time required to generate these reports. Also, most farmed land has crucial spatial diversity, which conventional farming methods ignore in favour of consistent field treatment [2]. The fast expansion of the field size as a result of mechanisation demands only served to amplify this. A method that agricultural land managers may use to better understand and regulate their fields is precision agriculture (PA), a management activity made possible by the adoption of sufficient information technology [3].(1), (2), and (3).Maximising agricultural yields and promoting management choices via the use of high-tech sensors and monitoring instruments is known as precision agriculture [6][7]. Improved output, less labour required, better control of irrigation, and fertiliser management are all goals of PA, a new method used on a worldwide scale [8]. The success of modern agricultural practices depends on closely monitoring several crop factors, such as irrigation efficiency, crop yield, soil quality, and the impact of fertilisers and pesticides [9]. Keeping track of all these elements at once is a problem for crop farmers. On the other hand, remote sensing (RS) may ease the way for more accurate tracking of agricultural development and health status [10]. Limitations in the sensor's spectral range, coarse spatial resolution, repetition coverage, and reaction time are the main causes of remote sensing's inadequacies in PA [11]. In order to keep tabs on environmental physical parameters, wireless sensor networks (WSNs) combine a number of wireless nodes [12][13]. The standard components of a wireless node are sensors, a wireless communication protocol, and a microcontroller that allows the node to communicate with gateways and relay sensor data. Utilised in many agricultural applications, such as climate monitoring and crop health forecasts based on soil nutrient data, WSN is a cost-effective method for increasing agricultural yields [14]. Energy efficiency, communication range, scalability, tolerance of failure, and appropriate deployment methods are some of the few challenges that hinder WSN's agricultural adoption [15]. For an agricultural application, the wireless communication protocol used will determine the WSN's energy efficiency and communication range.

Water quality monitoring, irrigation oversight, and pesticide control are some of the agricultural applications of Zigbee, a short-range communication protocol [16]. The environmental conditions of greenhouses may be monitored and controlled with the help of Zigbee and the Global System for Mobile communication/General Packet Radio Service (GSM/GPRS). To maintain the nodes' energy efficiency, most wireless sensor systems used in agricultural applications rely on short-range communication. However, WSN deployment is being hindered by the constraints of short-range communication.

2. Smart Farming Using IoT

The use of IoTs triggers massive amounts of data to provide crucial information. So far, a number of experiments have attempted to transform this information into useful data and insights. An WSN's investigation of plant-related sensor data to provide air power, purification, water, and bugs was the impetus for the system's design for social gatherings [5]. Through data mining, the system was able to discover learning from WSN's information. In light of field-level identification and distant sensors, this review focused on the interaction between yielding meteorological conditions and leaf spot disease monitoring [6]. The disease might be identified using a classifier. Another useful approach to Internet-based observation for IoTs is suggested, taking into account distributed computing. We demonstrated major helpful requirements for the usage of massive data analysis in agriculture after collecting sufficient data using an agricultural IoTs approach. The current study might compromise the information provided by the IoT as knowledge mining has only been employed in a small number of research to extract useful data and learning.

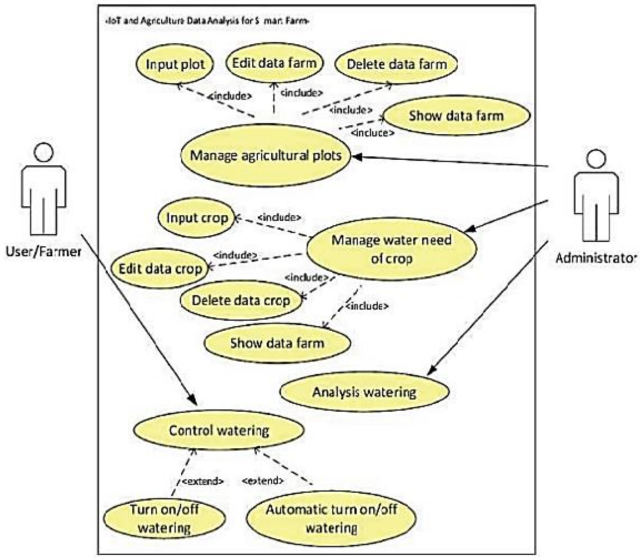

Figure 1: IoT Based Precision Agriculture Use Case Diagram

These modules include all regions' ongoing data from IoT systems. With the use of the electronic framework, a manager may monitor the circumstances surrounding the water needs of each crop. Furthermore, a chairman can handle any kind of farming by seeing the nuances of data from IoT sensors. Later on, this data was used to estimate how much water crops will need. The internet-based application to manage IoT data from any location and crop detail is shown in Figure 1.

3. Hybrid Region Division and Node Deployment Module

Agribusinesses may make use of wireless sensor networks (WSNs) to transmit massive amounts of data to farmers. Improvements in yield and quality may be achieved via the administrative process known as precision agriculture (PA), which makes use of new data innovations. Innovations in wireless sensors, along with better management software, will set in motion a very practical, environmentally friendly agricultural sector. It is possible to avoid disruptions to a daily routine that are crucial to a harvest thanks to PA's management of site problems. From many angles, PA will be improved by farm management. This includes ensuring that seeds have enough nutrition and not wasting pesticides on the wrong plant, pests, and infection control. Various wireless communication schemes are considered and mapped out in this study, as are the technical descriptions of WSNs' vitality-compliant and vitality-collection techniques as they pertain to horticultural observation settings, and the link between earlier research dealings with WSNs in farming and their later applications in analysis and classes.

The difficulties and impediments of WSNs are studied in the horticultural area, and a few power decreases and farming administration procedures for long haul checking are featured. Similarly, these methodologies can extend the chances of handling information on the Internet of Things (IoT).

4. Agriculture Management Information System (AMIS)

An intelligent information management system is the end product of this study. Its smart algorithm also makes it useful as a prediction model. You can see the many components of the AMIS process in Figure 6.1. Additionally, it reveals the approach used to derive the architecture of the AMIS application that is built on the Internet of Things... The product-line engineering process is the foundation of its operation. Development of a farm management information system (FMIS) and domain engineering are the two key components of this strategy. Domain Engineering is concerned with the general planning and development of the AMIS, whereas AMIS Development is more narrowly focused on one particular IoT-based FMIS. There are two stages to any task. There are three stages to the AMIS architecture as a whole. The development of the IoT AMIS family feature model is the first stage in domain engineering. In this article, we define the common and varied aspects of the various AMIS. The next phase involves creating the AMIS reference architecture for use with the Internet of Things. Making the reusable components required to build the AMIS-based reference architecture is the last phase. Making use of domain engineering's design and code, the first stage of AMIS development entails creating an IoT-FMIS application feature model. Step two involves applying the AMIS reference architecture based on the Internet of Things (IoT) to the domain engineering process in order to create the unique AMIS application architecture.

5. Feature Model for IoT

The required features for the IoT architectural layers are shown in Figure 2, which is the top-level feature diagram. It is not possible to build an IoT system without all of the layers. Within each layer, you may find descriptions of both shared and unique characteristics. Protocols for connection and communication are initiated at the session layer of the Internet of Things (IoT) diagram. The top-level feature diagram requires the protocol type as a necessary feature. This study's discovered protocols are described by the protocol type. The following protocols are acknowledged: MQTT, XAMPP, AMCP, DDS, and CoAP.

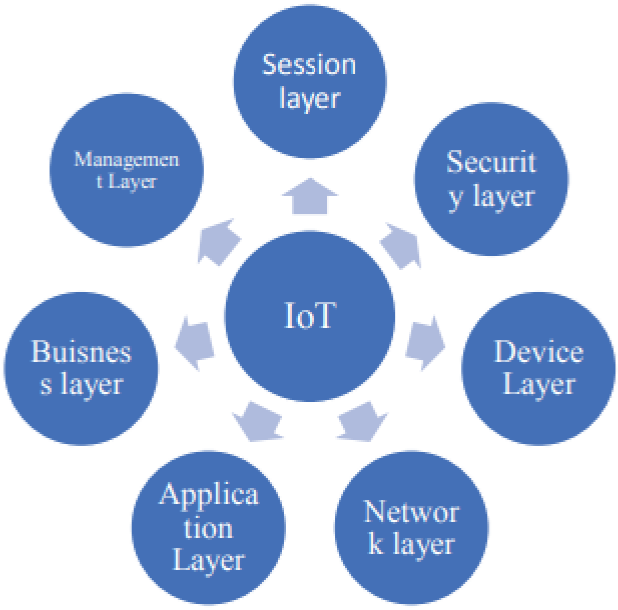

Figure 2: Feature diagram for IoT

Environmental unpredictability, distant deployment, and resource limits are some of the important factors addressed by the Internet of Things Compatibility Framework that this paper lays forth. The framework is applicable to the agricultural area. The architecture facilitates interoperability across diverse Internet of Things (IoT) devices and systems often used in agriculture by outlining requirements for device communication, data management, and platform integration. The use of open standards and protocols in the agricultural IoT ecosystem encourages innovation and cross-vendor interoperability.

In addition, the framework specifies how to conform to data protection laws and how to build strong security mechanisms, all of which are crucial to data security, privacy, and compliance. The framework maximises efficiency and decreases operating costs in resource-constrained agricultural situations by optimising data transmission and processing via the prioritisation of low-power, wide-area (LPWA) networks and edge computing technologies.

There are new prospects for innovation, productivity, and sustainability in farming methods that may be unlocked when farmers and agricultural stakeholders embrace the IoT Compatibility Framework. This framework streamlines the selection, implementation, and administration of IoT solutions.

In addition, governments, standards organisations, and business leaders may use the framework as a guide to build agricultural IoT ecosystems that are both interoperable and resilient to the future.

To keep up with the ever-changing demands of agriculture and new Internet of Things (IoT) technologies, stakeholders must work together continuously to refine and develop the IoT Compatibility Framework. The framework's use of standards, interoperability, and best practices strengthens the agricultural sector, making it more efficient, robust, and productive. This, in turn, helps achieve global sustainability and food security objectives.

6. Conclusion

A major step forward in solving the problems of interoperability, scalability, and reliability in agricultural IoT installations has been the creation of an IoT Compatibility Framework designed for efficient farming. This framework offers a methodical way to develop standards, norms, and protocols for the administration and integration of Internet of Things (IoT) technologies in agricultural operations.

Conflicts of Interest

The authors declare that they have no competing interests.

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