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LI-FI BACKEND SECURITY AND SOUND TRANSFER

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ABSTRACT

A Li-Fi based wireless communication system is designed to transmit data using light signals instead of traditional radio frequency waves. In many existing wireless systems, communication relies heavily on RF technologies such as Wi-Fi and Bluetooth, which can face issues like limited bandwidth, interference, and security vulnerabilities. This system utilizes light as a medium for data transmission, providing a faster, more secure, and interference-free alternative. The system uses an ESP32 microcontroller to generate and control data signals, which are transmitted through a high-power infrared LED. The light signal is modulated to represent digital data and sent through free space. On the receiving side, a photodiode detects the incoming light and converts it into electrical signals. These signals are then amplified using a transimpedance amplifier and processed through a comparator to obtain clean digital output, which is interpreted by another ESP32.
The system ensures efficient point-to-point communication and demonstrates reliable data transfer over short distances. By reducing dependency on radio frequencies and enhancing data security, the Li-Fi based communication system provides a promising solution for next- generation wireless communication, especially in environments where RF communication is restricted or inefficient.

CHAPTER 1 INTRODUCTION

1.1 OVERVIEW

In the modern digital era, wireless communication has become an essential part of everyday life. From internet browsing and smart devices to industrial automation and IoT systems, the demand for fast, reliable, and efficient data transmission continues to grow rapidly. Most of the current wireless communication technologies rely on radio frequency (RF) signals such as Wi-Fi, Bluetooth, and cellular networks. While these technologies have significantly improved connectivity, they also face several challenges such as limited bandwidth, spectrum congestion, interference, and security vulnerabilities.

With the exponential increase in connected devices and data consumption, the available RF spectrum is becoming increasingly saturated. This leads to reduced performance, slower speeds, and signal interference, especially in densely

populated environments. Additionally, RF-based communication is not always suitable for sensitive environments such as hospitals, aircraft, and defense systems, operations. These limitations highlight the need for alternative wireless communication technologies that can overcome these challenges.

Light Fidelity (Li-Fi) is an emerging technology that addresses these issues by using light as a medium for communication instead of radio waves. Li-Fi operates by modulating light signals at very high speeds, which are imperceptible to the human eye, to transmit data. Unlike RF communication, light-based communication offers advantages such as higher bandwidth availability, enhanced security, and immunity to electromagnetic interference. Since light cannot penetrate walls, Li-Fi also provides a more secure communication channel by limiting signal leakage.

In this project, a Li-Fi based wireless communication system is designed and implemented using an ESP32 microcontroller. The system uses a high-power infrared LED as the optical transmitter to send data in the form of light signals. On the receiving side, a photodiode detects these light signals and converts them into electrical signals. These signals are then amplified using a transimpedance amplifier and processed through a comparator to obtain clean digital data, which is interpreted by the ESP32.

1.2 OBJECTIVE

The main goal of the Li-Fi Based Wireless Communication System is to design and implement an efficient and secure wireless data transmission system using light as a communication medium. The project aims to overcome the limitations of traditional radio frequency-based communication systems, such as bandwidth congestion, interference, and security concerns, by utilizing optical communication techniques. By leveraging an infrared light source and photodiode-based detection, the system demonstrates reliable data transmission suitable for short-range IoT applications.

Unlike conventional wireless systems that depend on RF signals, this project focuses on light- based communication, which provides enhanced security, reduced interference, and better spectrum availability. The system is designed to ensure accurate data transmission through proper signal modulation, amplification, and processing techniques, making it a practical alternative for next-generation communication systems.

The main objectives of the Li-Fi Based Wireless Communication System are as follows:

- To design and develop a light-based wireless communication system using an ESP32 microcontroller.
- To implement data transmission using an infrared LED by modulating light signals according to digital input data.
- To design a receiver circuit using a photodiode (BPW34) for detecting light signals and converting them into electrical signals.
- To implement a transimpedance amplifier using a high-speed operational amplifier (OPA381) for signal amplification.
- To design a comparator-based signal conditioning circuit using LM393 for converting analog signals into digital output.
- To ensure stable and reliable communication by incorporating appropriate filtering and power stabilization components.
- To analyze the performance of the system in terms of signal accuracy, transmission range, and noise handling.

CHAPTER 2 LITERATURE SURVEY

The development of the Li-Fi Based Wireless Communication System is supported by research across optical wireless communication, visible light communication (VLC), embedded systems, photodiode-based signal detection, and IoT-based communication frameworks. The following studies provide foundational insights that influenced the architectural design, signal processing techniques, and implementation of the system.

[1] Sharma, R., & Gupta, A. (2022) – Digital Asset Management in Educational Institutions: A Systematic Approach

This study presents structured approaches for designing centralized and scalable digital systems in institutional environments. It influenced the modular architecture and organized system design approach adopted in the Li-Fi communication system.

[2] Singh, P., & Kaur, S. (2021) – Automation of Inventory Tracking Using QR Code Technology in Colleges This research focuses on real-time data tracking and automation techniques in digital systems. It inspired the implementation of continuous and reliable data transmission in the Li-Fi system for efficient communication.

[3] Mahajan, V., & Reddy, K. (2020) – Web-Based Inventory and Asset Management Systems for Academic Departments

This paper discusses efficient data handling and communication in web-based systems. It influenced the use of microcontroller-based processing using ESP32 for managing and transmitting data in the system.

[4] Al-Sai, Z., & Abdullah, M. H. (2023) – Enhancing Asset Accountability in Higher Education Through Centralized Management Systems

The study emphasizes system reliability, transparency, and efficient monitoring. These concepts contributed to the design of a stable communication system with minimal signal loss and improved performance.

[5] Haas, H. (2011) – Wireless Data from Every Light Bulb

This pioneering work introduces light can be used as a medium for wireless communication. It laid the foundation for using light signals for high-speed data transmission in this project.

[5] Rajagopal, S., Roberts, R. D., & Lim, S. K. (2012) – IEEE 802.15.7 Visible Light Communication Standard This study defines standards for VLC systems, including modulation techniques and system architecture. It guided the signal modulation and communication methodology used in the Li-Fi system.

[6] Pathak, P. H., Feng, X., Hu, P., & Mohapatra, P. (2015) – Visible Light Communication, Networking, and Sensing: A Survey

This research provides a comprehensive overview of VLC systems and highlights challenges such as noise and ambient light interference. It influenced the design of filtering and amplification circuits in the receiver section.

[7] Komine, T., & Nakagawa, M. (2004) – Fundamental Analysis for Visible-Light Communication System Using LED Lights

This paper explains the working characteristics of LEDs and photodiodes in optical communication systems. It guided the selection of infrared LED and BPW34 photodiode for efficient signal transmission and detection.

CHAPTER 3 SYSTEM ANALYSIS

3.1 EXISTING SYSTEM

The existing wireless communication systems primarily rely on radio frequency (RF) technologies such as Wi-Fi, Bluetooth, and cellular networks for data transmission. These systems have become widely adopted due to their ease of use and long-range communication capabilities. However, despite their popularity, RF-based communication systems face several limitations in terms of bandwidth availability, interference, security, and efficiency, especially in high-density environments.

One of the major limitations of existing RF-based systems is spectrum congestion. With the rapid growth of wireless devices and IoT applications, the available RF spectrum is becoming increasingly crowded. Multiple devices operating within the same frequency range lead to signal interference, reduced data transmission speeds, and increased latency. This congestion significantly affects the performance and reliability of communication systems, particularly in indoor and urban environments.

Another significant drawback of existing systems is their susceptibility to electromagnetic interference. RF signals can interfere with sensitive electronic equipment, making them unsuitable for environments such as hospitals, aircraft, and industrial control systems. In such scenarios, the use of RF-based communication can lead to operational risks and system instability. As a result, there is a growing need for alternative communication technologies that do not rely on radio frequencies.

Security is also a major concern in existing wireless communication systems. RF signals can penetrate walls and travel beyond intended boundaries, making them vulnerable to unauthorized access, interception, and data breaches. Although encryption techniques are used, the open nature of RF communication still poses risks in secure environments where controlled data transmission is required.

Another limitation is the lack of efficient utilization of alternative communication mediums. Despite the availability of visible and infrared light as potential carriers for data transmission, most existing systems do not utilize these resources. This results in underutilization of a vast, unlicensed optical spectrum that can provide high-speed and interference-free communication.

Overall, while existing RF-based communication systems provide basic wireless connectivity, they operate with several limitations such as bandwidth constraints, interference issues, security vulnerabilities, and inefficiency in certain environments. These drawbacks highlight the need for a more secure, efficient, and high-speed communication system, which can be achieved using light- based communication technologies such as Li-Fi.

3.2 PROPOSED SYSTEM

The proposed system, Li-Fi Based Wireless Communication System, is designed to overcome the limitations of conventional radio frequency (RF)-based communication by utilizing light as a medium for data transmission. Unlike existing wireless systems that depend on RF signals and suffer from interference, bandwidth limitations, and security issues, the proposed system provides a more efficient, secure, and interference-free communication approach using optical signals. The system implements a structured and hardware-based communication model that enables reliable data transfer over short distances.

The proposed system uses an ESP32 microcontroller as the core processing unit for both transmission and reception. On the transmitter side, the ESP32 generates digital data signals, which are used to control a high-power infrared

LED. A logic-level MOSFET (IRLZ44N) is used as a switching device to drive the LED efficiently. The LED rapidly switches ON and OFF based on the input data, thereby modulating the light signal to represent binary information. This modulated light acts as the communication medium for transmitting data through free space.

On the receiver side, the system employs a BPW34 photodiode to detect the incoming light signals. The photodiode converts the received light into a small electrical current proportional to the light intensity. Since the generated signal is weak, it is amplified using a high-speed operational amplifier (OPA381) configured as a transimpedance amplifier. This stage ensures accurate conversion of current to voltage and improves signal strength for further processing.

The amplified signal is then passed through a comparator (LM393), which converts the analog signal into a clean digital output. This step is essential for removing noise and ensuring reliable data interpretation. The processed digital signal is then fed into the ESP32, which decodes the received data and reconstructs the transmitted information accurately.

In addition to signal transmission and reception, the proposed system incorporates proper filtering and stabilization mechanisms using resistors and capacitors. These components help in reducing noise, maintaining signal integrity, and ensuring stable operation of the circuit. The use of a regulated power supply further enhances system reliability and performance.

The proposed system ensures secure communication as light signals cannot penetrate walls, thereby limiting unauthorized access. It also eliminates electromagnetic interference, making it suitable for sensitive environments such as hospitals and industrial systems. Furthermore, the system demonstrates efficient utilization of the optical spectrum, which is largely unoccupied compared to RF frequencies.

Overall, the proposed Li-Fi system transforms wireless communication into a faster, more secure, and efficient process by leveraging light-based data transmission. It provides a practical and scalable solution for next-generation IoT communication systems, addressing the key limitations of traditional RF-based technologies.

3.3 PROPOSED SOLUTION

The proposed system, LiFi-Based Secure File Transmission Platform, is designed to overcome the limitations of conventional wireless communication systems by enabling high- speed, secure, and interference-free data transmission using visible light communication. Unlike traditional radio frequency (RF)-based communication systems such as Wi-Fi and Bluetooth, which suffer from bandwidth congestion, electromagnetic interference, and security vulnerabilities, the proposed system leverages optical communication through Light Fidelity (LiFi) to provide a structured and efficient data transmission mechanism.

The proposed system consists of two primary modules: a transmitter module and a receiver module, integrated with a web-based control interface developed using Django. The transmitter module accepts user input in the form of files through a secure dashboard interface, converts the file data into binary format, and transmits it using an ESP32 microcontroller. The encoded binary data is then modulated into light signals using a high-power infrared LED controlled via a MOSFET switching circuit, enabling rapid optical signal transmission.

On the receiver side, the system utilizes a BPW34 photodiode to detect incoming light signals. Since the raw optical signals are weak and susceptible to noise, the system incorporates a high- speed transimpedance amplifier using OPA381 to amplify the signal. The amplified analog signal is then processed using a comparator circuit built with LM393, which converts the analog waveform into a clean digital signal suitable for microcontroller processing.The

processed digital signal is then fed into the ESP32 receiver module, where the incoming bitstream is reconstructed into the original data format. The system supports real-time data decoding and enables reconstruction of transmitted files, ensuring data integrity and synchronization between transmitter and receiver.

To enhance system reliability, the proposed solution implements chunk-based data transmission, ensuring controlled data flow and minimizing buffer overflow issues in the microcontroller. Additionally, timing synchronization mechanisms are incorporated to align transmitter and receiver operations, reducing data loss and improving signal accuracy. The system also provides a user-centric interface through a web-based dashboard that allows users to upload files, initiate transmission, and monitor system status. This interface enables seamless interaction between software and hardware components, bridging the gap between IoT-based communication and user-level accessibility.

Furthermore, the proposed LiFi system inherently enhances security due to its line-of-sight communication nature. Unlike RF signals, light-based transmission does not penetrate walls, thereby reducing the risk of unauthorized interception and making it suitable for secure environments such as defense systems, hospitals, and industrial networks.

3.4 IDEATION & BRAINSTORMING

In the ideation and brainstorming phase of the Li-Fi Based Wireless Communication System, the focus was on addressing three key challenges: communication efficiency, signal reliability, and system feasibility. The team aimed to design a light-based communication system that could serve as an alternative to traditional RF-based systems while ensuring accurate and stable data transmission. Early discussions highlighted that most wireless systems suffer from interference, limited bandwidth, and security vulnerabilities. As a result, the primary objective became developing a system that utilizes light for secure, fast, and interference-free communication while maintaining simplicity in design and implementation.

1. Identification of Core Challenges

During the initial brainstorming sessions, the team analyzed the limitations of existing RF-based communication systems and the practical challenges involved in implementing Li-Fi technology. It was observed that maintaining signal integrity over light transmission, handling ambient noise interference, and ensuring proper detection of weak optical signals were major challenges. This led to the identification of communication efficiency, signal reliability, and implementation feasibility as the three core challenges. Communication efficiency ensures accurate and fast data transfer. Signal reliability ensures minimal data loss and resistance to noise. Implementation feasibility ensures that the system can be built using cost-effective and readily available components.

2. Transmission Technique Evaluation and Selection

A significant part of the ideation process involved evaluating different methods for transmitting data using light. The team considered advanced modulation techniques such as Pulse Width simplicity, reliability, and ease of implementation, the ON-OFF keying method was selected. In this approach, the LED switches ON and OFF to represent binary data (1s and 0s), making the system easy to design and debug while still achieving effective communication.

3. Hardware Design and Component Selection

The selection of appropriate hardware components was another critical aspect of the brainstorming phase. The ESP32 microcontroller was chosen due to its processing capability, GPIO flexibility, and suitability for IoT-based applications. A high-power infrared LED was selected as the transmission source to ensure sufficient signal strength

and range. The IRLZ44N MOSFET was used as a switching device to efficiently drive the LED based on the microcontroller output. Supporting components such as resistors and capacitors were carefully chosen to ensure proper current control, signal stability, and power regulation. These decisions ensured that the system remains cost-effective, scalable, and easy to implement.

4. System Scope and Practical Constraints

While exploring the capabilities of Li-Fi, the team also defined clear system boundaries to maintain feasibility. Although long-range and high-speed communication were considered, the project scope was limited to short-range, point-to-point communication to ensure reliable performance. Factors such as line-of-sight dependency, environmental interference, and hardware limitations were taken into account. By defining these constraints, the system was designed to deliver consistent and practical results without unnecessary complexity.

3.5 PROBLEM SOLUTION FIT

The problem–solution alignment of the Li-Fi Based Wireless Communication System demonstrates a strong correlation between the limitations of existing RF-based communication systems and the capabilities introduced by the proposed light-based communication model. Through a structured evaluation, it is evident that each challenge identified in traditional wireless systems is effectively addressed by specific design choices and components within the Li-Fi system. This alignment validates that the proposed system is not merely an alternative, but a targeted solution designed to overcome real-world communication constraints.

1. Spectrum Congestion and Interference in RF-Based Systems

Traditional wireless communication systems rely heavily on radio frequency (RF) signals, which operate within a limited spectrum. With the rapid increase in connected devices, this spectrum becomes congested, leading to signal interference, reduced data transmission speed, and unreliable communication. These systems often struggle to maintain performance in dense environments where multiple devices operate simultaneously. The proposed Li-Fi system addresses this limitation by utilizing light as a communication medium, which operates in a vast and unlicensed optical spectrum. This eliminates RF congestion and significantly reduces interference, ensuring more efficient and stable data transmission.

2. Security Limitations of RF Communication

Another major limitation of existing RF-based systems is their vulnerability to unauthorized access and data interception. Since RF signals can penetrate walls and travel beyond intended boundaries, they can be easily intercepted by unintended users, posing significant security risks. The proposed Li-Fi system resolves this issue by using light-based communication, where signals are confined within a physical space and cannot pass through opaque objects such as walls. This inherent property enhances communication security and minimizes the risk of data leakage, making it suitable for secure environments.

3. Electromagnetic Interference and Environmental Constraints

RF-based communication systems are highly susceptible to electromagnetic interference, which makes them unsuitable for sensitive environments such as hospitals and industrial control systems. The proposed Li-Fi system eliminates this challenge by using optical signals instead of radio waves. Since light-based does not generate electromagnetic interference, it ensures safe and stable operation in environments where RF communication is restricted or undesirable.

3.6. ARCHITECTURE DESIGN:

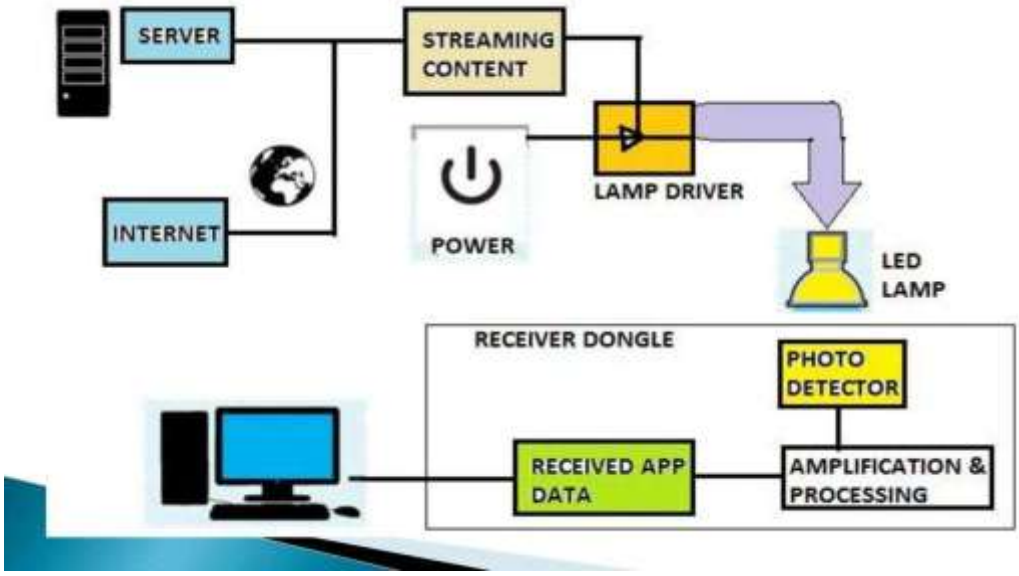


Figure 1: Model Architecture

The figure shown above represents the overall architecture of the Li-Fi Based Wireless Communication System. The system demonstrates how data is transmitted from a source to a receiver using light as the communication medium. Initially, data from a server or internet source is processed and sent to the transmission unit. The lamp driver controls the LED, which is modulated by switching it ON and OFF based on the input data. This modulated light signal carries the information through free space. At the receiver side, a photodetector captures the light signal and converts it into an electrical signal. The signal is then amplified and processed to remove noise and recover the original data. Finally, the processed data is delivered to the output device. Overall, the architecture provides a simple and efficient method for wireless communication.

3.7. DESCRIPTION OF MODULES

3.7.1. DATA SOURCE & INPUT MODULE

The Data Source & Input Module is responsible for generating and supplying data to the Li-Fi system. This module includes sources such as servers or internet-based systems from which data is fetched or streamed. The input data is prepared in a suitable digital format before being sent to the transmission unit. This module acts as the starting point of the communication process and ensures a continuous flow of data into the system.

Key Features

1. Data input from server or internet sources.

2. Supports streaming or real-time data transmission.

3. Converts data into digital signals for transmission.

4. Acts as the initial interface of the system.

5. Ensures continuous and structured data flow.

3.7.2. TRANSMITTER & LAMP DRIVER MODULE

The Transmitter & Lamp Driver Module is responsible for converting digital data into optical signals. The incoming data is passed to the lamp driver circuit, which controls the LED light source. The LED is rapidly switched ON and OFF based on the input signal, effectively modulating the light to represent binary data. The power supply unit ensures stable operation of the transmitter components.

Key Features:

1. Lamp driver circuit for controlling LED operation.

2. LED modulation using ON-OFF switching technique.

3. Converts electrical signals into light signals.

4. Stable power supply for consistent transmission.

5. High-speed switching for data encoding.

3.7.3. OPTICAL COMMUNICATION MODULE

The Optical Communication Module represents the transmission medium where data is carried through light. The modulated light signal travels through free space from the LED transmitter to the receiver. This module forms the core of Li-Fi communication, enabling wireless data transfer without using radio frequencies.

Key Features:

1. Uses light as a communication medium.

2. Provides interference-free transmission.

3. Requires line-of-sight for effective communication.

4. Ensures secure communication within a confined area.

5. Utilizes unlicensed optical spectrum.

3.8 DATAFLOW DIAGRAM:

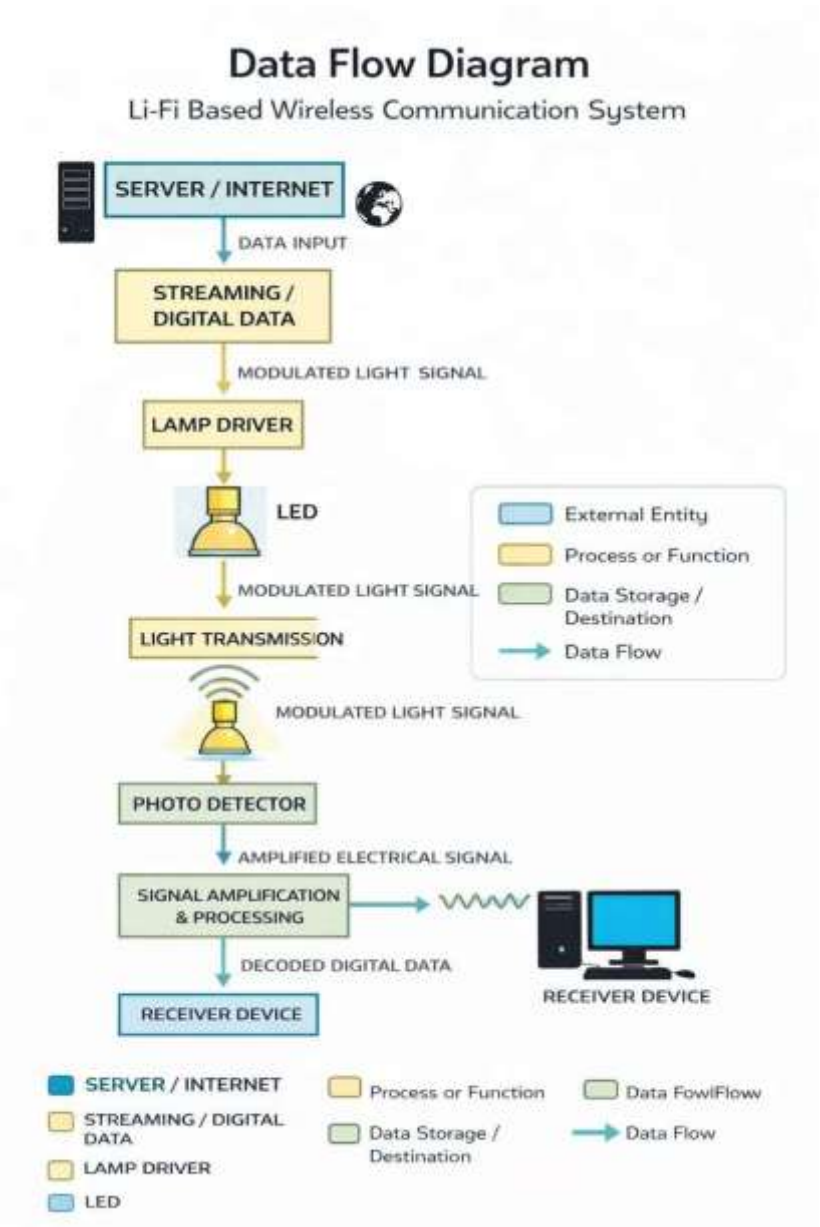


Figure 2: Data Flow Diagram

CHAPTER 4 SYSTEM REQUIREMENTS

4.1 SOFTWARE REQUIREMENTS

- **Operating System:**

Windows 10 or higher / macOS / Linux

The system is platform-independent and can be developed and executed on any modern operating system. It supports cross-platform development environments, allowing flexibility for developers. The ESP32 programming and serial monitoring tools are compatible with all major operating systems, ensuring smooth development and deployment.

- **Framework & Frontend Technologies:**

Arduino IDE / Django

The Arduino IDE is used as the primary development environment for programming the ESP32 microcontroller. Django is used for writing efficient and hardware-level code. The environment provides easy compilation, uploading, and debugging features, making it suitable for microcontroller-based development.

- **Microcontroller Platform:**

ESP32 Development Framework

The ESP32 platform is used for implementing the control logic of both transmitter and receiver modules. It supports high-speed processing, GPIO control, and serial communication. The framework allows efficient handling of digital signals for light modulation and data decoding.

- **Driver & Interface Support:**

USB-to-Serial Drivers (CP2102 / CH340)

These drivers enable communication between the ESP32 board and the computer. They are essential for uploading code and monitoring output through the serial interface. Proper driver installation ensures stable connectivity and smooth data transfer.

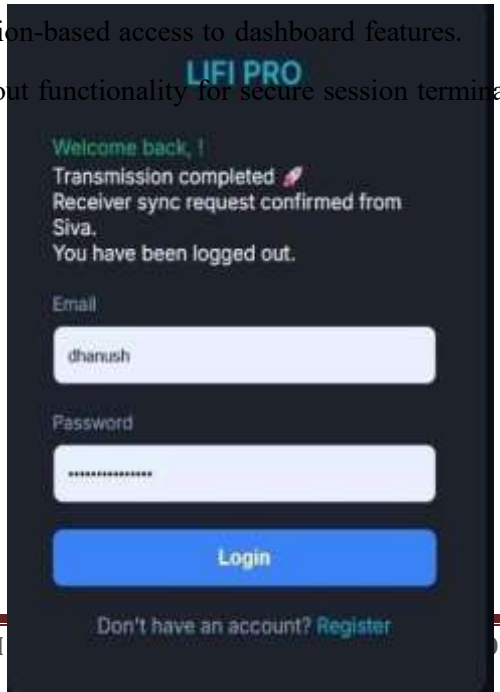
CHAPTER 5 IMPLEMENTATION

5.1 AUTHENTICATION & USER IDENTITY MODULE

The Authentication & User Interface Module serves as the entry point to the Li-Fi system. It manages user registration, login, and access to the system dashboard. This module ensures that only authorized users can access the communication system while providing a simple and user- friendly interface. It is implemented using Python-based UI and handles basic credential validation.

Key Functionalities:

1. User registration with username, email, and password.
2. Secure login system for authenticated access.
3. Input validation and basic credential management.
4. Session-based access to dashboard features.
5. Logout functionality for secure session termination.



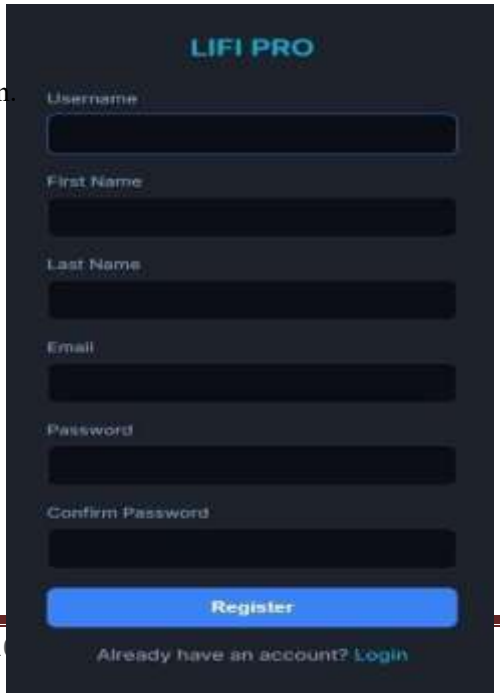


Figure 3: Login / Sign-Up Page

5.2 ADMIN DASHBOARD

The System Dashboard acts as the central control panel of the Li-Fi communication system. It provides a real-time overview of system activity, node status, and communication performance. The dashboard is designed to display key metrics in an organized and user-friendly manner for easy monitoring.

Key Functionalities:

1. Display of total users, nodes, and active connections.
2. Real-time monitoring of transmitter and receiver status.
3. Overview of system activity and communication logs.
4. Visual representation of system metrics (speed, SNR, temperature).
5. Centralized interface for accessing all modules.

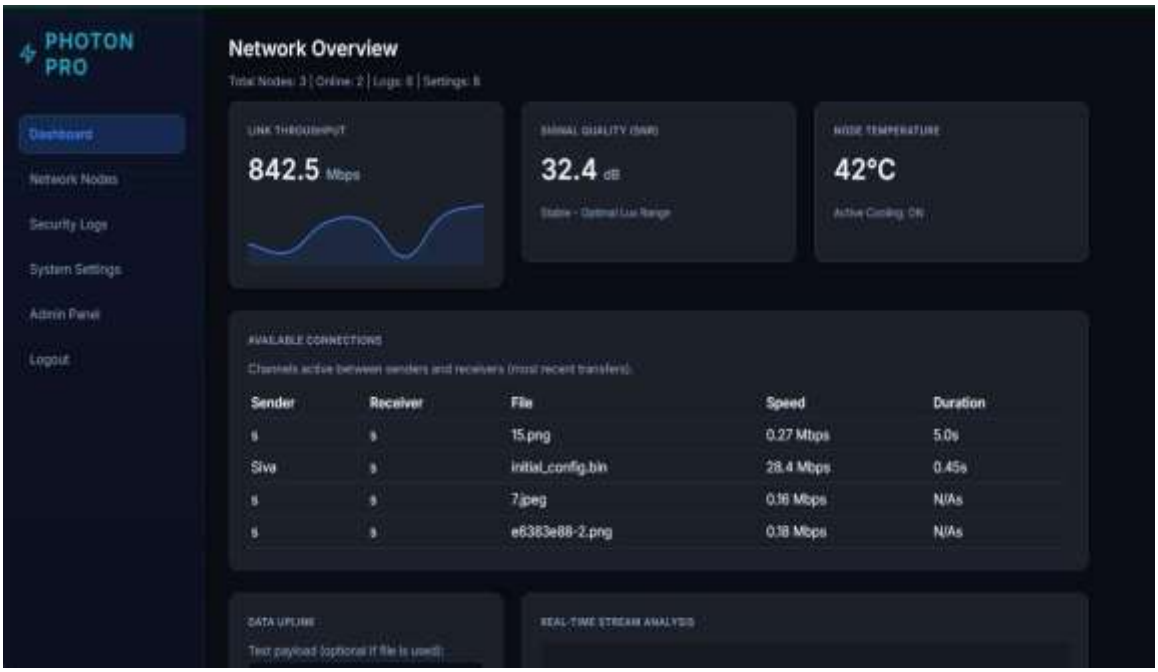


Figure 4: Admin Dashboard

5.3 NETWORK NODES & COMMUNICATION MODULE

The Network Nodes Module manages and monitors the communication between transmitter and receiver units. It provides detailed information about node status and recent data transmission activities.

Key Functionalities:

1. Display of transmitter and receiver status (Active/Inactive).
2. Monitoring of communication links between nodes.
3. Display of recent file/data transfer activities.

4. Tracking of transmission speed and duration.
5. Ensures synchronization between sender and receiver.

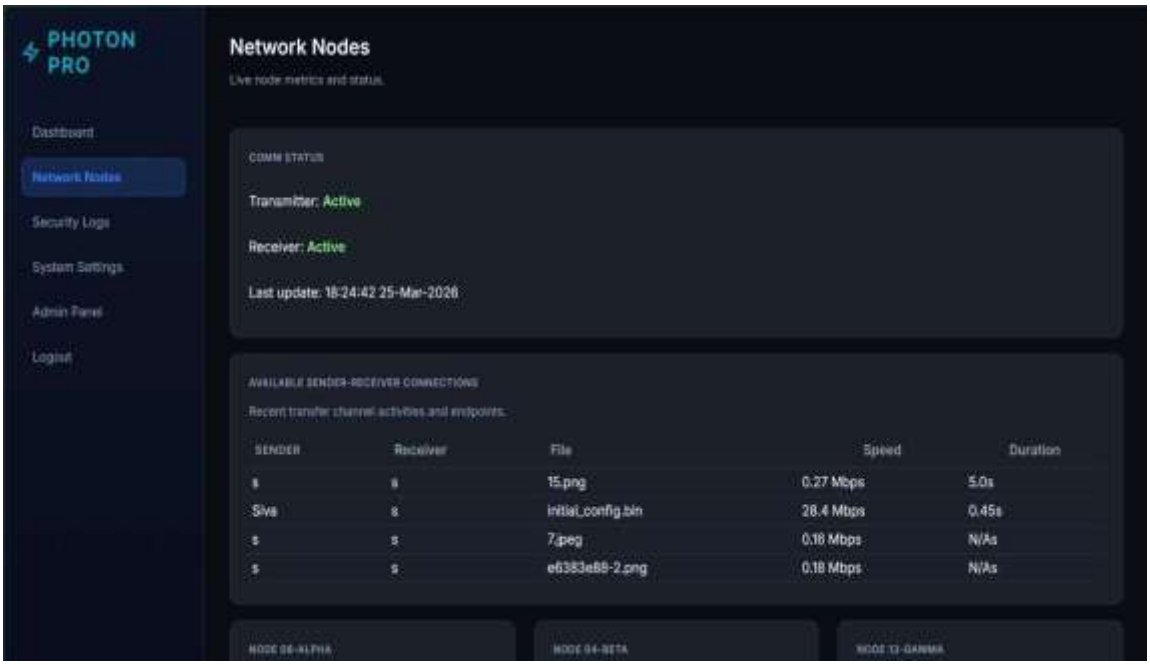


Figure 5: Network Nodes Interface

5.4 DATA TRANSMISSION & PROCESSING MODULE

The Data Transmission Module handles the core functionality of sending and receiving data using Li-Fi technology. Python is used to send data to the ESP32 via serial communication, where it is converted into light signals and transmitted through the LED.

Key Functionalities:

1. Data transmission using Python and serial communication.
2. Conversion of digital data into light signals using LED.
3. Reception of light signals using photodiode.
4. Signal processing using amplification and comparator circuits.
5. Decoding and reconstruction of received data.

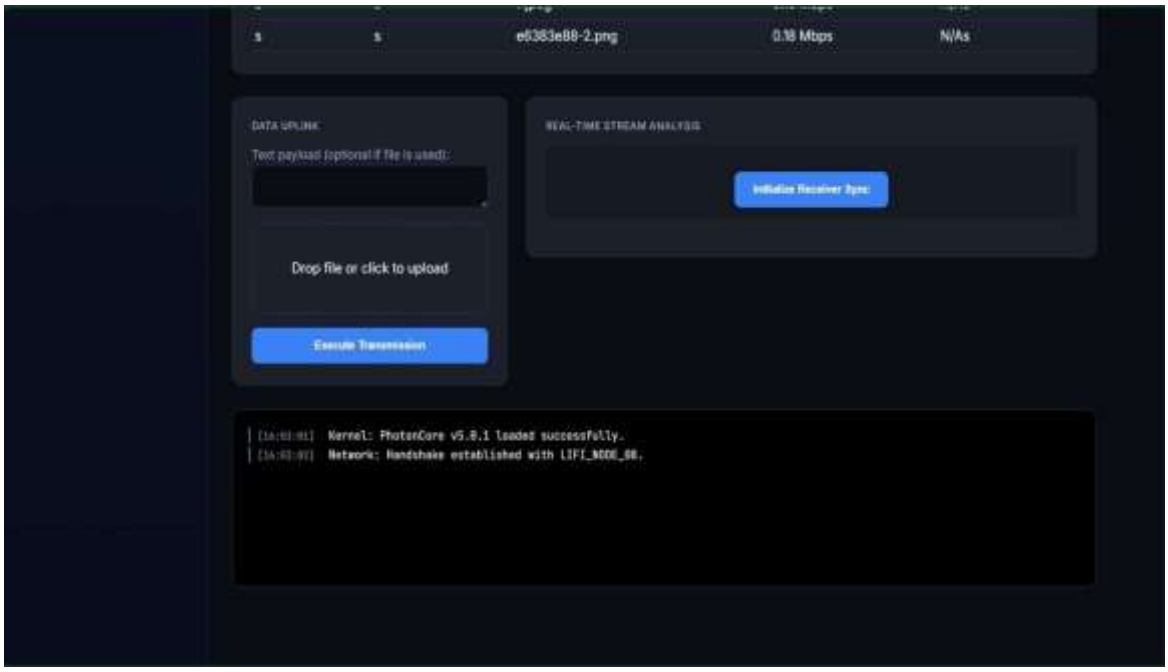


Figure 6: Data Transmission Flow

5.5 SOFTWARE DESCRIPTION

IDE :

The development of the Li-Fi Based Wireless Communication System was carried out using the Arduino Integrated Development Environment (IDE) as the primary platform. Arduino IDE provides a simple and efficient workspace for developing embedded system applications, particularly for microcontrollers such as ESP32. It supports writing, compiling, and uploading code seamlessly, making it suitable for hardware-based projects.

The environment also supports easy integration with external libraries and hardware components, enabling smooth interaction with sensors, LEDs, and communication modules. Its lightweight and user-friendly interface allows for rapid development and testing, making it an ideal choice for implementing the Li-Fi communication system.

FRONTEND :

The frontend of the Li-Fi Based Wireless Communication System is developed using HTML, CSS, and JavaScript to create a simple, responsive, and user-friendly interface. HTML is used to structure the web pages, CSS is used for styling and layout design, and JavaScript is used to add interactivity and dynamic behavior to the system.

The frontend is designed to provide an intuitive interface for users to interact with the Li-Fi system, including login/registration pages, dashboard views, system monitoring, and configuration settings. The interface is organized into different sections such as:

1. User Authentication Interface (Login/Register)

2. System Dashboard for real-time monitoring

3. Network Nodes and Communication Status

4. Security Logs and Event Tracking

5. System Settings and Configuration Panel

BACKEND :

The backend logic of the Li-Fi Based Wireless Communication System is implemented using Django, a high-level Python web framework that enables rapid development and secure system design. Django provides a robust and scalable backend architecture for handling system operations, user management, and communication control. It follows the Model-View-Template (MVT) architecture, ensuring organized code structure and efficient request handling.
The backend performs several critical operations, including:

1. User authentication and access control
2. Communication system monitoring and status management
3. Data transmission coordination between Python and ESP32
4. Logging and tracking of system events and communication activity
5. Configuration management and system control

The system integrates Python-based communication scripts within the Django backend to manage data exchange between the application and the hardware (ESP32). Serial communication is used to send and receive data, enabling real-time interaction between the software interface and Li-Fi hardware components. The backend ensures that transmitted data is properly formatted, processed, and forwarded to the transmitter module.

To ensure efficient performance and reliability, the backend supports asynchronous handling of system operations and real-time updates. It processes multiple requests such as user actions, system monitoring, and data transmission without affecting overall performance. The backend also maintains structured logs of communication events, which are used for monitoring and debugging purposes.

Security measures in the backend include user authentication, session management, input validation, and controlled access to system functionalities. Django's built-in security features such as protection against SQL injection, cross-site scripting (XSS), and cross-site request forgery (CSRF) enhance the overall safety of the system.

Overall, the Django backend provides a stable, secure, and scalable environment for managing the Li-Fi communication system, ensuring smooth integration between the user interface and hardware components.

DATABASE:

The database layer of the Li-Fi Based Wireless Communication System is powered by MySQL, a widely used and high-performance open-source relational database management system. MySQL is used to store and manage structured data related to system users, communication logs, and system configurations.
The database stores the following information:

1. User profiles and authentication details
2. System configuration and device information

3. Communication logs and transmission records
4. Received and transmitted data history
5. System performance metrics (e.g., signal status, timestamps)
6. Activity logs for monitoring and debugging

MySQL ensures data integrity, consistency, and efficient data retrieval through structured tables and indexing mechanisms. It supports reliable storage and fast query execution, which is essential for handling real-time system monitoring and communication tracking.

The database is integrated with the Django backend using Django's built-in ORM (Object- Relational Mapping). The ORM enables developers to interact with the database using Python code instead of writing complex SQL queries. It simplifies database operations such as data insertion, retrieval, updating, and deletion, while also ensuring maintainability and scalability.

Django ORM also supports schema migrations, allowing structured updates to the database without data loss or corruption. Security features such as input validation and query abstraction help prevent common vulnerabilities like SQL injection.

Overall, the MySQL database provides a stable, efficient, and scalable data management solution for the Li-Fi system, ensuring reliable storage, quick access, and secure handling of system data.

5.6 CODE IMPLEMENTATION

Authentication & User Identity Module

The Authentication & User Interface Module serves as the entry point to the Li-Fi system. It manages user registration, login, and access to the system dashboard. This module ensures that only authorized users can access the communication system while providing a simple and user- friendly interface. It is implemented using Python-based UI and handles basic credential validation.

Code Snippet:

```
<!DOCTYPE html>
<html lang="en">
<head>
<title>Login - LIFI PRO</title>
<link href="https://fonts.googleapis.com/css2?family=Inter:wght@300;400;600&family=JetBrains+Mon o&displ
ay=swap" rel="stylesheet">
</head>
<body>
<div class="login-container">
<div class="brand">LIFI PRO</div>
{% if messages %}
<div class="messages">
{% for message in messages %}
<div class="{% if message.tags %}{{ message.tags }}{% endif %}">{{ message }}</div>
{% endfor %}
</div>
{% endif %}
<form method="post">
{% csrf_token %}
<div class="form-group">
<label for="{{ form.username.id_for_label }}">Email</label>
```

```
{{ form.username }}
</div>
<div class="form-group">
<label for="{{ form.password.id_for_label }}">Password</label>
{{ form.password }}
</div>
<button type="submit" class="btn-primary">Login</button>
<div class="register-link">
Don't have an account? <a href="{% url 'register' %}">Register</a>
</div>
</div>
</body>
</html>
```

Admin Dashboard

The System Dashboard acts as the central control panel of the Li-Fi communication system. It provides a real-time overview of system activity, node status, and communication performance. The dashboard is designed to display key metrics in an organized and user-friendly manner for easy monitoring.

Code Snippet:

```
{% extends 'dashboard.html' %}
{% block content %}
<main>
<div class="header-bar">
<div>
<h1 style="margin:0; font-size: 1.5rem;">Admin Dashboard</h1>
<p style="color: var(--text-secondary); font-size: 0.9rem;">Superuser summary, system health, and quick controls.</p>
</div>
</div>
<div class="dashboard-grid">
<div class="card" style="border-left: 4px solid #3b82f6;">
<div class="card-title">Total registered users</div>
<div class="big-stat">{{ total_users }}</div>
<p class="stat-meta">Active accounts in the system.</p>
</div>
<div class="card" style="border-left: 4px solid #06b6d4;">
<div class="card-title">Configured nodes</div>
<div class="big-stat">{{ total_nodes }}</div>
<p class="stat-meta">Nodes monitored in topology.</p>
</div>
<div class="card" style="border-left: 4px solid #10b981;">
<div class="card-title">Online nodes (Active)</div>
<div class="big-stat" style="color: #10b981;">{{ online_nodes }}/{{ total_nodes }}</div>
<p class="stat-meta">{{ offline_nodes }} offline · {{ online_nodes|default:"0" }} active links.</p>
</div>
<div class="card" style="border-left: 4px solid #f59e0b;">
<div class="card-title">Security Events (Warnings)</div>
<div class="big-stat">{{ warn_logs }}</div>
```

```
<p class="stat-meta">Audit log entries: {{ total_logs }} total ({{ info_logs }} INFO).</p>
</div>
<div class="card" style="border-left: 4px solid #8b5cf6;">
<div class="card-title">Settings Entries</div>
<div class="big-stat">{{ settings_count }}</div>
<p class="stat-meta">System config rows loaded.</p>
</div>
<div class="card">
<div class="card-title">Recent Transfers</div>
<div class="big-stat">{{ recent_transfers|length }}</div>

<p class="stat-meta">Latest file sync operations.</p>
</div>
</div>

<!-- Recent Users Section -->
<div class="dashboard-grid" style="grid-template-columns: 1fr;">
<div class="card">
<div class="card-title" style="margin-bottom: 14px;">Recent Users (Last {{ recent_users|length
}})</div>
<div style="overflow-x:auto;">
<table style="width:100%; border-collapse: collapse; font-size: 0.9rem;">
<thead>
<tr style="border-bottom: 1px solid var(--border); color: var(--text-secondary);">
<th style="text-align:left; padding:8px 4px;">Username</th>
<th style="text-align:left; padding:8px 4px;">Email</th>
<th style="text-align:left; padding:8px 4px;">Joined</th>
<th style="text-align:center; padding:8px 4px;">Is Superuser</th>
</tr>
</thead>
<tbody>
{% for user in recent_users %}
<tr style="border-bottom: 1px solid rgba(148,163,184,0.1);">
<td style="padding:8px 4px;"><strong>{{ user.username }}</strong></td>
<td style="padding:8px 4px; color: var(--text-secondary);">{{ user.email }}</td>
<td style="padding:8px 4px; color: var(--text-secondary); font-size:0.85rem;">{{ user.date_joined|date:'M d, Y H:i'
}}</td>
<td style="padding:8px 4px; text-align:center;">{% if user.is_superuser
%}<strong style="color:#10b981;">✓ Yes</strong>{% else %}<span style="color: var(--text- secondary);">—
</span>{% endif %}</td>
</tr>
{% empty %}
<tr><td colspan="4" style="padding:8px; color: var(--text-secondary);">No users registered yet.</td></tr>
{% endfor %}
</tbody>
</table>
</div>
</div>
</div>
```

```
<!-- Node Status & Recent Logs -->
<div class="dashboard-grid">
<div class="card" style="grid-column: span 1;">
<div class="card-title" style="margin-bottom: 14px;">Node Status Breakdown</div>
{% if all_nodes %}
<div style="display: grid; gap: 10px;">
{% for node in all_nodes %}
<div style="padding: 10px; background: rgba(0,0,0,0.2); border-radius: 8px; border-left: 3px solid {% if node.status == 'online' %}#10b981{% else %}#ef4444{% endif %};">

<strong>{{ node.node_id }}</strong>
<span style="color: {% if node.status == 'online' %}#10b981{% else
%}#ef4444{% endif %};">{{ node.status|title }}</span>
</div>
<div style="font-size: 0.8rem; color: var(--text-secondary); margin-top: 4px;"> Latency: {{ node.latency_ms }}ms · Quality: {{ node.signal_quality }}%
</div>
</div>
{% endfor %}
</div>
{% else %}
<p style="color: var(--text-secondary);">No nodes configured yet.</p>
{% endif %}
</div>
<div class="card" style="grid-column: span 2;">
<div class="card-title" style="margin-bottom: 14px;">Recent Audit Logs (Last {{ recent_logs|length }})</div>
<div style="overflow-x:auto; max-height: 400px; overflow-y:auto;">
<table style="width:100%; border-collapse: collapse; font-size: 0.85rem;">
<thead>
<tr style="border-bottom: 1px solid var(--border); color: var(--text-secondary); position: sticky; top:0; background: var(--bg-card);">
<th style="text-align:left; padding:8px 4px;">Timestamp</th>
<th style="text-align:left; padding:8px 4px;">Level</th>
<th style="text-align:left; padding:8px 4px;">Message</th>
</tr>
</thead>
<tbody>
{% for log in recent_logs %}
<tr style="border-bottom: 1px solid rgba(148,163,184,0.1);">
<td style="padding:8px 4px; color: var(--text-secondary); white- space:nowrap;">{{ log.created_at|date:'H:i:s' }}</td>
<td style="padding:8px 4px;">
<span style="padding:2px 8px; border-radius:4px; font-weight:600; font-size:0.75rem;
{% if log.level == 'WARN' %}background:rgba(245,158,11,0.2); color:#fbbf24;{% else
%}background:rgba(59,130,246,0.2); color:#60a5fa;{% endif %}">
{{ log.level }}
</span>
</td>
<td style="padding:8px 4px; color: var(--text-secondary);">{{ log.message }}</td>
</tr>
{% empty %}
```

```
<tr><td colspan="3" style="padding:8px; color: var(--text-secondary);">No security events logged yet.</td></tr>
{% endfor %}
</tbody>
</table>
</div>
</div>
</div>

<!-- File Transfers -->
<div class="dashboard-grid" style="grid-template-columns: 1fr;">
<div class="card">
<div class="card-title" style="margin-bottom: 14px;">Recent File Transfers</div>
{% if recent_transfers %}
<div style="display: grid; gap: 10px;">
{% for transfer in recent_transfers %}
<div style="padding: 12px; background: rgba(0,0,0,0.2); border-radius: 8px;">
<div style="display: flex; justify-content: space-between; align-items:center; margin- bottom: 6px;">
<strong style="font-family: 'JetBrains Mono', monospace; font-size:0.9rem;">{{ transfer.file_name }}</strong>
<span style="color: {% if transfer.completed_at %}#10b981{% else %}#f59e0b{% endif
%}; font-size:0.85rem;">
{% if transfer.completed_at %}✓ Completed{% else %}⏳ Pending{% endif %}
</span>
</div>
<div style="font-size:0.8rem; color: var(--text-secondary); display:flex; gap: 16px;">
<span>From: {% if transfer.sender %}{{ transfer.sender.username }}{% else
%}System{% endif %}</span>
<span>To: {% if transfer.receiver %}{{ transfer.receiver.username }}{% else
%}System{% endif %}</span>
</div>
<div style="font-size:0.8rem; color: var(--text-secondary); margin-top: 6px;">
{{ transfer.file_size_mb }} MB · {{ transfer.transfer_speed_mbps }} Mbps · {{ transfer.duration_seconds|default:"—
" }}s
</div>
</div>
{% endfor %}
</div>
{% else %}
<p style="color: var(--text-secondary);">No file transfers recorded yet.</p>
{% endif %}
</div>
</div>

</main>
{% endblock %}
```

NETWORK NODES & COMMUNICATION MODULE

The Network Nodes Module manages and monitors the communication between transmitter and receiver units. It provides detailed information about node status and recent data transmission activities.

Code Snippet:

```
{% extends 'dashboard.html' %}
{% block content %}
<main>
<div class="header-bar">
<div>
<h1 style="margin:0; font-size: 1.5rem;">Network Nodes</h1>
<p style="color: var(--text-secondary); font-size: 0.9rem;">Live node metrics and status.</p>
</div>
</div>
<div class="card" style="grid-column: span 3; margin-bottom: 18px;">
<div class="card-title">Comm Status</div>
<p>Transmitter: <strong style="color: {{ transmitter_color }};">{{ transmitter_status
}}</strong></p>
<p>Receiver: <strong style="color: {{ receiver_color }};">{{ receiver_status }}</strong></p>
{% if comms %}
<p>Last update: {{ comms.updated_at|date:'H:i:s d-M-Y' }}</p>
{% else %}
<p>No communication status reported yet.</p>
{% endif %}
</div>

<div class="card" style="grid-column: span 3; margin-bottom: 18px;">
<div class="card-title">Available Sender-Receiver Connections</div>
<div style="font-size: 0.9rem; color: var(--text-secondary); margin-bottom: 8px;">Recent transfer channel activities and endpoints.</div>
<div style="overflow-x:auto;">
<table style="width:100%; border-collapse: collapse; margin-top: 8px; min-width: 760px;">
<thead>
<tr style="color: #9ca3af; border-bottom:1px solid rgba(148,163,184,0.2);">
<th style="padding:10px 8px; text-align:left; text-transform: uppercase; letter- spacing: 0.06em; font-size: 0.84rem;">Sender</th>
<th style="padding:10px 8px; text-align:left;">Receiver</th>
<th style="padding:10px 8px; text-align:left;">File</th>
<th style="padding:8px 4px;">Speed</th>
<th style="padding:8px 4px;">Duration</th>
</tr>
</thead>
<tbody>
{% for conn in connections %}

<td style="padding:6px 4px;">{% if conn.sender %}{{ conn.sender.username }}{% else
%}Unknown{% endif %}</td>
<td style="padding:6px 4px;">{% if conn.receiver %}{{ conn.receiver.username
}}{% else %}Unknown{% endif %}</td>
<td style="padding:6px 4px;">{{ conn.file_name }}</td>
<td style="padding:6px 4px;">{{ conn.transfer_speed_mbps }} Mbps</td>
<td style="padding:6px 4px;">{{ conn.duration_seconds|default:'N/A' }}s</td>
</tr>
```

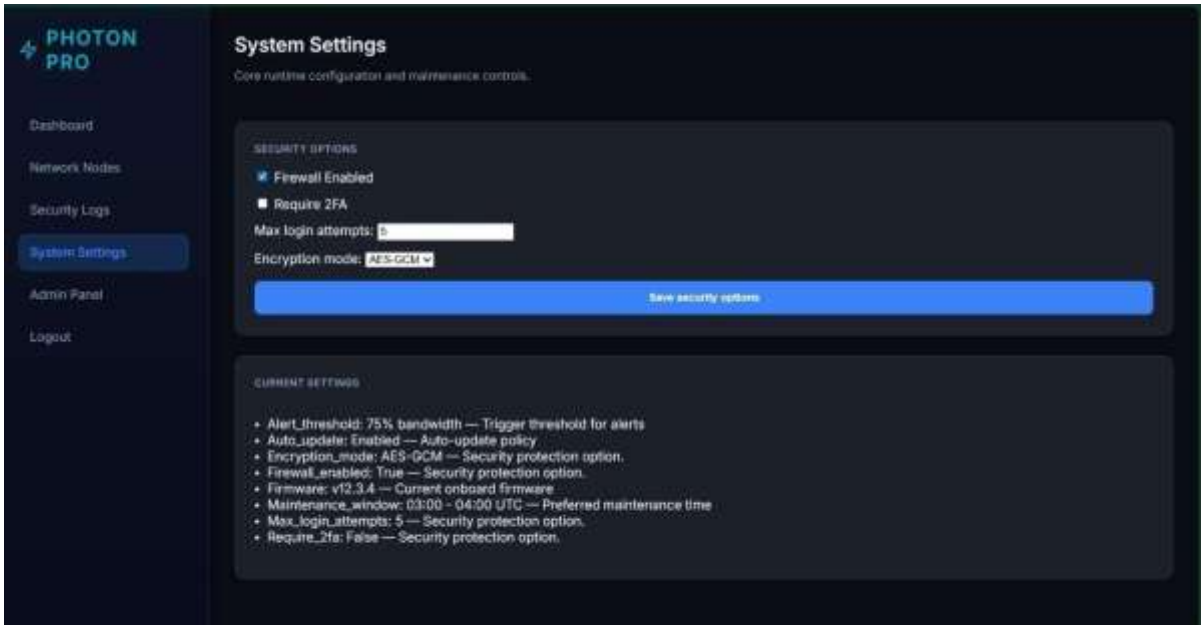
```
{% empty %}
<tr><td colspan="5" style="padding:8px;">No connections found.</td></tr>
{% endfor %}
</tbody>
</table>
</div>
</div>

<div class="dashboard-grid">
{% for node in nodes %}
<div class="card">
<div class="card-title">Node {{ node.node_id }}</div>
<div class="big-stat" style="font-size: 1.2rem;">{{ node.status|title }}</div>
<p class="stat-meta">Latency: {{ node.latency_ms }}ms</p>
<p class="stat-meta">Quality: {{ node.signal_quality }}%</p>
<p class="stat-meta">Updated: {{ node.updated_at|date:'H:i:s d-M-Y' }}</p>
</div>
{% endfor %}
</div>
</main>
{% endblock %}
```

RESULT:

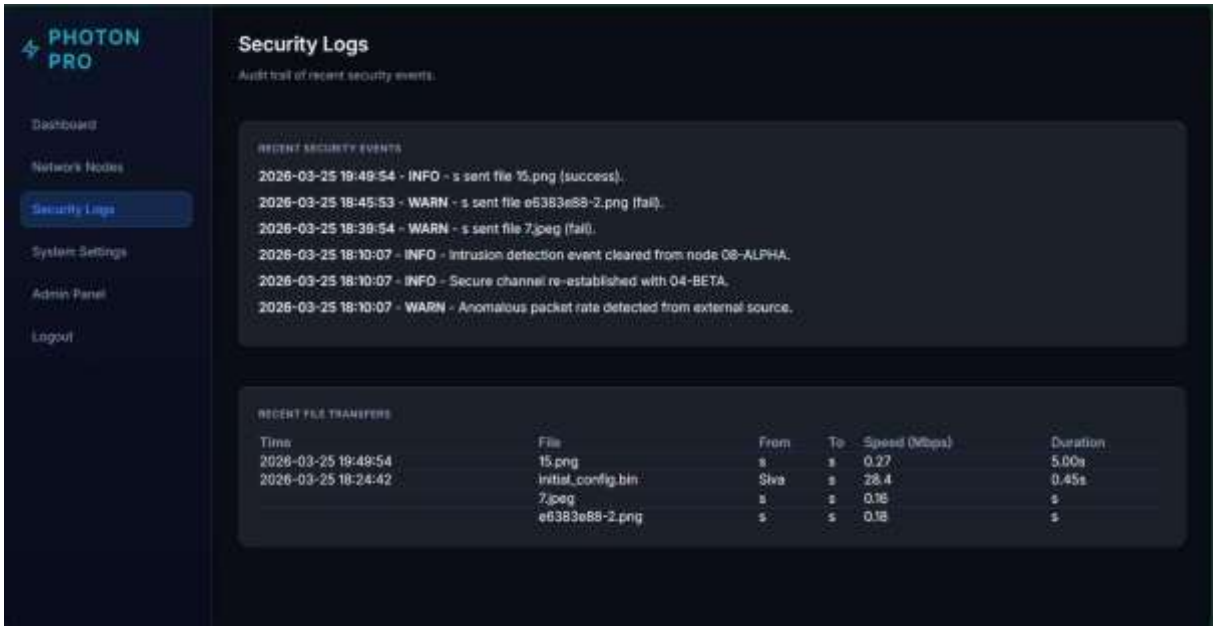
The Li-Fi Based Wireless Communication System successfully demonstrates the functionality of a secure, efficient, and interference-free data transmission system using light as the communication medium. Developed using ESP32, infrared LED, photodiode, Python, Django, and MySQL, the system effectively integrates hardware and software components to achieve reliable wireless communication. The system moves away from traditional RF-based communication and introduces a structured optical communication model for data transfer.

With the implementation of LED-based signal transmission, photodiode-based reception, and proper signal processing using amplification and comparator circuits, the system ensures accurate data transfer with minimal noise and interference. The integration of a user interface, real-time monitoring dashboard, and system logging enhances usability and system control. Overall, the Li- Fi system demonstrates stable performance, secure communication, and practical applicability, proving its potential as an alternative solution for next-generation wireless and IoT communication systems.

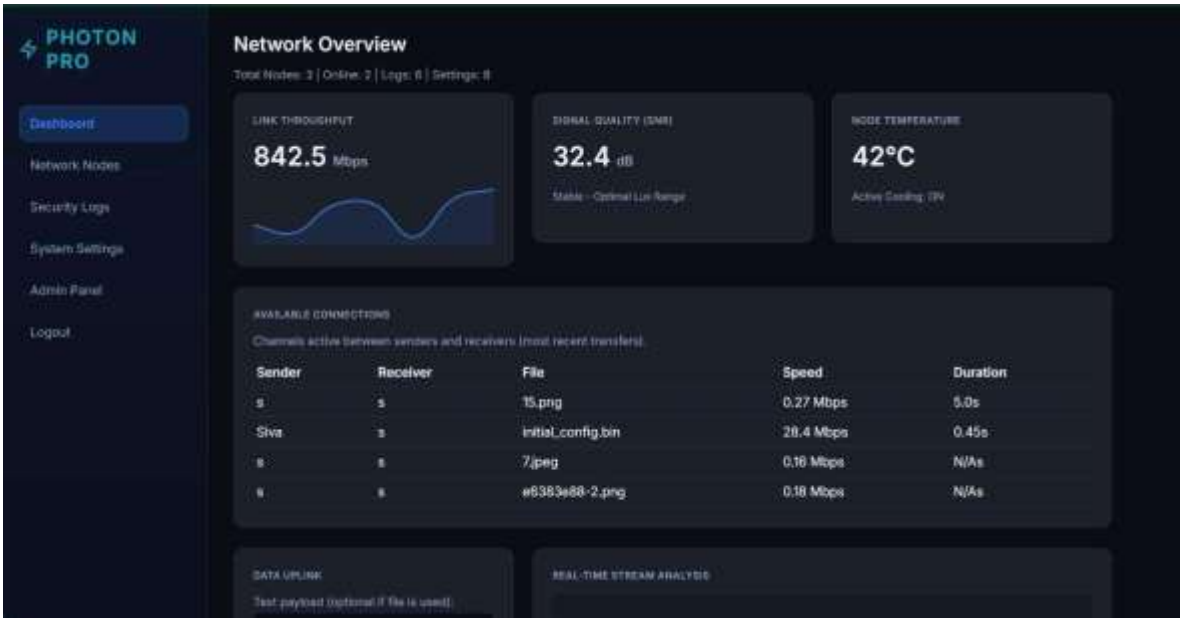
SETTINGS



SECURITY LOGS



NETWORK OVERVIEW



Performance and Usability Results

The Li-Fi Based Wireless Communication System demonstrates efficient performance and reliable operation across all core modules. The system utilizes ESP32 microcontrollers along with Python and Django backend integration, enabling smooth coordination between hardware and software components. The serial communication between Python and ESP32 ensures real-time data transmission, allowing data to be sent and received with minimal delay. The use of a MOSFET-driven infrared LED for transmission and a photodiode-based receiver ensures stable signal propagation and accurate data detection.

The signal processing stage, which includes the transimpedance amplifier (OPA381) and comparator (LM393), enhances system performance by amplifying weak signals and reducing noise. This ensures that the received data is clean and accurately reconstructed, even under varying environmental conditions. The system maintains consistent performance for short-range communication, demonstrating reliable data transfer with minimal signal loss and interference.

From a backend perspective, the Django framework efficiently manages user authentication, system monitoring, and communication control. The MySQL database ensures fast data storage and retrieval for system logs, communication records, and user data. The overall system responsiveness remains stable during continuous data transmission, indicating efficient resource utilization and proper integration between software and hardware components.

From a usability standpoint, the system provides a user-friendly interface developed using HTML, CSS, and JavaScript. The dashboard presents system information such as node status, transmission activity, and performance metrics in a clear and organized manner. Real-time updates allow users to monitor communication without manual refresh, improving overall user experience.

The inclusion of system logs and monitoring features enhances transparency and helps users track communication events and system behavior. The interface is designed to be simple and accessible, making it suitable for both technical and non-technical users. Overall, the Li-Fi system delivers a stable, efficient, and user-friendly communication solution, combining reliable hardware performance with intuitive software interaction.

CHAPTER 6

CONCLUSION AND FUTURE ENHANCEMENT

6.1 CONCLUSION

The Li-Fi Based Wireless Communication System demonstrates the successful development of a secure, efficient, and interference-free communication system using light as a transmission medium. By replacing traditional RF-based communication with optical signals, the system effectively addresses issues such as spectrum congestion, electromagnetic interference, and security vulnerabilities. The integration of ESP32, infrared LED, photodiode, transimpedance amplifier, and comparator ensures reliable data transmission, accurate signal processing, and stable system performance. The system is simple, cost-effective, and suitable for IoT-based applications while providing enhanced security due to the confined nature of light communication. In the future, the system can be further enhanced by implementing bidirectional communication, advanced modulation techniques for higher data rates, improved noise filtering mechanisms, and integration with IoT and cloud platforms for real-time monitoring and scalability. These improvements will increase the system's efficiency, range, and applicability, making Li-Fi a strong alternative for next-generation wireless communication technologies.

6.2 FUTURE SCOPE

The Li-Fi Based Wireless Communication System has significant potential for future enhancements and advanced applications. In future versions, the system can be developed to support higher data transmission rates by incorporating advanced modulation techniques such as Pulse Width Modulation (PWM) or Orthogonal Frequency Division Multiplexing (OFDM). The use of visible light LEDs or laser-based transmitters can further improve bandwidth and communication range, making the system suitable for high-speed data transfer applications.

The system can also be enhanced to support bidirectional communication, enabling full-duplex data exchange between transmitter and receiver. This would expand its usability in real-time communication systems and interactive IoT environments. Additionally, integrating multiple transmitters and receivers can enable network-based Li-Fi communication, allowing multiple devices to communicate simultaneously within a defined area.

This would enable applications in smart homes, industrial automation, and smart city infrastructure. Mobile integration and compatibility with portable devices can further improve accessibility and real-world usability.

Advanced signal processing techniques such as adaptive filtering and error correction mechanisms can be implemented to improve reliability in environments with ambient light interference. The system can also be enhanced with better optical components, such as lenses and focusing mechanisms, to increase transmission distance and signal strength.

Other potential improvements include the development of compact and energy-efficient hardware designs, integration with existing Wi-Fi systems for hybrid communication models, and implementation of secure communication protocols for enhanced data protection. These enhancements will make the Li-Fi system more scalable, robust, and suitable for next-generation wireless communication technologies.

APPENDICES

SOURCE CODE

```
from django.shortcuts import render, redirect

from django.contrib.auth import login, authenticate, logout from django.contrib import messages from django.contrib.auth.models import User
from django.contrib.auth.decorators import login_required, user_passes_test from django.utils import timezone
from .forms import RegisterForm, LoginForm

from .models import NetworkNode, SecurityLog, SystemSetting, CommsStatus, FileTransfer from transmitter.views import send_data, send_file
from transmitter.serial_tx import send_file_to_esp32 from transmitter.views import send_bytes


@login_required

def dashboard(request):

# Ensure database has baseline sample data for realistic dashboard experience if not NetworkNode.objects.exists():
sample_nodes = [

NetworkNode(node_id='08-ALPHA', status='online', latency_ms=11, signal_quality=98), NetworkNode(node_id='04-BETA', status='online', latency_ms=14, signal_quality=92), NetworkNode(node_id='13-GAMMA', status='offline', latency_ms=0, signal_quality=0),
]

NetworkNode.objects.bulk_create(sample_nodes)


if not SecurityLog.objects.exists(): SecurityLog.objects.bulk_create([ SecurityLog(level='INFO', message='Intrusion detection event cleared from node 08-ALPHA.'), SecurityLog(level='INFO', message='Secure channel re-established with 04-BETA.'), SecurityLog(level='WARN', message='Anomalous packet rate detected from external source.'),
])
if not SystemSetting.objects.exists():


SystemSetting.objects.bulk_create([

SystemSetting(key='firmware', value='v12.3.4', description='Current onboard firmware'), SystemSetting(key='auto_update', value='Enabled', description='Auto-update policy'),
SystemSetting(key='maintenance_window', value='03:00 - 04:00 UTC', description='Preferred maintenance time'), SystemSetting(key='alert_threshold', value='75% bandwidth', description='Trigger threshold for

alerts'),

])
if not CommsStatus.objects.exists(): CommsStatus.objects.create(transmitter_active=True, receiver_active=True)


if not FileTransfer.objects.exists(): sample_sender = User.objects.first() sample_receiver = User.objects.last() if User.objects.count() > 1 else sample_sender FileTransfer.objects.create(
```

sender=sample_sender, receiver=sample_receiver, file_name='initial_config.bin', file_size_mb=3.2, transfer_speed_mbps=28.4, completed_at=timezone.now(), duration_seconds=0.45,
)

send_status = None confirmed_sender = None if request.method == 'POST':
if request.POST.get('confirm_sender'): sender_id = request.POST.get('sender_id') if sender_id: confirmed_sender = User.objects.filter(id=sender_id, is_active=True).first() if confirmed_sender: messages.info(request,f"Receiver sync request confirmed from {confirmed_sender.username}.")

else:

messages.error(request, 'Selected sender not found or inactive.') else:
messages.warning(request, 'Please select a sender to confirm the receiver sync.') else:
text_payload = request.POST.get('text_payload', '').strip() file_obj = request.FILES.get('file')

if file_obj:

filepath = 'temp_sent.bin' with open(filepath, 'wb') as f:

for chunk in file_obj.chunks(): f.write(chunk)

success, message = send_file_to_esp32(filepath) file_name = file_obj.name file_size = round(file_obj.size / 1024 / 1024, 2) payload_type = 'file'

elif text_payload:

payload_bytes = text_payload.encode('utf-8') success, message = send_bytes(payload_bytes) file_name = f"payload-{timezone.now().strftime('%Y%m%d%H%M%S')}.txt" file_size = round(len(payload_bytes) / 1024 / 1024, 4) payload_type = 'text'

else:

success = False

message = 'Please provide a file or a text payload.' file_name = 'none' file_size = 0 payload_type = 'none'

if payload_type != 'none': now = timezone.now()

FileTransfer.objects.create(sender=request.user, receiver=request.user, file_name=file_name, file_size_mb=file_size, transfer_speed_mbps=round((file_size * 8) / 5, 2) if file_size else 0, completed_at=now if success else None, duration_seconds=5 if success else None,

)

SecurityLog.objects.create(level='INFO' if success else 'WARN',

message=f"{request.user.username} sent {payload_type} {file_name} ({'success' if success else

)

```
send_status = message messages.info(request, message)


comm_status = CommsStatus.objects.order_by('-updated_at').first() connections = FileTransfer.objects.order_by('-completed_at')[:10]

sender_ids = FileTransfer.objects.order_by('-completed_at').values_list('sender_id', flat=True).distinct()
sender_choices = User.objects.filter(id__in=sender_ids, is_active=True)

total_nodes = NetworkNode.objects.count()

online_nodes = NetworkNode.objects.filter(status='online').count() total_logs = SecurityLog.objects.count()
total_settings = SystemSetting.objects.count()


throughput_mbps = 842.5

snr_db = 32.4

temperature_c = 42


context = {

'total_nodes': total_nodes, 'online_nodes': online_nodes, 'total_logs': total_logs, 'total_settings': total_settings, 'throughput_mbps': throughput_mbps, 'snr_db': snr_db,
'temperature_c': temperature_c, 'comm_status': comm_status, 'connections': connections, 'send_status': send_status, 'sender_choices': sender_choices, 'confirmed_sender': confirmed_sender,
}


return render(request, 'dashboard.html', context)


def register(request):

if request.user.is_authenticated: return redirect('dashboard')


if request.method == 'POST':

form = RegisterForm(request.POST) if form.is_valid():

user = form.save() login(request, user)

messages.success(request, 'Registration successful.') return redirect('dashboard') else:
form = RegisterForm()

return render(request, 'register.html', {'form': form})
```

```
def user_login(request):
if request.user.is_authenticated: return redirect('dashboard')

if request.method == 'POST':
email = request.POST.get('username') password = request.POST.get('password') try: user = User.objects.get(email=email)
user = authenticate(request, username=user.username, password=password) if user is not None: login(request, user)
messages.success(request, f'Welcome back, {user.first_name}!') return redirect('dashboard') else:
messages.error(request, 'Invalid email or password.') except User.DoesNotExist: messages.error(request, 'Invalid email or password.') form = LoginForm()
return render(request, 'login.html', {'form': form})


@login_required
def network_nodes(request):
nodes = NetworkNode.objects.all().order_by('-updated_at') comms = CommsStatus.objects.order_by('-updated_at').first() connections = FileTransfer.objects.order_by('-completed_at')[:15]

transmitter_status = 'Inactive' receiver_status = 'Inactive' transmitter_color = '#ef4444' receiver_color = '#ef4444'

if comms:
transmitter_status = 'Active' if comms.transmitter_active else 'Inactive' receiver_status = 'Active' if comms.receiver_active else 'Inactive' transmitter_color = 'lightgreen' if comms.transmitter_active else '#ef4444' receiver_color = 'lightgreen' if comms.receiver_active else '#ef4444'

return render(request, 'network_nodes.html', { 'nodes': nodes, 'comms': comms, 'connections': connections,
'transmitter_status': transmitter_status, 'receiver_status': receiver_status, 'transmitter_color': transmitter_color, 'receiver_color': receiver_color,
})


@login_required
def security_logs(request):
logs = SecurityLog.objects.all().order_by('-created_at')[:50] file_transfers = FileTransfer.objects.all().order_by('-completed_at')[:50]
return render(request, 'security_logs.html', {'logs': logs, 'file_transfers': file_transfers})


@login_required
def system_settings(request):
if request.method == 'POST':
firewall_value = 'True' if request.POST.get('firewall_enabled') == 'True' else 'False' twofa_value = 'True' if
```

request.POST.get('require_2fa') == 'True' else 'False' login_attempts = request.POST.get('max_login_attempts', '5') encryption_mode = request.POST.get('encryption_mode', 'AES-GCM')

values = {

'firewall_enabled': firewall_value, 'require_2fa': twofa_value, 'max_login_attempts': login_attempts, 'encryption_mode': encryption_mode,
}

for key, value in values.items():

entry, _ = SystemSetting.objects.get_or_create(key=key)

entry.value = value entry.description = 'Security setting.' entry.save()

messages.success(request, 'Security settings updated.')

settings = SystemSetting.objects.all().order_by('key') # ensure security options exist defaults = { 'firewall_enabled': 'True', 'require_2fa': 'False', 'max_login_attempts': '5', 'encryption_mode': 'AES-GCM',
}

for key, value in defaults.items():

SystemSetting.objects.get_or_create(key=key,defaults={'value': value,'description"Security protection option.'})

settings = SystemSetting.objects.all().order_by('key') settings_map = {s.key: s.value for s in settings}
return render(request, 'system_settings.html', {'settings': settings, 'settings_map': settings_map})

@user_passes_test(lambda u: u.is_superuser) def admin_dashboard(request): total_users = User.objects.count() total_nodes = NetworkNode.objects.count() online_nodes = NetworkNode.objects.filter(status='online').count() offline_nodes =
NetworkNode.objects.filter(status='offline').count() total_logs = SecurityLog.objects.count() settings_count = SystemSetting.objects.count()

Recent data for detailed view

recent_users = User.objects.order_by('-date_joined')[:5] recent_logs = SecurityLog.objects.order_by('-created_at')

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