



International Journal of Innovative Research in Computer and Communication Engineering

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)





International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCCE)

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LAN Sync Music

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ABSTRACT: Synchronized audio playback across multiple devices on a local area network remains a challenging problem due to the lack of free, offline, and hardware-independent solutions. This paper presents LAN Sync Music, a lightweight, browser-based real-time audio synchronization system developed using Python Flask and Socket.IO. The system enables a single host device to control playback while multiple listener devices receive synchronized audio streams in real time. The architecture uses WebSockets for low-latency communication and a background synchronization mechanism to correct playback drift within 300 milliseconds. The system operates entirely on a local network without requiring internet access or application installation. Experimental results demonstrate near-zero latency synchronization across multiple devices, making the system suitable for classrooms, hostels, offices, and home environments. The proposed solution offers a scalable, cost-effective alternative to existing hardware-based and internet-dependent audio synchronization systems.

KEYWORDS: Audio Synchronization, Flask, Socket.IO, WebSockets, LAN System, Real-Time Communication.

I. INTRODUCTION

The demand for synchronized multi-device audio playback has increased significantly in shared environments such as hostels, offices, classrooms, and homes. Existing solutions either depend on expensive proprietary hardware or require continuous internet connectivity and subscriptions.

Technologies such as WebSockets and Python Flask now enable real-time communication systems capable of synchronizing multiple devices efficiently. LAN Sync Music leverages these technologies to provide a browser-based solution that requires no installation and works across all devices connected to the same network.

The system ensures:

- No internet dependency
- Cross-platform compatibility
- Real-time synchronization within 300 ms
- Secure host-based control

This project provides a practical and cost-effective solution for synchronized group listening.

II. METHODOLOGY

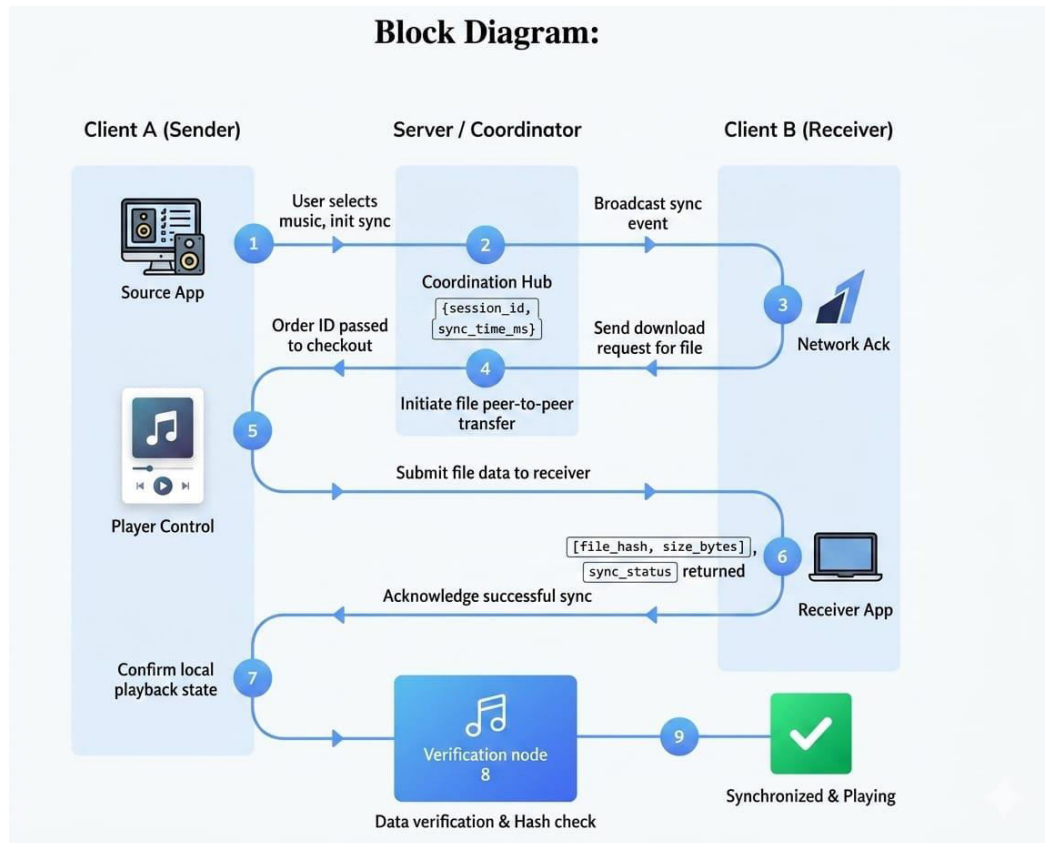
- The development of LAN Sync Music follows a structured methodology involving system design, implementation, and testing of a real-time communication framework. The system is designed as a client-server architecture where a Python Flask server acts as the central controller and multiple browser-based clients connect to it through a local network.
- The server is responsible for managing playback state, handling client connections, and broadcasting real-time events using the Socket.IO protocol. When the server is initiated, it scans a predefined directory for audio files and makes them available to all connected clients. Each client connects to the server through a web browser, eliminating the need for software installation.
- A unique host-listener model is implemented in which one user is assigned the role of the host using a secure key. The host has exclusive control over playback operations such as play, pause, seek, and song selection. These actions are transmitted to the server and then broadcast to all connected clients, ensuring synchronized playback.



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- To address the issue of audio drift caused by device clock differences, a background synchronization thread is implemented on the server side. This thread periodically calculates the current playback position and broadcasts synchronization updates to all clients. Each client compares its local playback time with the server’s reference time and adjusts accordingly if the drift exceeds a predefined threshold.300ms



III. MODELING AND ANALYSIS

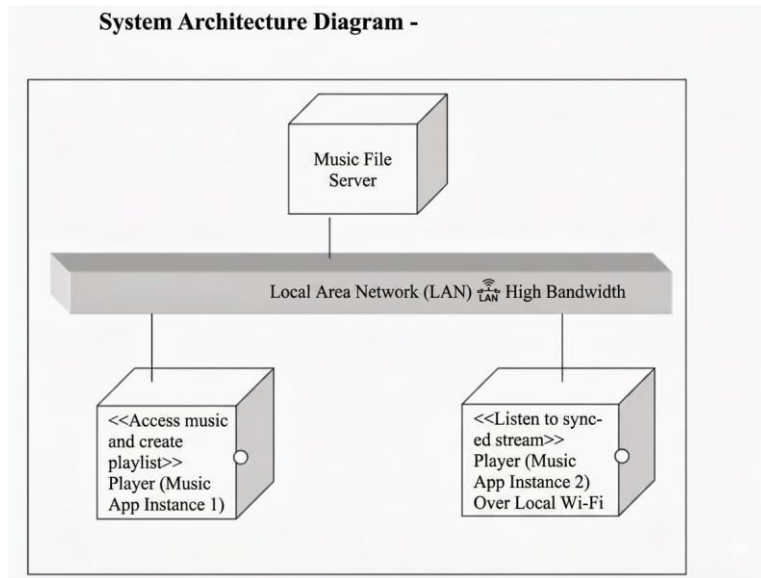
The LAN Sync Music system is modeled as a distributed real-time system consisting of a central server and multiple client nodes. The server maintains the global playback state, including the current song, playback position, and status. This state is stored in memory and protected using thread-safe mechanisms to ensure consistency during concurrent access. Communication between the server and clients is event-driven, where actions such as play, pause, and seek are transmitted as events using WebSockets. This approach enables low-latency communication and ensures that all clients receive updates simultaneously.

The system is analyzed based on synchronization accuracy, response time, and scalability. The synchronization mechanism maintains playback alignment within 300 milliseconds, which is acceptable for human perception. The use of WebSockets ensures minimal communication delay, while the background synchronization process continuously corrects any drift. The system also demonstrates scalability by supporting multiple clients simultaneously without significant performance degradation, making it suitable for real-world applications.



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IV. RESULTS AND DISCUSSION

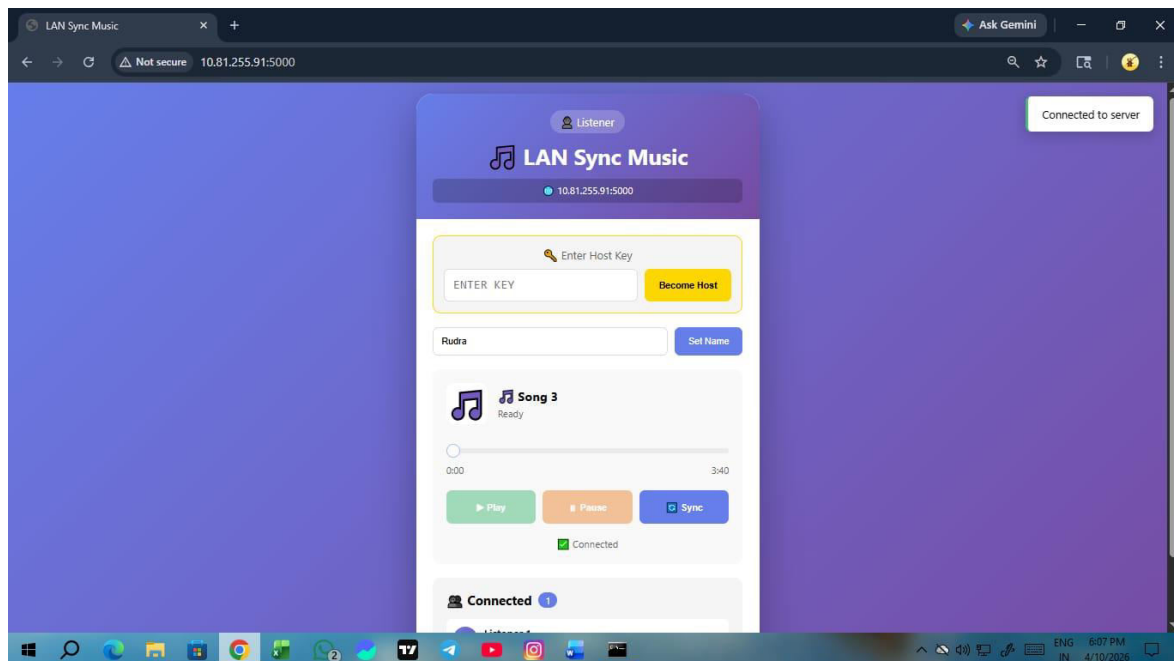


Figure 1 shows the host interface of the system. In this mode, the user is authenticated as the host and is provided with playback controls such as play, pause, seek, and song selection. The host can control the entire session and broadcast commands to all connected devices.



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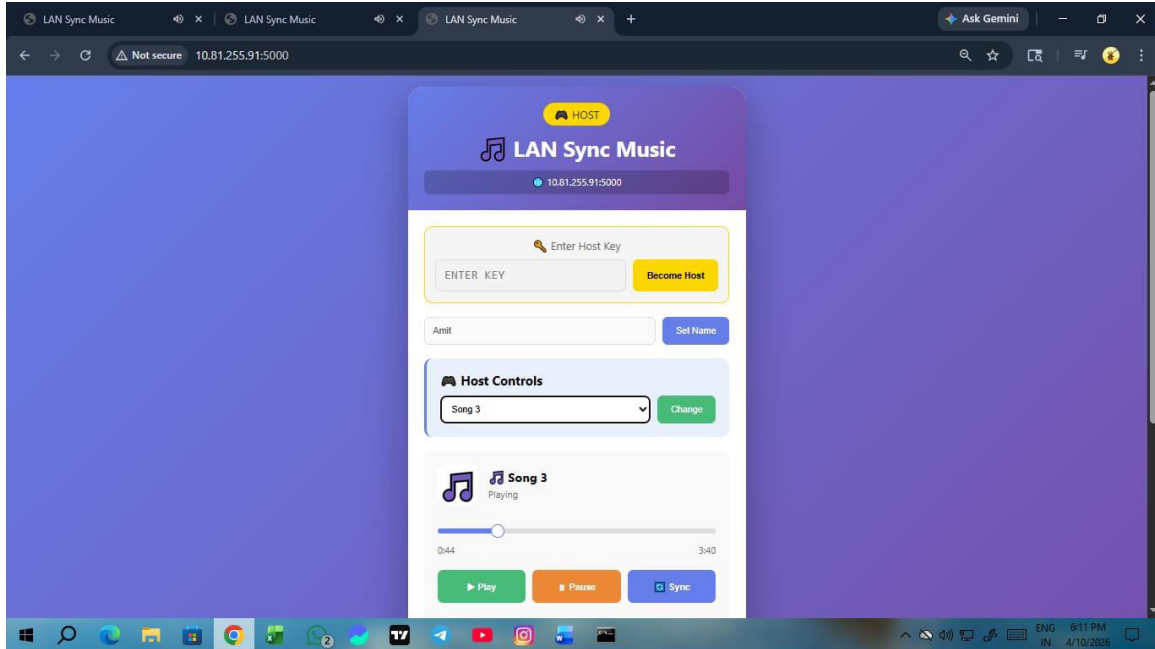


Figure 2 illustrates the song selection and playback interface. The host selects a song and initiates playback, which is instantly reflected on all connected devices. The system ensures that playback begins simultaneously across devices.

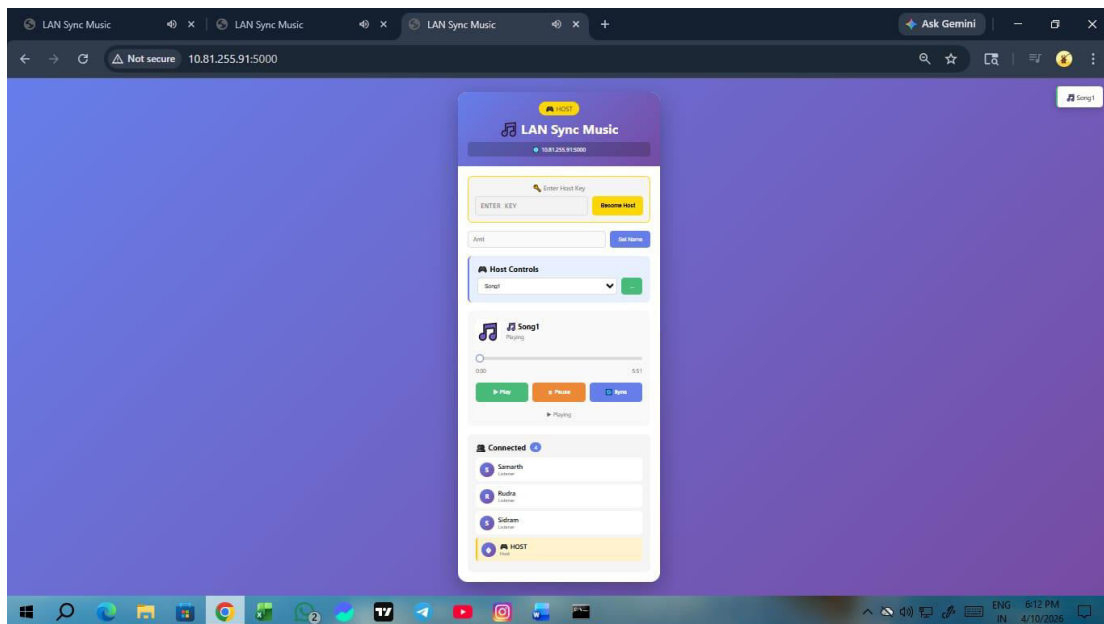


Figure 3 represents the listener interface. In this mode, users receive synchronized playback without control privileges. The interface displays playback status, connection status, and synchronization controls.

V. CONCLUSION

LAN Sync Music is a real-time audio synchronization system designed to enable simultaneous playback across multiple devices on a local area network. The system successfully eliminates the need for internet connectivity and expensive hardware while providing accurate synchronization and ease of use.



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The implementation demonstrates the effectiveness of WebSocket-based communication and background synchronization mechanisms in achieving real-time coordination. The system is scalable, cross-platform, and easy to deploy, making it suitable for various applications. Future work may include enhancements such as playlist management, authentication systems, and cloud integration to extend functionality beyond local networks.

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