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IoT-Network Automation System Design and Implementation Simulation for Smart Home Applications

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ABSTRACT The Internet of Things has made smart homes a reality (IoT). A smart home is a place where people live that is equipped with various internet-enabled gadgets that enable online monitoring and remote control. In order to test and evaluate system performance during the design and development of smart home systems, simulation tools are required. Using Cisco Packet Tracer, a popular network simulation tool in the networking industry, a smart home simulation model is proposed in this paper. A home network connects the various actuators, sensors, and smart home appliances that make up the suggested model. Through a web interface, users can monitor and control smart home devices with the simulation model, which also offers real-time feedback on system performance. The recommended model also includes automatic modules that monitor temperature, motion, smoke, humidity, and solar panel control using smart batteries. A platform for testing and assessing a range of smart home applications, including energy management, health monitoring, and home security, is the suggested smart home simulation model. Because it provides researchers and students studying smart home systems with a realistic learning environment, the simulation model is beneficial for education. Additionally, this article compared the response times for communication between IOT devices using the HTTP and MQTT protocols and this comparison showed the MQTT protocol outperformed the http protocol with the small size messages.

Keywords: IOT, Smart Home, HTTP, MQTT.

I. INTRODUCTION

"Smart homes," where multiple devices are networked and communicate with each other to create a seamless living environment, are now feasible thanks to the Internet of Things (IoT). Because it involves integrating multiple devices and technologies, designing, and developing smart home systems can be difficult. Because simulation tools enable the identification of potential problems and offer insight into system behavior, they are crucial for testing and assessing system performance prior to deployment.

A popular network simulation tool in the networking sector is Cisco Packet Tracer. It offers a virtual environment for network topologies and protocol design, configuration, and testing. While originally designed for networking simulations, Packet Tracer can also be used for simulating smart home systems due to its ability to simulate various IoT devices and protocols.

In this paper, we present a Cisco Packet Tracer-based smart home simulation model. Smart appliances, actuators, sensors, and other devices connected to a home network are all included in the simulation model. Additionally, it offers real-time system performance feedback and a web interface for users to monitor and control smart home appliances. It was designed to increase efficiency, safety, and comfort and can be used to automate household chores without the need for humans to constantly check the home's temperature, humidity, smoke levels, wind, or sound levels [1][2].

Home security, energy management, and health monitoring are just a few of the smart home applications that can be tested and evaluated using the suggested simulation model. The simulation model is also useful for teaching Because it offers scholars and students studying smart home systems an interactive learning environment, the simulation model is also helpful for teaching.

In this paper, we will discuss the design and implementation of the smart home simulation model

using the most modern release of the Cisco Packet Tracer (7.2), including the selection of smart devices, the configuration of the home network, and the development of the web interface [3]. We will also present the results of our experiments that compare the HTTP and MQTT protocols.
In the next section of this paper a motivation of this study will be provided, while in the third section the methodology will be provided followed by a comparison between building the IOT system using the HTTP protocol compared with the MQTT protocol regards the response time. Finally, we will provide a conclusion.

II. Motivation

By utilizing Cisco Packet Tracer (Version 8.0.1) to build a foundation for a Smart Home automation system, we show how simulation works in our project. A highly advanced network modelling tool from the Cisco System Academy, Cisco Packet Tracer can simulate or create a network without a physical one being present. It offers an easy drag and drop interface that is quite helpful for building complex networks [5] [6]. The Cisco Packet Tracer application has the following benefits for the project's development:

- Real-world IoT devices simulations and visualizations offered.
- Designing, construction, and customization of smart homes are permitted.
- Provision of a variety of smart items for use in the construction of smart homes
- Smart house design, construction, and customiz ation are permitted.
- Provision of a variety of smart items for use in th e construction of smart homes
- A device is supplied for controlling smart items.
- Encouraged users to explore IoT concepts.
- Sensor detectors provided.
- Energy consumption is monitored by an energy meter.
- Users have access to data in the form of readings through mobile applications.

The system's purpose being to give consumers the ability to quickly and easily utilize, manage, and maintain their homes via smart technology.
Sensor interfaces can be built into homes to track motion, illumination, temperature, and humidity conditions, among other things, and to let people turn on and off automation based on predetermined conditions. The network intends to offer a variety of services, including increased security, improved lifestyle, and energy efficiency. The system's integration with these areas of home automation gives us the chance to expand its influence by designing automation for manufacturing facilities and offices as well. This computerized network establishes a universal expected standard for using cloud technologies to connect smart devices to the internet. It gives user management over smart home devices like lighting, sprinkler irrigation, fire detection, solar energy panels, and web cameras, to mention a few.
These smart gadgets' expandability to connect with different networks makes it simple to implement security and energy management solutions.

III. METHODOLOGY

Using Cisco Packet Tracer, which offers an interactive environment that enables the development of virtual network environments to aid in the comprehension of ideas and standards for the justification, investigation, and analysis of network engineering methods, in a residential project, our concept intends to show off smart networking possibilities.
In this system, we use several home automation components, such as windows, fans, lighting, doors, garbage doors, lawn sprinklers, fire sprinklers, and a variety of sensors as shown in figure. 1. It is possible to control a variety of devices and sensors using the Home Gateway [7]. Through the registration of Home Gateway with the smart devices, Home Gateway offers a programming environment for controlling connected objects and control mechanisms.

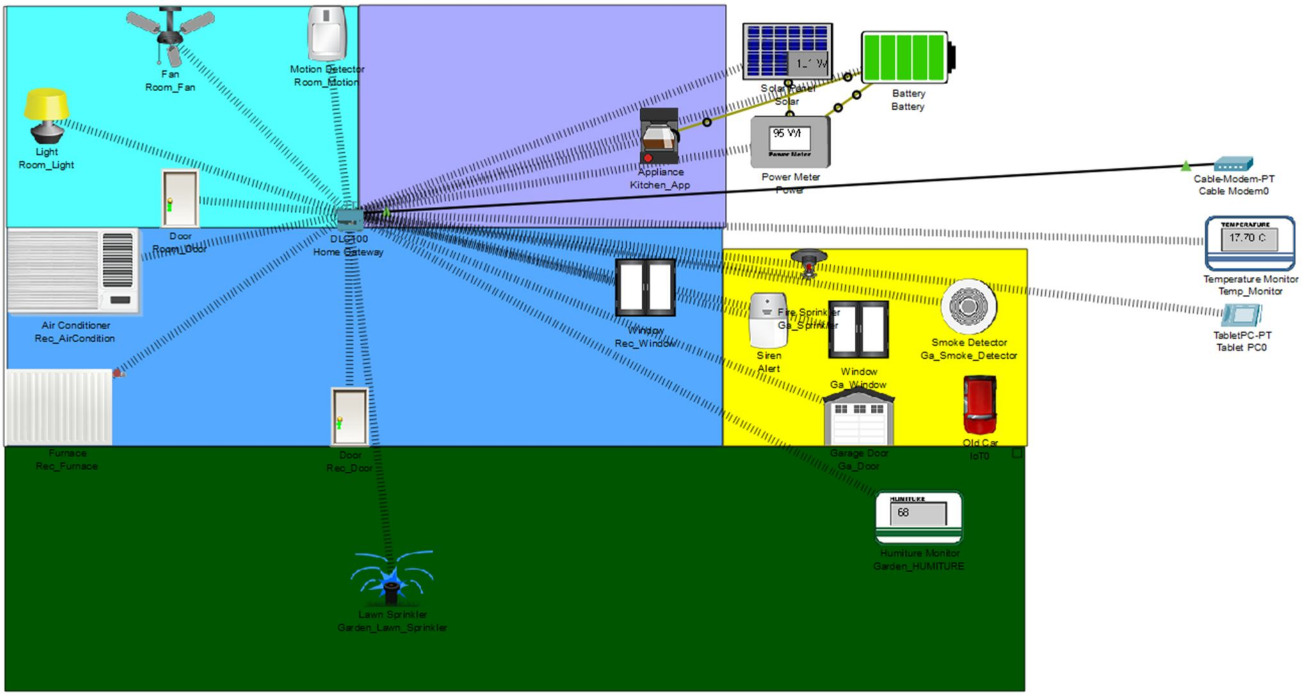

FIGURE 1: **System Design**

Home Gateway: There are 4 ethernet ports on the home gateway as shown in the figure. 2. For us to establish wireless links and connections using the SSID, it also contains a wireless contact point on channel 6. The home gateway establishes a connection to the internet using the WAN Ethernet port. This interface demonstrates it to be helpful in managing the automation network. Both Ethernet cables and wireless links enable local and remote device control. Both its internal and internet IP addresses can be used to access the home gateway. It also performs the function of a DHCP server, allocating IP addresses to the devices it is linked to.

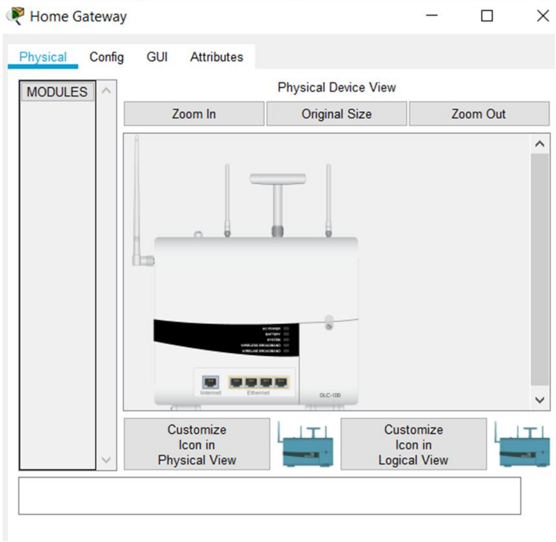

FIGURE 2: **Home Gateway**

Smart Tablet: all smart gadgets are wired or wirelessly connected to the home gateway via Ethernet cables. As shown in the figure. 3., these devices can be connected to the smartphone to give the user access to remote device control via the smartphone via the internet.

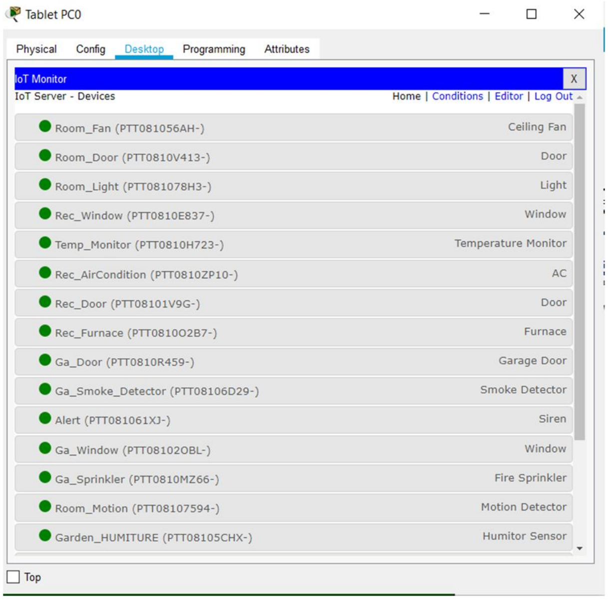

FIGURE 3: **A list of the network-connected devices that are connected to the IoT Server.**

Fire Detector: As shown in figure. 4. In the occurrence of a fire, the smoke level will rise, the alarm will ring, the fire sprinkler will activate, spray water, and the garage window and door will open. The following are the circumstances under which the fire detector will function:

- If the level (L) detected by the smoke detector is more than or equal to 0.1, the garage fire is set to be ON. the sprinkler, siren, window, and door locks will all turn ON.
- If the smoke detector detects a level (L) of less than 0.1, the garage fire is set to be OFF. Where there isn't a garage fire, the sprinkler, siren, window lock, and door lock will all turn OFF.

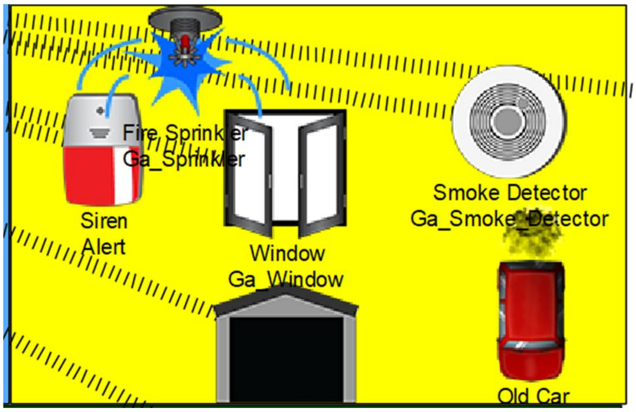

FIGURE 4: **The IOT devices connection for the fire detection**

Motion Detector: as soon as someone enters the room, as shown in the figure. 5, this sensor detects motion, turning on the lights and fans in response. This promotes energy efficiency when not in use. The following are the circumstances under which the motion sensors will function:

- If the motion detector indicates that there is movement, turn on the lights and set the fan to high.
- If the motion detector indicates that there is no movement, turn off the lights and the fan.

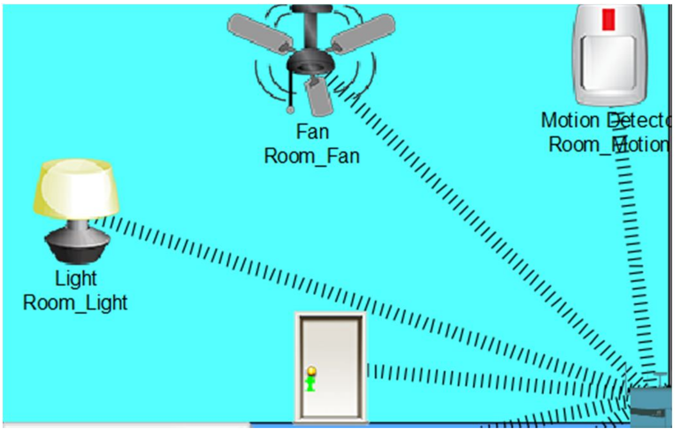

FIGURE 5: **The IOT devices connection for the motion detection**

Humiture Monitor: As shown in figure. 6. The lawn sprinkler is activated and deactivated based on the external temperature and humidity detected by this sensor. The following are the circumstances under which the humidity meter will function:

- The lawn sprinkler will turn on if the ambient temperature (t) is 50 degrees or higher.
- the sprinkler will turn off if the ambient temperature (t) is less than 50.

FIGURE 6: **The IOT devices connection for the humiture monitor.**

Solar Panel: As shown in figure. 7. This solar panel sensor detects the battery inside the solar panel and turns the coffee maker on and off in accordance. The following are the circumstances under whereby the sensor on the solar panel will operate:

- If the solar panel's battery capacity is greater than 60%, the coffee maker will turn on.
- If the solar panel's battery power falls below 60%, the coffee maker will turn off.

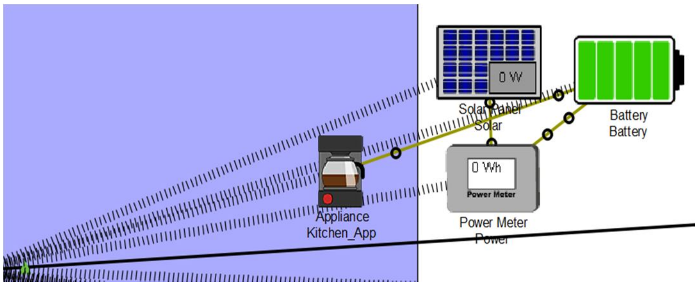

FIGURE 7: **The IOT devices connection for the solar panel.**

Temperature Monitor: as shown in the figure. 8. The air conditioner and furnace are activated and deactivated based on the external temperature detected by this sensor. The following are the circumstances under which the humidity meter will function:

- The air condition will turn on and the furnace will turn off if the temperature (t) is 18 degrees or higher.
- The air condition will turn of and the furnace will turn on if the temperature (t) is less than 18 degrees.

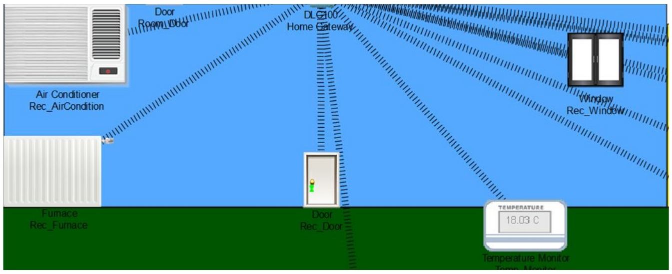

FIGURE 8: **The IOT devices connection for the temperature monitor.**

IV. THE COMPRISON BETWEEN HTTP AND MQTT PROTOCOLS IN IOT

The association created by TCP is distributed on each access when HTTP is used as an application protocol in the Internet of Things (IoT) over TCP/IP. This is due to the fact that URLs and IP addresses used for data transmission are constantly changing. As a result, after numerous attempts to establish and release a connection, the communication is successful. Therefore, because of the overhead of control packets and channel bandwidth waste in the network. In the smoke detector system in the simulation screen, We can see definitely that the overall time to detect the smoke problem and devices like alert be on is 0.053 – 0.063 = 0.01s as shown in figure. 9.

Vis.	Time(sec)	Last Device	At Device	Type
	0.052	Home Gate...	Ga_Window	HTTP
	0.052	Home Gate...	Ga_Smoke_Detector	HTTP
	0.057	--	Home Gateway	IoT TCP
	0.058	Home Gate...	Ga_Door	IoT TCP
	0.058	Home Gate...	Tablet PC0	IoT TCP
	0.058	Home Gate...	Alert	IoT TCP
	0.058	Home Gate...	Ga_Sprinkler	IoT TCP
	0.058	Home Gate...	Ga_Window	IoT TCP
	0.058	Home Gate...	Ga_Smoke_Detector	IoT TCP
	0.062	--	Home Gateway	TCP
	0.062	--	Home Gateway	HTTP
	0.063	Home Gate...	Ga_Door	HTTP
	0.063	Home Gate...	Tablet PC0	HTTP
	0.063	Home Gate...	Alert	HTTP
	0.063	Home Gate...	Ga_Sprinkler	HTTP
	0.063	Home Gate...	Ga_Window	HTTP
	0.063	Home Gate...	Ga_Smoke_Detector	HTTP

Figure 9: **Packet Capture Using HTTP**

Minimal throughput device communication is made feasible by MQTT protocol's short packets and extremely minimal control packet overhead. There is no need to use HTTP or FTP, which have significant overhead when used online. MQTT is made for Internet of Things applications that rely on publish-subscribe architecture and employ minimal packet sizes [8]. The publish/subscribe concept is the foundation of the protocol, which is used for machine-to-machine communication. In simulations, it is clearly observed that time to detect the smoke problem and devices like alert be on is 130.029s – 130.026s = 0.003s as shown in figure. 10.

Vis.	Time(sec)	Last Device	At Device	Type
	130.024	Home Gate...	Ga_Sprinkler	TCP
	130.024	Home Gate...	Ga_Window	TCP
	130.024	Home Gate...	Ga_Smoke_Detector	TCP
	130.025	--	Home Gateway	MQTT
	130.026	Home Gate...	Ga_Door	MQTT
	130.026	Home Gate...	Tablet PC0	MQTT
	130.026	Home Gate...	Ga_Smoke_Detector	MQTT
	130.026	--	Tablet PC0	TCP
	130.026	--	Tablet PC0	TCP
	130.026	Home Gate...	Alert	MQTT
	130.026	Home Gate...	Ga_Sprinkler	MQTT
	130.026	Home Gate...	Ga_Window	MQTT
	130.026	--	Tablet PC0	TCP
	130.027	--	Tablet PC0	TCP
	130.028	Tablet PC0	Home Gateway	TCP
	130.029	--	Home Gateway	MQTT
	130.030	Home Gate...	Ga_Door	MQTT

Figure 10: **Packet Capture Using MQTT**

From the simulation results it is observed that the MQTT protocol is faster than HTTP. As the MQTT protocol is utilized for tiny data transfer between M2M devices. whereas HTTP is used preferably for huge data collection in big data applications.

In addition to having a quick response time, MQTT connections allow for the transmission of any number of messages, including commands as well as data from the sensor to the back end. While HTTP processes requests one at a time, requiring overhead like authentication each time. So, depending on the paper proposed architecture the MQTT is more suitable than HTTP to be used regards the automatic systems such as fire detection, solar panel, temperature control, and others.

V. CONCLUSION

This paper discussed how the smart house was put into practice. In order to show how to construct a smart home, the most recent release of Cisco Packet Tracer (7.2), which includes a variety of detectors, actuators, and smart devices for controlling things at home, was used to demonstrate how to build a smart home. Systems including smoke detectors, temperature monitors, motion detectors, humidity monitors, and solar panels were put into place. Additionally, we compared the response times of the smart home implementations using the HTTP protocol and the MQTT protocol. The MQTT protocol is quicker than HTTP, according to the simulation results.

REFERENCES

1. Garima Jain, Nasreen Noorani, Nisha Kiran, Sourabh Sharma, Designing & simulation of topology network using Packet Tracer, International Research Journal of Engineering and Technology (IRJET), 2(2), 2015.

2. S. Raja Gopal, P. Saleem Akram , S. Sriram, T. Pavan Koushik, V. Mohana Krishna, ―Design and Analysis of Heterogeneous Hybrid topology for VLAN configuration―, International Journal of Emerging Trends in Engin
3.] Todd Lammle, Cisco Certified network associate study guide (Wiley Publishing Inc., 2007)
4. Saleem Akram P., Ramana T.V., "Stacked electromagnetic band gap ground optimization for low profile patch antenna design", International Journal of Engineering and Advanced Technology, ISSN:22498958
5. Saleem Akram, P .Ramana, T. V. (2019). Two dimensional beam steering using active progressive stacked electromagnetic band gap ground for wireless sensor network applications. Journal of Computational and Theoretical Nanoscience, 16(5-6), 2468-2478. doi:10.1166/jctn.2019.7918
6. Bhatt, P., Akram, P. S.Ramana, T. V. (2015). A novel on smart antennas to improve performance in wireless communications. Paper presented at the International Conference on Signal Processing and Communication Engineering Systems - Proceedings of SPACES 2015, in Association with IEEE, 187-190. doi:10.1109/SPACES.2015.7058245
7. Ravikanth, B., Akram, P. S., Ashlesha, V.Ramana, T. V. (2017). Tuning operating frequency of antenna by using metasurfaces. Paper presented at the International Conference on Signal Processing, Communication, Power and Embedded System, SCOPES 2016 - Proceedings, 2064-2068. doi:10.1109/SCOPES.2016.7955811
8. Krishna, P.G., Ravi, K.S., Kumar, V.S. and Kumar MS: Implementation of MQTT Protocol On Low Resourced Embedded Network, Int. J. Pure Appl. Math (IJPAM), 116, pp.161-166 (2017).
9. Ebrahiem, K.M., Soliman, H.Y., Abuelenin, S.M., El-Badawy, H.M.: A deep learning approach for channel estimation in 5G wireless communications. In: 2021 38th National Radio Science Conference (NRSC). Mansoura, Egypt, pp. 117–125 (2021)
10. El-Gaml EF, ElAttar H, El-Badawy HM “Evaluation of intrusion prevention technique in lte based network”. Int J Sci Eng Res 5:1395–1400, 2014
11. Wafaa Radi and Hesham El-Badawy. “Enhanced Implementation of Intelligent Transportation Systems (ITS) based on Machine Learning Approaches”, Intelligent and Sustainable Vehicle Networking Workshop, 20th ACS/IEEE International Conference on Computer Systems and Applications (AICCSA2023), Egypt, 4th -7th Dec2023.
12. Wafaa Radi, Hesham El-Badawy, Ahmed Mudassir and Hesham Kamel. “Traffic Accident Management System for Intelligent and Sustainable Vehicle Networking”, Intelligent and Sustainable Vehicle Networking Workshop, 20th ACS/IEEE International Conference on Computer Systems and Applications (AICCSA2023), Egypt, 4th -7th Dec2023
13. Rowayda Sadek and Alaa Khalifa, “Vision Transformer Based Intelligent Parking System for Smart Cities”, Intelligent and Sustainable Vehicle Networking Workshop, 20th ACS/IEEE International Conference on Computer Systems and Applications (AICCSA2023), Egypt, 4th -7th Dec2023