IoT in Agriculture and Horticultural Business

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[Document subtitle]

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2025

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# Part A

## 1. Introduction

Due to the widespread use of the Internet of Things (IoT), multiple industries including agriculture and horticulture have seen a tremendous revolution by enabling smart farming techniques to improve efficiency, productivity and sustainability. IoT in agriculture involves using connected sensors, devices and automation systems to collect and analyse real-time data that can lead to improved decision-making (Wolfert et al., 2017). With the rise of global food demands, IoT solutions are gaining significance for optimising resource usage, reducing waste and ensuring sustainable agricultural practices (Sharma et al., 2020)

## 2. Applications of IoT in Agriculture and Horticulture

### 2.1 Smart Greenhouses

IoT is used in smart houses to monitor environmental parameters such as temperature, humidity, soil moisture, and light intensity. These parameters are adjusted in real-time by automated control systems for optimal plant growth (Ray, 2017). For example, sensors are used to trigger ventilation and irrigation systems upon meeting certain thresholds which reduces manual intervention and improves the yield of crops. In this case, technologies like Zigbee, LoRaWan, WiFi based sensors and actuators are used.

### 2.2 Precision Farming

Precision farming involves using IoT sensors, GPS tracking and drones to monitor soil quality and crop health. By using these technologies, farmers are able to apply water, fertilisers and pesticides only where needed and thus minimise the waste and environmental impact (Kamilaris & Prenafeta-Boldú, 2018). For instance, IoT-enabled soil sensors are used to detect moisture levels and send alerts to farmers for optimised irrigation periods. For this purpose, GPS, drones, AI-powered analytics and machine learning algorithms are used.

### 2.3 Livestock management and monitoring

In livestock management, wearable sensors and RFID tags are used to monitor animal health, location and feeding patterns (Zhang et al., 2021). IoT collars track cattle movement and detect anomalies in activity levels, helping prevent disease outbreaks.

### 2.4 Supply chain and inventory management

Improvement in supply chain efficiency can be achieved by using IoT and enabling real-time tracking of produce, reducing spoilage and ensuring timely delivery ( Zhang et al., 2021). Farm shops use smart refrigerators and storage systems to track temperature conditions and alert managers to issues.

## 3. Benefits of IoT in Agriculture

There are several benefits of using IoT in the Agriculture and Horticulture industry. Some of them are discussed below:

* **Increased productivity:** Automated monitoring and precise farming may lead to better yield and livestock health (Wolfert et al., 2017).
* **Resource Efficiency:** Smart irrigation and fertilisation may result in the reduction of waste and conservation of water (Ray, 2017).
* **Cost Savings:** The reduction of manual labour and minimisation of losses can bring more profit (Kamilaris & Prenafeta-Boldú, 2018).
* **Environmental benefits:** Reduced chemical usage and efficient resource allocation lower environmental impact (Zhang et al., 2021).
* **Data-driven decision-making:** IoT devices provide real-time data that allows farmers to make informed decisions (Misra et al., 2020).

## 4. Challenges in IoT applications in Agriculture

While using IoT in agriculture is quite beneficial, there are some instances where it can be challenging to implement IoT technologies. The biggest challenges of IoT in agriculture are:

* **Connectivity Issues:** Rural areas lack network infrastructure for using IoT devices (Wolfert et al., 2017).
* **High Initial Investment:** IoT deployment requires significant capital for sensors, networking, and automation (Ray, 2017).
* **Data Security & Privacy:** Cybersecurity risks associated with cloud-based farming data (Kamilaris & Prenafeta-Boldú, 2018).
* **Technical Expertise:** Farmers need training to effectively use IoT systems (Zhang et al., 2021).
* **Scalability Issues:** Some IoT solutions may be difficult to scale across large agricultural landscapes (Sharma et al., 2020).

## 5. Case studies and real-world implementation

Many countries and organisations have already adopted the IoT technology for getting better results in agriculture.

* **Netherlands’ Smart Greenhouses:** AI-based greenhouses are used in the Netherlands to control climate and maximise crop production (Wolfert et al., 2017).
* **John Deere Precision Agriculture:** John Deere integrates IoT in machinery for optimised farming operations (Ray, 2017).
* **Indian Smart Irrigation Projects:** IoT-based irrigation systems are used in India to help conserve water in drought-prone regions (Kamilaris & Prenafeta-Boldú, 2018).
* **California’s Smart Vineyards:** IoT sensors monitor grapevine health and optimise irrigation. This results in the reduction of water usage by 25% (Sharma et al., 2020).

## 6. IoT Data Integration in Agriculture

Data from IoT devices are collected via wireless networks and processed using cloud computing and AI. These devices when integrated with farm management software enable predictive analytics and help farmers make data-driven decisions (Zhang et al., 2021). For example, AI-powered dashboards can display real-time soil moisture data which allows the farmers to make automatic irrigation adjustments. Here, technologies like cloud computing, big data analytics and AI-driven decision support systems are implemented.

## 7. Conclusion

To sum up, IoT devices have revolutionised the agriculture and horticulture industry. Despite some challenges,

# Part B- Network Design for Future Farm

## 1. Introduction

As the future farm has many IoT-enabled applications, a robust and efficient network system is needed to support them and run the farm effectively. There are many areas in the farm, including greenhouses, a market garden, a farm shop, a café, a “pick your own” area and administrative offices. It is important to ensure the seamless communication between IoT devices, security systems, POS systems and monitoring systems.

## 2. Network requirements

The network must support the following conditions :

* IoT sensors for environmental monitoring in greenhouses
* Smart irrigation systems
* Security surveillance cameras
* PoS systems in the farm shop and café
* Integrated scales and printers in the Pyo area
* Wireless connectivity for administrative offices and customer WiFi

## 3. Network Topology

To structure the network, a hybrid topology approach will be taken. This is as follows:

* **Star topology for core devices** (e.g., servers, routers, and PoS systems)
* **Mesh topology for IoT sensors** to ensure redundancy
* **Hierarchical architecture** with core, distribution, and access layers

## 4. Network components and hardware selection

* **Core Network:** Cisco Layer 2 switches and routers for routing and VLAN segmentation
* **Access Points:** Cisco wireless access points to provide Wi-Fi across the farm
* **IoT Gateway:** A dedicated IoT gateway for sensor data aggregation
* **PoS and Office Devices:** Ethernet connections for stable transactions
* **Security Cameras:** Networked IP cameras connected via PoE switches
* **Cloud Integration:** Remote monitoring via cloud-connected dashboards

## 5. Subnetting and IP Addressing

The farm’s network will subnet based on different functional areas. This will ensure efficient network management.

* **192.168.0.1/24** - Core network
* **192.168.1.1/24** - IoT devices
* **192.168.2.1/24** - PoS and farm shop
* **192.168.3.1/24** - Security cameras
* **192.168.4.1/24** - Guest Wi-Fi

Each subnet will be assigned a VLAN, ensuring traffic isolation and security.

## 6. Security Protocols

* **VLAN Segmentation** to isolate IoT, PoS, and guest traffic
* **WPA3 Encryption** for Wi-Fi security
* **Firewall Configuration** to prevent unauthorised access
* **Intrusion Detection System (IDS)** for network monitoring
* **MAC Address Filtering** for device authentication

## 7. Cisco packet tracer simulation plan

### 7.1. Network Topology Overview

The network is designed to support different operational areas of the farm, ensuring efficient communication, security, and data transfer. The topology includes:

* **Router (Core Network)** – Acts as the central point for inter-VLAN communication and internet access.
* **Layer 2 Switches** – Handles traffic for specific VLANs (IoT, PoS, Security, Guest Wi-Fi).
* **Wireless Access Points** – Provides connectivity for IoT devices and guest users.
* **End Devices** – PCs, PoS terminals, security cameras, and IoT sensors.

### 7.2. VLAN Configuration

To segment network traffic efficiently, VLANs are implemented as follows:

* **VLAN 10 (IoT Devices)** – Connects all IoT-enabled sensors and controllers.
* **VLAN 20 (PoS System)** – Ensures secure payment transactions.
* **VLAN 30 (Security Cameras)** – Isolates security monitoring traffic.
* **VLAN 40 (Guest Wi-Fi)** – Provides internet access for visitors without interfering with internal operations.

Each VLAN has a dedicated subnet:

* **192.168.0.0/24** – Core network
* **192.168.1.0/24** – IoT devices
* **192.168.2.0/24** – PoS and farm shop
* **192.168.3.0/24** – Security cameras
* **192.168.4.0/24** – Guest Wi-Fi

### 7.3. Router and Switch Configuration

The router is configured with sub interfaces for each VLAN, using **Router-on-a-Stick** methodology. The Layer 3 switch handles inter-VLAN routing to optimize performance. Each switch is configured with appropriate VLAN memberships and trunk links to the router and other switches.

**Implementation Steps:**

1. **Assign VLANs to Switch Ports** – PCs, PoS terminals, and cameras are mapped to their respective VLANs.
2. **Configure Trunk Links** – Ensures VLAN traffic can pass between switches and the router.
3. **Set Up Inter-VLAN Routing** – Enables communication between VLANs where necessary.
4. **Enable DHCP for Automatic IP Assignment** – Ensures devices receive proper network configurations.

### 7.4. Wireless Network Setup

* **SSID for Staff and IoT Devices** – Securely connects internal farm operations.
* **Guest Wi-Fi SSID** – Segregated network for visitors with restricted access.
* **WPA2 Encryption** – Enhances security to prevent unauthorized access.

### 7.5. IoT Device Integration

The IoT sensors and controllers are connected to the network using wireless and wired connections, depending on their function. These devices monitor:

* **Soil moisture levels**
* **Temperature and humidity**
* **Water levels**

The farm manager can access IoT data remotely via a dashboard.

### 7.6. Security Measures

To protect the network, security measures include:

* **Access Control Lists (ACLs)** – Restricts VLAN communication.
* **Port Security** – Prevents unauthorised device connections.
* **Firewall Rules** – Blocks external threats and secures PoS transactions.
* **Disabled Unused Ports** – Reduces attack vectors.

### 7.7. Testing and Validation

The following tests are performed to ensure the network functions as intended:

* **Ping Tests** – Checks connectivity between devices.
* **VLAN Isolation Test** – Ensures security between different network segments.
* **Internet Access Validation** – Confirms connectivity for authorised VLANs.
* **PoS Transaction Simulation** – Verifies smooth operation of payment systems.
* **IoT Data Transmission** – Tests sensor communication and cloud integration.

## 8. Conclusion

The network design demonstrated above ensures the efficient operation of the future farm, providing connectivity for IoT sensors, business transactions and security monitoring.

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