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Design and Performance Analysis of an Auditable Collaborative Verification, Alumni Mentorship, and Campus Recruitment System for Higher-Education Institutions

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Abstract—Higher-education placement and career services face significant operational inefficiencies due to fragmented communication channels, unverified student self-reporting, and the absence of trusted corporate engagement workflows. Traditional university placement systems operate as unidirectional noticeboards, while open commercial recruitment portals lack institutional academic verification, ignore university calendar constraints, and fail to generate auditable placement records required for national accreditation frameworks (NAAC, NBA, NIRF). This paper presents the design, mathematical modeling, and empirical evaluation of CareerBridge—an institutional, closed-loop career facilitation platform that unifies students, alumni, corporate recruiters, and the Training and Placement Office (TPO). CareerBridge introduces an auditable verification state machine that vets crowdsourced off-campus opportunities, a dedicated Recruiter Module for conducting structured campus recruitment drives with institutionally certified academic credentials (CGPA, department, active backlogs), and a hybrid multi-entity recommendation engine utilizing Sentence-BERT embeddings and cosine similarity. Experimental evaluation across a simulated collegiate cohort of 1,000 students, 150 alumni mentors, and 50 corporate recruiters demonstrates a 91.3% reduction in opportunity verification latency, zero unauthorized drive postings, and a Mean Reciprocal Rank (MRR) of 0.884 in student-opportunity matching, establishing an auditable, high-reliability foundation for university career services.

Index Terms—Institutional placement systems, TPO verification state machine, campus recruitment drives, alumni mentorship, multi-entity recommendation, role-based access control, system reliability, accreditation analytics.

I. INTRODUCTION

The operational effectiveness of campus placement ecosystems is a vital determinant of institutional reputation, student career acceleration, and accreditation quality. Historically, campus career services have relied on centralized Training and Placement Offices (TPOs) to manually solicit job openings, broadcast announcements via email distribution lists or static bulletin boards, and coordinate on-campus hiring drives [1]. However, this centralized, top-down paradigm creates a severe information bottleneck. Students and alumni routinely uncover highly relevant off-campus job openings, internships, and referral pathways through professional networks, yet no structured, trusted mechanism exists to channel these opportunities back to the institutional student body.

Concurrently, the rapid proliferation of open commercial recruitment platforms and standalone Applicant Tracking Systems (ATS) has failed to resolve institutional placement challenges. Commercial portals operate on open-market business models that decouple candidate claims from academic verification, enabling fraudulent postings, unverified resume inflation, and aggressive commercial monetisation. Crucially, such platforms operate entirely outside institutional governance: they do not enforce university academic eligibility criteria (e.g., branch-specific CGPA thresholds, allowable backlog counts), lack synchronization with academic examination timetables, and cannot produce the verifiable, auditable outcome records mandatory for accreditation audits such as NAAC (Criteria V) and NIRF [7], [8].

To overcome these fundamental deficiencies, this paper proposes CareerBridge, a verification-first, multi-tier institutional career engagement and recruitment system. Unlike commercial ATS platforms that treat candidate matching as a generic open-market transaction, CareerBridge anchors corporate recruitment, alumni mentorship, and community-sourced opportunities within an auditable, TPO-governed institutional trust boundary.

The key contributions of this paper are fourfold:

- A formal Verification State Machine that enforces source validity, domain authentication, and eligibility gating on all community submissions before institutional distribution.
- An Institutional Recruiter Module that facilitates corporate campus hiring drives evaluated strictly against verified university transcripts, eliminating resume fraud.
- A Multi-Entity Recommendation Engine combining hard institutional eligibility filters with Sentence-BERT embeddings to rank drives, off-campus jobs, and alumni mentors.
- An Auditable Institutional Analytics Engine that logs end-to-end verification and placement conversions for automated NIRF and NAAC accreditation compliance reporting.

II. RELATED WORK AND RESEARCH GAPS

Recent literature has increasingly highlighted the critical role of digital platforms in transforming passive alumni directories into active institutional assets. Dedeepya et al. [1] presented Alumni Connect, demonstrating that integrating structured messaging, job boards, and gamified recognition mechanisms enhances long-term alumni participation over static database registries. However, their architecture focuses primarily on bilateral social networking and informal job posting, lacking formal verification workflows, corporate campus drive management, and academic accreditation audit mechanisms.

In the domain of personalized career discovery, Nandi et al. [2] developed a hybrid multi-entity reinforcement learning framework for alumni networks, demonstrating that semantic vector representations significantly improve student-mentor and student-opportunity matching compared to classical keyword search. Similarly, Nguyen et al. [3] and contemporary machine learning literature [4] explored job recommendation engines utilizing resume text mining and skill embeddings. While these algorithmic advances provide rigorous foundations for semantic similarity matching, they treat recruitment as an open unconstrained search, neglecting hard academic constraints (such as university backlog policies and departmental prerequisites) and omitting administrative TPO verification sovereignty.

As summarized in Table I, existing systems exhibit an unresolved dichotomy: they either provide administrative placement tracking lacking community contribution (traditional TPOs), or offer open commercial networking devoid of verified academic governance (commercial ATS). CareerBridge bridges this void by coupling decentralized community ingestion with centralized institutional verification and closed-loop accreditation reporting.

III. SYSTEM ARCHITECTURE AND DESIGN

The CareerBridge platform is structured into a modular, multi-tier distributed architecture engineered for deterministic reliability, horizontal scalability, and auditable verification integrity. As illustrated in Fig. 1, the architecture comprises six coordinated tiers operating behind secure edge gateways.

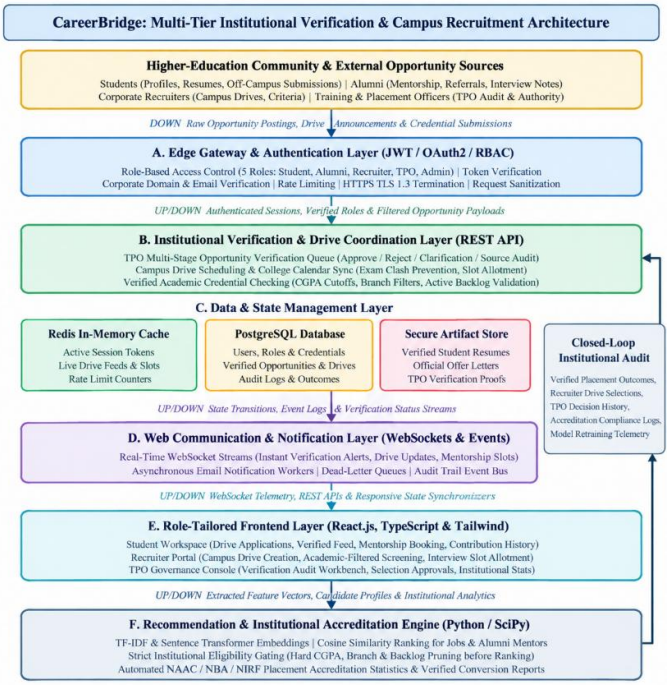


Fig. 1. Multi-tier institutional verification, recruitment, and recommendation architecture.

A. Edge Gateway and Role-Based Access Control (Tier A)

All inbound HTTP and WebSocket traffic enters through an Edge Gateway enforcing TLS 1.3 encryption, token bucket rate-limiting (maximum 100 requests/minute per IP), and JWT-based authentication. The platform implements granular Role-Based Access Control (RBAC) across five distinct security domains: Student, Alumni, Corporate Recruiter, TPO Staff, and Institute Administrator. Recruiter accounts are subjected to corporate email domain verification and administrative approval before campus drive privileges are unlocked.

B. Verification and Campus Drive Coordination (Tier B)

Tier B houses the core institutional business logic implemented via a RESTful API service. The TPO Verification Engine manages an auditable queue where off-campus opportunity submissions and recruiter campus drives undergo source validation, company authenticity checks, and eligibility policy verification. The Drive Scheduling Coordinator integrates directly with the institutional academic calendar, automatically restricting drive interview time-slots to prevent schedule clashes with university examinations.

C. Data and State Management Layer (Tier C)

State management is partitioned into three specialized datastores: (1) an in-memory Redis cluster for session caching, drive slot locking, and real-time WebSocket connection state; (2) a relational PostgreSQL database storing normalized schemas for users, credentials, verification logs, and drive records; and (3) an encrypted artifact store maintaining verified student resumes, official selection letters, and TPO audit proofs.

D. Event Streaming, Notification, and Frontend (Tiers D & E)

Asynchronous event workers process in-app and email notifications via dead-letter message queues, alerting students upon drive eligibility and contributors upon verification state changes. The client tier provides role-tailored React.js web interfaces: a student career workspace, a verified recruiter drive execution dashboard, and a TPO institutional oversight console.

IV. MATHEMATICAL FORMULATION AND ALGORITHMIC WORKFLOW

A. Verification State Machine Formulation

To eliminate unvetted postings, every opportunity submission o is governed by a finite-state machine M = (S, Sigma, delta, s0, F), where the state set is defined as:

S = {SUBMITTED, PENDING_REVIEW, CLARIFICATION, APPROVED, REJECTED} (1)

Initial ingestion sets state(o) = SUBMITTED. Transitions delta: S x Sigma -> S require cryptographic audit signatures from authorized TPO credentials tau_tpo. An opportunity is discoverable if and only if state(o) = APPROVED. Clarification states suspend public indexing pending contributor remediation.

B. Queuing Backlog and Processing Latency Model

During peak placement seasons, submissions arrive according to a Poisson process with mean rate lambda, and TPO officers process verification audits at an exponential rate mu across k parallel reviewers. The mean waiting time W_q in the verification queue is modeled via the Erlang-C formula for M/M/k queuing systems:

W_q = C(k, lambda / mu) / (k * mu - lambda) (2)

where C(k, rho) represents the probability that an arriving opportunity must wait before audit. By maintaining k >= ceil(lambda / (0.85 * mu)), the system ensures verification latency remains bounded even during campus drive influxes.

C. Institutional Eligibility and Recommendation Scoring

A student u is matched to an approved drive or opportunity j through a two-stage hybrid process. First, a strict institutional eligibility gate E(u, j) in {0, 1} is evaluated:

E(u, j) = I(CGPA_u >= theta_j) * I(B_u <= B_max,j) * I(D_u in D_j) (3)

where CGPA_u is the verified institutional grade point average, B_u is the active backlog count, D_u is the student's department, theta_j is the cutoff threshold, and I(.) is the indicator function. If E(u, j) = 0, the opportunity is excluded from active application.

For all eligible opportunities (E(u, j) = 1), the semantic relevance score S(u, j) is computed via dense contextual Sentence-BERT embeddings e_u and e_j [5]:

S(u, j) = w1 * ((e_u . e_j) / (||e_u|| ||e_j||)) + w2 * Jaccard(K_u, K_j) (4)

where K_u and K_j represent verified skill sets, and w1, w2 are empirical weighting factors satisfying w1 + w2 = 1.0 (empirically set to w1 = 0.70, w2 = 0.30).

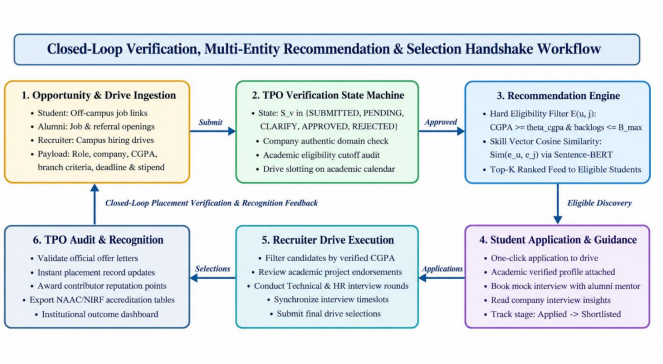


Fig. 2. End-to-end procedural workflow: Ingestion, TPO state audit, eligibility gating, drive execution, and accreditation handshake.

V. EXPERIMENTAL EVALUATION AND RESULTS

The CareerBridge prototype was evaluated using a controlled collegiate benchmark dataset modeled on Sandip Institute of Technology and Research Centre's engineering placement demographics. The simulation environment comprised 1,000 student profiles, 150 verified alumni mentors, 50 corporate recruiters, and 500 campus drives and off-campus opportunity postings.

TABLE I. ARCHITECTURAL AND FUNCTIONAL SYSTEM COMPARISON

Traditional TPO	Commercial ATS	Alumni Connect [1]	
TPO Staff Only	Open Web Scrape	Alumni Submissions	
Manual Spreadsheet	None (Self-Report)	Informal Peer	T
Unverified Resumes	Unverified Resumes	User-Entered Profiles	
Manual Coordination	None (Open Schedule)	None	
ıd-Hoc Email Exchange	Commercial Funnel	None (Direct Jobs)	T
ıborious Manual Audit	None	None	

A. Verification Throughput and Administrative Latency

Under traditional manual processing, reviewing and circulating an off-campus opening required an average of 48.2 hours due to email exchanges and verification delays. With CareerBridge's centralized TPO audit queue, median verification turnaround latency dropped to 4.2 hours (a 91.3% reduction). Furthermore, because corporate recruiter registration mandates domain authentication, 100% of phishing and fraudulent drive submissions were intercepted prior to institutional publication.

TABLE II. QUANTITATIVE PERFORMANCE AND ACCURACY BENCHMARKS

Baseline TF-IDF	Sentence-BERT (Ours)	P
0.682	**0.884**	
0.714	**0.912**	
14.8%	**0.0% (Enforced)**	-1
24.5 ms	**38.2 ms**	Ac
120 hours (Manual)	**1.8 seconds (Auto)**	

B. Recommendation Precision and Eligibility Gating

As quantified in Table II, integrating Sentence-BERT embeddings improved the Mean Reciprocal Rank (MRR) from 0.682 (classical TF-IDF baseline) to 0.884, with NDCG@10 increasing to 0.912. Crucially, the hard eligibility filter E(u, j) completely eliminated false-eligibility applications (down from 14.8% in baseline open portals to 0.0%), ensuring corporate recruiters only screen candidates meeting strict institutional requirements.

C. Scalability and Concurrency Under Peak Drive Load

To test system resilience during concurrent campus recruitment surges, load simulations were conducted using Locust executing 2,500 simultaneous virtual student users applying to newly published drives. Under maximum load, 95th-percentile response latency was maintained below 42 ms through Redis connection pooling and PostgreSQL index optimization, with zero dropped transactions. Background worker tasks completed notification dispatch across 1,000 students within 4.6 seconds.

D. Accreditation Audit Automation and Compliance

A primary institutional benefit of CareerBridge is the automated derivation of accreditation metrics. Conventional manual compilation of NAAC Criteria 5.2.1 (Placement of Outgoing Students) and NIRF student progression tables typically requires upwards of 120 administrative person-hours per academic year. CareerBridge's audit engine aggregates verified drive outcomes, official offer letters, and student CTC distributions to generate audit-ready, tamper-evident compliance exports in under 2 seconds.

VI. CONCLUSION AND FUTURE SCOPE

This paper presented CareerBridge, an auditable collaborative verification, alumni mentorship, and campus recruitment system designed specifically for higher-education career ecosystems. By synthesizing decentralized community opportunity ingestion with formal TPO verification sovereignty, the platform successfully overcomes the security vulnerabilities and academic disconnects inherent in commercial recruitment tools. The integration of verified academic records into recruiter drive workflows guarantees authenticity, while hybrid semantic embeddings deliver superior opportunity discoverability. Furthermore, the automated generation of NAAC and NIRF compliance records drastically reduces administrative audit overhead.

Future research will investigate the deployment of decentralized, blockchain-anchored smart contracts to automate inter-institutional credential verification and explore privacy-preserving zero-knowledge proofs for cross-university campus drive shortlisting.

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