Design and Simulation of an IP-Based Real-Time Patient Monitoring System

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***Abstract*—The paper suggests a simulated real-time patient monitoring network with Cisco Packet Tracer, a simulator a smart hospital facility. Sensor vital signs, such as temperature and heart rate, are transmitted to a central IP-based communication monitoring system. The network is equipped with routers, switches, gateways, and servers that run under dynamically assigned IPs. Protocols like TCP, ICMP, HTTP, DHCP, DTP, and STP are utilized to provide reliable data flow and redundancy. The simulation is a basis framework for comprehension of embedded healthcare IoT systems in a healthcare environment.**

***Index Terms*—Smart hospital, patient monitoring, Cisco Packet Tracer, IP networking, DHCP, TCP/IP, IoT in healthcare, sensor network**

I. Introduction

The health care sector is quickly adopting IP-based technology technologies to enhance the speed, accuracy, and reliability of patient monitoring systems. Embedded technology has enhanced. IoT networks, real-time health information can now be sent over to monitoring stations or cloud servers. This paper describes a simulation project designed with Cisco Packet Tracer, demonstrating that patient vital signs can be obtained from sensors and channeled through a network for real-time processing and alerting. The aim is to create a realistic hospital simulation environment through which heart rate and temperature sensors transmit readings to a healthcare team via a secure, scalable, and dynamically configured network.

II. System Architecture

The architecture is of simplified star topology without intermediate switches, where direct communication between devices and central control. Key constituents are:

A. Sensors

There are two mock sensors in patient rooms:

- **Temperature Sensor:** Detects patient body temperature.
- **Heart Rate Sensor:** Offers pulse rate in BPM.

B. Home Gateway

The home gateway is a Wi-Fi access point and interface between the sensors and the network in general. It provides IP-based communication between sensors, the workstation, and the server, routing data securely and efficiently.

C. Router

A single router is used to handle DHCP settings, IP assignment, and routing responsibilities. It is directly associated to the home gateway, the server, and to the PC (workstation).

D. Workstation

A terminal at the nurse's/doctor's station accepts and displays real-time data. It possesses a web interface for displaying the output generated by the sensors.

E. Server

The central server maintains the patient information and has a light-weight web program for sensor log and real-time updates. It is accessed via HTTP.

F. IP Addressing

All the machines are set up in the subnet`192.168.25.0/24`. The IP addresses are dynamically allocated through DHCP, and the default gateway to `192.168.25.1`.

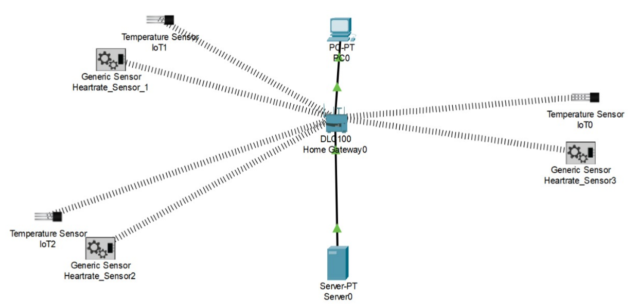

Fig. 1. Network topology as implemented in Cisco Packet Tracer

III. Protocol Stack and Functionality

Perform the following procedures during the simulation:

- DHCP: Assigns IP addresses to devices dynamically on the network.
- TCP/IP: Ensures delivery of the sensor data.
- HTTP: Web interface for physicians to view patient data.
- ICMP: To check device connectivity using ping.
- DTP (Dynamic Trunking Protocol): Between switches for trunk negotiation.
- STP (Spanning Tree Protocol): Prevents switching loops, enhancing fault tolerance.

IV. Configuration Details

All the simulation equipment was calibrated with the following

- Router: Configured as DHCP server.It assigned IP addresses within the range 192.168.25.10–192.168.25.100, with the subnet mask 255.255.255.0. Default gateway was set to 192.168.25.1.
- Sensors: To be dynamically allocated IP addresses via DHCP. One of the heart rate sensors was programmed to simulate a high BPM reading to verify alert mechanisms.
- Workstation (PC): Configured to access the HTTP server hosted on the central server. It continuously monitored sensor data and reported them through a web interface. It also triggered visual alerts in case of abnormal values.
- Server: Hosted a simple web application developed with HTML. It consumed sensor data and served it over HTTPto the workstation. It also maintained log files for databackup and analysis.

Connectivity of the device was determined through ICMP ping tests. All segments reacted favorably, verifying the validity of IP addressing, DHCP setup, and physical connectivity.

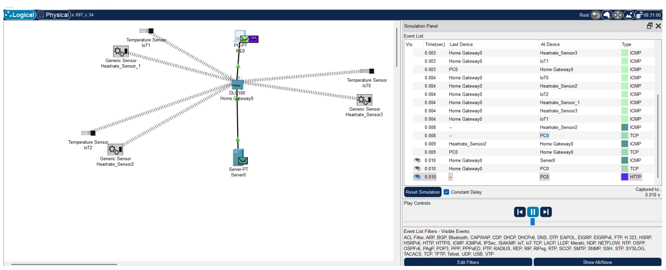

Fig. 2. Workstation receiving and visualizing sensor data via HTTP

V. Results and Observations

Simulation was an effective real-time health monitoring capacity. The key findings are:

- DHCP had certain IP addresses allocated to all the connected devices free of conflicts.
- Sensor readings were sent to the server and workstation.
- TCP was utilized for delivering reliably and losslessly of sensor data.
- The web interface at the workstation refreshed data in real-time and provided alerts when high BPM or abnormal readings of temperature were recorded.
- ICMP ping tests confirmed complete connectivity and proper function of network routing.

VI. Companion Website

Alongside the simulation, a responsive companion website was designed for user consumption and documentation assistance. It had the following factors:

- **Home:** Gave an overview of the patient monitoring project with the major objectives, health- care and motivation. It also presented the Key Innovations Features.
- **Topology:** Disclosed a labeled image of the Cisco Packet Tracer simulation, unveiling real-time floor-by-floor connectivity exercise between routers, servers, and monitoring stations, and network devices. Device icons were also color-coded and by space to indicate their job titles and ranks in the hospital system.
- **Documentation:** Offer a thorough characterization of IP-patient monitoring system, and the key goals features (such as real-time monitoring and instant notifications), and the entire stack of technology. Tabbed pages like as Overview, Architecture, Implementation, and Testing facilitated organizing the content for easy retrieval and appreciation.
- **File Upload/Download:** Enabled users to view and download all project files related to the Packet Tracer (.pkt) simulation, report, presentation, and summary. Files were grouped into folders for team and individual authors, with GitHub support offering real-time synchronizing and collaborative updating.
- **Team Page:** Included contributor profiles with names, institutional affiliation, and student IDs. Institutional affiliation is displayed graphically united the project team to facilitate recognition and potential educational or co-operative outreach.

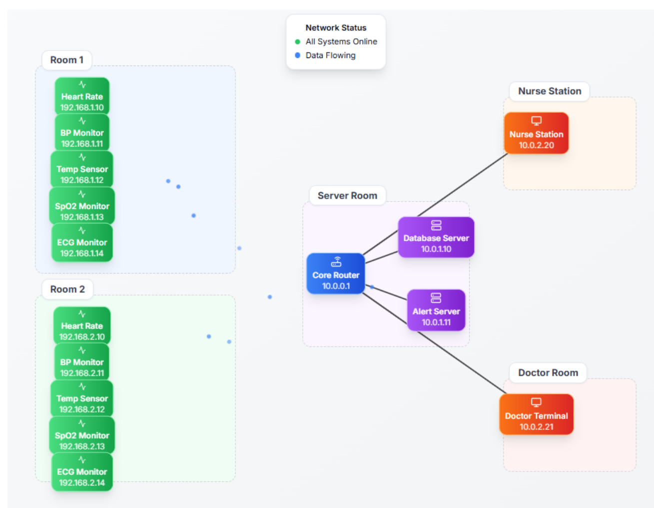

Fig. 3. Live topology section from the website showing device info

VII. Conclusion

Effective utilization of the simulated IP-based patient monitoring network stresses its worth as a low-cost and scalable intelligent hospital infrastructure vision. With the using the Cisco Packet Tracer tool, the assignment was successfully completed proved how critical patient data—such as temperature and heart rate—can be transmitted stored, and presented in real time on extensively tested network protocols like TCP/IP, DHCP, and HTTP.

The system offered equal data flow via dynamically IP addressing and reliable routing mechanisms assigned. Real-time reminders were displayed on a workstation screen, enhancing the performance of the network and the reactivity of the network under simulated clinical conditions. It is also possible to use a central server, web interface, and sensor-based monitoring system makes this model an effective model of learning for comprehending IoT-based healthcare systems. Not only does it symbolize the culture of network design and design and completes the gap between clinical sites and embedded systems.

With further enhancements, such as the inclusion of security controls or cloud analysis, such elementary simulation can be scaled up to a deployable medical IoT framework—asserting its value in future health research and facilities.

VIII. Future Work

Whereas the current simulation provides a solid basis for real-time patient monitoring over IP-based communications, a number of aspects of enhancement can be utilized to improve its functionality, scalability, and practical applicability:

- Integration of Other Sensors: The upcoming releases can comprise other medical sensors (e.g., SpO2, ECG,blood pressure) to deliver more complex health profile of the patient.
- Cloud Connectivity: The data from the local server can be they were moved to cloud platforms (e.g., AWS IoT, Azure, or to enable remote monitoring by doctors and healthcare professionals,increased access and availability of information.
- Mobile App Development: A dedicated tablet or mobile application can be made for doctors and nurses to be notified, look at patient records, and review earlier trends in real time.
- Security Improvements: Deployment of security protocols methods such as HTTPS, data encryption, and user authentication procedures would ensure confidentiality of data and protection against unauthorized access between a shared hospital settingments.
- Predictive Alerts based on Machine Learning: With core Machine learning algorithms would assist in forecasting anomalous conditions with sensor pattern-based approaches to encourage preventive care and minimizing human observation effort.
- Multi-Room and Multi-Floor Scaling: The existing simulation can be extended to cover a series of wards or hospital hierarchically routed floors and VLAN configuration to accommodate enterprise-class hospital networks.
- Real Hardware Prototyping: From simulation to a physical microcontroller-based ical prototype (e.g.,ESP32, Raspberry Pi and actual sensors would subsequently verify the model under real conditions.

These upcoming advancements tend to revolutionize the simulation from conceptual model to an operational, deploy effective solution that is in accordance with the needs of modern digital health systems.