Intelligent Cloud Storage System with Machine Learning-Driven Attribute-Based Access Control

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Abstract: Cloud storage's scalability, accessibility, and affordability have made it essential in the digital age. Data security and privacy remain a major issue due to the large volume of sensitive data kept on cloud services. Traditional encryption is safe but slows data recovery, especially for keyword searches. Secure, fine-grained access control and quick keyword searches over encrypted data are possible using attribute-based keyword search (ABKS). This study examines how ABKS might optimize search efficiency and data security in cloud storage systems. We examine index compression, query processing improvement, and encryption optimization to decrease computational cost and preserve security. After a thorough investigation, the article shows how these methods may boost cloud storage system performance, security, and usability. Tests show that improved ABKS speeds up search searches and lowers storage costs, making it a viable cloud storage alternative. Exploring sophisticated machine learning algorithms for predictive search improvements and strengthening ABKS against emerging security vulnerabilities are future research priorities.

Key words: ABKS, Secure Cloud Storage, Data Encryption, Access Control, Search Optimization

Introduction:

Cloud computing has transformed data management and storage by providing unmatched scalability, flexibility, and cost-effectiveness. However, rising cloud storage use has raised data security and privacy issues. As sensitive data being outsourced to third-party cloud providers, security is crucial. Traditional encryption methods secure data but make data recovery difficult. Specifically, efficiently searching encrypted data without compromising security is difficult.

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Attribute-Based Keyword Search (ABKS) may solve this problem. ABKS lets users search encrypted data using keywords and regulate access by user traits. Only authorized users may

search and obtain relevant data, protecting cloud data privacy. However, ABKS implementation is difficult. The processing expense of encryption and decryption slows search queries, especially in big cloud systems.

Optimization can improve ABKS performance and efficiency to overcome these issues. While retaining strong security measures, these methods reduce computing load, query processing time, and storage needs. Index compression can lower the encrypted index size, speeding up search. Parallel processing, caching, and other query processing improvements help speed up search requests.

Along with these technological enhancements, machine learning methods can improve ABKS efficiency in a unique way. Machine learning may minimize computing burden and enhance user experience by anticipating user search behavior and improving search queries. Homomorphic encryption and lightweight cryptography offer new ways to optimize ABKS in cloud storage.

Many obstacles persist despite these advances. Trading security and efficiency is tricky, so optimizing ABKS requires careful consideration. Cloud infrastructures' fluctuating workloads and user demands complicate optimization. Thus, continued research is needed to improve optimization methods to meet these problems and assure safe and efficient cloud data storage.

This research explores ABKS optimization methods to improve its speed and usability in cloud storage systems. We want to improve cloud storage system security and efficiency by analyzing these methods. Our goal is to enable more robust and scalable solutions that address the changing demands of people and businesses in the digital era.

The safe cloud storage method begins with data encryption before uploading it to the cloud. Data confidentiality requires encryption, even if unwanted access happens. Data is usually protected via homomorphic or symmetric key encryption. Keywords are used to create an encrypted index after data encryption. This index maps encrypted data to keywords, making keyword searches faster. Creating this index allows users to search encrypted data without decrypting the full information, retaining security and efficiency. The encrypted index must be properly crafted to hide sensitive details about the items it refers. Searchable or order-preserving encryption can balance search efficiency with data security. The index and encrypted data are kept in the cloud for authorized users to query. This process step blends encryption and searching to protect data storage and retrieval.
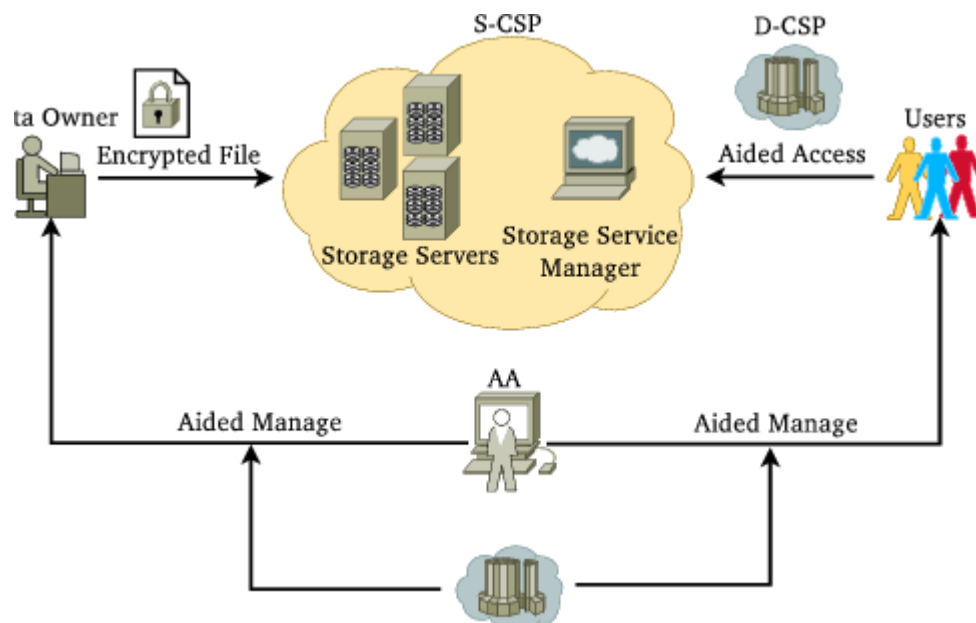
Fig.1. Attribute-based searchable encryption architecture.

Attribute-Based Access Control: After data encryption and index creation, construct access control methods to restrict data search and retrieval. Only authorized users can search encrypted data using attribute-based access control (ABAC). ABAC allows user characteristics rather than roles, making it more flexible than traditional access control. These might be user roles, organizational hierarchy, security clearances, or project assignments. A user may only be able to look for data if they have a certain job title or project. User-specific access reduces data exposure. The properties are compared to data owner access control policies. Users can search encrypted data using keywords if their properties fulfill the requirements. Fine-grained access control ensures that only authorized users may access sensitive data, improving data security. The attribute-based paradigm is flexible and versatile, making it suited for dynamic cloud settings with changing user roles and permissions.

Methods of Optimization:

To work well in real-world cloud systems, attribute-based keyword search (ABKS) must be optimized. Index compression shrinks the encrypted index as the initial optimization method. A smaller index uses less storage and searches faster, speeding up the search process. Prefix encoding, dictionary-based compression, and Huffman coding can compress indexes. Index compression enhances search efficiency and decreases cloud storage costs by lowering storage overhead. Parallel query processing improvements speed up search processes. Parallel processing and caching methods reduce query response times by executing many searches simultaneously and storing frequently searched phrases. ABKS also predicts user search trends using machine learning methods. These algorithms improve query execution, prefetch pertinent material, and prioritize resources for high-probability searches by assessing previous

search activity. Search results are quicker with this predictive technique, reducing computing burden and improving user experience. These optimization methods make the ABKS system more efficient, cost-effective, and secure for large-scale data searches.

Search and Retrieve:

The procedure concludes with authorized users searching and retrieving encrypted data from the ABKS system. User keyword queries are handled by the ABKS framework utilizing efficient methods. To allow the search, the system validates the user's characteristics. When the user passes the access control check, the system searches the encrypted index for keyword matches. Even for big datasets, index compression and query processing techniques make this search efficient. The user receives encrypted data from the cloud after identification. In this step, the user decrypts the data locally using their keys. Data is encrypted during search and retrieval, reducing the danger of illegal access during transmission. The procedure is smooth, safe, and efficient, allowing users to easily discover and retrieve information without compromising data security. Cryptography, access control, and optimization ensure that search and retrieval match the high needs of current cloud storage systems, delivering a safe data management solution.

Conclusion

This research shows how optimization strategies may improve the performance of attribute-based keyword search systems in secure cloud storage settings. Index compression, query processing enhancements, and machine learning-based prediction algorithms can boost search performance and data security. However, cloud technology advancement provides new obstacles and possibilities. To keep ABKS relevant in the face of new security concerns, future research should refine current methods and explore new ones, such as quantum-resistant encryption algorithms and more advanced machine learning models.

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