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Abstract— Alumni Connect is a cross-platform mobile application designed to bridge the gap between graduating students and their alma mater by providing a robust digital ecosystem for alumni networking, professional engagement, and institutional contribution. Built using Flutter for the frontend and Firebase as the cloud backend, the application integrates six core modules: Alumni Directory, real-time Messaging, Event Management with RSVP, Job Postings, Mentorship Matching, Donation Facilitation, and Push Notifications. The system adopts the Model-View-ViewModel (MVVM) architectural pattern to ensure clean separation of concerns and scalable development. Firebase Firestore serves as the NoSQL real-time database, while Firebase Authentication and Firebase Cloud Messaging power secure login and targeted notifications respectively. Experimental evaluation conducted during a 30-day pilot with 120 users demonstrates an average API response latency under 430 ms, a System Usability Scale (SUS) score of 87.4, and a 63.2% improvement in alumni engagement over traditional email-based outreach. This paper presents the design, architecture, implementation, and evaluation of Alumni Connect, demonstrating its potential to modernise alumni relations for educational institutions.

Keywords — Alumni Connect, Flutter, Firebase, Firestore, MVVM, Mobile Application, Alumni Networking, Push Notifications, Real-Time Database, Human-Computer Interaction.

I. INTRODUCTION

The relationship between an educational institution and its alumni represents one of the most enduring and mutually beneficial partnerships in the academic ecosystem. Alumni serve as ambassadors of their institutions, contributing to mentorship programmes, financial donations, industry collaborations, and campus recruitment drives. Despite this profound significance, most institutions continue to rely on outdated outreach mechanisms — physical newsletters, periodic email blasts, and annual reunion events — which fail to cultivate sustained, meaningful engagement in an increasingly digital world.

The proliferation of smartphones and mobile internet connectivity has fundamentally altered how individuals communicate, collaborate, and build professional networks. Platforms such as LinkedIn, WhatsApp, and Facebook have demonstrated the immense appetite for digital community-building; however, these general-purpose platforms lack the institutional context, academic features, and privacy controls necessary for a dedicated alumni ecosystem.

Alumni Connect addresses this gap by providing an institution-specific mobile application that unifies all alumni engagement touchpoints into a single, intuitive interface. The application is developed using Flutter, Google's open-source UI toolkit, which enables simultaneous deployment on Android and iOS platforms from a single codebase. Firebase, a Backend-as-a-Service (BaaS) platform, powers data persistence, authentication, and notification infrastructure, providing real-time synchronisation and scalability without dedicated server management overhead.

This paper is structured as follows: Section II presents the conceptual and technical theoretical foundations. Section III reviews related literature. Section IV describes the system methodology. Section V reports experimental results. Section VI discusses advantages and limitations. Section VII concludes with future scope.

II. THEORETICAL BACKGROUND

A. Conceptual Theory

Alumni networking refers to the organised practice of maintaining and leveraging professional and social relationships formed during an individual's academic tenure. Research in higher education management has consistently demonstrated that robust alumni networks correlate positively with improved institutional rankings,

higher donation rates, and stronger industry-academia linkages (Drezner, 2011). The concept of social capital — the aggregate of actual and potential resources embedded within social relationships — forms the theoretical backbone of alumni engagement initiatives.

Mobile applications have emerged as the dominant channel for delivering digital services to end users. According to Statista (2024), over 6.3 billion smartphone users exist globally, with mobile applications accounting for more than 90% of total mobile internet usage time. In the context of alumni services, mobile applications offer push-based communication, location-aware features, and personalised content delivery that static web portals cannot provide.

Cloud computing, particularly the Platform-as-a-Service (PaaS) and Backend-as-a-Service (BaaS) paradigms, has democratised the deployment of scalable applications. Concepts such as NoSQL databases, event-driven architectures, and serverless functions are central to modern cloud-native application development. Community engagement theory, as articulated by McMillan and Chavis (1986), identifies four dimensions of sense of community: membership, influence, integration and fulfilment of needs, and shared emotional connection. The feature design of Alumni Connect is explicitly informed by these dimensions — the Alumni Directory and Messaging modules foster membership; Events and Donations modules encourage influence; and Jobs and Mentorship modules address professional fulfilment.

B. Technical Theory

Flutter is an open-source UI software development kit developed by Google, utilising the Dart programming language. Unlike traditional cross-platform frameworks that rely on web views or native component wrappers, Flutter renders its own widgets via the Skia graphics engine, resulting in consistent, high-performance UIs across Android, iOS, and web platforms from a single codebase. The reactive programming model and hot-reload capability significantly accelerate the development lifecycle.

Firebase is a comprehensive app development platform encompassing cloud-based services for data storage, authentication, and messaging. Firebase Firestore is a scalable, document-oriented NoSQL database supporting real-time data synchronisation across connected clients. Firestore organises data into collections of documents with key-value pairs and nested sub-collections. This schema-flexible model is well-suited to the heterogeneous

data structures characteristic of alumni profile management.

Firebase Authentication provides a fully managed identity service supporting email/password, Google Sign-In, and phone OTP methods. Firebase Cloud Messaging (FCM) enables targeted push notifications to individual devices or topic-based subscriber groups, supporting both foreground and background notification handling.

The Model-View-ViewModel (MVVM) architectural pattern separates the application into three layers: the Model, which encapsulates business logic and data access; the View, responsible for UI rendering; and the ViewModel, which serves as an intermediary exposing observable data streams to the View. In Flutter, the provider or riverpod packages facilitate MVVM through reactive state management, ensuring UI components automatically re-render in response to data changes without tightly coupling View to Model.

III. LITERATURE REVIEW

The intersection of mobile technology, cloud computing, and alumni engagement has attracted increasing scholarly attention. Existing literature broadly falls into three categories: alumni relationship management (ARM), mobile application architectures for social platforms, and cloud-based real-time systems.

A. Alumni Relationship Management

Weerts and Ronca (2008) established that alumni giving behaviour is strongly correlated with perceived institutional quality and the strength of emotional bonds formed during the student experience. Their study highlighted the inadequacy of one-way communication channels and advocated for participatory engagement platforms. Drezner (2011) documented how digital platforms can significantly augment philanthropic engagement among younger alumni cohorts who demonstrate reduced responsiveness to traditional direct-mail campaigns.

Gaier (2005) conducted a longitudinal analysis of alumni satisfaction and found that alumni who maintained active professional ties with their institutions reported significantly higher life satisfaction scores and stronger institutional loyalty, underscoring the importance of robust professional networking infrastructure.

B. Mobile Application Architectures

Kumar et al. (2021) demonstrated that Firestore's real-time listener architecture reduces average data synchronisation latency to below 300 ms for documents

under 1 MB, making it suitable for chat and feed-based applications. Their study confirmed that Firestore's offline persistence layer substantially improves application resilience in low-connectivity environments.

Chaturvedi and Singh (2022) evaluated Flutter against React Native and Xamarin, finding that Flutter applications demonstrated 18% lower average frame rendering times and 12% reduced memory consumption. Patel et al. (2023) showed that Flutter applications adopting MVVM with Riverpod exhibit a 35% reduction in boilerplate code and a 40% improvement in unit test coverage.

C. Research Gap

Despite the wealth of literature on alumni engagement platforms and mobile application development, a notable gap exists for purpose-built, institution-specific mobile alumni platforms integrating networking, event management, mentorship, and donation features within a unified real-time architecture. Alumni Connect addresses this gap by combining Flutter and Firebase with a clean MVVM design to deliver a comprehensive, real-time alumni engagement solution.

IV. METHODOLOGY

A. System Architecture

The Alumni Connect system is structured into a three-tier architecture in accordance with the MVVM pattern. The Presentation Layer consists of Flutter widgets organised into feature-specific screen modules; each screen subscribes to a corresponding ViewModel via a state management provider. The ViewModel layer contains all business logic, input validation, and data transformation, exposing reactive streams observed by the View. The Data Layer comprises repository classes that abstract Firestore queries, FCM API calls, and Firebase Auth operations.

The backend is entirely managed through Firebase, eliminating server provisioning overhead. Firestore serves as the primary data store; Firebase Authentication handles user identity; FCM manages push notification delivery; and Firebase Storage holds user-uploaded media assets such as profile photographs and event banners.

B. Module Descriptions

1. Alumni Directory: The directory provides a searchable, filterable catalogue of all registered alumni profiles. Each Firestore profile document stores name, graduation year, department, current employer, location, and contact

preferences. Composite Firestore indices enable efficient multi-field queries with sub-second response times.

2. Messaging: The real-time messaging system leverages Firestore onSnapshot listeners for a low-latency chat experience. Each conversation is a Firestore sub-collection under a conversations document, with message documents containing sender UID, body, timestamp, and read-receipt status, rendered in a paginated lazy-loaded list.

3. Events and RSVP: Institutional events are stored as Firestore documents containing metadata, capacity limits, and an array of RSVP'd user UIDs. Firestore transactions enforce atomic capacity constraints preventing over-registration. FCM topic subscriptions deliver event reminder notifications 24 hours before scheduled events.

4. Jobs and Mentorship: Alumni can post job openings or mentorship opportunities, indexed and searchable by role, industry, and location. A tag-based similarity score computed client-side suggests compatible mentor-mentee pairs based on shared industry experience and academic background.

5. Donations: Alumni contribute to institution-designated funds with optional anonymisation. Contribution records are maintained in Firestore with real-time fundraising progress updates delivered to campaign dashboards via document listeners.

6. Notifications: FCM powers multi-channel notifications supporting topic-based broadcasts, individual targeted messages, and in-app notification banners. Per-user notification preferences stored in Firestore are enforced by Cloud Functions responsible for dispatching messages.

C. System Workflow

- User Registration: A new user registers using their institutional email. Firebase Authentication creates a UID-linked profile document in Firestore.
- Profile Onboarding: The user completes a guided onboarding flow populating academic history, professional details, and profile photograph.
- Home Feed: The home screen aggregates recent events, job postings, and network activity using real-time Firestore listeners; ViewModel classes transform raw documents into domain model objects.
- Feature Interaction: Module interactions trigger ViewModel methods executing Firestore reads, writes, or transactions.
- Notification Dispatch: Background Cloud Functions monitor Firestore document changes and

dispatch FCM notifications to relevant subscriber groups.

- Session Management: Firebase Authentication tokens refresh automatically; session state persists across restarts via secure local storage.

D. Data Flow

Data flows through Alumni Connect in a unidirectional reactive pipeline consistent with MVVM. User interactions trigger action callbacks on the ViewModel, which invokes repository methods constructing Firestore queries or mutations. Firestore returns data as Future responses or continuous Stream snapshots. The ViewModel transforms incoming data into observable state objects; the View subscribes via provider listeners and triggers partial widget rebuilds limited to affected subtrees. This architecture ensures network latency never blocks the UI thread, maintaining smooth 60 FPS rendering.

V. EXPERIMENTAL RESULTS

A. Test Setup

The Alumni Connect application was evaluated on a cohort of 120 registered users — 85 alumni and 35 final-year students — during a 30-day pilot. Testing was performed on devices ranging from mid-range (Snapdragon 665, 4 GB RAM) to high-end (Snapdragon 888, 8 GB RAM) smartphones running Android 11 and iOS 15. Network conditions were simulated across 4G LTE (25 Mbps) and Wi-Fi (75 Mbps) environments.

B. Response Latency

Average end-to-end API response latency was measured from user interaction trigger to UI update completion across all six modules. Results are presented in Table I.

Module	4G (ms)	Wi-Fi (ms)	FPS
Alumni Directory	387	245	60
Real-Time Messaging	142	98	60
Events & RSVP	412	268	60
Jobs & Mentorship	428	301	58
Donations	395	257	60
Push Notifications	520	385	N/A

TABLE I: Module-wise Response Latency

All modules achieve real-time performance within acceptable latency thresholds. The messaging module

demonstrates the lowest latency due to its persistent Firestore listener architecture. Push notification delivery exhibits the highest latency, attributable to FCM routing overhead, yet delivery within 520 ms remains well within acceptable limits for asynchronous alerts.

C. Usability Evaluation

System usability was measured using the System Usability Scale (SUS), administered to 80 pilot users. The application achieved an average SUS score of 87.4, placing it in the 'Excellent' grade category. Positive feedback highlighted intuitive navigation, fast search, and seamless notifications. Areas for improvement include onboarding flow length and notification preference granularity.

Criterion	Score (/100)	Grade
Overall SUS Score	87.4	Excellent
Ease of Navigation	89.1	Excellent
Feature Discoverability	84.6	Good
Notification Relevance	86.3	Excellent
Profile Management	88.9	Excellent

TABLE II: SUS Evaluation Results

D. Engagement Metrics

Alumni engagement was quantified by comparing interaction rates during the 30-day pilot against historical email-based outreach over the same calendar period in the preceding year. The application registered an average of 4.7 logins per active user per week, an event RSVP conversion rate of 58.3%, and a job posting click-through rate of 41.7%. The overall alumni engagement index improved by 63.2% relative to the email baseline, validating that mobile-first platforms substantially outperform passive communication channels.

VI. DISCUSSION

A. Advantages

The cross-platform Flutter architecture ensures consistent user experience across Android and iOS without separate development efforts, reducing time-to-market and long-term maintenance costs. The Firebase backend eliminates server management overhead, enabling small institutional IT teams to operate a scalable, globally distributed infrastructure. Real-time Firestore synchronisation propagates data changes instantaneously to all connected clients, creating a dynamic community environment

analogous to mainstream social platforms. The MVVM architecture facilitates unit testing of business logic in isolation from UI components, contributing to a more maintainable and robust codebase.

B. Limitations

Firebase's pricing model, scaling with read/write operations and stored data volume, may impose non-trivial costs for large institutions with alumni networks exceeding 50,000 active users. Institutions with strict data sovereignty requirements may encounter challenges with Firebase's limited data residency options. The current mentorship matching algorithm relies on a simplistic tag-based similarity measure that does not account for nuanced compatibility factors. Performance under simultaneous high-concurrency events has not been evaluated beyond the 120-user pilot cohort. The absence of an integrated payment gateway means the donations module redirects to external payment pages, introducing friction in the contribution flow.

VII. FUTURE SCOPE

- **AI-Powered Recommendations:** Integration of machine learning models via Firebase ML or TensorFlow Lite for personalised content recommendations, semantic mentor-mentee matching using profile embeddings, and predictive donor propensity scoring.
- **Integrated Payment Processing:** Native in-app payment processing using the Stripe or Razorpay SDK to eliminate redirection-based donation flow, enabling one-tap contributions and recurring donation schedules.
- **Analytics Dashboard:** A real-time administrative analytics dashboard with visualisations of engagement metrics, event attendance trends, and donation campaign performance via Firebase Analytics and BigQuery.
- **AR Campus Tour Module:** An augmented reality campus tour experience leveraging ARCore and ARKit capabilities accessible through Flutter for immersive alumni re-engagement.
- **Gamification:** A gamified achievement system rewarding alumni for mentoring, event participation, and community contributions to sustain long-term engagement.
- **Web Portal Companion:** A Flutter Web companion portal extending Alumni Connect to desktop users with enhanced administrative management capabilities.

VIII. CONCLUSION

This paper has presented Alumni Connect, a comprehensive cross-platform mobile application designed to modernise alumni networking and engagement for educational institutions. By integrating six functional modules within a cohesive Firebase-powered architecture and a clean MVVM design pattern, the application delivers a scalable, real-time, and user-friendly platform that addresses the well-documented limitations of traditional alumni outreach methods.

Experimental evaluation during a 30-day pilot with 120 users demonstrated average module response latencies below 430 ms, an excellent SUS score of 87.4, and a 63.2% improvement in alumni engagement over the email-based baseline. These results confirm the technical viability and practical impact of the proposed system.

The adoption of Flutter and Firebase positions Alumni Connect for rapid iteration and deployment across diverse institutional contexts. The MVVM architectural pattern ensures the application can evolve with institutional requirements without accumulating prohibitive technical debt. Future developments focusing on AI-driven personalisation, integrated payments, and analytics will further amplify the platform's value, establishing it as an essential tool for educational institutions committed to building thriving alumni communities in the digital age.

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