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IoT Based Smart Greenhouse Monitoring System using Visual Simulation Tool

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Abstract

The creation of a smart greenhouse has become an essential component of modern agriculture. The smart greenhouse uses cutting-edge technology to maximize plant growth while minimizing energy consumption. Cisco Packet Tracer, which allows the virtual creation and testing of various network topologies, is one of the most widely used tools for simulating and designing such systems. This paper contains an abstract of a project aimed at developing a smart greenhouse model using Cisco Packet Tracer. The model contains a number of sensors and actuators that control environmental parameters such as temperature, humidity, and light, and the data is transmitted via a network of interconnected devices. The project's goal is to demonstrate Cisco Packet Tracer's capabilities while also providing a cost-effective solution for farmers to improve yields and reduce energy consumption. The paper discusses the model's architecture, the design process, and the simulation results. According to the findings, the smart greenhouse model developed in Cisco Packet Tracer can effectively monitor and control the environmental factors inside the greenhouse, resulting in improved plant growth, yield, and energy efficiency.

Keywords

Smart Greenhouse, Cisco Packet Tracer, Plant, Environment, IOT (Internet of Things), Sensors.

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1. Iintroduction

The arena of ubiquitous computing offers access to information technology infrastructures for end users at anytime and anywhere [1, 2] during this digital information age.

Greenhouses are used to protect plants from harsh environmental conditions as well as to grow plants in a controlled environment. It monitors extreme environmental conditions in order to promote plant growth. Climate change, resource shortages, and rising populations have combined to put tremendous pressure on the world's agriculture industry. However, Various techniques can be used to make greenhouses smarter.

This paper mainly focuses on designing smart greenhouses and implemented using Cisco packet tracer. The output is verified with the expected results [7, 9].

The idea itself comprises a typical greenhouse with sensors that control temperature, humidity, and light to enhance plant development. This enables the crops that are being planted to mature more quickly and retain the greatest amount of nutrients. Additionally, it regulates soil moisture to automatically add the right amount of water to all crops. The "If This, Then That" protocol serves as the foundation for this technology because the supply and execution of these features are exclusively dependent on automatic triggers that result in calculated conclusions and precise actions.

IoT is an acronym of the Internet of Things that denotes distinctively recognizable things and their simulated depictions in global long-haul network setups [4]. IoT is an interconnection of heterogeneous smart devices on massive networks [5].

The Internet of Things (IoT) is playing a significant role in modern life because it has simplified our lives. IoT is essentially the connection of the surrounding environment to the network. IoT is the concept of connecting devices to a network and monitoring and controlling them using smart devices from anywhere in the world. As a result, it allows the monitoring and control of any devices connected to the internet from anywhere in the world.

Greenhouses must be manually monitored, whereas smart greenhouses, which use IoT technology, can be monitored from faraway as well. Different sensors are used depending on the requirements to monitor the greenhouse and perform actions based on the parameters sensed. The conditions are predefined by the maintainer so that environmental conditions do not affect plant growth.

IoT technology developments in recent years have reignited interest in the creation of greenhouse technology systems. There were a few things that made me groan, including remembering how to manually operate the watering system and keeping track of the process. Furthermore, adverse conditions like temperature and light can kill plants.

For Middle Eastern nations like The Sultanate of Oman, Saudi Arabia, the United Arab Emirates, and Qatar, an IOT-based Intelligent Agriculture Greenhouse Environment Monitoring System is crucial. However, the adoption of a smart greenhouse might be a significant step towards improving plant development and aiding those countries in producing their own independent food supply as the heat plays a significant role in farming and food supplies in such countries. In order to create a coordinated circuit organization for sensors and automation technologies, administered by an ICT (Information and Communication Technologies) approach, for agricultural objectives, the work aims to accelerate greenhouse society innovation

2. Research Objectives

1. To investigate the cases in which smart greenhouse is affected by cisco packet tracer software
2. To analyze the IOT (Internet of things) devices present in Cisco packet tracer which helps in the process of smart greenhouse.
3. To find suitable monitoring ways to measure the change in environmental conditions like humidity change, temperature change, CO_2, lightning, moisture maintenance.
4. To find suitable precautionary measures, sensors and controls that manage the changes in smart green houses with the help of Cisco packet tracer software

3. Methodology

The research proposal investigates the effect of Cisco packet tracer software on the development of smart greenhouse. The research methodology used in this research study is qualitative methodology to investigate the changes in internal environmental conditions of smart greenhouses by using the software Cisco packet tracer. The main advantage of using the qualitative research methodology is that it enables the researcher to modify and improve the existing research concepts as investigation proceeds. The data was gathered from a particular database and authentic academic resources which was published from the year 2015 to year 2022. The data was gathered from the latest publications from journal, Springer, IEEE, and books.

This methodology helps the researcher to find out in-depth solutions, methods, techniques, and latest research on Cisco packet tracer[3], the IoT used in software and smart greenhouse effects. The quantitative methodology is also being used to record the changes in environmental conditions with the help of Cisco packet tracer. The statistical data and the graphs developed by recordings increase the validity and reliability of current research study. Addition to it, the Practical experiments will be conducted in a way that conditions will be modified for specific time periods and their effect on smart greenhouse will be measured by the help of Cisco packet tracer.

Table 1 Smart Green House Systems

NO	Devices	Functions
Smart Door System		
1.	Smart Door	Smart door opens only when RFID reader status is valid.
2.	RFID Reader	Radio frequency identification reader is used to read the RFID card given to the maintainers.
3.	RFID Card	The status of RFID reader is valid only when the card Id which is read by the reader matches with any one of the card Ids given to it.
Soil Moisture Monitoring System		
4.	Water Level Monitor	measures the water content present in soil which is the indication for moisture content in soil. Particular amount of moisture has to be maintained in soil for healthy plant growth.
5.	Lawn sprinkler	When the moisture content falls below the pre-set value water sprinkler is activated.

Fire Safety System		
6.	Fire Detector	a device that senses the presence of fire by the presence of smoke which is caused by fire.
7.	Fire Sprinkler	When there is any fire emergency, the sprinkler will be activated by itself as soon as the fire detector detects fire.
8.	Siren	As soon as the fire is detected a message is delivered to the security panel and fire alarm is activated.
CO2 Detecting System		
9.	CO2 detector	Carbon dioxide detector is a device which senses the concentration of carbon dioxide in the atmosphere.
10.	Exhaust Fan	when CO2 detected in greenhouse is high with respect to desired value exhaust fan is operated at high speed and when CO2 detected with respect to acceptable value is moderate exhaust fan is operated at low speed and when CO2 is within the acceptable range exhaust fan is turned off
Smart Light System		
11.	Smart Light	Smart lighting systems are implemented by using smart light. Based on the sunlight detected by the sensor inbuilt in the smart light it will be activated. when the sunlight is above the desired level smart light is off and if the sunlight is below the desired level smart light will be turned on.
Temperature Monitoring System		

12.	Temperature Sensors	Temperature sensor keeps check on the temperature of the environment and displays the value on a connected LED or monitor.
13.	Thermostats	The temperature sensed by the sensor is converted into appropriate form and is given as input to the Thermostat. Thermostat is used to control temperature in a greenhouse based on the temperature sensed by the temperature sensor.
14.	Heating Elements	Heater is activated when the temperature falls below the pre-set value
15.	Cooling Element	cooler is activated when the temperature is greater than the pre-set value
Humidity Monitoring System		
16.	Humidity Sensors	Humidity sensors measure the amount of water (humidity) content present in the air.
17.	Humidifiers	A humidifier is used to maintain the moisture content in the air. Humidifier is activated when the humidity percentage in the greenhouse falls below the desired value.
Solar Cell		
18.	Solar Panel	l converts sunlight into electricity by using the appropriate technique
19.	Power Meter	The power produced by the solar panel can be known using the power meter (which measures power across the device to which it is connected).

20.	Battery	The electricity generated by the solar panel is converted and stored in a battery which is connected to all the devices.

Fig.1 Smart Green House system

4. Implementation

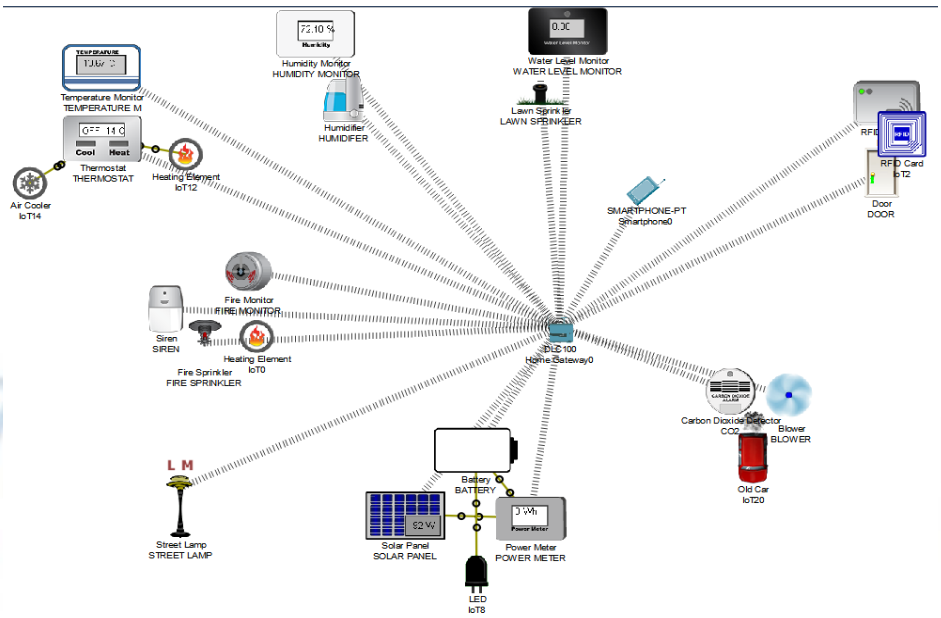
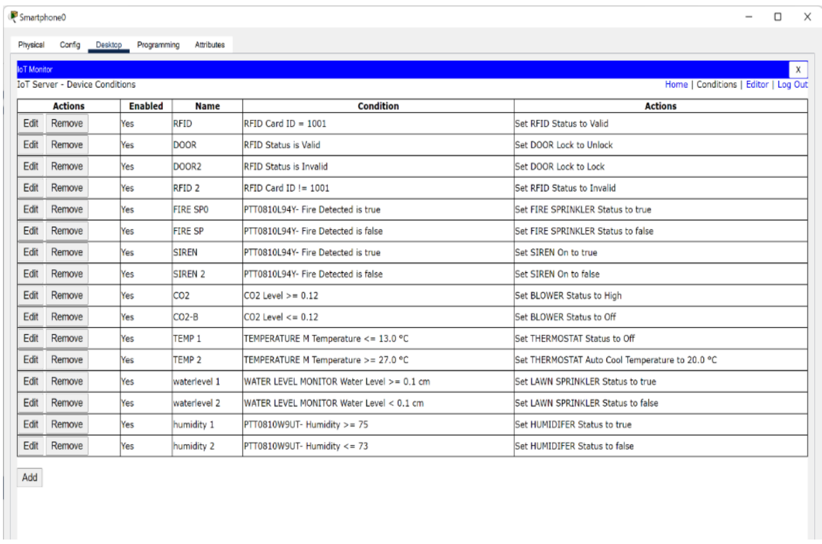


Fig. 2. Cisco Packet Tracer Smart Green House

Fig.2 shows the monitoring of devices in greenhouse using smart phone.


Smartphone0

Physical | Config | Desktop | Programming | Attributes

IoT Monitor

IoT Server - Device Conditions — Home | Conditions | Editor | Log Out

Actions		Enabled	Name	Condition	Actions
Edit	Remove	Yes	RFID	RFID Card ID = 1001	Set RFID Status to Valid
Edit	Remove	Yes	DOOR	RFID Status is Valid	Set DOOR Lock to Unlock
Edit	Remove	Yes	DOOR2	RFID Status is Invalid	Set DOOR Lock to Lock
Edit	Remove	Yes	RFID 2	RFID Card ID != 1001	Set RFID Status to Invalid
Edit	Remove	Yes	FIRE SP0	PTT0810L94Y- Fire Detected is true	Set FIRE SPRINKLER Status to true
Edit	Remove	Yes	FIRE SP	PTT0810L94Y- Fire Detected is false	Set FIRE SPRINKLER Status to false
Edit	Remove	Yes	SIREN	PTT0810L94Y- Fire Detected is true	Set SIREN On to true
Edit	Remove	Yes	SIREN 2	PTT0810L94Y- Fire Detected is false	Set SIREN On to false
Edit	Remove	Yes	CO2	CO2 Level >= 0.12	Set BLOWER Status to High
Edit	Remove	Yes	CO2-B	CO2 Level <= 0.12	Set BLOWER Status to Off
Edit	Remove	Yes	TEMP 1	TEMPERATURE M Temperature <= 13.0 °C	Set THERMOSTAT Status to Off
Edit	Remove	Yes	TEMP 2	TEMPERATURE M Temperature >= 27.0 °C	Set THERMOSTAT Auto Cool Temperature to 20.0 °C
Edit	Remove	Yes	waterlevel 1	WATER LEVEL MONITOR Water Level >= 0.1 cm	Set LAWN SPRINKLER Status to true
Edit	Remove	Yes	waterlevel 2	WATER LEVEL MONITOR Water Level < 0.1 cm	Set LAWN SPRINKLER Status to false
Edit	Remove	Yes	humidity 1	PTT0810W9UT- Humidity >= 75	Set HUMIDIFER Status to true
Edit	Remove	Yes	humidity 2	PTT0810W9UT- Humidity <= 73	Set HUMIDIFER Status to false

Add

Fig. 3. Cisco packet tracer iot configuration

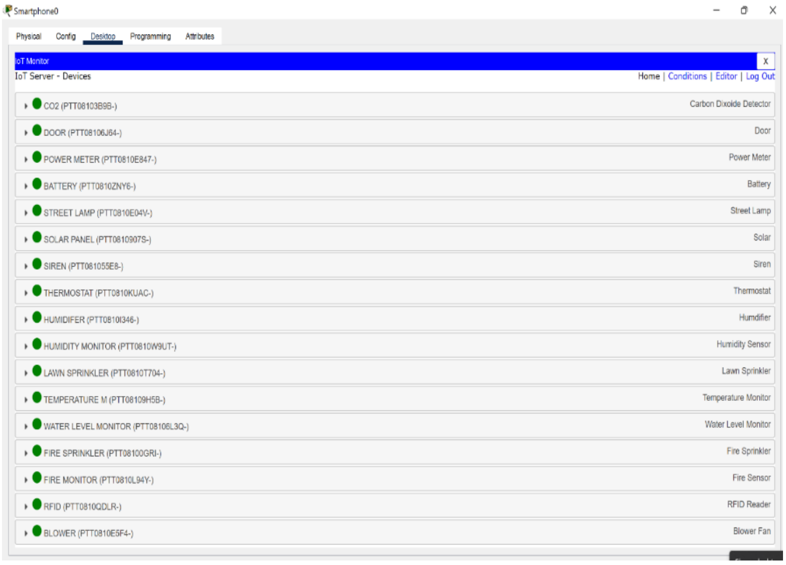


Fig. 4. Cisco packet tracer server devices

To determine the positive growth of the plant thermostat is getting applied which is going to be on or off based on the conditional statement programmed in java script and python [10].
The status of RFID reader is valid only when the card Id which is read by the reader matches with any one of the card Ids given to it [10].
The actuators are activated based on the input given following predefined conditions [6].
A solar panel transforms sunlight into electricity by using the suitable technique. The power generated by the solar panel can be identified using power meter (which measures power across the device to which it is connected). The electricity produced by solar panel is converted and stored in battery which is connected to all the devices. In this proposed idea we use solar cell to supply energy for all the devices which is also eco-friendly [8].
Smart lighting system is applied by using smart light [7]. Based on the sunlight detected by the sensor inbuilt in the smart light it will be activated. when the sunlight is above the desired level smart light is off and if the sunlight is below the desired level smart light will be turned on. This proposed model uses smart lighting system to maintain the lighting arrangements.
Water level examines the quantity of water currently available in soil which is the indication for moisture content in soil. Specific amount of moisture has to be maintained in soil for healthy plant growth. When the moisture content falls below the preset value water sprinkler is activated. In this paper water level monitor is used to measure the moisture in soil and when the moisture level falls below certain value lawn sprinkler is turned on so that the moisture content in soil is well maintained.

All the system's devices are linked to the Homegateway via wireless network connectivity. It enables a connection between a local area network and a wide area network. It is where, as pointed out, all devices and the Internet of Things are connected. One Home Gateway was configured in this design. The subnetmask is 255.255.255.0, and the IPv4 address is 192.168.25.1 (often the default IP address for the home gateway). While the SSID is changed to greenhouse to match the server's username, authentication for this is turned off. Using the username and password created on the server, all IoT devices are connected to Homegateway.

Temperature Sensor:

- If the temperature exceeds beyond the limit set, then a fan will be automatically switched ON as a coolant to reduce the temperature.
- When it reaches the desired temperature, the fan will be switched OFF automatically with the help of a relay.
- But if the temperature decreases below the optimum temperature a bulb as a heater will be switched ON to set the temperature within the desired range.

Light Sensor:

Light sensors sense the light and set an optimum light in the greenhouse for the plants.
An artificial light will be switched ON automatically by the light sensor with the help of relay if there is insufficient light for the plants in the greenhouse and the light is switched OFF automatically when the plants get sufficient light from the sun.

Moisture Sensor:

- Soil moisture sensor checks the water present in the soil.
- If there is not proper water in the soil, then moisture sensor sends signal to the water pump which as a result pumps up the water from the tank and provide sufficient amount of water to the soil.
- When the sensor senses the threshold value of water level in the soil it automatically turns OFF the pump.

Humidity Sensor:

- Humidity sensor is used to check the humidity of the air in the greenhouse.
- If the humidity exceeds the limit set then an exhaust fan will be switched ON with the help of relay to throw the humid air out of the greenhouse to maintain the suitable environment for the plants.

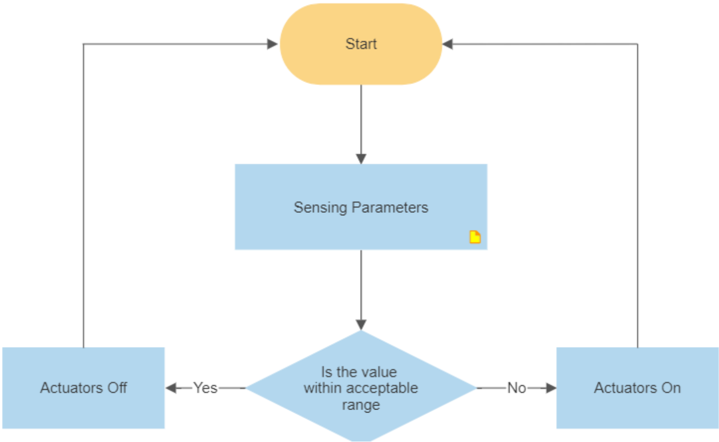


Fig. 5. Flowchart

Here Fig.6 shows the network used for this project representing smart greenhouse. If the sensing parameters meets the requirement and falls within the given acceptable range then Actuators will be activated otherwise it is going to be turned off.

5. Security Aspects

To create and maintain secure communication channels, IPsec (Internet Protocol Security) VPNs use the Internet Key Exchange (IKE) protocol. IKE can be used in the context of a smart greenhouse to secure data transfer between various devices or elements of the greenhouse network.

Building a network architecture that incorporates the various elements of the smart greenhouse, such as sensors, actuators, controllers, and a central server, to mimic this scenario using Cisco Packet Tracer.

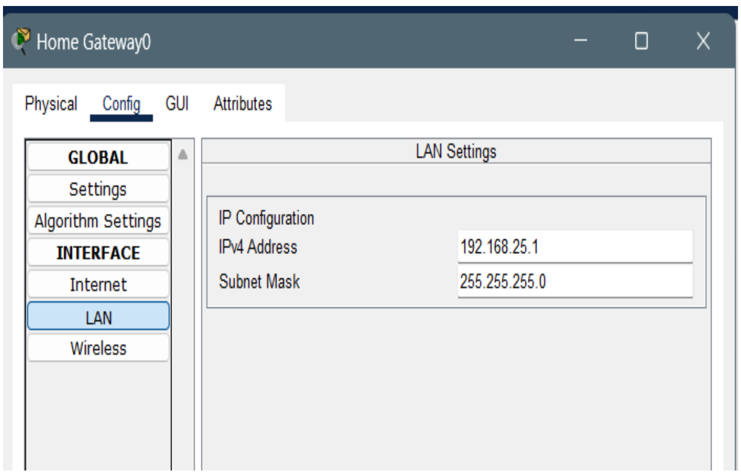


Fig. 6. Homegateway IP Address

The process for using IKE to secure data exchange:

1. Implemented VPN Tunnels: VPN tunnels have been established between the different elements of the smart greenhouse network. For example, tunnels have been created between the actuators and controllers, as well as between the sensors and the main server.
2. Configured IPsec Policies: IPsec policies have been set up to define the security parameters for the VPN tunnels. This includes selecting encryption algorithms, authentication methods, and key exchange protocols. IKE has been implemented for key exchange in the IPsec VPNs.
3. Activated IKE Phase 1: IKE Phase 1 parameters have been configured, establishing a secure channel between the VPN endpoints. Authentication methods, such as pre-shared keys or digital certificates, have been defined to ensure the authenticity of the connecting devices.
4. Enabled IKE Phase 2: IKE Phase 2 parameters have been configured to establish the IPsec Security Association (SA) and negotiate the encryption and authentication mechanisms for securing the data transmission. Session keys for data encryption have also been negotiated during IKE Phase 2.
5. Implemented Security Policies: Security guidelines have been implemented to control user access to the smart greenhouse network's components. Access control lists (ACLs), firewall rules, and other security measures have been put into action to prevent unauthorized access and protect against potential threats.
6. Monitored and Troubleshot: Cisco Packet Tracer's monitoring and troubleshooting tools have been utilized to ensure the proper functioning of the IKE VPN tunnels. This includes monitoring the status of the tunnels, analyzing IKE and IPsec logs, and addressing any identified issues.

6. Troubleshooting and Maintenance Techniques

The management of a network of smart greenhouses must include both maintenance and troubleshooting. To ensure the network performs at its best, they entail identifying and resolving potential problems as well as putting regular maintenance procedures into place. Here are some important things to think about:

Monitoring Tools:

- Utilize the Cisco Packet Tracer monitoring tools to keep tabs on the performance and health of the network.
- Keep track of sensor readings, device status, connectivity to the network, and other pertinent details.
- Set up notifications and alerts to receive notice of any urgent situations or unusual circumstances.

Identifying Network Issues

- Start the troubleshooting process by determining the symptoms and gathering data regarding the issue.
- Utilize the diagnostic tools in Cisco Packet Tracer to examine log files, device configurations, and network connectivity.
- Verify the network configuration for any faults, connectivity issues, or misconfigurations.

Network testing

- To ensure proper operation, test your network frequently.
- Check that all devices, including sensors, controllers, and actuators, are connected.
- To ensure accurate transmission, test the channels for data exchange and communication.

Device maintenance:

- Make sure your devices have the most recent security updates and bug fixes by regularly updating their firmware and software.
- Cleaning sensors, changing batteries, and checking physical connections are examples of routine maintenance duties.
- Make sure that equipment is calibrated correctly and in accordance with the manufacturer's instructions.

Backup and restoration

- Implement a backup and restoration strategy for important network configurations, data, and components.
- Backup configurations and device settings on a regular basis to a safe location.
- Restore configurations from backups in the event of network outages or device replacements to reduce downtime.

Documentation:

- Keep complete records of the network configuration for the smart greenhouse, including device configurations, IP addresses, and network diagrams.
- Any network modifications or updates should be documented.
- This documentation is used as a guide for future maintenance and troubleshooting.

Knowledge and Expertise:

- Make that the network administrators and maintenance staff are knowledgeable and skilled in networking, Cisco Packet Tracer, and smart greenhouse technology.
- Keep up with the most recent developments in network management techniques and smart greenhouse technology.

Collaboration and Support

- When faced with complicated problems or difficulties, get in touch with the supplier or manufacturer for support and assistance.
- Join forces with other industry experts by participating in forums, groups, or events to share information and experiences.
- You can reduce network downtime, quickly find and fix problems, and keep the smart greenhouse network operating at its best by implementing these troubleshooting and maintenance techniques.

Future Work

There are several future directions that can be explored in the Smart Greenhouse using Cisco Packet Tracer project:

1. Integration of advanced technologies: The current model can be improved by integrating advanced technologies such as Artificial Intelligence and Machine Learning to make the smart greenhouse more efficient and effective. AI can be used to analyze the data collected by the sensors and actuators and make real-time adjustments to optimize the growth of plants.
2. Optimization of resource consumption: The next step could be to optimize the resource consumption of the smart greenhouse. This can be achieved by using data analytics to predict plant growth and adjust the environmental parameters accordingly. Additionally, renewable energy sources such as solar panels can be incorporated to reduce the greenhouse's dependence on fossil fuels.

3. Validation of the model: The model developed in Cisco Packet Tracer can be validated by implementing it in a physical smart greenhouse and comparing the results with the simulation. This will provide a better understanding of the accuracy of the simulation and the effectiveness of the model in a real-world setting.
4. Implementation of remote monitoring and control: The smart greenhouse can be enhanced by implementing remote monitoring and control capabilities. This will allow farmers to monitor and control the environmental parameters of the greenhouse from anywhere, anytime, using a mobile application or a web interface.
5. Integration with the supply chain: The smart greenhouse can be integrated with the supply chain to enable real-time monitoring of the supply and demand of crops. This will help farmers to optimize their production and reduce wastage, leading to a more sustainable and profitable farming business.

Conclusion

Greenhouse is widely used in the current context of global warming to foster the efficiency and grow vegetations and plants in supervised environment. To increase the productivity, efficiency and applicability proposed idea can be implemented as an automation system rather than manual method to monitor the environmental conditions manually. IoT based sensors can be used to sense and actuators are activated according to the predefined conditions programmed for heating element, water sprinkler, thermostats, and humidifier to maintain the greenhouse conditions with electricity generation using solar energy, smart lighting and other monitoring systems. This paper emphasizes to apply an innovative idea which has been tested using simulator without any expenditure to get the basic idea of implementing the greenhouse to grow plants and vegetations and to improve plant growth, yield, and energy efficiency.

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