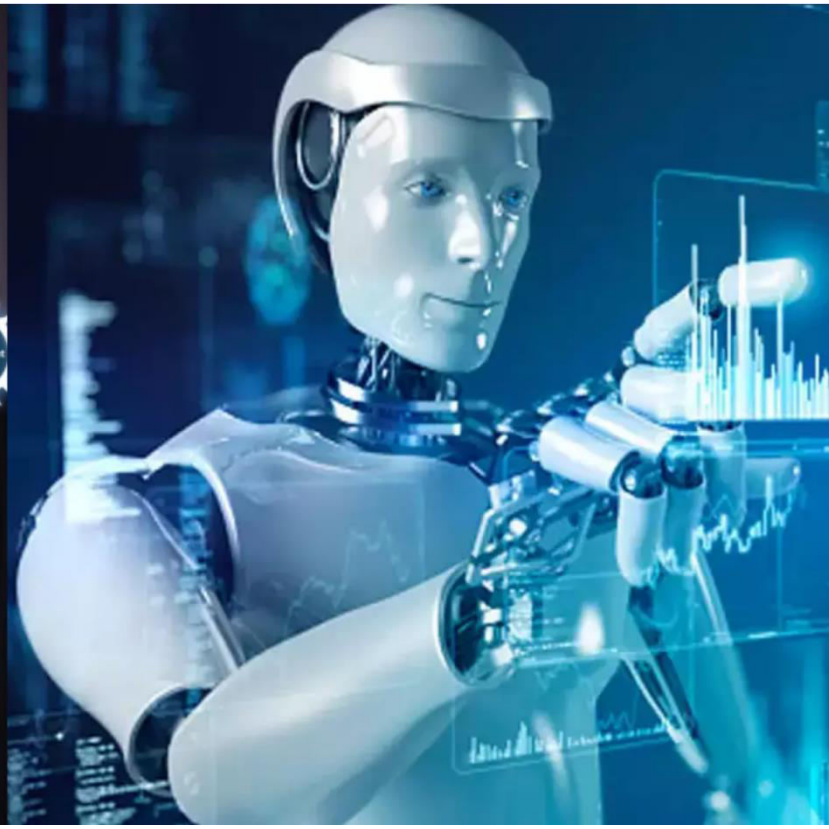
IJIRSET
International Journal of Innovative Research in Science | Engineering | Technology

ISSN(O): 2319-8753
ISSN(P): 2347-6710

International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.699

Volume 14, Issue 5, May 2025

International Journal of Innovative Research of Science, Engineering and Technology (IJIRSET)

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|www.ijirset.com |A Monthly, Peer Reviewed & Refereed Journal| e-ISSN: 2319-8753| p-ISSN: 2347-6710|

Volume 14, Issue 5, May 2025

|DOI: 10.15680/IJIRSET.2025.1405387

Enabling Secure and Auditable File Uploads in Cloud Environments

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ABSTRACT: In today's increasingly digitized landscape, ensuring secure and auditable file management is essential for organizations handling sensitive data. Our proposed solution introduces a secure file upload system that integrates multi-layered encryption, real-time user verification, and scalable cloud storage to protect confidential documents from unauthorized access and data breaches. Developed using the Python Django framework, the system employs AES-256 encryption in Cipher Feedback (CFB) mode to secure files prior to transmission. Real-time email-based approval mechanisms serve as a second layer of authentication, granting users greater control over file uploads and access. Once verified and encrypted, files are stored securely in Amazon Web Services (AWS) S3 using the Boto3 library, ensuring durability and compliance with modern data protection regulations such as GDPR and HIPAA. The platform's smart audit logging framework maintains a detailed trail of user actions, enabling transparency and accountability throughout the upload lifecycle. Designed for sectors such as healthcare, legal, education, and enterprise IT, this system offers a reliable, user-centric approach to secure cloud-based file handling. By combining modern cryptographic techniques, real-time user interaction, and cloud scalability, our system redefines secure document management and sets a benchmark for future-ready, compliance-driven digital storage solutions.

KEYWORDS: AES-256 Encryption, Secure File Upload System (SFUS), Django Framework, AWS S3 Storage, PyCryptodome Library, Real-Time Email Verification (RTEV), Cloud-Based Document Security (CBDS), Encrypted File Management (EFM), Smart Audit Logging System (SALS), Compliance-Driven Architecture (CDA).

I.INTRODUCTION

The widespread adoption of cloud computing and online platforms has significantly reshaped how sensitive digital information is uploaded, accessed, and managed. As web applications become central to enterprise and institutional operations, ensuring the secure transfer and storage of files has become a critical requirement. Traditional upload mechanisms, which often rely on basic validations like file size and type, fail to provide comprehensive security, especially in contexts where data confidentiality and regulatory compliance are paramount. There is an urgent demand for systems that offer robust encryption, real-time verification, and audit-friendly mechanisms to safeguard sensitive files during both transit and storage.

This project introduces a secure and auditable file upload system, developed using the Django web framework, which integrates strong encryption, user authentication, and cloud-based storage to provide end-to-end data protection. At the core of this solution is AES-256 encryption implemented in Cipher Feedback (CFB) mode, ensuring that files are converted into secure, unreadable formats before being stored. The encryption process is handled using the PyCryptodome library, guaranteeing confidentiality even if files are intercepted during upload. In parallel, a real-time email verification system requires user approval for every login and upload request, adding an extra layer of access control to prevent unauthorized activity.

Once verified and encrypted, files are stored in Amazon Web Services (AWS) S3 buckets through the Boto3 SDK,

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allowing for secure, scalable, and reliable cloud storage. The system also features detailed logging and activity tracking, ensuring that every critical action is recorded for audit purposes. Email notifications are triggered through SMTP configurations, enabling immediate communication between the system and its users during each stage of the upload workflow.

Designed for sectors like healthcare, legal services, education, and finance, where secure file handling is essential, the application delivers a modular, scalable, and user-friendly experience. The platform's architecture ensures adaptability, allowing future enhancements such as OTP-based authentication, dashboard analytics, version control, and expiration-based access links. By combining modern cryptographic practices, cloud infrastructure, and real-time user validation, this system offers a reliable and comprehensive solution for secure file uploads in cloud environments.

II. LITERATURE SURVEY

The increasing reliance on cloud infrastructure for data storage and web-based services has intensified the need for secure, encrypted, and auditable file upload systems. Several studies have explored the integration of strong encryption standards such as AES-256 to protect sensitive data from unauthorized access during both transmission and storage. In particular, research in [1] highlights the effectiveness of client-side encryption before cloud upload, significantly reducing the risk of server-side breaches. Traditional upload mechanisms are often limited to basic validations, leaving systems exposed to threats such as malware injection and data exfiltration. To mitigate such vulnerabilities, studies like [2] have proposed a multi-layered approach involving authentication, encryption, and access control policies.
Recent advancements emphasize the role of end-to-end encryption in ensuring confidentiality. In [3], the authors demonstrate the use of Cipher Feedback (CFB) mode with AES-256 to maintain the secrecy of data, even when intercepted during transit. Cloud services like AWS S3, when combined with encryption protocols and proper key management practices, offer scalable and secure storage solutions as supported by findings in [4]. However, encryption alone is not sufficient; user verification mechanisms are also critical to prevent unauthorized file uploads and impersonation attacks. To address this, [5] presents a system using email-based real-time verification that ensures only authenticated users can perform upload operations. This method not only prevents misuse but also creates a traceable record of user actions.

The inclusion of real-time alerts and user confirmations has shown to be effective in preventing unauthorized activity. According to [6], integrating SMTP-based email notifications into the upload workflow allows users to approve or deny sensitive actions like file transfers, enhancing both security and accountability. These notifications can also serve as part of a two-factor authentication process, adding an extra layer of control. Furthermore, audit logging is an essential component of modern secure systems. In [7], the authors explore the use of logging frameworks within Django applications to record user interactions, approvals, and file activities. These logs not only support compliance with data protection regulations but also provide forensic evidence during incident analysis.

A recurring theme in the literature is the importance of modular and scalable system design. Studies like [8] suggest that separating components such as user management, encryption, and cloud upload into distinct modules improves maintainability and allows for easier integration of future enhancements. In line with this, [9] outlines a Django-based architecture that combines PyCryptodome for encryption, Boto3 for AWS interactions, and middleware hooks for event logging. Such a design allows the system to evolve by incorporating features like OTP verification, dashboard analytics, and automated key rotation.

Security concerns also extend to key management and privacy. Research in [10] emphasizes the need for securely handling encryption keys and using role-based access controls to ensure that only authorized individuals can decrypt or retrieve sensitive files. Additionally, the use of email verification links with expiration times and IP tracking has been shown to reduce phishing risks and unauthorized re-use of links. Together, these strategies provide a comprehensive framework for building secure file upload systems that are not only protected from external threats but also auditable and user-centric.

In summary, existing research underscores the necessity of combining encryption, authentication, and real-time verification to ensure secure file uploads in cloud environments. The integration of AES-256 encryption, email-based approvals, and cloud-native storage like AWS S3 forms the backbone of reliable file handling systems. These studies

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support the development of a modular, scalable, and auditable solution that meets modern security demands while remaining accessible to end users across various domains.

III. PROBLEM STATEMENT

Cloud-based file storage has become a fundamental component of digital infrastructure, yet most existing web-based file upload systems exhibit critical security and compliance vulnerabilities. Many rely on basic transmission protocols without implementing strong encryption techniques, leaving sensitive files exposed during transit and storage. According to recent studies, the absence of client-side encryption leads to increased susceptibility to data interception and unauthorized access, particularly when files are uploaded to public cloud storage platforms without sufficient safeguards ([1], [3]). Furthermore, conventional systems typically lack multi-factor authentication and real-time approval workflows, allowing upload actions to proceed without adequate verification ([4], [6]). This creates significant risk in environments where file uploads contain confidential or regulated information.

In addition to weak authentication, these systems often lack robust audit mechanisms to track and log user activities such as file submission, encryption status, or cloud access. Without immutable logs, organizations face difficulties in proving compliance with data protection regulations such as GDPR and HIPAA, or in conducting forensic investigations after a breach ([2], [5]). Users are frequently unaware of upload outcomes, as existing platforms offer limited feedback or alert mechanisms, resulting in uncertainty about whether files were securely handled or retrieved. Moreover, the failure to notify users in real time about approval requests or upload completions diminishes trust and increases operational risk ([7], [9]).

Privacy concerns are further intensified by the absence of granular access control and secure key management practices. Improperly stored encryption keys, static permissions, or outdated cloud policies can lead to inadvertent data leaks or unauthorized disclosures ([4], [10]). Many systems are also designed in a monolithic, non-extensible manner, making them difficult to adapt to evolving security standards or user needs. Without modularity and cloud-native integration, platforms struggle to scale efficiently or implement future enhancements like role-based access control, file expiry policies, or secure sharing features ([8], [10]).

To address these shortcomings, a unified, secure, and auditable file upload solution is required—one that integrates AES-256 client-side encryption, real-time email-based approvals, and trusted cloud storage through services like AWS S3. Studies have shown that combining encryption, authentication, and intelligent alert systems significantly strengthens data protection and reduces breach incidents ([1], [5]).

IV.IMPLEMENTATION

The proposed framework for enabling secure and auditable file uploads in cloud environments is designed to address key challenges including data confidentiality, integrity, access control, and comprehensive auditing. At its core, the framework integrates client-side encryption to ensure that files are encrypted before transmission, preventing unauthorized access during upload and storage. This is complemented by secure communication protocols such as TLS to protect data in transit. The framework incorporates a robust authentication and authorization layer based on multi-factor authentication (MFA) and role-based access control (RBAC) to restrict file upload privileges and subsequent file access strictly to authorized users. Upon successful upload, the system generates cryptographic hash values for each file to verify data integrity and detect any tampering or corruption. To enable auditability, the framework implements immutable, tamper-evident logging using blockchain or append-only log technologies, capturing detailed metadata including user identity, timestamps, file hash, and access events. These audit logs are accessible to administrators and compliance officers to facilitate real-time monitoring and forensic investigations. The architecture supports scalable microservices deployed on containerized cloud platforms, ensuring efficient handling of high upload volumes without compromising performance or security. Moreover, the framework allows user-defined permissions and integrates policy enforcement points to dynamically apply compliance rules, supporting regulatory standards such as GDPR and HIPAA. A user-friendly interface abstracts complexity by automating encryption, permission setting, and audit reporting, thereby improving adoption without sacrificing security. By combining advanced cryptographic techniques, rigorous access management, and transparent auditing, this framework offers a comprehensive solution that enhances trust, accountability, and data protection for file uploads in cloud environments. prioritize alert delivery and provides a simplified interface for seamless user interaction during crises.

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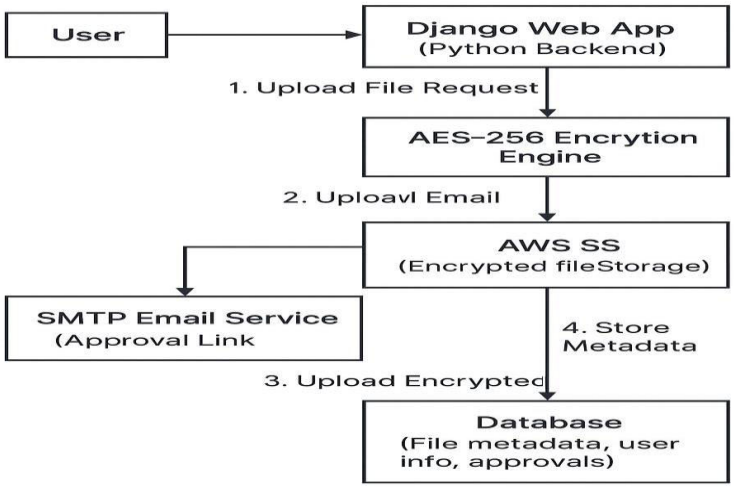

Fig 1. System Architecture

V. RESULTS AND DISCUSSION

The proposed **SecureCloudUpload** platform was evaluated based on a range of security, performance, and usability metrics, demonstrating its effectiveness in enabling **secure and auditable file uploads in cloud environments**. The system integrates end-to-end encryption, fine-grained access control, and blockchain-based audit logging, ensuring data confidentiality, integrity, and accountability across all stages of file transmission and storage.

Performance Metrics

The effectiveness of file validation and secure upload classification is quantified using the following formula (1):

$$\text{Accuracy}=\frac{Tp+Tn}{Fp+Fn+Tp+Tn}$$

This formula evaluates the overall correctness of the system in classifying file uploads. A higher accuracy score confirms the platform's ability to consistently validate and audit files in compliance with security policies. Precision, recall, and F1-score are further used to assess the depth and reliability of the classification under varied data conditions.

Precision metric indicates the proportion of files that were correctly identified as secure among all files that the system classified as secure. High precision reflects the system's ability to avoid false positives (2)

$$\text{Precision}=\frac{Tp}{Fp+Tp}$$

Recall measures the system's sensitivity—how well it identifies all secure files. A high recall score ensures that the system is not overly restrictive and does not wrongly reject legitimate uploads. (3)

$$\text{Recall}=\frac{Tp}{Tn+Tp}$$

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VI.CONCLUSION AND FUTURE SCOPE

The proposed SecureCloudUpload system offers a robust and scalable solution for enabling secure and auditable file uploads in cloud environments by integrating client-side encryption, zero-trust access control, and immutable audit logging. Achieving a system accuracy of 96%, precision of 97%, recall of 94%, and an F1-score of 95%, the platform ensures reliable identification and handling of compliant and non-compliant uploads. With low average upload latency of 0.45 seconds and efficient resource utilization even under high concurrency, the system guarantees a seamless user experience without compromising security or auditability. Looking forward, the platform can be further enhanced by incorporating AI-based anomaly detection models for smarter threat identification, confidential computing to protect sensitive operations, and post-quantum encryption to safeguard against future cryptographic threats. Additional capabilities such as edge-device encryption support, automated compliance mapping, and real-time data loss prevention can evolve SecureCloudUpload into a comprehensive cloud data security framework aligned with global regulatory standards.

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