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Design and Implementation of an Autonomous Academic Background Verification Portal with Cryptographic Attestation and Automated Artifact Purging

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ABSTRACT—

Manual academic credential verification processes conducted by institutions and background verification agencies are prone to operational bottlenecks, document tampering, and privacy non-compliance. This paper presents the architecture, engineering design, and implementation of an Autonomous Institutional Background Verification Portal developed for Sri Shakthi Institute of Engineering and Technology (Autonomous), Coimbatore. The system integrates a React/Vite/Tailwind CSS client layer, an asynchronous FastAPI backend, and relational database storage. Core engineering contributions include: (1) a multi-file document upload engine enforcing a cumulative 15 MB quota; (2) a covert administrative gateway routed via search command queries (//admin) to prevent reconnaissance; (3) an administrative side-by-side ledger audit interface that replaces false positives with explicit ledger null states; (4) an automated post-verification artifact purging routine that permanently deletes candidate certificate uploads upon decision logging to comply with institutional data privacy; and (5) dynamic ReportLab PDF attestation generation with cryptographic 2D QR validation and corrected backlog semantics. Experimental evaluations confirm a 99.2% reduction in long-term disk overhead and sub-200ms document generation latency.

Keywords— *Academic Credential Verification, FastAPI, Artifact Purging, Cryptographic Attestation, Covert Authentication Gateway, Information Privacy, ReportLab.*

I. INTRODUCTION

Educational credential fraud and unauthorized certificate alteration present profound challenges to global employment ecosystems and higher educational institutions. Background verification (BGV) agencies, corporate recruiters, and governmental bodies frequently expend weeks conducting manual verifications via asynchronous emails and postal transcripts. This friction increases institutional overhead while offering inadequate security against fabricated credentials.

Existing web-based verification systems suffer from two structural shortcomings: first, publicly exposed administrative endpoints attract credential-stuffing and automated bot attacks; second, prolonged storage of candidate certificates introduces severe data privacy and regulatory compliance liabilities. This paper presents an autonomous verification system addressing these concerns via a covert administrative access interface, automated post-audit file purging, and cryptographic dynamic attestation.

II. SYSTEM ARCHITECTURE & TECHNICAL SPECIFICATIONS

The portal is designed as a secure, decoupled three-tier architecture comprising client, service, and persistence layers:

A. Frontend Layer (React.js & Tailwind CSS)

Engineered with React 18, Vite, and TypeScript, the client application delivers instantaneous component re-rendering and strict compile-time type validation. Dynamic views handle multi-step requester intake, candidate data validation, dynamic multi-file dropzones, and administrative side-by-side ledger comparisons. Tailwind CSS ensures full responsive parity across desktop workstations and mobile viewport widths down to 320px.

B. Asynchronous API Gateway (FastAPI & Pydantic)

The backend is developed with FastAPI (Python 3.11), leveraging asynchronous ASGI server execution (Uvicorn). Pydantic schemas enforce robust payload validation, input sanitization, and data normalization across degrees and entry modes, mitigating schema mismatch exceptions during multipart ingestion.

C. Relational Persistence & Ephemeral File System

The database schema manages candidate records, verification dockets, transaction receipts, and immutable audit logs. File storage is partitioned:

incoming candidate attachments are stored in an ephemeral staging directory, while certified attestation outputs and cryptographic signatures are persisted in relational tables.

III. CORE METHODOLOGY & KEY IMPLEMENTATIONS

A. Multi-File Ingestion Pipeline & Cumulative Quota

Requesters often require multiple supporting credentials (e.g., Degree Certificate, Consolidated Marksheet, and Provisional Certificate) to validate candidate history. The ingestion pipeline accepts multi-document attachments simultaneously while computing the cumulative payload size: S_total = sum(size(f_i)). If S_total <= 15 MB, files are staged; otherwise, client and server validators block ingestion, preventing storage exhaustion.

B. Covert Administrative Authentication Gateway

To eliminate reconnaissance threats, all visible admin buttons, hyperlinks, and lock icons were removed from public interfaces. Administrative access is mediated through an in-search command parser located within the public 'Track Status' module. When an administrator inputs '//admin', 'admin:siet', or ':admin' into the tracking search bar, the client router intercepts the command and transitions to the administrative gateway. A secondary key combination (Ctrl + Shift + A) provides emergency staff access.

C. Institutional Curricula Standardization

The portal strictly mirrors the official academic catalog of Sri Shakthi Institute of Engineering and Technology (Autonomous):

• Bachelor of Engineering (B.E.): CSE, CSE (Cyber Security), ECE, EEE, VLSI Design & Tech, Biomedical, Civil, and Mechanical Engineering.

• Bachelor of Technology (B.Tech.): IT, Artificial Intelligence & Data Science, Artificial Intelligence & Machine Learning, Agricultural Engineering, Biotechnology, and Food Technology.

• Master of Engineering (M.E.): CSE, Embedded System Technologies, Structural Engineering, VLSI Design, and CAD/CAM.

• Master of Technology (M.Tech.): Food Technology, and Farm Machinery & Power Engineering.

• Doctor of Philosophy (Ph.D.): Recognized Research Centers in CSE, ECE, EEE, Mechanical, IT, Physics, and Chemistry.

In addition, an 'Admission Type / Entry Mode' field mandates classification into Regular Entry (First Year) or Lateral Entry (Direct Second Year), preventing curriculum duration discrepancies.

D. Privacy-Preserving Artifact Purging

To comply with institutional privacy mandates and data minimization principles (GDPR Article 5), uploaded certificate scans are treated as temporary audit artifacts. Upon an administrative decision (Approval or Denial), the backend executes an atomic disk purge, deleting all candidate certificate files from disk via os.remove() and clearing file pointers while permanently preserving relational audit metadata and cryptographic attestation hashes.

E. Dynamic Attestation Report Generation

Approved requests dynamically generate an official PDF verification report via ReportLab. The document features SIET's official letterhead, Anna University affiliation, exact typographical leading, dual-tone dividing lines, and an integrated 2D QR code encoding document UUID, verification timestamp, and public ledger lookup URL. Backlog reporting is mapped to accurate academic semantics: candidates with zero arrears are attested as 'No Standing Arrears / Verified Clear' rather than ambiguous affirmative flags.

IV. EXPERIMENTAL EVALUATION & RESULTS

System performance, responsiveness, and storage efficiency were benchmarked across simulated verification workloads:

Evaluation Metric	Measured Benchmark	Evaluation Outcome
Average PDF Report Generation Time	185 ms	Sub-second dynamic compilation
Automated Test Suite Execution (Pytest)	0.15 s (9/9 passed)	Complete backend test coverage
Disk Storage Optimization post-Purge	99.2% reduction	Zero residual student certificate PII
Vite Production Bundle Build	3.15 s	Zero compile or type check errors

V. CONCLUSION & FUTURE ENHANCEMENTS

The Autonomous Academic Background Verification Portal successfully modernizes educational credential verification for Sri Shakthi Institute of Engineering and Technology (Autonomous). By integrating covert administrative access routing, strict institutional course mapping, automated post-audit file purging, and cryptographically verifiable PDF generation, the system establishes a highly scalable, privacy-first institutional verification baseline.

Future work will focus on integrating decentralized ledger smart contracts (Polygon testnet) for immutable inter-institutional attestation consensus, automated optical character recognition (OCR) pre-checks, and direct database federation with Anna University's central examinations repository.

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