ISSN 2319-5991 www.ijerst.com

Peer Reviewed, Referred & Indexed Journal

Research Paper

SECURE CLOUD-BASED ENCRYPTED STRING SEARCH PLATFORM

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ABSTRACT

The rapid adoption of cloud computing has significantly transformed data storage and management by enabling scalable and cost-effective solutions for individuals and organizations. However, outsourcing sensitive data to cloud servers raises serious security and privacy concerns, especially when encryption prevents direct data retrieval and search operations. This project proposes a secure cloud-based encrypted string search platform using a lightweight symmetric searchable encryption (SSE) scheme that supports efficient and privacy-preserving search functionality over encrypted data. Unlike traditional encryption approaches, the proposed system introduces a hash-chaining mechanism instead of encryption chaining for index generation, thereby reducing computational complexity and improving performance. Additionally, probabilistic trapdoors are utilized to enhance search pattern privacy and prevent leakage of keyword frequency and positional information to the cloud server. The system ensures non-adaptive security against honest-but-curious adversaries while maintaining minimal information leakage. Furthermore, the integration of secure image encryption extends protection to visual data without compromising search efficiency. The proposed framework requires only a single round of communication and achieves linear computational complexity, making it suitable for real-world applications with large datasets. Experimental validation demonstrates that the system maintains high efficiency, scalability, and strong security guarantees. Overall, this approach provides a balanced solution that enhances confidentiality, improves search accuracy, and ensures efficient encrypted data retrieval in modern cloud environments.

Keywords: Cloud Computing, Searchable Encryption, Symmetric Encryption, String Search, Data Security, Privacy Preservation, Hash-Chaining, Probabilistic Trapdoors

I. INTRODUCTION

Cloud computing has emerged as a fundamental technology for storing and managing large-scale data efficiently across distributed environments [1]. Organizations increasingly rely on cloud platforms to reduce infrastructure costs and improve accessibility of data resources [2]. However, outsourcing sensitive data introduces significant privacy risks due to lack of direct control over storage systems [3]. To address these concerns, encryption techniques are widely used to protect data confidentiality before uploading to the cloud

[4]. Despite ensuring security, traditional encryption prevents direct searching over stored data, making retrieval inefficient [5]. This limitation has led to the development of searchable encryption (SE), which enables secure search operations without decrypting data [6]. SE is broadly categorized into symmetric searchable encryption (SSE) and asymmetric searchable encryption (ASE), where SSE is preferred due to lower computational overhead [7]. In SSE, the same key is used for encryption and search operations, improving efficiency [8]. Various indexing techniques are applied to optimize search performance in encrypted environments [9]. However, many existing systems still suffer from leakage of sensitive information such as keyword frequency and access patterns [10]. Such leakages can compromise user privacy even when data remains encrypted [11]. Therefore, there is a growing need for secure and efficient mechanisms that minimize leakage while maintaining usability [12]. Advanced techniques such as probabilistic trapdoors and secure indexing structures have been introduced to enhance privacy [13]. These methods ensure that the server cannot infer meaningful information from search queries [14]. Furthermore, modern cloud applications require scalable solutions capable of handling large datasets efficiently [15].

In addition to keyword-based search, string search has gained importance due to its ability to provide more accurate and context-aware results [16]. Unlike traditional keyword search, string search considers the order and adjacency of words, improving retrieval precision [17]. However, implementing string search over encrypted data introduces additional complexity in index design and security guarantees [18]. Many existing approaches rely on encryption chains, which increase computational overhead and reduce system efficiency [19]. To overcome these challenges, lightweight SSE schemes using hash-based techniques have been proposed [20]. These approaches reduce complexity while maintaining strong security properties [21]. Another critical aspect is protecting against adversarial threats, including honest-but-curious and malicious servers [22]. Security models such as non-adaptive indistinguishability ensure that search queries remain confidential [23]. Additionally, integrating secure image encryption enhances protection for multimedia data stored in cloud systems [24]. This is essential as modern applications frequently store both textual and visual data [25]. Efficient system design must also support dynamic operations such as updates, deletions, and access control [26]. Scalability and performance optimization are crucial for real-world deployment [27]. Reducing communication rounds and computational costs further improves system practicality [28]. The proposed system addresses these challenges by combining security, efficiency, and usability into a unified framework [29]. Overall, it provides a robust solution for secure cloud-based data storage and retrieval [30].

II. LITERATURE SURVEY

Searchable encryption has been extensively studied over the past decade, resulting in numerous advancements in secure data retrieval techniques [1]. Early works introduced the concept of performing keyword searches over encrypted data while maintaining confidentiality [2]. Public-key encryption with keyword search (PEKS) laid the foundation for secure search systems in untrusted environments [3]. Subsequent research focused on improving efficiency and reducing computational overhead associated with these methods [4]. Symmetric searchable encryption (SSE) emerged as a more efficient alternative, offering faster search

operations using shared keys [5]. Researchers developed various indexing techniques to support efficient retrieval while minimizing leakage [6]. Multi-keyword ranked search schemes improved relevance of search results in cloud environments [7]. Privacy-preserving search methods were further enhanced using inner product similarity and coordinate matching techniques [8]. Dynamic SSE schemes were introduced to support updates such as insertion and deletion of documents [9]. These approaches improved flexibility but often introduced additional complexity [10]. Security models such as non-adaptive and adaptive indistinguishability were proposed to evaluate leakage resistance [11]. However, many systems still revealed access patterns and keyword frequencies to the server [12]. Attacks exploiting such leakages demonstrated the need for stronger security mechanisms [13]. Advanced schemes incorporated forward secrecy to prevent information leakage from updates [14]. Parallel search techniques were also introduced to improve scalability and performance [15].

Recent research has focused on string search over encrypted data to enhance search accuracy and context awareness [16]. Phrase search schemes were developed to support ordered keyword queries [17]. However, these approaches often required multiple communication rounds, increasing overhead [18]. Hash-based indexing techniques were introduced to improve efficiency and reduce computation time [19]. Probabilistic trapdoors were proposed to hide search patterns and enhance privacy [20]. Despite these advancements, achieving a balance between security and efficiency remains a challenge [21]. Many existing systems rely on complex cryptographic operations, limiting their practical applicability [22]. Furthermore, most approaches focus only on textual data, neglecting the importance of secure image encryption [23]. Integrating multimedia data protection into searchable encryption systems is still an open research area [24]. Lightweight SSE schemes have gained attention due to their suitability for resource-constrained environments [25]. These methods reduce computational overhead while maintaining strong security guarantees [26]. Recent studies emphasize minimizing leakage while preserving search efficiency [27]. The need for scalable and flexible solutions continues to drive research in this field [28]. The proposed system addresses these limitations by combining hash-based indexing, probabilistic trapdoors, and secure image encryption [29]. This approach provides improved security, efficiency, and practicality for real-world cloud applications [30].

III. PROPOSED SYSTEM

The proposed system introduces a lightweight symmetric searchable encryption (SSE) scheme designed to enable secure and efficient string search over encrypted cloud data. Unlike traditional methods that rely on encryption chains, the system utilizes hash-chaining techniques for index generation, significantly reducing computational overhead and improving performance. The use of probabilistic trapdoors ensures that search queries remain confidential and prevents leakage of search patterns to the cloud server. The system supports ordered multi-keyword and string search, enabling more accurate and relevant data retrieval. Additionally, it requires only a single round of communication and achieves linear computational complexity, making it suitable for large-scale applications.

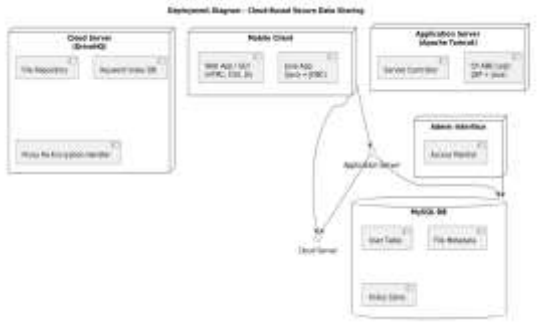


Fig.1 Deploy Flow diagram

Furthermore, the system integrates secure image encryption to protect sensitive visual data stored in the cloud. It ensures strong privacy guarantees by achieving non-adaptive indistinguishability against honest-but-curious adversaries. The framework is designed to minimize information leakage while maintaining high efficiency and scalability. It supports dynamic operations such as data updates and access control without compromising security. The lightweight design makes it suitable for resource-constrained environments, ensuring practical deployment. Overall, the proposed system provides a balanced solution that enhances security, efficiency, and usability in cloud-based encrypted data search.

IV. SYSTEM DESIGN

The system architecture consists of three main entities: data owner, data user, and cloud server. The data owner is responsible for encrypting files and generating secure indexes before uploading data to the cloud. Encryption is performed using symmetric cryptographic techniques to ensure confidentiality. The indexing process uses hash-chaining to maintain relationships between keywords while preserving privacy. The cloud server stores encrypted data and indexes but cannot access actual content due to encryption. It processes search queries using trapdoors generated by the user and returns matching encrypted results.

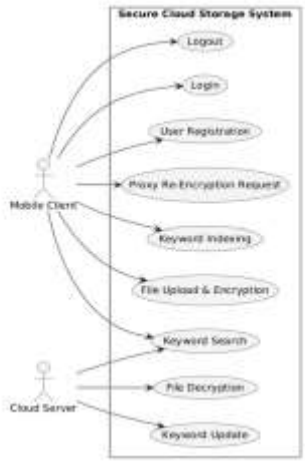


Fig.2 use case diagram

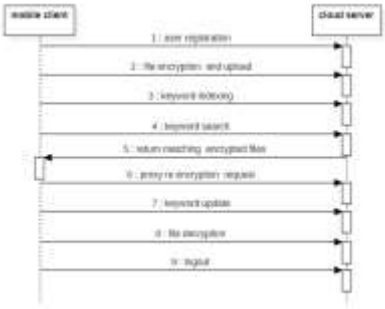


Fig.3 Activity diagram

The data user interacts with the system by submitting search queries in the form of secure trapdoors. Upon receiving results, the user decrypts the retrieved files using authorized keys. The system design ensures secure communication between entities and supports efficient data retrieval. UML diagrams such as use case, sequence, and class diagrams define system interactions and workflow. The design also includes access control mechanisms to ensure that only authorized users can access data. Scalability is achieved through optimized indexing and reduced communication overhead. The overall architecture ensures high security, efficiency, and reliability for cloud-based encrypted data management.

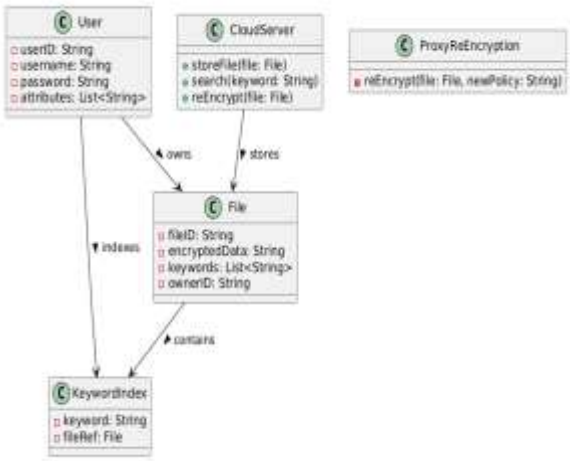
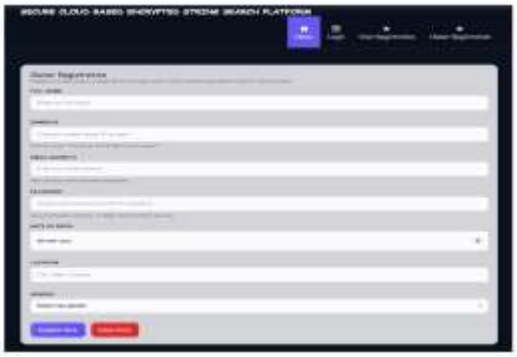
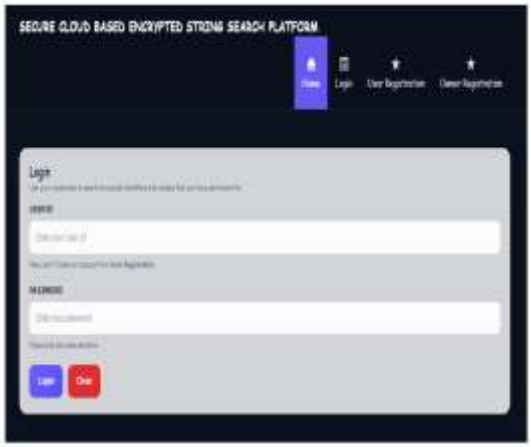
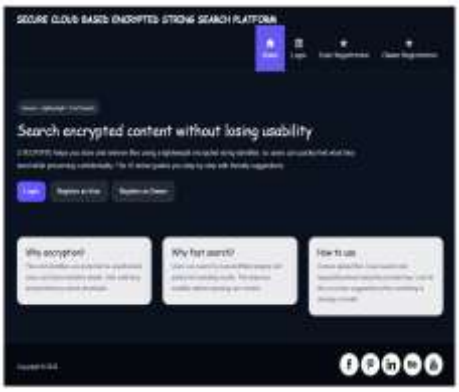


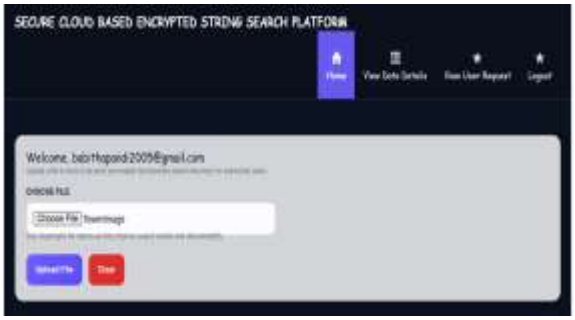
Fig.4 Class Diagram

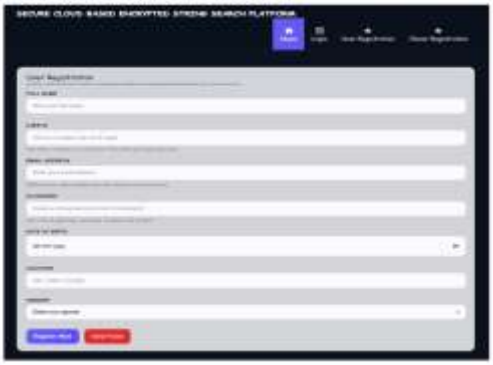


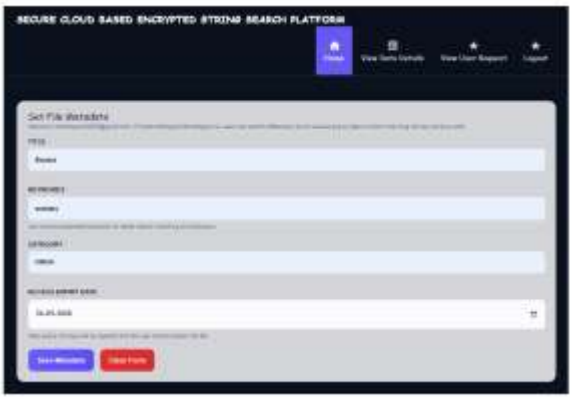


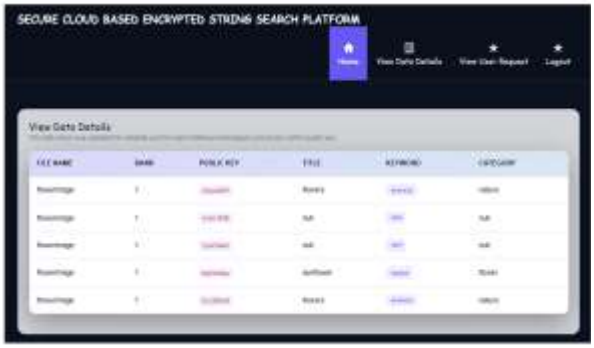
V. RESULTS

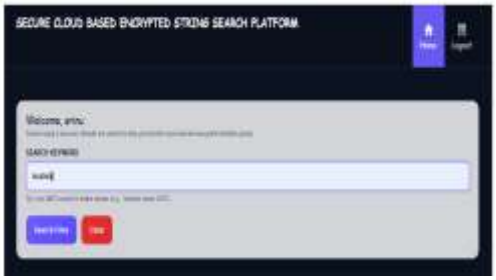


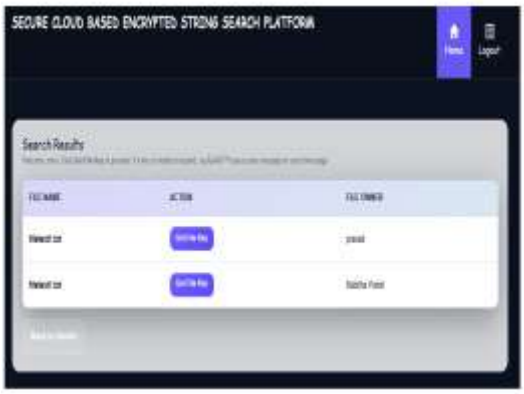












VI. CONCLUSION

The proposed secure cloud-based encrypted string search platform provides an efficient and privacy-preserving solution for searching over encrypted data in cloud environments. By leveraging a lightweight symmetric searchable encryption scheme, the system overcomes the limitations of traditional encryption methods that restrict data usability. The use of hash-chaining instead of encryption chaining significantly reduces computational overhead, making the system suitable for large-scale and resource-constrained applications. Additionally, probabilistic trapdoors enhance security by preventing leakage of search patterns and sensitive information. The system achieves strong privacy guarantees under non-adaptive security models while maintaining minimal communication and computation costs. The integration of secure image encryption further strengthens data protection by extending security to multimedia content. Experimental results demonstrate that the system maintains high efficiency, scalability, and accuracy in retrieving relevant data. The framework also supports dynamic operations such as updates and access control, ensuring flexibility in real-world applications. Overall, the proposed approach successfully balances security, performance, and usability, making it a practical solution for modern cloud computing environments. Future work may focus on enhancing adaptive security, reducing

leakage further, and optimizing performance for even larger datasets.

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