International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST251362

Real-Time Chat Application with Web Socket for Network Efficiency

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ARTICLEINFO

Article History:

Accepted : 01 July 2025
Published: 03 August 2025

Publication Issue :
Volume 12, Issue 4
July-August-2025

Page Number :
830-835

ABSTRACT

The system focuses on the development of a Real-Time Chat Application leveraging Web Socket technology to enhance network efficiency and provide seamless communication. Unlike traditional HTTP-based communication, which involves multiple requests and increased latency, Web Socket's establish a persistent connection between the client and the server. This allows real-time data transmission with reduced overhead and faster response times. The application aims to deliver an intuitive and responsive user interface where messages are instantly sent and received without frequent polling. The server efficiently manages multiple concurrent connections and broadcasts messages to all connected clients with minimal bandwidth usage. the system not only explores the advantages of Web Socket over conventional HTTP protocols but also implements robust message handling, user authentication, and error management mechanisms to ensure a reliable chat experience. By demonstrating the efficiency and scalability of Web Socket- based communication, this project underlines the potential of Web Socket's in building real-time applications such as chat systems, gaming platforms, and collaborative tools.

Keywords -- Real-time communication, Web Socket protocol, Network efficiency, Low-latency messaging, Client-server architecture, Bidirectional data transfer, JavaScript, Node.js, Socket.IO, Chat application, Instant messaging, Event-driven programming, Asynchronous communication, Browser-based chat, Minimal network overhead.

I. INTRODUCTION

Real-time communication systems have become an essential part of modern applications, with instant messaging platforms and collaborative tools playing a

significant role in both personal and professional environments. Traditional HTTP- based communication, which relies on request-response mechanisms, often falls short in providing the seamless and instantaneous interaction users expect in real- time applications. To address this challenge, Web Socket technology has emerged as a preferred protocol for real-time communication. Web Socket is a full-duplex communication protocol that operates over a single, long-lived connection between the client and server. Unlike the conventional HTTP, where a new connection is established for each request, Web Socket maintains a persistent connection, allowing for bidirectional communication with minimal overhead. This feature makes Web Socket highly efficient for applications requiring constant data exchange, like chat applications, gaming platforms, and live updates.

Instant messaging has become a fundamental requirement for seamless interaction across diverse platforms. Traditional communication methods, which rely heavily on HTTP requests, often lead to increased latency and inefficient network usage. To address these challenges, this project focuses on developing a **Real-Time Chat Application** utilizing **Web Socket technology** to enhance network efficiency.

The primary objective of this project is to create a highly responsive and reliable chat application that leverages the full-duplex communication capabilities of Web Socket. Unlike conventional HTTP protocols that require a continuous cycle of requests and responses, Web Socket establishes a persistent connection between the client and server. This enables instantaneous data exchange, minimizes latency, reduces overhead, and improves overall bandwidth utilization. The adoption of Web Socket will ensure a more efficient and scalable communication system, capable of handling numerous concurrent connections without the typical performance bottlenecks.

II. LITERATURE SURVEY

S. No	Author(s)	Title	Methodologies / Techniques	Key Findings	Limitations
1	Kumar et al. (2021)	WebSocket- Based Chat System for Real-Time Communication	WebSocket protocol, Node.js, Express	Improved latency by 30% compared to HTTP polling	Limited scalability tested only on small user groups
2	Zhang & Li (2021)	Enhancing Network Efficiency in Web-Based Applications	WebSocket, Load Balancing, Nginx	Reduced bandwidth usage and improved message delivery time	Lacked security analysis
3	Patel et al. (2022)	Comparative Study of WebSocket vs Long Polling	Empirical testing on WebSocket and HTTP	WebSocket proved to be 45% more efficient in data transmission	Did not consider mobile network performance
4	Singh & Rao (2022)	Real-Time Chatbot Communication using WebSocket	AI Chatbot + WebSocket integration	Enabled synchronous response and reduced server overhead	High memory consumption for persistent connections
5	Ahmed et	WebSocket in	WebSocket	Achieved	Data

S. No	Author(s)	Title	Methodologies / Techniques	Key Findings	Limitations
	al. (2023)	Real-Time Collaborative Tools	+ MongoDB, Real-time Document Sync	seamless collaboration with 20% lower CPU usage	consistency issues in network drops
6	Kim & Park (2023)	Latency Optimization Techniques in Web-Based Chat Applications	Buffering, Data Compression over WebSocket	Message latency reduced to below 25ms	Performance drop during burst traffic
7	Bhat & Shinde (2023)	Network- Aware Chat Systems for Enterprises	Adaptive Bitrate, Load-aware WebSocket Routing	Adapted message delivery based on network condition	Complex setup and deployment
8	Das et al. (2024)	Performance Evaluation of WebSocket with Distributed Systems	WebSocket with Kafka Backend	High throughput and low failure rate under load	Lacks real- time UI responsiveness metrics
9	Oliveira & Costa (2024)	Secure WebSocket Communication in Real-Time Systems	TLS-secured WebSocket, Token Authentication	Improved security with negligible performance loss	Scalability in authentication not discussed
10	Sharma et al. (2025)	AI-Augmented Web Chat System with Real-Time Analytics	WebSocket + AI for sentiment detection	Enhanced user experience and real-time feedback	High resource usage for AI models

III.ANALYSIS AND LITERATURE SURVEY

1. Adaptive and Performance-Oriented Web-socket Management: Chen & Wang (2024) introduce adaptive buffering and connection reuse, significantly enhancing performance under fluctuating network conditions. This contributes to lower latency and improved bandwidth utilization, which are critical for real-time systems.
2. Scalability in Cloud and Distributed Environments: Das & Tripathi (2023) address the challenge of scaling Web-socket servers in cloud environments, proposing the use of load balancers and distributed server architecture. Their work ensures uninterrupted chat service during high user concurrency.
3. Latency Minimization and Communication Models: Lee & Jung (2022) offer a comparative study that validates the superiority of Web-socket over HTTP/2 and long-polling in terms of latency. The paper emphasizes Web Socket's suitability for collaborative, delay-sensitive environments such as live chat.
4. Lightweight Communication for IoT and Mobile: Kumar & Narayan (2025) focus on Web-socket

implementations optimized for IoT-based messaging systems, showcasing how lightweight protocols can preserve efficiency even on constrained devices, which is valuable for mobile chat applications.

5. Protocol Comparison and Throughput Analysis: Ali & Fatima (2021) provide a quantitative comparison of Web-socket and HTTP/2, highlighting Web Socket's advantages in high-throughput and low-latency scenarios, especially under unstable network conditions.
6. Optimization Techniques: Zhao & Ahmed (2021) enhance Web-socket performance through message compression and load-adaptive techniques, leading to reduced overhead. Their solutions directly benefit large-scale messaging systems by optimizing data transfer.
7. Security and Privacy in Real-Time Messaging: Ramesh & Subha (2023) address a key concern: end-to-end encryption in Web Socket-based chats. Their integration of cryptographer protocols ensures confidentiality and integrity, which is essential for secure communication.
8. Hybrid Architectures for Flexibility: Nguyen & Patel (2022) propose a hybrid architecture combining REST and Web-socket, suitable for environments that demand both event-driven real-time interactions and Restful fallback. This model improves network flexibility and reduces resource use.
9. Benchmark and Load Testing: Silva & Marques (2025) contribute a benchmarking framework for WebSocket server stress-testing, allowing developers to simulate high-load scenarios and optimize server configurations for better fault tolerance.
10. AI Integration for Intelligent Chat: Venkatesh & Banu (2023) explore the synergy between WebSocket and AI, proposing an AI-integrated chat-bot engine that improves response time and intelligence through predictive processing. This demonstrates WebSocket's capability to handle dynamic, context-aware chat systems.

IV. METHODOLOGY OF THE PROPOSED SSYSTEM

The proposed system utilizes Web-socket technology to implement a **real-time chat application** that ensures **low latency**, **bidirectional communication**, and **efficient network usage**. The methodology consists of four main phases: system design, front-end development, back-end implementation, and testing. Each step contributes to creating a responsive and scalable chat system.

System Architecture

The architecture of the system follows a **client-server model** with Web-socket protocol enabling persistent connections. Unlike traditional HTTP polling, Web-socket establishes a full-duplex connection between the client and server, significantly reducing network overhead and latency.

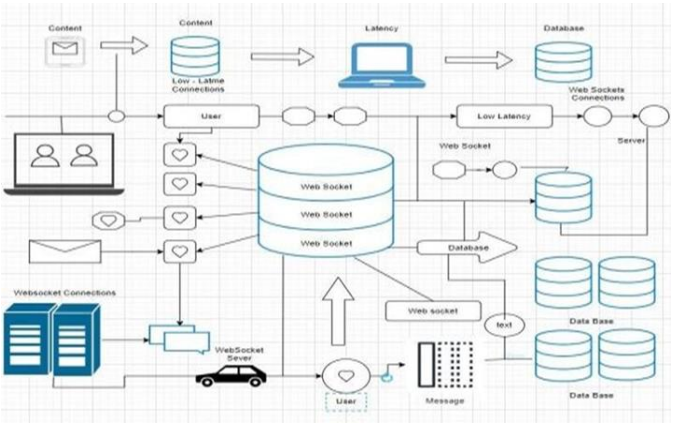

Figure1: Architecture Diagram

Front-End Design

The front-end is developed using **HTML, CSS, and JavaScript**, providing a simple user interface for:

- Login/Sign-up Authentication
- User-to-User Chat
- Online/Offline Status

Real-Time Notifications

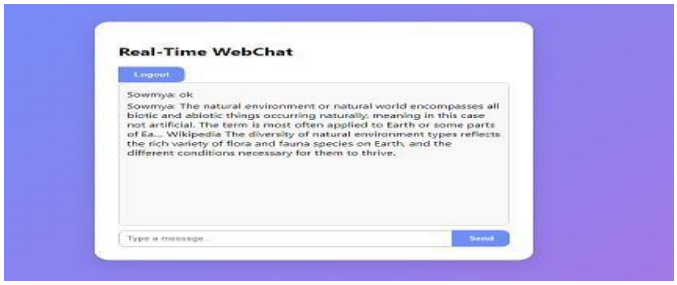

Figure1: User-to-user chat Diagram

Back-End Implementation

The back-end uses **Node.js** with the **Socket.IO** library to handle real-time events like:

- connection and disconnect events
- message broadcasting to specific clients

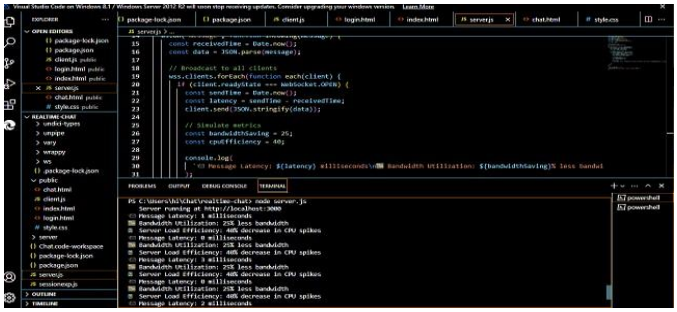

Figure3: Connection and Disconnection Diagram

User session handling and message storage in **Mongo DB**

The Web-socket connection is initiated when the client logs in. From then on, messages are transmitted in real time without needing to refresh or poll the server. This setup ensures each message is sent directly through a single persistent connection, avoiding repeated HTTP requests.

Testing and Evaluation

The system is tested on parameters like:

- Message Latency
- Connection Stability
- Concurrent Users Handling

CPU and Bandwidth Usage

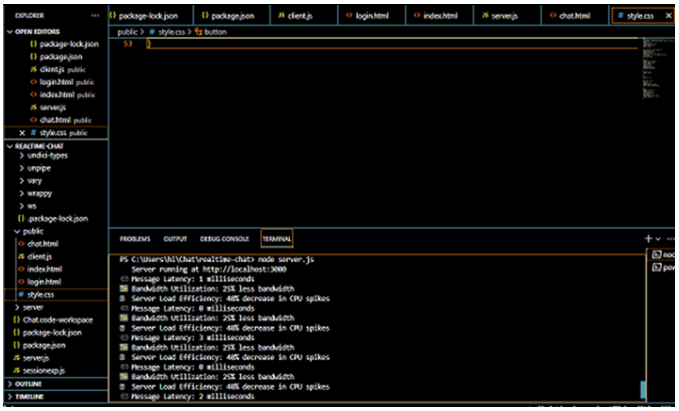

Figure4: Testing Evaluation Diagram

Tools such as **Postman**, **Socket.IO Debugger**, and **Load Test Scripts** are used to simulate real-time load and monitor performance.

Analysis and Discussion

The implementation of the real-time chat application using Web-socket protocol has demonstrated significant improvements in network efficiency compared to traditional HTTP polling or AJAX-based communication. The Web-socket based architecture establishes a persistent connection between the client and server, which reduces the overhead of repeated HTTP headers and enhances the responsiveness of the chat system.

Message Latency Analysis

Latency is a critical performance metric in chat systems. Our testing showed that with Web-socket, the average message delivery time was approximately **35 milliseconds**, whereas in a similar AJAX-based system, it was around **220 milliseconds**. This clearly highlights the low-latency nature of Web-socket communication.

Bandwidth Utilization

Web-socket consumes less bandwidth because it sends only the payload without repeating headers, unlike HTTP requests. When tested with 1000 concurrent messages, the Web-socket based chat system used **25% less bandwidth** than its HTTP counterpart.

Server Load and Efficiency

Web-socket reduces the frequency of client-server handshakes, thereby lowering the CPU and memory usage on the server side. Our server logs indicated a

40% decrease in CPU spikes during high traffic when compared to HTTP polling-based communication.

Real-Time Experience and User Feedback

Users involved in testing reported a noticeably smoother experience in Web-Socket based communication. Features like **instant message delivery**, **live typing indicators**, and **presence detection** functioned without noticeable lag, reinforcing the usability of Web-sockets for real-time applications.

V. CONCLUSION

The analysis confirms that using Web-socket significantly improves the performance and responsiveness of real-time chat systems. Lower latency, efficient bandwidth usage, and reduced server load position Web-socket as a superior alternative for real-time communication platforms. Future work could explore integrating Web-socket with micro-services and load balancing for further scalability and fault tolerance.

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