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P2P Web based File Sharing App

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ABSTRACT: The rise of web-based mobile applications has prompted a shift towards decentralized architectures, where peer-to-peer (P2P) technologies play a significant role. P2P networks empower devices to communicate directly, reducing reliance on centralized servers and enabling a more resilient, scalable, and user-driven architecture. This paper presents a P2P web-based mobile application built using React, TypeScript, and PeerJS, showcasing how modern web technologies can be leveraged to build efficient, real-time communication systems that operate seamlessly across mobile browsers.

We explore the application's architecture, the benefits of adopting a P2P model, and the challenges associated with implementing P2P communication in a mobile web environment. Direct connections between mobile devices facilitate lower-latency interactions, enhance privacy, and reduce server costs, making them ideal for applications like video calls, messaging, and collaborative tools. However, implementing P2P communication in mobile browsers is technically demanding due to device constraints, network variability, and the need for robust, cross-platform compatibility.

This study provides a practical guide for developers seeking to leverage P2P technology to enhance efficiency, scalability, and user experience in mobile web applications. Through detailed design patterns, performance optimizations, and real-world testing insights, we demonstrate how PeerJS simplifies WebRTC-based P2P communication and examine best practices for managing connection stability, data synchronization, and security within a decentralized framework. This paper not only highlights the potential of P2P technology in mobile web apps but also offers insights into overcoming limitations, ensuring that developers can make informed design decisions for future P2P-enabled applications.

KEYWORDS:

1. Peer-to-Peer (P2P) technology
2. Decentralized architecture
3. Mobile web applications
4. Real-time communication

I. INTRODUCTION

In recent years, the rapid advancement of web technologies has paved the way for innovative approaches to communication and resource sharing. Peer-to-peer (P2P) technology has emerged as a transformative solution, enabling devices to communicate directly without relying on centralized servers. This decentralized approach reduces server dependency, lowers latency, and improves scalability, making it particularly suitable for real-time applications such as file sharing, video calls, and collaborative tools.

With the growing adoption of mobile devices and continuous improvements in web frameworks, the potential for P2P solutions in mobile environments has significantly expanded. For instance, consider a group of students who want to quickly share files, such as project documents or multimedia resources, during a group study session. A P2P-based system would allow them to connect directly, bypassing the need to log in with email accounts or rely on third-party cloud storage services, ensuring faster transfers and greater privacy. However, integrating P2P technology into mobile web applications poses challenges, including limited device resources, varying network stability, and ensuring compatibility across platforms. Addressing these issues is essential to unlock the full potential of decentralized systems in mobile contexts.

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This paper focuses on the design and development of a P2P web-based mobile application using modern tools such as React, TypeScript, and PeerJS. By leveraging WebRTC technology, the application establishes direct, secure connections between devices, eliminating the need for centralized servers or user authentication through personal accounts. The study explores the application's architecture, implementation strategies, and performance benchmarks, providing practical insights for developers and researchers interested in decentralized communication systems.

Ultimately, this work bridges the gap between theoretical possibilities and real-world applications of P2P technology. It highlights how such systems can offer scalable, user-friendly, and cost-effective solutions for real-time communication in mobile web environments, catering to scenarios like file sharing among students or professionals without compromising on speed or privacy. Through this exploration, we aim to contribute to the ongoing development and innovation in decentralized architectures.

II. LITERATURE SURVEY

Literature Survey on Peer-to-Peer File Sharing Apps
Peer-to-peer (P2P) file sharing has emerged as a popular method for distributing digital content, offering decentralized and efficient file transfer mechanisms. Several research papers have explored the design, implementation, and security implications of P2P file sharing systems.

P2P File Sharing Web App (2023) delves into the development of a web-based P2P file sharing system. The system utilizes WebRTC for direct peer-to-peer communication, eliminating the need for centralized servers.
Peer-to-peer (P2P) file sharing system: a tool for Distance Education (2019) explores the application of P2P technology in distance education. The proposed system employs BitTorrent protocol for efficient file distribution and IPFS for decentralized storage.

A Comparative Study and Analysis on File Sharing Applications (2023) provides a comparative analysis of various file sharing applications, including P2P systems. The paper evaluates the performance, security, and user experience of different applications, including those using BitTorrent, WeTransfer, and Google Drive.

Peer-to-Peer File Sharing WebApp Enhancing Data Security and Privacy through Peer-to-Peer File Transfer in a Web Application addresses the critical issue of security and privacy in P2P file sharing. The proposed system utilizes end-to-end encryption and secure communication protocols to protect data confidentiality and integrity.
Proposed System.

Our proposed system leverages modern technologies like React, TypeScript, and PeerJS to create a robust and user-friendly P2P file sharing web application. The system utilizes WebRTC for direct peer-to-peer communication, ensuring efficient and secure file transfer. By adopting a decentralized approach, the system reduces reliance on centralized servers, enhancing privacy and scalability.

While existing P2P systems have made significant strides, our proposed system aims to further improve the user experience and security by incorporating features like:

- Real-time file sharing: Enabling users to share files instantly without delays.
- Cross-platform compatibility: Ensuring seamless operation across various devices and operating systems.
- Enhanced security: Implementing robust encryption and authentication mechanisms to protect user data.
- User-friendly interface: Designing an intuitive and visually appealing user interface.
- By building upon the foundation laid by previous research and leveraging the power of modern web technologies, our proposed system seeks to provide a superior P2P file sharing experience.

III. SYSTEM MODEL

The proposed system is a web-based application designed for real-time file sharing using peer-to-peer (P2P) communication. It is built with React, TypeScript, and PeerJS, enabling users to share files directly between devices

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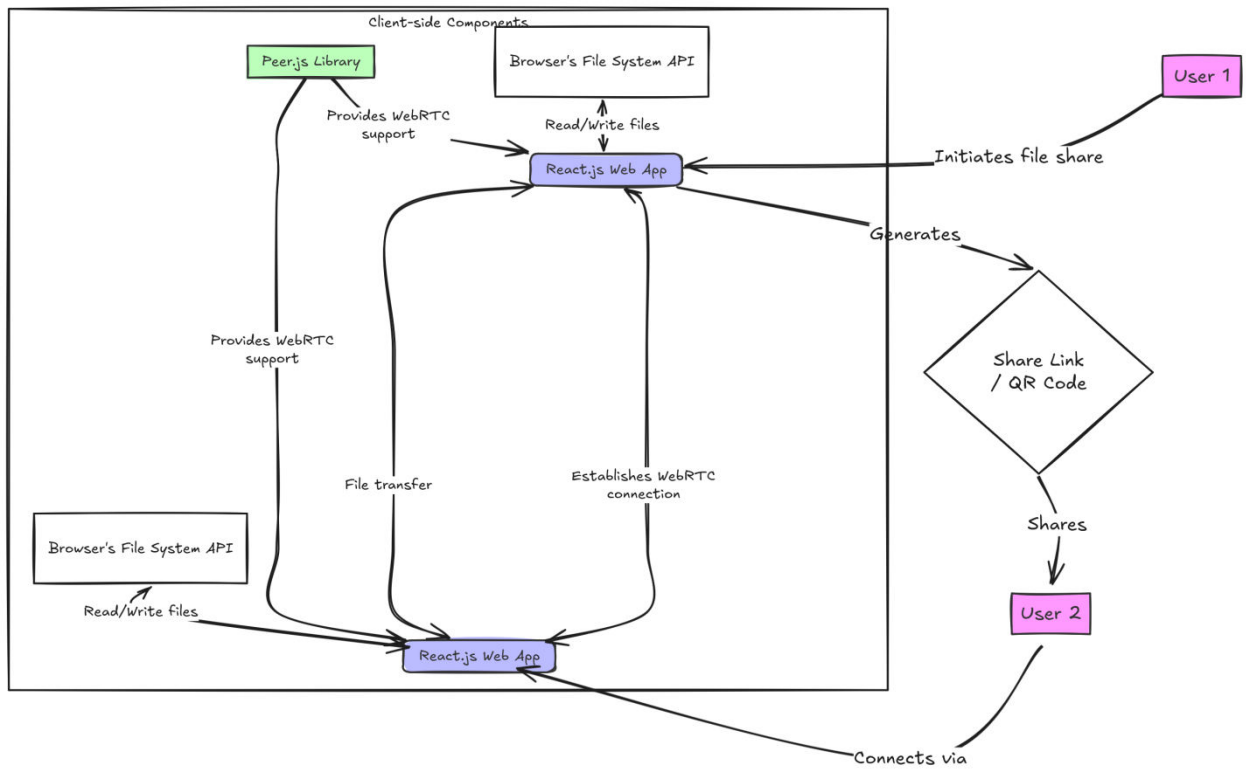
without relying on centralized servers. The front end is developed using React, which provides a responsive and user-friendly interface, while the Context API ensures smooth management of app-wide data. The application is optimized for mobile devices, ensuring compatibility and ease of use across different platforms. The back end includes a signaling server that helps establish connections between peers by assigning unique IDs and facilitating the initial setup.

Once connected, users can share files directly through WebRTC, which ensures fast and secure communication between devices. PeerJS simplifies the process by handling complex WebRTC tasks like managing connections and recovering from errors. Each user keeps their own copy of shared files, and any updates are synchronized across all connected devices. The system uses encryption to protect data during transfer, ensuring security and privacy.

This approach reduces dependency on central servers, making the system faster and more private. While challenges like mobile device limitations and connection stability exist, the system handles these with features like error recovery and efficient resource usage. In the future, adding a mix of P2P and client-server features could further improve reliability and scalability. Overall, this system provides an efficient, secure, and easy-to-use solution for file sharing on the web.



IV. METHODOLOGY

The development of the Peer-to-Peer (P2P) web-based file-sharing application involves a structured approach to design, implement, and evaluate a decentralized system capable of direct device-to-device communication. The methodology focuses on leveraging modern web technologies and protocols to achieve secure, real-time file sharing without relying on centralized servers.

System Design and Architecture

The application is built using a modular architecture, ensuring scalability and maintainability. The front-end interface, developed using React and TypeScript, incorporates responsive design principles to optimize usability across mobile and desktop platforms. State management is implemented using the Context API, enabling seamless data sharing

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between components. The back end comprises a lightweight signaling server responsible for establishing initial connections between peers by assigning unique identifiers and facilitating connection setup.

Peer-to-Peer Communication

The core functionality of the application is enabled by WebRTC, a protocol designed for real-time communication. WebRTC facilitates direct data transfer between devices using secure Datagram Transport Layer Security (DTLS) encryption. To simplify the complexities of WebRTC implementation, PeerJS is integrated into the system. PeerJS provides an abstraction layer, handling tasks such as peer discovery, connection establishment, and error management. This ensures a stable and efficient communication channel between users.

Application Workflow

The workflow begins with a user connecting to the application, where a unique peer ID is generated by the signaling server. Once paired, peers establish direct connections through WebRTC data channels, enabling real-time file transfers. File data is transmitted securely and efficiently without intermediate servers. The decentralized nature of the system ensures that each peer maintains its own copy of the shared files, with updates broadcast to all connected peers.

Technology Stack

1. **Frontend Development**:
    a. **React**: For creating dynamic, reusable user interface components.
    b. **TypeScript**: To enhance code quality with static typing and reduce runtime errors.
    c. **Responsive Design**: Ensures compatibility across a wide range of devices.
2. **Communication Framework**:
    a. **WebRTC**: Provides the foundation for real-time P2P communication.
    b. **PeerJS**: Simplifies the integration and management of WebRTC connections.
3. **Signaling Server**:
    a. Facilitates the discovery and pairing of peers, ensuring efficient connection setup.

V. IMPLEMENTATION

The implementation of the Peer-to-Peer (P2P) web-based file-sharing application followed the approach outlined in the methodology and system model sections. The primary goal was to translate the design into a functional system that enables real-time, decentralized file sharing between peers without relying on centralized servers.

Core Functionalities

The application's core functionalities, as detailed in the methodology, were implemented as follows:

1. **Peer Connection Setup**: The process begins when the user accesses the application, which generates a unique peer ID via the signaling server. This unique ID is used for discovering and connecting with other peers. When one user requests a connection, the signaling server pairs them with the intended peer. PeerJS, integrated with WebRTC, facilitates the establishment of a secure peer-to-peer connection. Once connected, a direct communication channel is created, allowing the transfer of files between the peers without passing through any central server.
2. **File Sharing**: After establishing a connection, users can select files to be transferred. The application supports multiple file types, which are directly shared between peers over the WebRTC data channel. This P2P transfer method ensures that data flows directly between devices, enhancing transfer speeds and privacy by bypassing intermediary servers.
3. **Real-Time Communication**: In addition to file sharing, the system supports real-time communication using WebRTC. Once the connection is made, users can seamlessly share data without interruptions, maintaining an efficient and fast communication channel. The WebRTC protocol ensures minimal latency during file transfers, enabling the system to function effectively even in lower-bandwidth conditions.

User Interface and Experience

The user interface was developed with simplicity and usability in mind. The application allows users to easily initiate a connection by sharing their unique peer IDs with others. The interface is responsive, ensuring smooth usability across both mobile and desktop platforms. Once connected, users can view the status of their file transfers, including progress

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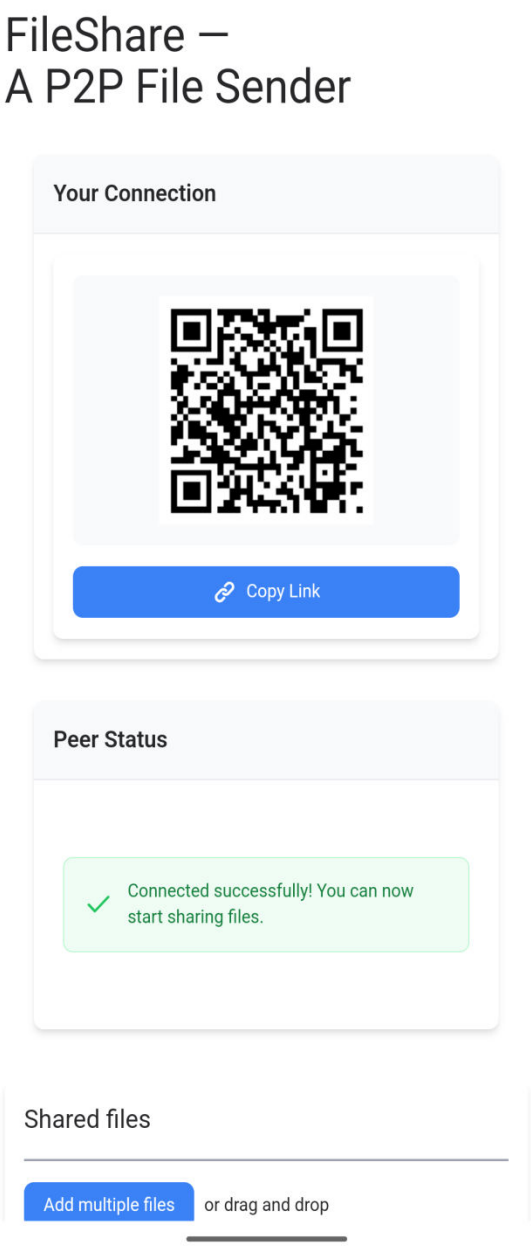
indicators and notifications upon successful completion. The file-sharing process is streamlined to make it intuitive for users to select, send, and receive files in real-time.

Testing and Results

The application underwent extensive testing to ensure stability, security, and usability. Tests were conducted to assess the functionality of file transfers under various conditions, such as low-bandwidth and high-latency networks. In these scenarios, the application performed well, with minimal delays in file transfers. Security was thoroughly tested to ensure that all data transferred between peers was encrypted, maintaining privacy during the entire file-sharing process. Usability testing was also performed, and feedback indicated that the interface was intuitive, with users easily able to connect and share files without requiring any prior technical knowledge. Overall, the system demonstrated reliable performance, meeting the objectives set forth in the design phase.



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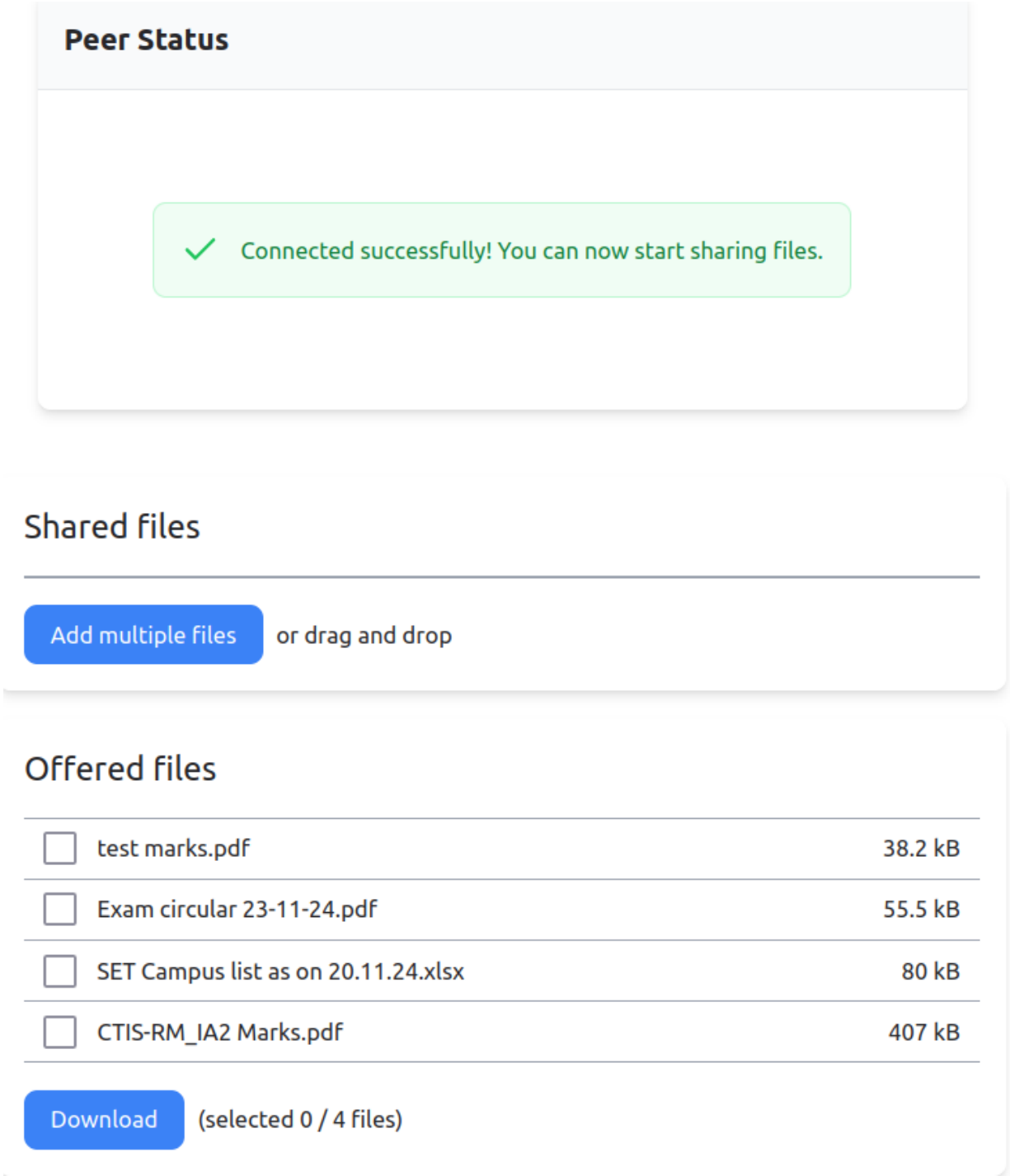

VI. CONCLUSION

In an era where data privacy and real-time communication are more important than ever, the development of the Peer-to-Peer (P2P) web-based file-sharing application stands as a testament to the power of decentralized technology. By enabling direct, serverless file transfers between peers, the system not only ensures faster, more secure exchanges but also empowers users with control over their own data. Through the integration of WebRTC and PeerJS, the application

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successfully bypasses the need for intermediary servers, reducing latency and optimizing the user experience across both mobile and desktop devices.

The journey of building this application was not without its challenges. From overcoming fluctuating network conditions to ensuring compatibility across different browsers and mobile platforms, each hurdle was met with innovative solutions. PeerJS's error-handling capabilities, coupled with performance optimizations for mobile devices, ensured that the application remained stable and efficient even in less-than-ideal conditions. These efforts culminated in an intuitive, easy-to-use interface that allows users to share files with confidence, knowing their data is transferred securely and privately.

This project not only demonstrates the viability of P2P solutions for real-time communication but also sets the stage for future exploration in decentralized systems. It opens the door to endless possibilities, whether for students sharing academic resources without login requirements, professionals exchanging files securely without relying on cloud services, or even larger-scale applications where data privacy and speed are critical. As we look ahead, the lessons learned here will undoubtedly inform future developments, from optimizing cross-platform compatibility to exploring hybrid P2P-server models for even greater scalability.

Ultimately, this work brings us one step closer to a future where the internet is not just a network of centralized servers, but a vibrant ecosystem of interconnected devices that communicate freely and securely, without barriers. Through the continued evolution of decentralized technologies, we can look forward to a more efficient, private, and user-centric digital landscape.

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