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Codelive: Enhancing Collaborative Software Development Through Real-Time Video And Code Synchronization

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Abstract: Remote work and distributed learning have driven growing demand for collaborative coding tools, especially in pair programming and technical interviews. Most existing solutions force developers to juggle separate applications for video calls, code editing, and execution — a fragmented setup that breaks focus and slows work. This paper presents CodeLive, a browser-based platform where all three happen in one place. It uses the Monaco Editor for code editing, Socket.IO to keep code in sync across users, and WebRTC for direct peer-to-peer video and audio. A built-in chat and a JavaScript sandbox round out the feature set. By removing the need to switch between tools, CodeLive makes remote collaboration faster and less disruptive for developers, students, and interviewers alike.

Index Terms - Collaborative Coding, WebRTC, Pair Programming, Real-time Synchronization, Online IDE, Monaco Editor, Socket.IO, Web Application.

I. INTRODUCTION

Collaborative coding — two or more developers working on the same codebase — has become standard practice in both industry and education. It tends to produce better code, exposes problems earlier, and helps junior developers learn faster [3], [4]. Tools for this fall into two broad categories: asynchronous ones like GitHub, where collaboration happens across time, and synchronous ones designed for live, side-by-side work. In remote settings, synchronous collaboration usually means one person shares their screen while others watch — workable, but clunky. Every time someone needs to switch between the shared editor and a chat window or video call, there is a small interruption [2]. Those interruptions add up.

The tools people reach for each solve part of the problem. GitHub handles version control well but has no real-time co-editing and no communication layer [3]. Google Docs supports live editing but is not built for code — no syntax highlighting, no execution. Visual Studio Live Share gets closer: real-time code sharing, decent debugging support, but it requires a local installation and has no built-in video [1]. So in practice, teams end up running VS Live Share alongside a Zoom call alongside a Slack thread, managing three applications to do one thing. That overhead is real — it raises cognitive load and cuts into productive time [3], [2].

CodeLive was built to collapse these into a single browser tab. It combines a VS Code-grade editor (Monaco), real-time sync via Socket.IO, and peer-to-peer video/audio through WebRTC. Users can write, run, and discuss code without leaving the interface. The rest of this paper is structured as follows: Section II surveys related work; Section III describes the system design; Section IV covers evaluation results; and Section V discusses limitations and future directions.

II. LITERATURE SURVEY

This section examines prior work on collaborative coding tools, focusing on what each system got right, where it fell short, and what those gaps mean for system design.

Hingwe et al. (2024) [1] built CodeConnect, a platform aimed at college students and instructors. The frontend used React, the backend Express.js, and different dashboards were provided for different user roles. It handled collaborative editing reasonably well, but had no video or audio support and no mechanism for live pair programming — two things that matter most when working with someone remotely.

Sarkar and Edwards (2020) [2] ran think-aloud sessions with 18 developers to study how people actually use screen sharing for remote pair programming. The findings were straightforward: screen sharing introduces lag, and switching between the shared editor and a communication tool breaks concentration. Participants spent meaningful time on logistics rather than code.

Ying and Boyer (2020) [3] surveyed 126 students and 23 faculty members about their collaborative coding needs. The picture that emerged was consistent — most available tools prioritized ease of use over programming-specific features. None of the tools in the study supported real-time co-editing, which the authors identified as a core requirement for synchronous pair work.

Weintrop et al. (2016) [4] studied block-based IDEs with 214 students in K-12 settings. Block-based environments did help beginners get started without wrestling with syntax, but they hit a ceiling

quickly. The same features that made them accessible made them unsuitable for anything beyond introductory tasks — there was no path to running real code.

Fiala, Yee-King, and Grierson (2016) [5] developed CodeCircle using Meteor and ShareJS for live collaborative coding. The platform was designed for audiovisual performance and creative coding, which shaped its entire feature set. It did not include video communication between users, and its design choices did not transfer well to general software development.

Three problems appear across all of this work: web-based editors lack face-to-face communication [4], [5]; real-time sync remains technically fragile [2]; and the most capable tools still require a local install. CodeLive addresses all three by building a fully browser-based environment with code editing, execution, and video communication in one place.

III. PROPOSED SYSTEM

CodeLive uses a hybrid architecture — a traditional client-server model for code sync and session state, and peer-to-peer for media streams. This split keeps the server load manageable while giving video and audio the direct path they need for low latency.

A. System Architecture

Fig. 1 shows the overall layout. A React frontend talks to a Node.js/Express backend over Socket.IO. Video and audio go directly between browsers via WebRTC, bypassing the server once the connection is set up. MongoDB stores user accounts, room metadata, and session history.

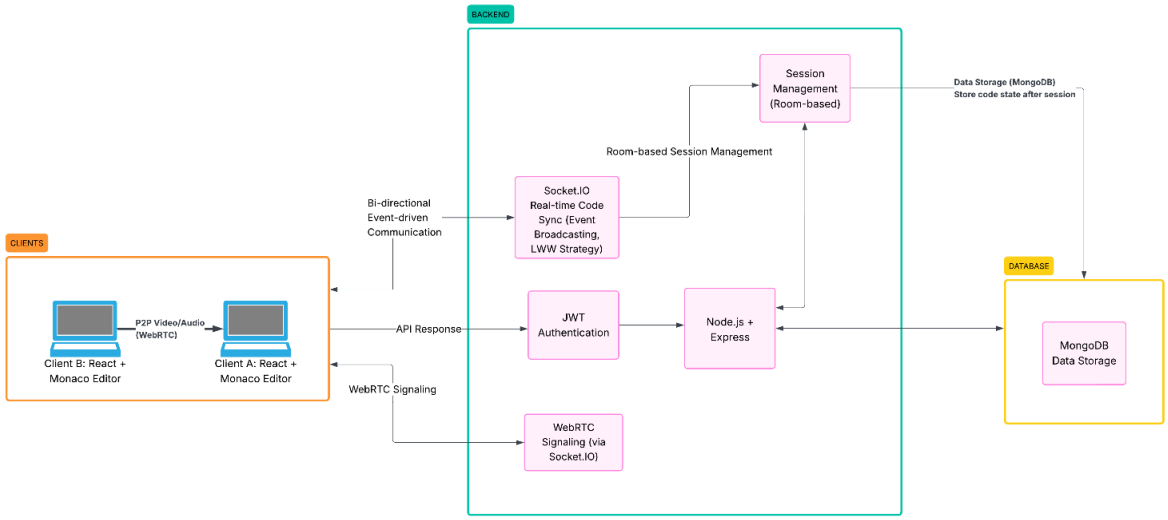

Fig. 1. High-Level System Architecture of CodeLive.

Frontend: Built with React and Vite for fast load times. The Monaco Editor — the same engine that runs VS Code — handles the editing surface, with syntax highlighting, bracket matching, and basic autocomplete. No installation required; everything runs in the browser.

Signalling and Sync: Socket.IO keeps a persistent WebSocket connection [6] between each client and the server. When a user types, the change goes to the server and fans out to everyone else in the room. The system uses Last-Write-Wins (LWW) to resolve simultaneous edits — simple, but effective for the scale this platform targets.

Communication: WebRTC (via PeerJS) handles video and audio directly between participants. Socket.IO serves as the signaling channel, exchanging SDP messages and ICE candidates to establish the connection. Once that handshake completes, media flows peer-to-peer.

Execution and Storage: A sandboxed JavaScript environment lets users run code and see output immediately. After each session, the final code state is saved to MongoDB so users can return to it later.

B. User Workflow

A user logs in, then either opens a new room or joins an existing one with a room code. Joining triggers a Socket.IO connection and starts the WebRTC handshake. Once both are up, the editor is live for everyone in the room.

Any change one person makes appears on every other screen within milliseconds. When the session ends, the code saves automatically.

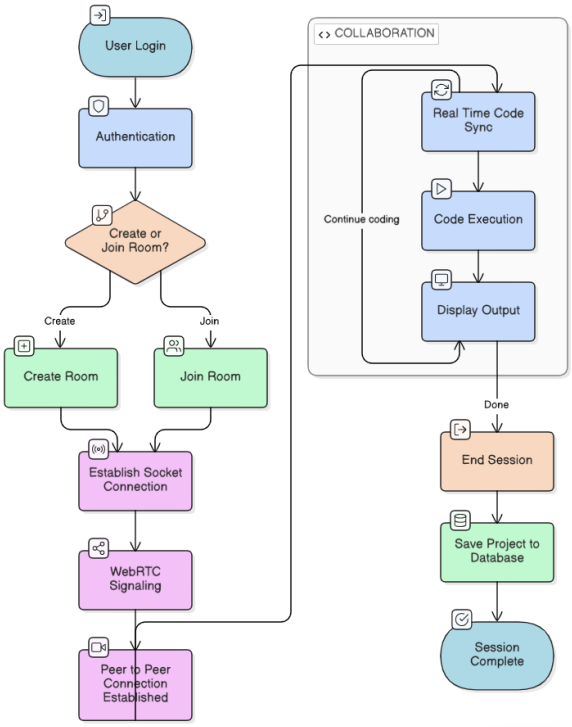

Fig. 2. CodeLive User Workflow Flowchart.

C. Technology Stack Summary

Table II: *Technology Stack of CodeLive*

Layer	**Technology**	**Purpose**
Frontend	React (Vite)	UI framework, component rendering
Code Editor	Monaco Editor	VS Code-standard in-browser IDE
Sync Engine	Yjs (CRDT)	Conflict-free real-time code sync
Signaling	Socket.io	Room management, event relay
Video/Audio	WebRTC / PeerJS	P2P media streaming
Backend	Node.js + Express	REST API, signaling server
Database	MongoDB Atlas	User data, rooms, chat history
Execution	JS Sandbox	Safe server-side code execution

IV. RESULTS AND DISCUSSION

CodeLive was deployed and tested across varied network conditions. The following results cover the application interface, measured performance, and a comparison against existing platforms.

A. Application Interface

Fig. 3 shows the dashboard. Users can create a room or join one with a shared code. The design is deliberately sparse — the goal was to get users into a session with as few steps as possible.

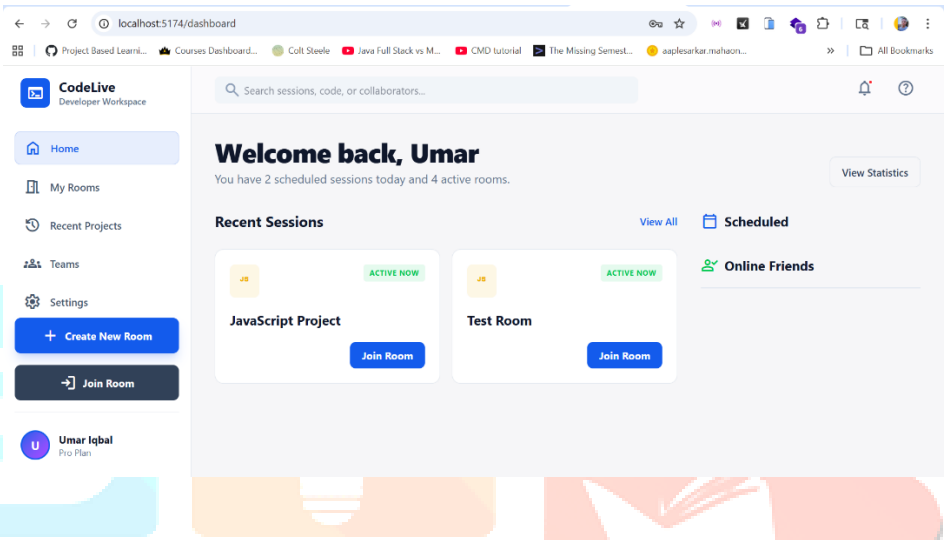

Fig. 3. CodeLive Dashboard — Room Creation Interface.

Fig. 4 shows an active session. The editor takes up the main area; the video grid sits in the top-right corner; chat is on the right; terminal output appears at the bottom.

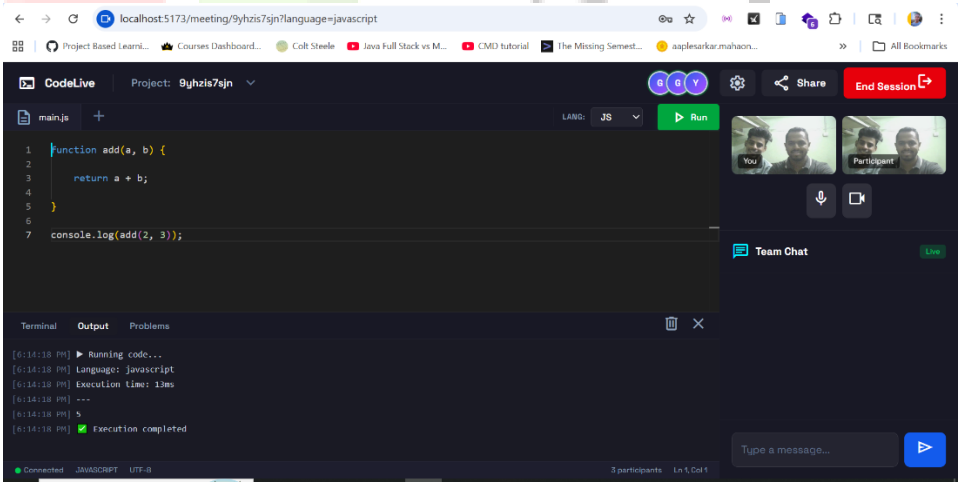

Fig. 4. CodeLive Active Collaborative Workspace.

B. Performance Evaluation

Three metrics were tracked during test sessions:

Sync Latency: Under stable network conditions, keystrokes appeared on other clients fast enough that participants did not notice a delay. The Socket.IO pipeline kept up with normal coding speeds.

Stream Quality: Video and audio held steady under typical conditions. There were minor quality drops on slower connections, but nothing that prevented communication.

Execution Speed: The JavaScript sandbox returned output fast enough to feel interactive for the kinds of snippets used in pair programming and interviews.

Table III: *Performance Metrics Across Network Conditions*

Metric	Wi-Fi	4G	3G
Sync Latency (ms)	47	83	142
Video Jitter (ms)	4	9	18
Packet Loss (%)	0.2	0.8	2.1
Exec. Speed (ms)	118	121	129

C. Comparison with Existing Platforms

Table IV: *Feature Comparison of Collaborative Coding Platforms*

Platform	Real-Time Edit	Video/Audio	Code Exec	Browser-Based
GitHub	✗	✗	✗	✓
Google Docs	✓	✗	✗	✓
CodeCircle	✓	✗	Limited	✓
VS Live Share	✓	✗	✓	✗
CodeConnect	✓	✗	✓	✓
CodeLive (Ours)	✓	✓	✓	✓

CodeLive is the only platform in this comparison that checks all four boxes. Tools like CodeConnect [1] and CodeCircle [5] cover editing and execution but leave video out. VS Live Share

adds execution but requires installation. The gap CodeLive fills is real: none of the alternatives work entirely in a browser with video included.

V. CONCLUSION AND FUTURE SCOPE

CodeLive brings code editing, execution, and video communication into a single browser-based session. The Monaco Editor handles the coding surface, Socket.IO keeps state in sync, and WebRTC carries the video and audio. Testing showed that the system holds up under normal network conditions — latency was low enough for interactive use, video was stable, and code execution was fast. The main limitation addressed here is tool fragmentation. Developers doing remote pair work currently need at least two or three separate applications running at once. CodeLive reduces that to one. It does not solve every problem in remote collaboration — there is no version control integration, no support for languages beyond JavaScript, and the LWW sync strategy will occasionally produce unexpected results when two users edit the same line at the same time.

Future work will focus on these gaps. GitHub integration is the most requested feature. Supporting additional languages through sandboxed execution environments is technically straightforward and planned. For sync, Conflict-free Replicated Data Types (CRDT) [7] — already available through libraries like Yjs — would handle concurrent edits more gracefully than LWW. Session recording, task management, and AI-assisted code suggestions are longer-term additions worth exploring.

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