DEPT. Of Computer Science Engineering

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18CSE451T – WIRELESS SENSOR NETWORKS

WSN MINI PROJECT

SEMESTER VI

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SECTION

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BONAFIDE CERTIFICATE

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ABSTRACT

This paper presents a new approach to utilize technology in a practical and meaningful manner within a smart home system that can be widely deployed into residential settings. In the modern world, people are rapidly turning to technology as a fast and cost-effective way of improving quality of daily living. This primary goal is to address the needs of the end user by employing networked low-power sensors sensitive to the environment, so it can be altered to their liking. The proposed system consists of following steps: direct environment sensing, collecting and analysing data and then allowing user to customize the settings and initiate specific commands. This research will present the design and implementation of a practical and simple smart home system, which can be further extended. The system is based on: group of sensors, Raspberry Pi device as a server system and Bluetooth as a communication protocol. These devices can be easily controlled via user-friendly interface for Android phones. The main advantage of the proposed system is that it is a sensible, secure and easily configurable system that provides end users with a neat home automation solution.

INTRODUCTION

Smart home itself does not mean smart when the home is built friendly to the environment, how space it uses, or using solar power and recycling waste water, but what makes it smart is the interactive technologies that it contains

1. A smart home is called "intelligent", because its computer systems can monitor many aspects of daily life.
2. The concept of the smart home is a promising and cost-effective way of improving home care for the elderly and the disabled in a non-obtrusive way, allowing greater independence, maintaining good health and preventing social isolation.
3. Smart home consists of home appliances, sensors, actuators and data processors and analyzers.
4. Home automation of appliances can be either wired or wireless.
5. In this paper model of smart home based on Raspberry PI and Android device is suggested. Mobile application has been developed in order to manage smart home behaviour. The main contribution of this paper is that it presents easy to implement, flexible and scalable solution for making a smart home environment. Smart home system presented in this paper is based on mobile device, because of constant growth of smartphones and tablets usage.

Smart home systems have been gaining popularity in recent years, with more and more people looking for ways to automate their homes and make everyday tasks easier. One of the key components of a smart home system is the use of sensors to control various aspects of the home, from lighting and temperature to security and entertainment. Improved data communications lead to faster transfer of information within businesses and between partners and customers. It Connects with your appliances to automate specific tasks and is typically remotely controlled.

Types of Sensors Used in Smart Home Systems

- There are several types of sensors commonly used in smart home systems, including motion sensors, temperature sensors, light sensors, and humidity sensors.
- Motion sensors can be used to turn lights on and off automatically when someone enters or leaves a room.
- Temperature sensors can help regulate heating and cooling systems based on the current conditions in the home.
- Light sensing smart devices can turn off the light switch when you don't remember to and smart bulbs let you set lighting schedules.
- The temperature and humidity sensor monitors the indoor temperature and humidity in real-time and displays the value through the LCD.

Challenges of Implementing Smart Home Systems with Sensors

For the reader's convenience, we have listed some of the major challenges discussed above in the implementation of IOT based smart home systems based on the review.

1. Human Motion Detection
2. Security and Privacy
3. Scalability
4. Lack of Global Standards
5. Interoperability
6. Device Connectivity
7. Affordable Cost

- **Human Motion Detection**

  Human motion detection is one of the potential challenges in the smart home living environment. Deep learning techniques such as convolution neural networks and recurrent neural networks are applied on time series data obtained from sensors for human motion detection by developing human behavioural models. Many researchers showed the effectiveness of these techniques in human activity detection. However, wearable technologies, sensors, and cameras play an important role in reliable data collection. Implementation of sensor technology efficiently might be a future challenge towards human activities detection. Various efforts are made by researchers towards the analysis of human activity detection in the smart home environment. Human motion detection is crucial for older people to protect them from falling. The researchers should investigate new machine/deep learning approaches for human activity detection in an efficient manner. At the same time, we can monitor human activities in a Realtime

environment. For any human activity recognition, two aspects are essential. The first one is to identify the human activities, and another one is to make the prediction based on those activities. Machine learning techniques can be helpful to solve these two aspects.

- **Scalability**

  Scalability is the property of the cloud to accommodate the growing number of smart homes based on specific requirements. Fog and cloud computing technologies supports scalability and flexibility of resources in smart home IoT based environment. However, various researchers provide a scalable solution towards IoT-based smart homes. Low cost and scalable solutions based on multiple sensors are proposed to improve indoor quality. Another scalable architecture based on IoT-based smart homes is proposed to handle huge amounts of data and reduce the system's complexity. However, a comparison between cloud and fog computing shows more scalability in fog computing because, in the cloud, the deployment of new data centres is cost-bidden.

- **Lack of Global Standards**

  IoT-assisted smart home environment involves various stakeholders like devices and various cloud service providers. Therefore, the lack of global standards is still a challenge to make a smart home environment simpler, cost-effective, compatible among stakeholders. Global standardization is very much required to provide efficient home-based cloud services to manage various system resources. Lack of standards in IoT-based smart home solutions remains a great challenge because of the heterogeneity of connecting devices and fractured solutions. Technological solutions can be useful to make global standards in IoT-based solutions. However, very few researchers attempt to study global standards for interoperability and security. Different device manufacturing companies should be more focused on how to standardize and provide another framework. At the same time, users have to decide to select a compatible device with the existing communicating devices.

- **Interoperability**

  Interoperability is the ability where two or more systems can exchange the information without any difficulties. Interoperability issues arise in IoT-based smart home solutions, which each of them provides its infrastructure, devices, data standards, and protocols. Smart home interoperability is a significant challenge in terms of communication, connectivity, and integration protocols. Lack of global standards and proprietary communication protocols for devices leads to a lack of interoperability in the home automation system. Further, these interoperability issues create significant problems such as the development of cross-platform IoT-based architecture, incompatibility of devices with other devices, and finally stops the large-scale integration of IoT-based solutions. However, different interoperability solutions are proposed by researchers to facilitate IoT vendors to share information and work together. An interoperability framework with selected characteristics is proposed for smart home communication protocols to facilitate working with different IoT platforms. Another self-evolving algorithmic approach for data

interoperability in IoT systems is proposed in an IoT environment. A multi layered cloud architectural model is proposed for handling interoperability issues in heterogeneous IoT-based platforms. However, various solutions are proposed for a specific perspective of interoperability, but very few consider different perspectives. IoT device capabilities should also be considered while solving the interoperability issues. Also, it is essential to connect other platforms and capacity to add more platforms in the future for the smart IoT ecosystem.

- **Device Connectivity**

  Various household devices can be connected to provide a more efficient way for data exchange. To understand the system's current state, we need multiple sensors to communicate with each other seamlessly for helpful information exchange. However, the communication of these devices and sensors will be decided by the appropriate communication protocols. Further, these protocols can be categorized into three categories such as wireless, wired, or hybrid. Some of the wired communication protocols are Ethernet, X10, Universal Powerline Bus (UPB), INSTEON, Multimedia over Coax (MoCA), and KNX and wireless protocols are Wireless Fidelity (Wi-Fi 802.11n), Bluetooth, Bluetooth LE, ZigBee, Z-Wave, and 6LoWPAN. A framework for seamless device connections in a smart environment is proposed, which ensures interoperability across all the devices. Still, researchers expect much research to solve device connectivity issues such as security and privacy.

- **Affordable Cost**

  As the number of devices increases in IoT-assisted smart home environments, efficient communication between them to share the information over sensory networks becomes important with affordable cost. Energy-efficient devices based on low power solutions and efficient resource utilization leads to reasonable implementation cost over interconnecting networks. Affordable price plays a vital role in converting traditional house to intelligent house. Therefore, it is essential to make sensor devices more energy-efficient and automated, reducing overall implementation costs. Low-cost long-range (LoRa) is one of wireless technology which provides solution a low price. Various solutions are proposed by researchers based on affordable cost. A wind-driven bacterial foraging algorithm is proposed and devised as a strategy based on monitoring power consumption in IoT buildings and home appliances. Another application of intelligent home automation based on the low cost, which integrates software and hardware, is implemented successfully. Another application that uses Bluetooth-Low-Energy with fuzzy approaches in intelligent home automation systems showed the best performance. More research is needed to find more cost affordable smart home solutions for the extensive integration of IoT.

Future of Smart Home Systems with Sensors

"Smart Homes" denotes the use of technical systems, automated processes and connected, remote-controlled devices in apartments and houses. The main objective of the functions is to improve the quality of life and convenience in the home. Other goals are greater security and more efficient use of energy thanks to connected, remote-controllable devices. Home appliances such as the washing machine, lights or the coffee maker, can be time-controlled. Devices like motion sensors, cameras, shutters or thermostats initiate user-programmed processes. The heart of the smart home is the central control unit, with which various smart components are connected and can be controlled from the PC, smartphone or tablet. Common wireless standards such as Wi-Fi, Bluetooth, ZigBee or Z-Wave are used for communication or controlling devices. The central control unit is also termed a hub or gateway. It's human nature to find ways that make everyday life easier and more pleasant. The area of "home automation" – in effect the predecessor of the smart home – was brought to life through technological progress, in particular through the Internet and computer. Science fiction literature in the 1950s portrayed the first visions of homes that are monitored and controlled fully automatically by machines. The 1999 Disney film "Smart House" was about household computers and the consequences when smart machines take on a life of their own. And Disney proved to be unintentionally visionary in the part of the movie where the house's intelligent control unit develops the feeling of jealousy. In reality, it will likely be a few years before machines can "generate" emotions – fortunately.

Scientists have already been working for more than 30 years on connecting home appliances and automating their use.

Yet it's only been in the past 15 years that the issue of the smart home has aroused broad public interest. The main reasons: Current challenges as a result of trends like an aging society, greater environmental awareness and the related wish for a sustainable energy supply. Increasing digitization and new means of enhancing convenience in our own four walls were further factors that put the smart home at the centre of public interest at the turn of the millennium. The Fraunhofer inhauls Centre, which was opened in Duisburg in 2001, is a lighthouse project in German-speaking countries. The project involves exploring and testing new system solutions and products from the smart home segment in a residential environment. "The House of the Present" in Munich showcased a connected home with centrally controlled electronic processes from 2005 to 2011. The first T-Com House from Deutsche Telekom in Berlin was opened to interested visitors in 2005. The focus of this model project was on connecting various home appliances and controlling them by means of different input devices.

FUTURE

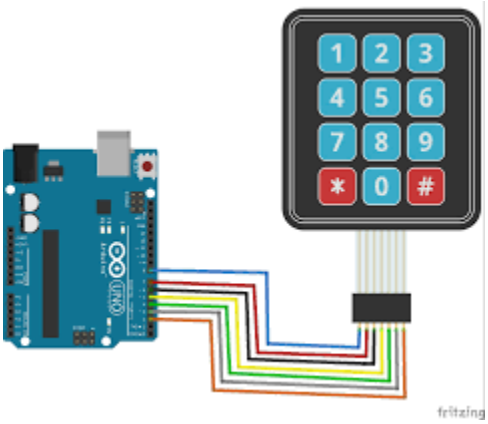
- As technology continues to advance, the future of smart home systems with sensors looks promising.
- In the coming years, we can expect to see even more advanced sensors and devices that are capable of providing more accurate readings and greater control over various aspects of the home.
- Additionally, advancements in artificial Intelligence and machine learning could allow for even more sophisticated automation and customization of smart home systems.

Design and implementation

In this project, we will use WSNs to control various appliances in a smart home. We will use nodes equipped with temperature and light sensors to monitor the temperature and lighting conditions in the home. We will also use nodes with motion sensors to detect the presence of people in the home. The data collected by these nodes will be sent to the base station, which will make decisions based on the data.

The proposed system consists of two main parts, the first part is a security system and the second part is an automation control system. The security system consists of the PIR sensor and the laser beam with Light Dependent Resistance (LDR). When the thief passes in front of the PIR sensor,

the sensor analyses the infrared radiation that emitted from its body, then the Arduino Nano activating the alarm, Wi-Fi camera, and send logic “1” to the NodeMCU in order to display the alarming message on the GUI. Besides, when the thief cuts the directed laser beam to the LDR, the resistance value will increase and the Arduino Nano doing the same previous steps. The security system is powered by a control system based on the Arduino Mega, relay controller, and a 4 × 4 keypad. In order to turn ON/OFF the security as well as the automation system, a different password for both the ON and OFF states should be entered. In addition, a 16 × 2 liquid crystal display is also utilised to indicate that the system in the ON or OFF state.



The automation and control part based on the Arduino Nano microcontroller with many types of sensors, such as the two gas sensors, the flame sensor, the soil moisture sensor, LM 35 temperature sensor, and the water level sensor, the task of each sensor in this part is demonstrated. In addition, the two parts of the proposed system are linked to the NodeMCU microcontroller, which supports the IoT technology, where the Arduino Nano read the sensors data and send logic “1” or “0” to the NodeMCU to display the necessary messages on the GUI, this method is utilised due to the limited analogue input pins of the NodeMCU as well as to provide the reliability to the proposed system, if one of the microcontrollers fail or damaged will not effects on the rest of the system. The homeowner can continuously monitor his home remotely via local IP address, enabling him to access the GUI which is programmed to monitor the home in different cases. The

HC-05 Bluetooth with its compatible Android app and the servo motor is also utilised to remotely control the garage gate.

Hardware Design

Hardware design is the process of creating the physical components and systems of a product, such as electronic devices or mechanical systems. It involves making decisions about the components, layout, and structure of the hardware, based on the requirements of the product.

The hardware design process typically involves the following steps:

1. Requirements Analysis: The first step in hardware design is to identify the requirements of the product. This involves gathering information from stakeholders, analyzing existing systems, and identifying functional and non-functional requirements.

2. System Design: Based on the requirements analysis, the system architecture is designed. This involves identifying the components of the system, their interactions, and their relationships.

3. Detailed Design: The detailed design involves creating the low-level design of the hardware components. This includes selecting the electronic components, specifying the connections between them, and designing the mechanical components.

4. Prototyping: A prototype of the hardware is built to test the design and identify any issues that need to be resolved.

5. Testing: The hardware is tested to ensure that it meets the specified requirements and quality standards.

6. Manufacturing: Once the hardware design is finalized, it is manufactured in large quantities for commercial distribution.

Some important aspects of hardware design include:

1. Component Selection: Selecting the right components is critical for the success of a hardware product. Components should be chosen based on their performance, reliability, cost, and availability.

2. Layout and Routing: The layout and routing of the components on the printed circuit board (PCB) or other substrates should be carefully designed to ensure optimal performance and minimal interference between components.

3. Power Management: The design should include measures to manage the power consumption of the hardware, to maximize battery life and reduce energy costs.

4. Thermal Management: The design should include measures to manage the heat generated by the hardware, to prevent overheating and ensure reliable operation.

In conclusion, hardware design is a crucial aspect of product development, and it involves making critical decisions about the components, layout, and structure of the hardware, based on the requirements of the product. A well-designed hardware system can provide optimal performance, reliability, and energy efficiency, which are essential for its success.

Software Design

Software design is the process of defining the architecture, components, interfaces, and other characteristics of a software system. It involves making critical decisions about the system's structure, behaviour, and functionality, based on requirements analysis and system specifications.

The software design process typically involves the following steps:

1. Requirements Analysis: The first step in software design is to identify the requirements of the system. This involves gathering information from stakeholders, analysing existing systems, and identifying functional and non-functional requirements.
2. System Design: Based on the requirements analysis, the system architecture is designed. This involves identifying the components of the system, their interactions, and their relationships.
3. Detailed Design: The detailed design involves creating the low-level design of the system components. This includes defining the interfaces, data structures, algorithms, and procedures required for each component.
4. Implementation: In this phase, the actual coding of the system is done using the design specifications created in the previous steps.

5. Testing: The system is tested to ensure that it meets the specified requirements and quality standards.
6. Maintenance: Once the system is deployed, it will require ongoing maintenance and updates to ensure that it continues to function as expected.

Some important aspects of software design include:

Modularity: A well-designed software system should be modular, with components that can be easily added, removed, or modified without affecting the functionality of other components.

Scalability: A software system should be designed to accommodate changes in requirements, data volume, and user traffic, without requiring major modifications.

Maintainability: The software system should be designed in a way that makes it easy to maintain and update, even as the system evolves over time.

Security: The design should include measures to protect the system from unauthorized access and to ensure the confidentiality, integrity, and availability of data.

In conclusion, software design is a crucial aspect of software development, and it involves making critical decisions about the system's structure, behaviour, and functionality. A well-designed software system can provide scalability, maintainability, modularity, and security, which are essential for its success.

Uses

The future scope of smart home systems using WSNs is immense, and it is expected that the adoption of such systems will continue to grow in the coming years. Here are some potential areas of development for smart home systems using WSNs:

- ✓ Integration with AI: With the advancements in artificial intelligence (AI), it is expected that smart home systems will be able to learn and adapt to the behavior of the occupants of the home. For example, the system could learn the habits of the occupants and automatically adjust the temperature and lighting conditions in the home based on their preferences.

- ✓ Energy Efficiency: The use of WSNs can help reduce energy consumption in the home by optimizing the use of appliances based on the occupancy and the environmental conditions. For example, the system could turn off the lights and appliances when no one is in the room or adjust the thermostat based on the outdoor temperature.

- ✓ Health Monitoring: The use of WSNs in smart homes can also be extended to monitor the health of the occupants. For example, the system could monitor the heart rate, blood pressure, and other vital signs of elderly occupants and alert caregivers in case of any abnormality.

- ✓ Security: Smart home systems using WSNs can also be used to enhance the security of the home. For example, the system could detect unauthorized entry into the home and alert the occupants or authorities.

- ✓ Integration with other Smart Systems: Smart home systems can be integrated with other smart systems, such as smart cities, to create a more efficient and sustainable environment. For example, the system could adjust the energy consumption of the home based on the energy demand in the city.

In conclusion, the future of smart home systems using WSNs is promising, and there is a lot of potential for development in various areas such as AI, energy efficiency, health monitoring, security, and integration with other smart systems. The use of WSNs in smart homes can bring about significant improvements in the quality of life of the occupants and contribute to the creation of a sustainable and efficient environment.

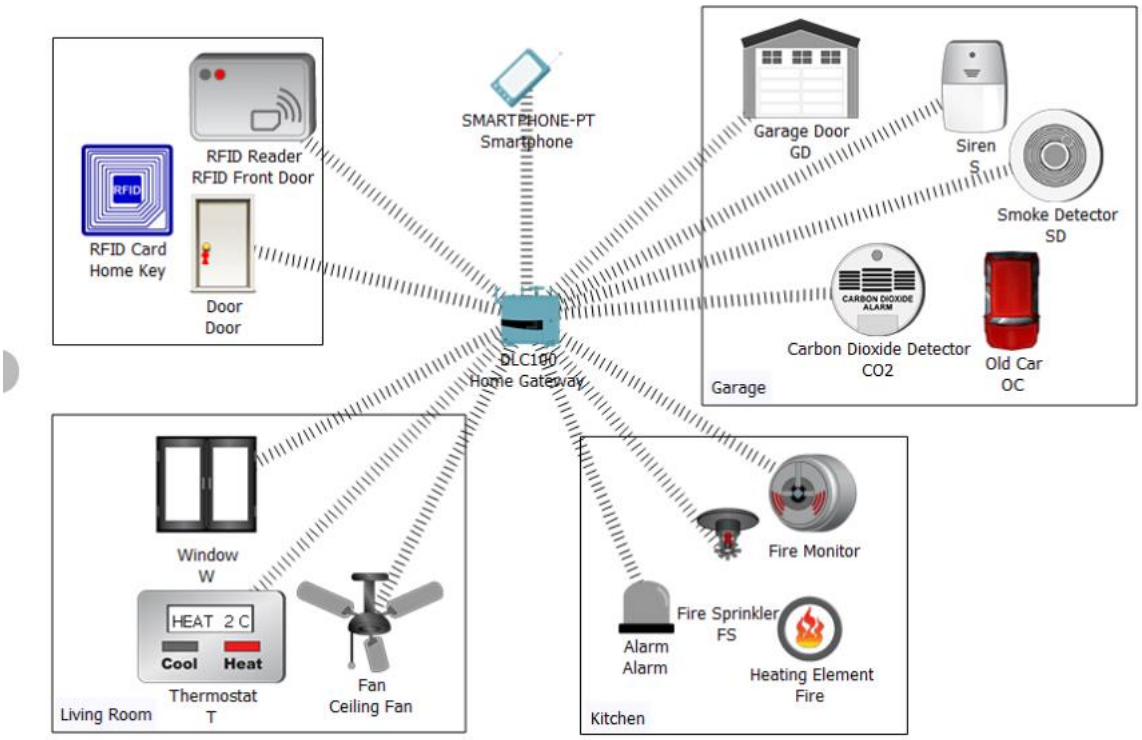
Challenges

Hardware design faces several challenges that must be addressed to ensure a successful product. Some of these challenges include:

- Complexity: With the increasing complexity of electronic devices and mechanical systems, hardware designers must deal with a large number of components, interfaces, and interactions. Managing this complexity can be challenging, requiring careful planning and organization.
- Cost: The cost of electronic components and mechanical parts can vary widely, making it challenging to design a product that is both high-quality and affordable. Hardware designers must balance the cost of components with the performance and functionality required by the product.
- Time-to-market: In today's fast-paced business environment, time-to-market is critical for the success of a product. Hardware designers must work quickly to develop a product that meets customer needs and is competitive in the market.
- Compatibility: The hardware must be compatible with other components and systems, including software, firmware, and other hardware devices. Ensuring compatibility can be challenging, requiring extensive testing and validation.

- Reliability: Hardware devices must be reliable and robust, able to withstand a variety of operating conditions and environments. Designers must ensure that the hardware is resistant to damage from shock, vibration, temperature extremes, and other factors.

- Security: Hardware devices must be secure, protecting sensitive data and preventing unauthorized access. Designers must ensure that the hardware includes appropriate security features, such as encryption, authentication, and access controls.



Benefits

Smart home sensors provide several benefits for homeowners, including:

- ✓ Increased Safety: Smart home sensors can provide added safety by detecting potential hazards such as gas leaks, smoke, and carbon monoxide. They can also alert homeowners to water leaks, which can prevent costly damage to the home.
- ✓ Energy Efficiency: Smart home sensors can help homeowners save on energy costs by controlling the heating and cooling of the home based on occupancy and ambient temperature. This reduces energy waste and improves overall efficiency.
- ✓ Home Automation: Smart home sensors can be used to automate various tasks, such as turning off lights and appliances when not in use, opening and closing blinds based on the time of day, and setting the temperature to the desired level.
- ✓ Security: Smart home sensors can provide added security by alerting homeowners to unusual activity, such as motion detected outside the home, or the front door opening unexpectedly. They can also be used to monitor the home while away, providing peace of mind.
- ✓ Health and Wellness: Smart home sensors can be used to monitor the health and wellness of homeowners, including tracking activity levels, monitoring sleep patterns, and providing reminders for medication and other health-related tasks.

- ✓ Convenience: Smart home sensors can make life more convenient by automating routine tasks, such as turning on the coffee maker in the morning or starting the laundry cycle.

Conclusion

In conclusion, the implementation of smart home sensor projects offers a wide range of benefits for homeowners, including increased safety, energy efficiency, home automation, security, health and wellness monitoring, and convenience.

Smart home sensors allow homeowners to detect potential hazards such as gas leaks, smoke, and carbon monoxide, as well as alert homeowners to water leaks which can prevent costly damage to the home. These sensors can also help homeowners save on energy costs by controlling the heating and cooling of the home based on occupancy and ambient temperature, reducing energy waste and improving overall efficiency. Smart home sensors can also be used to automate various tasks, making life more convenient for homeowners. They can automate routine tasks such as turning on the coffee maker in the morning, starting the laundry cycle or turning off lights and appliances when not in use.

Furthermore, smart home sensors provide added security by alerting homeowners to unusual activity and can also be used to monitor the home while away, providing peace of mind. In addition, they can monitor the health and wellness of homeowners, including tracking activity levels, monitoring sleep patterns, and providing reminders for medication and other health-related tasks.

However, implementing smart home sensors can also pose challenges, such as the need for careful hardware and software design, ensuring compatibility and reliability of the sensors, and addressing privacy and security concerns. Overall, smart home sensors have the potential to significantly improve the lives of homeowners, offering increased safety, convenience, energy efficiency, and security. As technology continues to advance, we can expect to see further developments and improvements in smart home sensors, leading to even greater benefits for homeowners in the future.

REFERNCES

- We have referred Youtube video to learn smart home system configuration (https://youtu.be/uJnveEz8sFI).
- https://www.geeksforgeeks.org/setting-up-a-basic-home-network-using-packet-tracer/)