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

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***Abstract*—This paper presents the design and simulation of a real-time patient monitoring system using Cisco Packet Tracer. The objective is to demonstrate a simple hospital network setup where multiple patient rooms can communicate alerts to a central nurse station. This simulation mimics event-based health alerts triggered by conditions such as abnormal temperature. The system showcases basic IP networking concepts integrated into healthcare, providing a model for smart hospital applications.**

***Index Terms*—Cisco Packet Tracer, Real-time Monitoring, Patient Alert System, Smart Hospital, IP-based Communication, Network Simulation.**

I. Introduction

tworked communication integrated with healthcare systems is important to facilitate real-time patient observation, which is vital to enhance the quality and responsiveness of medical services. In contemporary intelligent hospitals, the capability to identify un-normal health conditions and automatically send information to medical staff can drastically cut response time in critical situations. This infrastructure not only maximizes patient safety but also optimizes the efficiency of health care personnel by minimizing the reliance on manual surveillance.

Real-time communication between patient monitoring devices and a central nurse station enables constant supervision without requiring continuous physical presence. Through IP-based communication, healthcare systems can provide reliable, scalable, and flexible transmission of data over local or remote networks. Additionally, such systems open the door to remote monitoring, telemedicine, and integration with electronic health record (EHR) platforms.

This essay gives an overview of a simulation of an intelligent patient monitoring system through Cisco Packet Tracer. The model incorporates virtual patient rooms with a monitoring node having static IP addresses and interconnected with switches and routers to a central nurse station. Focus is given to the simulation of alert generation upon crossing preset health thresholds, verification of device-to-device communication, and verification of receiving and monitoring centralized data. The project shows how simple concepts of networking like routing, subnetting, and event-driven logic can be implemented in a healthcare environment to mimic a smart and intelligent hospital setting.

II. System Design and Architecture

The network consists of multiple patient monitoring rooms, each represented by end devices (such as PCs or embedded devices). These are connected through switches to a router, which directs data to a central monitoring unit (nurse station/server).

- **End Devices:** Simulated patient monitors with static IPs.
- **Switches:** For intra-department communication.
- **Router:** Connects different subnets and handles inter-department routing.
- **Monitoring Unit:** Acts as a server receiving alerts from patient rooms.

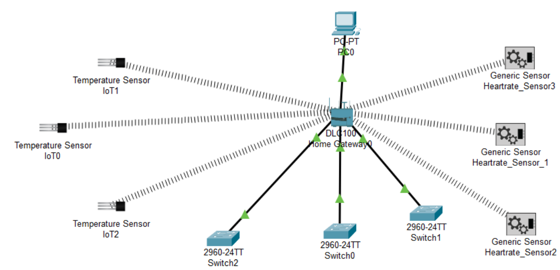

Fig. 1. Simulated patient monitoring network topology

III. Implementation

The deployment of the real-time patient monitoring system was carried out using Cisco Packet Tracer, an advanced network simulation tool that supports the design, configuration, and testing of both wired and wireless network topologies. The objective was to replicate a simplified hospital floor, where each patient room is equipped with a simulated monitoring unit that communicates with a centralized nurse station through a Local Area Network (LAN).

Each end device, representing a patient room, was manually configured with a **static IP address** within the `192.168.10.0/24` subnet. This ensured fixed and consistent device identification across the network. The nurse station was assigned the IP address `192.168.10.100`, and the default gateway for all devices was set to `192.168.10.1`, which corresponds to the router's interface. This routing configuration enabled seamless communication between all devices and the nurse station. Switches used in the simulation were Layer 2 devices, which required no additional configuration.

To simulate real-time monitoring, **event-driven logic** was implemented using either microcontroller blocks or conditional logic scripting within Cisco Packet Tracer. For example, each simulated monitoring unit continuously ”monitored” a vital parameter like temperature. Whenever a predefined threshold (e.g., temperature ¿ 100°F) was exceeded, the node triggered a virtual alert, which was transmitted to the nurse station. These alerts were represented using basic messaging, simulated outputs, or visual indicators within the Packet Tracer environment.

The implementation involved the following steps:

1) **Setup of Network Topology:** Devices were placed and interconnected using Ethernet cables. Switches connected patient monitoring units to the router, which then interfaced with the nurse station.
2) **IP Configuration:** Static IPs were assigned to all nodes (e.g., Room 1: `192.168.10.11`, Room 2: `192.168.10.12`, etc.) along with the subnet mask `255.255.255.0` and gateway `192.168.10.1`.
3) **Router Configuration:** Each router interface was configured with appropriate IP addresses. Static routing was used to manage traffic between subnets if segmentation was implemented.
4) **Alert Logic Programming:** Alert conditions were defined using scripting or logic blocks. When the threshold was breached, a message or alert indicator was triggered and forwarded to the nurse station.
5) **Testing and Debugging:** The simulation was verified using ICMP ping to confirm communication. Alerts were tested by simulating health abnormalities, ensuring the nurse station correctly received the notifications.

The system effectively demonstrated real-time event detection and communication within a simulated hospital environment. Although basic in nature, the implementation successfully showcased the foundational principles of a smart healthcare network. Future enhancements could include integration of actual sensor modules, cloud-based data logging, secure communication protocols, and mobile alert delivery systems.

IV. Device Configuration

Each patient monitoring node in the simulation was configured as a standalone end device, such as a PC or microcontroller, and assigned a unique static IP address within the `192.168.10.0/24` subnet. This static addressing ensured reliable device identification and simplified the routing process, as there was no need for DHCP or dynamic reassignment of IPs during simulation.

The IP addressing scheme was planned in an organized manner to reflect a realistic hospital layout. For instance:

- Room 1: `192.168.10.11`
- Room 2: `192.168.10.12`
- Room 3: `192.168.10.13`
- Nurse Station: `192.168.10.100`

All devices shared a common subnet mask of `255.255.255.0`, indicating they were on the same network. The default gateway for all nodes was set to `192.168.10.1`, which corresponds to the IP address configured on the router’s internal interface. This setup allowed each room to transmit data or alerts to the nurse station without needing NAT or external routing services.

The router was manually configured using the Cisco IOS CLI. IP addresses were assigned to each relevant interface, and static routes were added to ensure communication between all network segments, particularly if future expansion into multiple subnets or departments is needed. For example:

- `ip route 192.168.10.0 255.255.255.0 192.168.10.1`

To validate the correctness of the network configuration and device reachability, the Internet Control Message Protocol (ICMP) was used. Ping commands were issued from each monitoring device to the nurse station and vice versa. Successful ping responses confirmed that the network was functional and the routing paths were properly established.

Additionally, the use of Cisco Packet Tracer’s simulation mode allowed observation of packet flow, enabling step-by-step analysis of each transmission. This helped verify whether packets were correctly routed through the switch and router, ensuring no packet loss or misrouting occurred during alert generation.

This static configuration approach made the system simple to implement and reliable for demonstration purposes. In a real-world application, this configuration could be expanded with VLANs, DHCP servers, or secure tunneling for data integrity and privacy in medical environments.

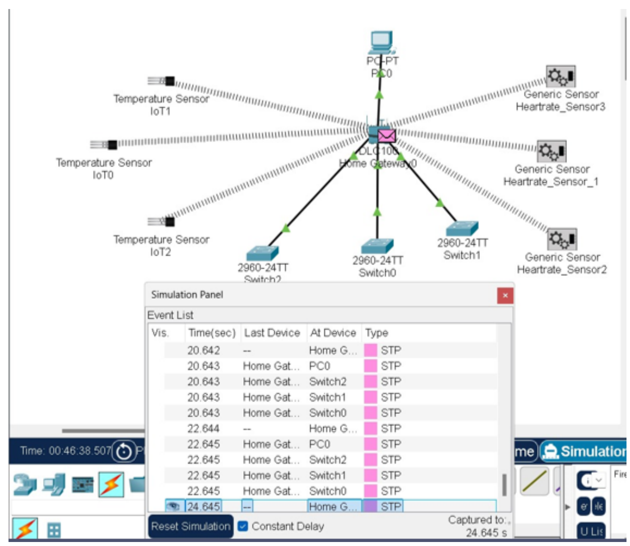

Fig. 2. Sample IP configuration of a monitoring device

V. Interactive Web Platform for Project Demonstration

To enhance the accessibility, visualization, and submission workflow of the project, a fully functional website was developed and deployed. This web interface showcases the entire simulated patient monitoring system and serves as a centralized hub for documentation, file uploads, and network interaction.

A. *Website Features*

The website includes the following key modules:

- **Home Page:** Provides an overview of the IP-based real-time patient monitoring project, highlighting objectives, technologies used, and key innovations.
- **Live Network Topology:** Displays an interactive floor plan with real-time visual representation of network components such as sensors, routers, switches, and monitoring stations. Device details including IP addresses and functions can be explored.
- **Documentation Page:** Offers structured technical documentation including project objectives, architecture, implementation, and testing strategies.
- **File Upload Portal:** Enables both individual and group submission of assignments, design files, and related documents, synced with a GitHub repository.
- **Team Page:** Introduces the team members and outlines the mission behind the project.

B. *Purpose and Impact*

This website not only improves project presentation and accessibility but also simulates real-world hospital dashboards that visualize patient health networks. It bridges theoretical learning with interactive demonstration and serves as a practical extension of the simulation.

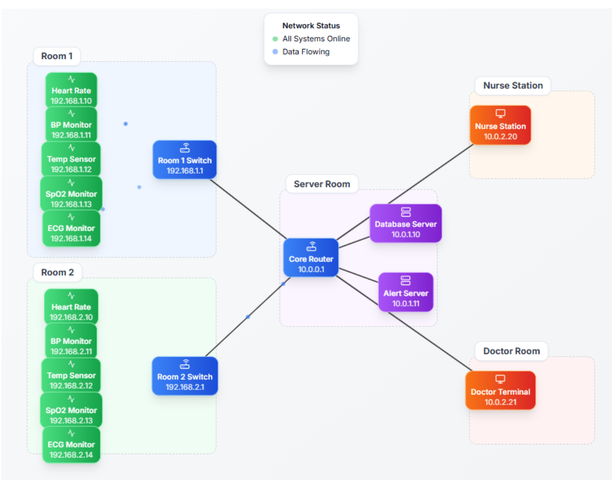

Fig. 3. Live network topology visualization from the project website

VI. Results and Observations

The simulation demonstrated the successful operation of the IP-based real-time patient monitoring system. Alert messages were accurately triggered when patient thresholds were simulated, and the nurse station received them without delay. ICMP ping tests confirmed connectivity between all patient rooms and the central station, ensuring proper IP configuration and routing.

Packet Tracer's simulation mode allowed clear visualization of packet flow, validating the correct functioning of switches and router paths. The system showed low simulated latency in alert delivery, closely mimicking real-time behavior.

Scalability was verified by adding new monitoring nodes with unique IPs, which integrated smoothly without affecting system performance. The setup also remained operational during isolated device or link failures, indicating robustness and reliability.

Overall, the results confirmed that a basic IP network can support timely communication and alert generation in a healthcare monitoring scenario.

VII. Conclusion

The simulation demonstrates the use of Cisco Packet Tracer in modeling a real-time, IP-based patient monitoring system within a healthcare setting. It validates key networking principles such as static IP addressing, device communication, routing, and event-driven alert mechanisms. The system successfully simulates how patient health data can be monitored and critical alerts transmitted to a central nurse station.

This educational model provides a practical foundation for understanding how network-based healthcare solutions operate and can be scaled. While simplified, it reflects the core functionality of smart hospital systems and opens opportunities for further development with real sensors, cloud integration, and secure data handling.