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Devdock: A Collaborative Git-Integrated Web Development Platform With Real-Time Editing And AI Assistance

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Abstract- — DevDock is a comprehensive, cloud-based collaborative development platform designed to provide developers and students with a unified environment for repository management, real-time code collaboration, AI-assisted coding, and social networking. Inspired by the architecture of GitHub and similar platforms, DevDock introduces a DevDock- first approach where all repositories are created, stored, and managed natively within the platform, with GitHub serving as an optional publishing or backup mirror. The platform integrates Google OAuth 2.0 authentication for seamless login, a graphical repository creation and management system supporting multiple file types including .html, .js, .css, .env, .txt, .mp4, .png and more, a live multi-user collaborative code editor with PIN-secured rooms, an AI-powered coding assistant powered by the GROQ API leveraging open-source large language models, a real-time Instagram-inspired messenger module with friend management, a Git-like version history and rollback system, Markdown README rendering, role- based access control for public and private repositories, and basic repository analytics. This paper presents the complete system architecture, feature design rationale, database schema, security model, testing methodology, and results achieved during the development of DevDock as a final year engineering capstone project.

Keywords: Repository Management, Git Integration, Real-Time Collaboration, Google OAuth 2.0, GROQ AI, Syntax Highlighting, Version Control, Live Code Editor, Markdown Rendering, Social Coding, WebSocket, JWT Authentication, DevDock-First Architecture.

I. INTRODUCTION

The modern software development ecosystem is increasingly collaborative, distributed, and technology- driven. As teams grow larger and more geographically dispersed, the need for platforms that provide version control, real-time collaborative editing, social interaction, and AI assistance under a single roof has never been greater. The rapid evolution of cloud infrastructure, WebSocket technology, and large language models has created an unprecedented opportunity to build developer tools that are simultaneously powerful, intelligent, and accessible.

Existing platforms such as GitHub, GitLab, and Bitbucket have made enormous contributions to open-source culture and professional software development. However, these platforms are primarily designed for experienced developers who are already familiar with Git's command- line interface and distributed version control concepts. For student developers and newcomers to software engineering, the steep learning curve of Git, combined with the absence of native real-time collaboration and AI assistance, creates significant barriers to entry.

DevDock is conceived as a response to these challenges. It is a web-based platform that serves as a centralized hub for developers to create, manage, and collaborate on code repositories through an intuitive graphical interface. Unlike conventional platforms, DevDock eliminates the need for command-line Git knowledge while preserving the core principles of version control — commits, history, rollback, and visibility management. The platform further differentiates itself by embedding real-time multi-user editing, an AI coding assistant, and a social networking layer directly within the core product.

This paper is organized as follows: Section II defines the problem statement. Section III lists the project objectives. Section IV reviews relevant literature. Section V describes the system architecture. Section VI details each feature. Section VII covers the technology stack. Section VIII discusses the database design. Section IX outlines security measures. Section X describes the testing approach. Section XI presents results, and Section XII concludes the paper.

The significance of DevDock extends beyond its technical implementation. In an academic context, it demonstrates how computer science concepts — distributed systems, real-time

networking, database design, security, and machine learning APIs — can be synthesized into a production-grade software product. From a practical standpoint, DevDock lowers the barrier for student developers to engage in collaborative, version-controlled software development without requiring professional-level Git expertise or expensive tooling subscriptions.

DevDock was developed by a team of four final-year B.Tech students over approximately six months using an Agile methodology with two-week sprint cycles, peer code reviews, and iterative user feedback. The platform is fully browser-based, requiring no local installation beyond a modern web browser, making it immediately accessible to students across all operating systems and device configurations.

II. PROBLEM STATEMENT

Despite the widespread availability of version control platforms, several critical gaps persist for student developers and small development teams working in academic and early-career settings:

First, existing platforms such as GitHub and GitLab require users to interact with Git primarily through command-line tools. This creates a significant barrier for students who are learning to code and have not yet mastered terminal-based workflows. While web-based interfaces exist, they are supplementary to — not replacements for — the CLI.

Second, real-time collaborative coding is not natively supported on any major repository platform. Tools like VS Code Live Share or Replit exist for collaboration, but they are completely separate from the repository management ecosystem, forcing developers to switch between multiple tools and contexts.

Third, AI-assisted coding — despite being a transformative productivity tool — is available only through browser extensions (GitHub Copilot, Tabnine) rather than being built directly into the repository platform. This fragmentation reduces accessibility for students who may not have paid subscriptions.

Fourth, the absence of a social layer — friend connections, real-time messaging, notifications — within developer platforms means that community building, peer code review, and informal knowledge sharing must happen on separate communication platforms such as Slack, Discord, or WhatsApp.

DevDock addresses all four of these gaps by providing a unified, browser-based platform that integrates repository management, real-time collaboration, AI assistance, and social networking into a single cohesive product.

III. OBJECTIVES

The primary objectives of the DevDock project are: (i) To design and implement a full-stack web application providing graphical repository creation and management without requiring Git CLI knowledge; (ii) To integrate Google OAuth 2.0 and GitHub OAuth for secure, frictionless user authentication; (iii) To develop a live, multi-user collaborative code editor with PIN-secured room-based access control; (iv) To embed an AI coding assistant powered by the GROQ API using open-source large language models; (v) To build a real-time messenger module with friend management and notification delivery; (vi) To implement a Git-like version history and rollback system tracking commit messages, timestamps, author details, and repository state snapshots; (vii) To provide Markdown README rendering, syntax-highlighted file editing, and repository analytics; (viii) To offer optional GitHub repository mirroring following a DevDock-first architecture; and (ix) To ensure robust security through bcrypt password hashing, JWT session management, server-side access control, and HTTPS communication.

Secondary objectives that guided the design philosophy include: (x) To create a platform that is fully accessible through a standard web browser without requiring any local software installation beyond Node.js for development; (xi) To implement a scalable cloud-based file storage architecture capable of handling diverse file types including source code, media, and binary assets; (xii) To design a notification system that delivers real-time alerts for friend requests, repository collaborations, and system events; and (xiii) To build a theme-aware UI supporting both light and dark mode preferences to reduce visual fatigue during extended development sessions.

The success criteria for the project were defined as: (a) all 19 planned features must be in a fully functional state; (b) the platform must support at least 5 simultaneous users in a live editor session without perceptible degradation; (c) the AI assistant must deliver responses within 500ms for code completion queries; (d) user acceptance testing must achieve an average satisfaction score of 4.0 or above on a 5-point scale; and (e) the codebase must have at least 75% unit test coverage for core business logic modules.

IV. LITERATURE REVIEW

A.Version Control and Repository Platforms

GitHub, launched in 2008, revolutionized software collaboration by building a social layer on top of Git's distributed version control model [1]. Features such as pull requests, issue tracking, and Actions for CI/CD pipelines have set the industry standard for collaborative development. GitLab extended this model with an integrated DevOps platform. However, both platforms remain primarily CLI-oriented and lack native real-time collaboration and AI assistance.

Loeliger and McCullough [2] provide an authoritative treatment of Git's internal model — directed acyclic graphs of commits, tree objects, blob objects, and references — which forms the theoretical foundation for DevDock's version history and rollback implementation. Understanding Git's object model informed the design of DevDock's commit snapshot system.

B.Real-Time Collaborative Editing

The foundational work on real-time collaboration was conducted by Ellis and Gibbs [3] who introduced the Operational Transformation (OT) algorithm. OT enables concurrent text edits from multiple users to be merged consistently regardless of network latency or ordering. Subsequent research on Conflict-Free Replicated Data Types (CRDTs) by Shapiro et al. [4] provided a mathematically sound alternative for distributed consistency. DevDock's Live Editor draws on these principles, implemented via WebSocket-based state synchronization using Socket.io.

C.AI-Assisted Software Development

The release of OpenAI Codex and subsequent models such as Meta's Code Llama and Mistral Codestral demonstrated that transformer-based large language models (LLMs) can generate, complete, and explain code across dozens of programming languages with remarkable accuracy [5]. GitHub Copilot, built on Codex, reportedly improves developer productivity by up to 55% according to GitHub's own studies. DevDock integrates AI assistance using the GROQ API, which provides near-instant inference for open-source LLMs such as Llama-3 and Mixtral, making AI assistance cost-effective for a student-developed platform.

D.Authentication and Security

OAuth 2.0, defined in RFC 6749 by Hardt [6], is the de facto industry standard for delegated authorization. Google's implementation of OAuth 2.0 via its Identity Services API provides a battle-tested, phishing-resistant authentication mechanism. JSON Web Tokens (JWT), defined in RFC 7519 [7], are used for stateless session management. OWASP's Top Ten [8] guidelines for web application security inform DevDock's approach to input validation, access control, and sensitive data exposure prevention.

E.Related Platforms and Tools

Replit is the closest existing platform to DevDock in terms of combining browser-based coding with collaboration features. However, Replit focuses on code execution environments rather than repository management. CodeSandbox and StackBlitz similarly offer collaborative browser-based coding but lack version control, social features, and AI assistance in a single integrated product. DevDock's novelty lies in unifying all these capabilities within a repository-centric platform.

F.WebSocket and Real-Time Communication

WebSocket, standardized in RFC 6455, provides a full- duplex communication channel over a single TCP connection, enabling low-latency bidirectional data exchange between the server and connected clients [9]. Socket.io builds on WebSocket with automatic fallback to long-polling for environments where WebSocket is unavailable, connection state recovery, and built-in support for rooms and namespaces — features that map directly to DevDock's live editor room model and messenger module. Research by Pimentel and Nickerson [10] demonstrated that WebSocket reduces message latency by up to 500% compared to HTTP long-polling for real-time applications, validating its adoption in DevDock's architecture.

G.Markdown and Developer Documentation

Markdown, originally designed by John Gruber in 2004, has become the universal standard for developer documentation. Its adoption by GitHub for README files established a convention that DevDock faithfully follows. Research on developer experience by Dorn and Sonntag [11] found that well-rendered project documentation significantly improves code comprehension and onboarding time for new contributors. DevDock's automatic README detection and Markdown rendering directly addresses this finding by ensuring that every repository with a README.md immediately presents a professional, readable project overview to all visitors.

V. SYSTEM ARCHITECTURE

DevDock follows a modular three-tier client-server architecture. The three tiers comprise: the Presentation Layer (frontend), the Application Layer (backend), and the Data Layer (database and file storage). Each tier communicates through well-defined interfaces — REST APIs for standard CRUD operations and WebSocket channels for real-time events.

A. Presentation Layer (Frontend)
The frontend is built using React.js, providing a component-based, declarative UI architecture. The dashboard, repository workspace, live editor, and messenger are implemented as separate React modules that share a global authentication context. Real-time updates — new messages, commit notifications, friend requests — are received via a persistent Socket.io connection. The Monaco Editor library provides the code editing experience with full syntax highlighting for over 30 programming languages.

B. Application Layer (Backend)
The backend is implemented using Node.js with the Express.js framework. It exposes a RESTful API for all standard operations including user management, repository CRUD, commit creation, rollback, and analytics retrieval. A Socket.io server runs alongside the HTTP server, handling real-time events for the live editor rooms and the messenger module. All business logic — access control, commit diffing, GitHub publish operations — resides in this layer. The backend is stateless; session state is managed through JWTs validated on each request.

C. Data Layer
User profiles, repository metadata, commit records, file references, friend connections, messages, and analytics counters are stored in MongoDB, a document-oriented NoSQL database chosen for its schema flexibility. Actual file content is stored in cloud object storage (AWS S3 or Firebase Storage), with the database storing only metadata and storage URLs. A separate backup collection captures pre-commit states for private repositories to support the automatic backup-and-commit failure recovery mechanism.

D. External Integrations
DevDock integrates four external services: (1) Google OAuth 2.0 API for user authentication; (2) GitHub OAuth API for optional repository mirroring and live editor authentication; (3) GROQ API for AI assistant inference; and (4) cloud object storage for file persistence. All external API credentials are stored as server-side environment variables and are never transmitted to the client.

VI. FEATURE DESCRIPTION

A. Authentication and Account Management
DevDock supports three authentication pathways: (1) traditional email and password registration with bcrypt- hashed credential storage; (2) Google OAuth 2.0 login with single-click access via Google's Identity Services popup; and (3) GitHub OAuth login available within the Live Editor module. Upon successful authentication, a JWT is issued and stored client-side for subsequent API authorization.
Account management is accessible through the profile dropdown in the navigation bar. The Settings panel allows users to: change their username (requiring current password verification); change their password (requiring current password verification); publish or host a repository; and delete their DevDock account. Account deletion requires the user to manually type the confirmation phrase 'I am sure to delete [USERNAME] from DevDock' before submission, preventing accidental or unauthorized deletions.

B. Dashboard Layout and Navigation
The dashboard is organized into a three-panel layout that remains consistent across the platform. The top navigation bar provides access to the Talk to AI button (present on all pages with a navigation bar), the Live Editor button, a notification bell icon displaying real-time alerts for friend requests and repository activities, and a profile dropdown menu with options for Settings, Theme Toggle (light/dark mode), and Logout.
The left sidebar presents the user's personalized repository ecosystem: a Create Repo button at the top, followed by the Created Repositories list (labeled Repo_1, Repo_2, ... Repo_n), a Starred Repositories section for bookmarked public repositories, and a Recently Opened Repos section for quick access. The right sidebar contains the messenger icon (which opens a dedicated messenger tab), and below it, a friend suggestion list enabling users to discover and connect with other developers on the platform.

The central content area features a search box for discovering public repositories uploaded by other users, and below it a dynamically generated feed of suggested, latest, or trending public repositories curated for the logged-in user.

C. Repository Creation and Management
Repository creation is initiated by clicking the Create Repo button. A dedicated page opens — with no sidebar — presenting a graphical input form where the user specifies:
(1) the repository name; (2) an optional description; and (3) visibility setting (Public or Private). Upon submission, the repository workspace opens, displaying the folder structure and file management controls.

The repository workspace supports uploading files and folders, creating new files and folders directly in the browser, and editing existing files with full syntax highlighting for code files. The platform supports a broad range of file extensions including .env, .html, .css, .js, .ts,.py, .java, .cpp, .txt, .md, .json, .xml, .png, .jpg, .mp4, and.mp3. Non-code formats such as .txt

and .docx display content without syntax highlighting, while code files receive language-appropriate highlighting.

All file changes require an explicit commit action. The failure-handling mechanism differentiates by repository type: for Private Repositories, any client-side or server-side failure automatically saves a backup copy and then auto- commits to prevent data loss; for Public Repositories, failures save a draft that the user must review and manually commit, preserving intentional control over the public commit history.

D. Repository Editing and Collaboration

When a user selects an existing repository, a dedicated editing page opens displaying the repository name below the navigation bar and the full folder structure in place of a sidebar. A context-aware menu appears on the right side of the navigation bar providing repository-specific actions. For public repositories, this menu includes options to: make the repository private, invite collaborators by username or email, and add more files or folders. For private repositories, the menu includes options to: make the repository public and add more files or folders.

Collaborators invited to a repository gain access to the same file management and commit capabilities as the owner, enabling asynchronous team-based development. All commits by collaborators are recorded with their author identity, maintaining a complete and attributable audit trail.

E. Live Collaborative Code Editor

The Live Editor is a standalone feature accessible from the navigation bar. It opens in a new browser tab, providing an isolated collaborative coding environment separate from the main repository workspace. Authentication within the Live Editor is independent and supports three methods: username/password, Google OAuth, and GitHub OAuth, allowing developers to collaborate even without a DevDock account.

A user without an existing room clicks Create Room. The system auto-generates a unique alphanumeric room ID and prompts the user to set a 6-digit numeric PIN to secure the room. The room creator and all invited collaborators enter the Room ID and PIN to join. Once inside, all connected users see each other's keystrokes and cursor positions in real time, enabling synchronous pair or group programming sessions. The editor supports syntax highlighting for all major programming languages and does not impose any limit on the number of simultaneous users.

F. AI Coding Assistant (GROQ Integration)

The Talk to AI button appears in the navigation bar of every page that has a navigation bar. Clicking it opens an AI assistant panel as a sidebar or modal, allowing users to ask questions, request code explanations, get debugging help, or receive code generation suggestions without leaving their current page. The assistant maintains context within a session, allowing follow-up questions on previous responses.

Within the repository file editor, an additional inline 'AI Suggestion' button appears, enabling the AI to analyze the current file's content and provide context-aware completions, refactoring suggestions, or bug fixes. The AI assistant is powered by the GROQ API, which uses a hardware-accelerated inference architecture to deliver responses with latency as low as 50–200ms for typical queries — significantly faster than conventional cloud AI endpoints. Open-source LLMs available through GROQ (such as Meta's Llama-3 and Mistral's Mixtral) provide the underlying language intelligence.

G. Messenger and Social Networking

The messenger module is accessed by clicking the chat icon in the right sidebar of the dashboard. It opens in a new browser tab with a UI modeled after Instagram's Direct Messages interface — featuring a conversation list panel on the left and the active chat window on the right, with message bubbles, timestamps, and read receipts. Only text- based one-on-one conversations are supported in the current version; voice and video calling are explicitly excluded from the scope.

The friend suggestion list in the right sidebar displays other DevDock users whom the logged-in user may know, based on shared connections or activity. A user can send a friend request directly from this list. Upon receiving a friend request, the recipient sees a real-time notification pop-up and an updated notification count on the notification bell icon. Accepted connections appear in the messenger's conversation list. An unfriend option is available from within the messenger window. These social features foster a developer community within the platform, enabling informal code sharing and peer support.

H. GitHub Integration (DevDock-First)

DevDock's GitHub integration follows a strictly DevDock- first philosophy: all repositories are authoritative on DevDock, and GitHub is used only as a voluntary publishing or backup destination. Users can optionally connect their GitHub account through GitHub OAuth from the Settings panel. Once connected, they may choose to:

(1) publish a DevDock repository as a new GitHub repository; or (2) push updates from a DevDock repository to an existing linked GitHub repository. Both operations are initiated manually by the user; there is no background synchronization or webhook-based mirroring. This design ensures minimal GitHub API usage, avoids rate limit concerns, and gives users full control over what is published publicly.

I. Version History and Rollback

Every commit operation in DevDock records a structured version entry in the database containing: (1) a unique commit ID; (2) the commit message entered by the user; (3) the commit timestamp; (4) the author's user ID and display name; and (5) a snapshot reference pointing to the complete file and folder structure of the repository at that point in time. This snapshot can be stored as a complete copy or as an incremental delta, depending on repository size, to optimize storage costs.

The commit history page for a repository displays all version entries in reverse chronological order, showing commit messages, authors, and timestamps. Repository owners and collaborators can click any commit entry to view the repository state at that point, and can initiate a Rollback operation that restores all files and folders to the selected commit state. The rollback itself is recorded as a new commit entry with a system-generated message indicating the rollback action and the target commit ID, ensuring full auditability. This feature is restricted to owners and collaborators; public viewers can read the commit history but cannot initiate rollbacks.

J. README Preview and Repository Analytics

If a repository's root directory contains a file named README.md, DevDock automatically detects it on page load and renders a formatted Markdown preview below the repository name and above the file structure listing. The Markdown renderer supports standard elements including headings (H1–H6), bold and italic text, ordered and unordered lists, inline code and fenced code blocks with language-specific syntax highlighting, hyperlinks, blockquotes, horizontal rules, and inline HTML. This gives repositories the same professional first-impression as GitHub projects.

Each repository page includes an analytics panel displaying: (1) total number of commits; (2) total number of files and folders in the repository; (3) last updated date and time; and (4) repository visibility status (Public or Private). These metrics are automatically recalculated and updated after every commit operation. For public repositories, the analytics panel is visible to all visitors. For private repositories, it is visible only to the owner and collaborators.

VII. TECHNOLOGY STACK

Table I presents the complete technology stack used in Dev Dock's development, organized by functional category.

Table I Dev dock Technology Stack

Category	Technology	Purpose
Frontend	React.js, HTML5, CSS3	UI component architecture
Backend	Node.js + Express.js	REST API & business logic
Real-Time	Socket.io / WebSocket	Live editor & messenger
Database	MongoDB (NoSQL)	Data persistence
Auth	Google OAuth 2.0, JWT	Secure authentication
GitHub API	GitHub OAuth v2	Repository mirroring
AI / LLM	GROQ API + Llama-3	AI coding assistant
File Storage	AWS S3 / Firebase	Repository file storage
Code Editor	Monaco Editor	Syntax highlighting
Markdown	Marked.js	README rendering
Security	bcrypt, Helmet.js	Password hashing, headers
Version Ctrl	Custom commit engine	History & rollback

VIII. DATABASE DESIGN

DevDock's database schema is organized into six primary collections in MongoDB, each responsible for a distinct domain of the application:

A. Users Collection

The Users collection stores: unique user ID (UUID), username, email address, bcrypt-hashed password (null for OAuth-only accounts), profile picture URL, authentication provider (google / github / local), GitHub access token (encrypted, for mirroring), friend connections array (list of user IDs), notification preferences, account creation timestamp, and last

login timestamp. The email field carries a unique index to prevent duplicate registrations.

B. Repositories Collection
The Repositories collection stores: repository ID, owner user ID (foreign key to Users), repository name, optional description, visibility flag (public/private), list of collaborator user IDs, GitHub mirror repository URL (if linked), creation timestamp, last updated timestamp, total commit count (denormalized counter), and total file count (denormalized counter). A compound index on (owner ID, repository name) enforces uniqueness of repository names per user.

C. Commits Collection
Each document in the Commits collection represents one version snapshot: commit ID, parent repository ID, commit message, author user ID, commit timestamp, commit type (user_commit / auto_backup / rollback), target commit ID (for rollback entries), and a snapshot reference array listing all file IDs and their storage URLs at the time of the commit. Commits are stored in append-only fashion; no existing commit document is ever modified after creation.

D. Files Collection
The Files collection tracks individual file and folder entities: file ID, repository ID, parent folder ID (null for root-level items), file name, file extension, storage URL (for files; null for folders), file size in bytes, MIME type, created timestamp, and last modified timestamp. A soft- delete flag allows files to be logically removed without immediately purging cloud storage, supporting rollback operations.

E. Messages and Friends Collections
The Messages collection stores individual chat messages: message ID, sender user ID, recipient user ID, message text, sent timestamp, and read status flag. The Friends collection records connection relationships: a document per friendship containing both user IDs (sorted lexicographically), status (pending / accepted / rejected), requester user ID, and creation timestamp. Real-time delivery of new messages and friend request notifications is handled via Socket.io events rather than polling.

IX. SECURITY CONSIDERATIONS

Security is a foundational design priority throughout DevDock's architecture. The following measures are implemented across the stack:

Password Security: All locally registered user passwords are hashed using bcrypt with a work factor of 12 (salt rounds), making brute-force attacks computationally prohibitive. Plaintext passwords are never logged or stored. Before allowing username or password changes, the system requires current password verification.

Token Management: OAuth access tokens from Google and GitHub are validated server-side via the respective OAuth introspection endpoints and are never stored in plaintext in the database. GitHub access tokens required for repository mirroring are encrypted using AES-256 before storage. Session JWTs are signed using RS256 (RSA + SHA-256) asymmetric keys, with a short expiry of 24 hours, and refresh tokens are issued for extended sessions.

Access Control: Every API endpoint that touches repository data performs a server-side ownership and collaborator check before executing. Private repository files, commit history, and analytics are inaccessible to non- collaborators regardless of the URL. The live editor room PIN provides an additional layer of access control for collaborative coding sessions.

Account Deletion: The account deletion flow requires the user to type a specific personalized phrase — 'I am sure to delete [USERNAME] from DevDock' — into a text input before the delete button is activated. This two-step confirmation prevents both accidental deletion and unauthorized deletion by casual attackers.
Infrastructure Security: All client-server communication is conducted over HTTPS (TLS 1.2+). HTTP Strict Transport Security (HSTS) headers are served. API keys and secrets for Google OAuth, GitHub OAuth, and GROQ are stored exclusively as server-side environment variables and are never bundled into client-side JavaScript. The Helmet.js middleware sets security-relevant HTTP response headers including Content-Security-Policy, X-Frame-Options, and X-Content-Type-Options.

X. TESTING AND VALIDATION

A. Unit Testing
Individual service modules — the authentication service, repository CRUD service, commit creation service, rollback service, and analytics calculation service — are tested in isolation using the Jest testing framework. Test cases cover expected behavior for valid inputs, boundary conditions, and error responses for invalid inputs. Mock objects are used to isolate modules from database and external API dependencies. A total of 87 unit test cases were written, achieving approximately 78% line coverage across tested modules.

B. Integration Testing

Integration tests validate end-to-end user flows across the full application stack. Key scenarios tested include: (1) the complete Google OAuth authentication journey from redirect to JWT issuance; (2) repository creation followed by file upload, commit, and commit history retrieval; (3) live editor room creation, PIN verification, and two-user simultaneous editing session; (4) AI assistant query submission and response rendering; (5) friend request sending, notification delivery, and messenger message exchange. Integration tests use a dedicated test MongoDB instance and mock the GROQ API to avoid costs during automated testing.

C.User Acceptance Testing (UAT)

A UAT session was conducted with 15 student developers from the Computer Science department who used DevDock for a structured evaluation lasting 45 minutes each. Participants were asked to complete a set of prescribed tasks — creating a repository, uploading files, committing changes, using the AI assistant, sending a friend request, and joining a live editor room — and then completed a structured questionnaire using a 5-point Likert scale. Table II summarizes the UAT results.

Table II Uat Results Summary (N=15)

Evaluation Criterion	Mean Score (/5)	Std Dev
Ease of Use	4.3	0.41
Feature Completeness	4.1	0.52
Visual Design & Navigation	4.5	0.37
AI Assistant Usefulness	4.4	0.48
Live Editor Responsiveness	4.2	0.55
Overall Satisfaction	4.3	0.43

XI. RESULTS AND DISCUSSION

The DevDock platform was successfully implemented with all 19 specified features in a functional state. The development was completed over a period of approximately six months using an Agile iterative approach, with bi-weekly sprints and regular feedback integration.

Authentication: The Google OAuth integration provides a frictionless login experience, with average authentication completion time under 3 seconds. The custom account deletion flow with the typed confirmation phrase successfully prevented accidental deletions in all UAT sessions.

Repository Management: The graphical repository creation and file management system was well-received by participants, with 13 of 15 UAT participants successfully completing all repository tasks without external assistance. The failure-handling mechanism — auto-commit for private repositories and draft-save for public repositories — was tested under simulated network interruption conditions and performed correctly in 100% of test runs.

Live Editor: The multi-user collaborative editing sessions demonstrated stable real-time synchronization with up to 5 simultaneous users in test scenarios. Latency between a keystroke event and its propagation to all connected peers averaged 42ms on a local network and 180ms over a wide- area network, which is well within the threshold for perceived real-time collaboration.

AI Assistant: GROQ API integration delivered average response times of 120ms for code completion queries and 280ms for longer explanation requests, significantly outperforming the 800–1500ms typical of conventional

cloud AI endpoints. Participants in UAT rated the AI assistant as the most-liked feature of the platform, with comments highlighting its speed and contextual relevance.

Messenger: One-on-one messaging showed real-time delivery with an average message-to-display latency of 35ms in LAN conditions. Friend request notifications appeared within 1 second of the request being sent, providing a satisfying and responsive social interaction experience.

Version Control: The commit history and rollback mechanism was tested with repositories containing up to 50 commits and 200 files. Rollback to any commit state completed successfully in all test cases, with average rollback operation duration of 1.8 seconds for a repository of 50 files.

Areas for Improvement: UAT participants suggested additions including a mobile app, pull request / code review workflows, video calling in the messenger, and a contribution activity graph (similar to GitHub's contribution heatmap). These are documented as future work items.

The codebase at the time of UAT consisted of approximately 12,400 lines of JavaScript and JSX across the frontend and backend, organized into 86 source files. The backend comprised 34 route handler files, 12 service modules, 8 database model definitions, and 4 middleware modules. Unit test coverage of core service modules reached 79%, exceeding the 75% target set in the project objectives. The frontend consisted of 31 React components and 7 context providers

managing global state for authentication, repository selection, theme, and notifications.

Deployment was accomplished on a cloud VPS instance running Ubuntu 22.04 with Node.js 20 LTS, MongoDB 7.0, and Nginx as a reverse proxy. SSL/TLS certificates were provisioned via Let's Encrypt. Average server CPU utilization during UAT sessions remained below 35%, and memory consumption averaged 380MB, indicating comfortable headroom for scaling to a larger user base without hardware upgrades.

XII. CONCLUSION

This paper has presented DevDock, a comprehensive collaborative web development platform that unifies repository management, real-time collaborative coding, AI-assisted development, social networking, and version control within a single browser-based application. DevDock successfully demonstrates that a student- developed platform can address real and significant developer needs when built with a clear user-first philosophy and modern web technologies.

The DevDock-first approach to repository management ensures platform independence while still allowing users to leverage the GitHub ecosystem when desired. The use of the GROQ API for AI inference demonstrates a viable, cost-effective, and high-performance alternative to premium AI services for educational projects. The social

and messenger features provide an important community dimension that existing repository platforms lack.

The platform received strong positive feedback in user acceptance testing across all evaluation criteria, with overall satisfaction averaging 4.3 out of 5. The live collaborative editor and AI assistant were identified as standout features that provide unique value not available in any existing single platform.

Future development will focus on: (1) building native iOS and Android mobile applications; (2) implementing voice and video calling within the messenger module; (3) adding pull request workflows with inline code review and comment threads; (4) integrating CI/CD pipeline support for automated testing and deployment; (5) introducing team-level organizations with shared repositories; (6) adding contribution activity graphs and advanced repository analytics; and (7) creating a plugin or extension marketplace for custom editor enhancements. DevDock represents a meaningful contribution to the ecosystem of developer tools for students and early-career engineers.

XIII. PERFORMANCE ANALYSIS

Dev Dock's performance was evaluated across key functional areas to validate its suitability as a production- ready platform for student developers. Measurements were conducted on a cloud-hosted deployment instance with standard configuration, simulating real-world usage conditions.

A. API Response Times

RESTful API endpoint response times were measured using automated load testing scripts across 100 simulated concurrent users. Authentication endpoints (login, token refresh) averaged 85ms response time. Repository CRUD operations (create, read, update, delete) averaged 120ms. Commit creation, which involves file metadata updates and snapshot generation, averaged 340ms for repositories with up to 100 files. Rollback operations, which involve restoring a complete repository state from a commit snapshot, averaged 1.8 seconds for 50-file repositories — well within acceptable interactive response thresholds.

B. Real-Time Collaboration Latency

Live editor keystroke propagation latency was measured across varying network conditions. On local area network (LAN) conditions, the average end-to-end latency from keystroke to peer-screen update was 42ms. Over wide-area network (WAN) conditions simulating typical broadband internet connections, the average latency was 180ms. Both figures are within the 250ms threshold that research identifies as the maximum acceptable latency for perceived real-time collaboration. With up to 5 simultaneous users in a single room, no statistically significant increase in latency was observed, confirming the scalability of the Socket.io room-based architecture.

C. AI Assistant Response Performance

The GROQ API integration was benchmarked against alternative AI inference endpoints. For code completion queries (average prompt length: 150 tokens, response length: 80 tokens), GROQ delivered an average response

time of 120ms. For longer explanation queries (average prompt length: 300 tokens, response length: 250 tokens), the average response time was 280ms. In comparison, equivalent queries to OpenAI's API averaged 850ms and 1,400ms respectively under comparable conditions. This 5- 7x speed advantage makes GROQ uniquely suitable for interactive, low-latency AI assistance within a coding environment.

D. File Storage and Upload Performance

File upload performance was tested for various file sizes and types. Text-based source code files (average 10KB) were uploaded and committed within 450ms. Larger binary files such as images (average 500KB) completed within 1.2 seconds, and video files (average 10MB) completed within 8 seconds on a standard broadband connection. The cloud storage integration with automatic backup triggering added an average of 180ms overhead for private repository commits, which is transparent to the user in normal operation.

XIV. COMPARATIVE ANALYSIS

Table III presents a structured feature comparison between DevDock and three leading existing platforms: GitHub, GitLab, and Replit. The comparison evaluates each platform across twelve key dimensions relevant to student developers and collaborative coding environments.

Table III Feature Comparison: Dev dock Vs. Existing Platforms

Feature	DevDock	GitHub	GitLab	Replit
GUI Repo Management	Yes	Partial	Partial	No
No CLI Required	Yes	No	No	Yes
Live Multi-User Editor	Yes	No	No	Yes
Built-in AI Assistant	Yes	Paid	No	Partial
Integrated Messenger	Yes	No	No	No
Version Rollback (GUI)	Yes	No	No	No
README Rendering	Yes	Yes	Yes	No
Repository Analytics	Yes	Yes	Yes	Partial
Free AI Inference	Yes	No	No	Partial
GitHub Mirroring	Yes	N/A	Yes	No
PIN-Secured Rooms	Yes	No	No	No

The comparative analysis in Table III clearly illustrates that DevDock is the only platform in the comparison that natively provides GUI-based repository management without CLI dependency, an integrated live multi-user editor, a built-in social messaging system, a free AI coding assistant, and PIN-secured collaborative rooms — all within a single, unified platform. GitHub and GitLab excel at professional-grade version control but do not address the collaborative and social needs of student developers. Replit provides a strong code execution environment but lacks repository management depth, version history, and social features.

XV. CHALLENGES AND LIMITATIONS

A. Technical Challenges

Several significant technical challenges were encountered and resolved during DevDock's development. The most complex challenge was designing the version history and rollback system. Unlike Git's content-addressable object store model, DevDock needed to implement a snapshot system that was understandable to non-expert users while still providing reliable rollback guarantees. The solution adopted was a hybrid approach: storing complete file metadata snapshots for small repositories (under 50 files) and switching to delta-based snapshots for larger ones, with a lazy restoration algorithm that reconstructs the file tree on rollback.

The second major challenge was achieving consistent real- time synchronization in the live editor without Operational Transformation or CRDT libraries (which have complex integration requirements). The adopted approach uses a server-as-arbiter model: all edit events are routed through the server which serializes them and broadcasts the canonical sequence to all connected clients. This provides eventual consistency with minimal implementation complexity, at the cost of slightly higher latency for clients geographically distant from the server.

B. Limitations of Current Implementation

The current version of DevDock has several acknowledged limitations. First, the live editor uses a server-arbitrated synchronization model that may exhibit increased latency for users connecting from regions geographically distant from the server. A future implementation using CRDTs would eliminate this dependency on server round-trips. Second, the messenger module currently supports only text-based one-on-one conversations; group chats, file attachments, and audio/video calling are not yet supported. Third, the platform does not yet implement a pull request or code review workflow, which limits its utility for formal team-based development processes. Fourth, the repository file size limit is currently capped at

100MB per file and 2GB per repository, which may be restrictive for projects involving large datasets or media assets.

C. Scalability Considerations

The current DevDock deployment architecture uses a single-server Node.js instance with a single MongoDB cluster. This configuration is suitable for development and moderate-scale academic use but would require horizontal scaling using a load balancer, multiple application server instances, and a Redis-based shared Socket.io adapter to support thousands of concurrent users. Database read performance could be improved by adding MongoDB replica sets and read replicas for analytics-heavy queries. These scalability enhancements are documented as infrastructure roadmap items for a future production deployment.

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