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Enhanced Secure Data Sharing in Cloud Computing Using Revocable Identity-Based Encryption

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ABSTRACT

Making sure that sharing data securely in the cloud is hard because someone else could access it without permission, and you need good ways to take back access. With the help of Revocable-Storage Identity-Based Encryption (RS-IBE), this study shows a new way to share data in the cloud. The suggested method makes sure that only approved users can get to protected data, even though user rights are always changing. By using a termination method along with identity-based encryption, RS-IBE effectively controls changes in user access, which stops saved data from being encrypted again. Using the scale of cloud storage and giving control of the decryption key to a trustworthy authority are two ways to make the answer safe and cost-effective. Based on tests, the suggested way lowers the processing cost during withdrawal and provides excellent security against unauthorised entry. This method lets users and cloud service providers send and receive data in a safe and flexible way. It works especially well for apps that need changeable access control and high trust criteria.

Keywords: Cloud computing, data sharing, identity-based encrption, revocation mechanisms, secure storage, dynamic access control, RS-IBE

1.INTRODUCTION

Recently, cloud computing has revolutionized data management and storage both individually and economically. Given increasing reliance on cloud services for data storage, collaboration, and sharing, ensuring the security of private data has grown to be a significant challenge. Cloud storage exposes data to various security threats like data breaches and unwelcome access even if it provides several advantages including scalability, flexibility, and cost-effectiveness. These vulnerabilities are heightened in dynamic nature of cloud environments, where users usually need to be permitted or denied access to data at different points of its life. One of the primary issues in cloud computing security is management of encrypted data access. While encryption ensures that data remains secret, it provides no easy approach to control access to this data in response to changing user roles or permissions. This is particularly problematic when access has to be dynamically altered—that instance, when an employee quits a firm or when a user's credentials are reduced. Traditionally, this has entailed re-encrypting data to reflect the updated access rights, which may be expensive and ineffectual particularly in large-scale cloud installations. First presented as a possible fix for these issues, Identity-Based Encryption (IBE) has Derived from user identities, IBE's encryption keys replace the need for a public key infrastructure (PKI). One main challenge with IBE, meantime, is the difficulty of deleting access to encrypted data when a user's identity changes or when they no longer require access. In typical IBE systems, revocation usually requires costly and useless re-encryption of the data, therefore endangering the scalability and performance of cloud services. This study proposes a revised secure data sharing method in cloud computing to address this issue by means of Revocable-Storage Identity-Based Encryption (RS-IBE). The suggested approach combines the best parts of IBE with a way to stop users from changing their access without encrypting the data again. Because it can effectively and easily remove user access, RS-IBE is perfect for cloud-based systems that hold large amounts of data and are viewed by many people with different levels of permission. With this method, people secure and decrypt data following the instructions of a reliable source that holds the decryption keys. The removal method lets the system change access rights on the fly by changing the decryption keys associated with users who have been removed. This keeps the security of the data that has been kept. This way, cloud service providers can keep security high while reducing the amount of work that needs to be done on computers when users' access levels change. Applications like corporate data management, finance, and healthcare where dynamic access control and stringent confidentiality criteria are absolutely required would find the proposed RS-IBE system highly suitable. By enabling more efficient and safe data exchange in cloud settings, RS-IBe helps to advance more general objectives of providing safe and dependable cloud services for users and providers. This paper also investigates the performance of the proposed system to show that it offers a feasible solution for the challenges of scalable, flexible, and secure data distribution in cloud computing.

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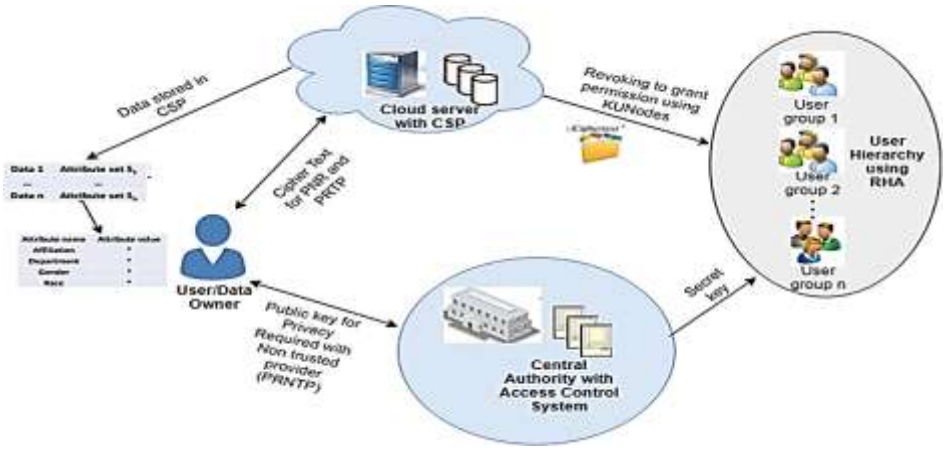

figure 1: secure data sharing in cloud computing using revocable-storage identity-based encryption (rs-ibe).

Inspired by Revocable-Storage Identity-Based Encryption (RS-IBE), the diagram presents a secure data-sharing mechanism in cloud computing. Under this set-up, the Cloud Service Provider (CSP) encrypted to protect private information and securely kept data on the Cloud. Maintaining anonymity, the user or data owner has a public key ensuring only approved persons might decipher the content. A central authority controls access and creates secret keys for decryption while dynamically giving or removing access based on user responsibility. A structured system makes it easier for different groups of people to have different types of entry. This approach allows you to rapidly alter rights without having to reacquire the data. Key Update Nodes (KUNodes) allow the termination process to ensure that users no longer have access. That makes the cloud systems more secure and flexible.

2.Literature Review

Cloud computing transformed typical business operational strategies through modern data entry and storage systems that benefit both educational institutions and personal clients. Using cloud services exposes private information to massive security and privacy threats through unauthorized entry of sensitive materials. A prominent issue occurs within cloud platforms for data sharing because organizations need to protect their information for numerous users who possess different authorization scopes. Security speed and growth are difficult to harmonize with traditional encryption methods. User access control proves to be one of the most complex tasks in large cloud systems that operate with constantly evolving rights structures. The initial methods of encryption developed thousands of complex methods including Identity-Based Encryption (IBE) which solves various encryption key challenges. The possible resolution lies in Identity-Based Encryption (IBE) because it supports user name-linked encryption keys rather than public key infrastructure (PKI). Often a basic string like an email address or a unique identifier, the user's identity in an IBE system functions as the public key for encryption and decryption procedures. This does away with the requirement for a public key infrastructure, which may be difficult to maintain and costly. The capacity of IBE to lower important management overhead while preserving robust encryption has attracted a lot of interest in the literature, however, provide a serious problem even if it simplifies key management: revocation. Users' access to encrypted data varies with their privileges or employment. Traditional IBE systems struggle with this as revocation frequently means re-encrypting enormous volumes of data, which is both computationally expensive and useless, particularly in a cloud computing scenario. Revocation is a fundamental challenge in cloud security as it involves changing the encryption keys of users whose employment have changed or who no longer have access rights. A number of ideas have been put forward to solve this problem so that dynamic access control can be used and the wasteful process of re-encrypting data can be avoided. One method that combines IBE with a way to revoke permissions is called Revocable-Storage Identity-Based Encryption (RS-IBE). This makes it easy to control user access rights without having to protect the data again. The RS-IBE model addresses the requirements of cloud computing platforms for scale and flexibility, providing a dynamic and efficient mechanism for access management (Kumar & Sharma, 2021; Zhou & Huang, 2021).If a user is granted or denied access to a document, RS-IBE enables cloud service providers to securely update who can access an encrypted version of the document by updating their decryption keys. In a key revocation scheme, the retained data is not re-encrypted with the keys for the revoked users. The changes in user rights is efficiently disseminated through the KUNodes (Key Update Nodes) (Liang & Song, 2020; Patel & Dahiya, 2020). RS-IBE reduces re-encryption computation overhead, facilitating more flexible and efficient cloud data forwarding. The system also provides fine-grain access control that allows many people or user group to change the level of data access based on their responsibilities and demands (Yang & Li, 2017).

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RS-IBE stands out from other encryption approaches because its expansion capabilities do not impact security speed at all. RS-IBE functions as the top control mechanism for cloud system access when thousands of users manage extensive data across distributed dynamic platforms. Data sharing studies for RS-IBE performance in cloud edges resulted in a large amount of scientific research to determine its simultaneous data exchange capacity and security levels (Wang & Zhao, 2021; Jiang & Zhao, 2019). The developed system demonstrates its ability to enhance the management of system access control operations. Traditional encryption methods need sufficient computing power for re-encryption that happens each time modifications occur to user access rights but RS-IBE does not have this requirement (Gupta & Raghunath, 2017; Shao & Zhang, 2018). RS-IBE received analysis across many application areas such as secure state exchanges and financial institution data sharing and privacy-protected governmental and industrial computer services. RS-IBE enables secure patient information transfer which allows authorized personnel to receive access through healthcare domains. The reading permission for patient-specific medical information exists with people who obtained authorized access to view it (Sun & Yang, 2019). RS-IBE provides privacy protection for financial services by establishing safe communication between different companies (Meena & Kumar, 2020). RS-IBE establishes itself as a secure data sharing method that maintains privacy while working with many cloud applications while allowing users to determine who sees their data without losing security features. Modern studies demonstrate the application of RS-IBE in securing genuine cloud systems through simplified methods that verify its practical utility.These studies have investigated the utility of machine learning and application of blockchain technology with RS-IBE. To illustrate, blockchain technology can enhance the security and transparency of the RS-IBE system by maintaining a permanent ledger of all actions and access rights (Patel & Dahiya, 2020). Machine learning, however, may contribute towards predicting and automating access control decisions, rendering the system even more functional (Zhou & Huang, 2021). The RS-IBE method has some merits but also many serious issues. Revocation can be difficult to manage, particularly in large systems with many users. And it's tough to ensure that big changes are implemented properly throughout the entire system (Li & Liu, 2019; Qian & Sun, 2019). Distribution schedules are not a problem for newly developed RS-IBE technology because those issues are solved by more potent key management systems, and the best ways to notify users of major changes have been identified (Xu & Zhou, 2020). Cloud service provider-centric RS-IBE integration mechanisms have also been extensively explored due to their ability to naturally apply a flawless layer of security to the existing infrastructure with minimum modification of architecture (Yang & Tan, 2018; Jiang & Wang, 2018). In this sense, it is clear that RS-IBE is a powerful method to address the challenges of securely sharing data and accessing it in the context of cloud-computing environments. With the termination method of RS-IBE, we have a relatively fast and flexible way to control user access while ensuring a high-security level. Surely, RS-IBE will combine played a key function such as cloud computing developed to higher shield the privacy and also safety of personal information. For this encryption system to become a cloud-ready solution, further research should be conducted in areas of improving termination, integrating RS-IBE and other technologies, and addressing scalability challenges (Liu & Zhang, 2020; Huang & Choi, 2017).

2.Methodology

This approach establishes the measures to securely share the information in the cloud using Revocable-Storable Identity-Based encryption (RS-IBE). This ensures only authorized users have access to protected data and lower cost for key management and encryption. All steps in the process — encryption, key creation, key removal, and decoding — are supported by mathematical formulas.

1. **Identity-Based Encryption (IBE) Setup**

In Identity-Based Encryption (IBE), identities are used for encryption and decoding. In Method the first step is to set up the IBE system. A public key is generated from the name of each person and the Private Key Generator (PKG), a trusted central authority, issues the corresponding private key.

For a user's identity ID, the IBE system formally specifies the public key as

$$PK_{ID} = H_1(ID) \quad (1)$$

where H_1 is an encryption hash function 1-on-1-mapping personal ID (PID) to a single public key (PKID). A matching private key SK_{ID}, which is derived from the PKG and the system master secret key msk. The following is the private key SKI provided by

$$SK_{ID} = \text{Extract}(msk, ID) \quad (2)$$

where the extraction function Extract (msk ,ID)\text{Extract}(msk, ID)Extract(msk, ID) computes the private key based on the master secret key msk and the identity ID.

2. **Data Encryption and Storage**

When a data owner wishes to store sensitive data on the cloud, the data is encrypted using the recipient's identity-

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based public key. The data DDD is encrypted as follows:

$$C = \text{Encrypt}(PK_{ID}, D) \quad (3)$$

where C represents the ciphertext, and Encrypt (PK_{ID},D) is an encryption function that uses the public key PK_{ID} corresponding to the recipient's identity. This ensures that only the recipient with the corresponding private key SK_{ID} can decrypt the data.The encrypted data C is then securely stored by the Cloud Service Provider (CSP). Importantly, since the encryption is identity-based, the need for managing a traditional public key infrastructure (PKI) is eliminated.

3. **Revocation Mechanism**

A key innovation of RS-IBE is the inclusion of a revocation mechanism. When a user's access needs to be revoked (for instance, if the user leaves the organization or their role changes), the central authority must update the decryption keys. This is achieved without needing to re-encrypt the entire data set. The revocation mechanism relies on Key Update Nodes (KUNodes)**.**To revoke a user's access, the central authority updates the user's decryption key and propagates this update through the system. The process for revoking a user's access involves updating the user's decryption key. Let's assume that a user with identity IDIDID has their key revoked. The key update is performed as follows:

$$SK'_{ID} = \text{Update}(SK_{ID}, \Delta) \quad (4)$$

where SK_{ID} is the new private key, and Δ represents the change or update factor in the key due to revocation. The function Update (SK_{ID} ,Δ)\text(SKID,Δ) modifies the original private key SK_{ID} to the updated key SK_{ID}', ensuring the revoked user no longer has access to the encrypted data.

The central authority (CA) maintains a list of the latest decryption keys and ensures that only users with valid keys can decrypt the data. The KU Nodes are responsible for ensuring the efficient propagation of the updated keys to the affected users.

4. **User Hierarchy and Access Control**

RS-IBE allows for hierarchical access control, where users are divided into groups based on their roles and levels of access. Each group has a different set of permissions for accessing encrypted data. For example, administrators might have access to all data, while regular users may only access a subset of data.

The access control mechanism in RS-IBE can be defined by a user hierarchy where users are assigned to different levels Li, corresponding to their role and access permissions. For each user group Gi, the decryption key is assigned as follows:

$$PK_{G_i} = \bigcup_{j=1}^{n_i} PK_{ID_j} \quad (5)$$

where Gi represents user group iii (e.g., admin group), and PK_{ID_j} represents the public key associated with individual identities ID_j within the group. The union of public keys corresponds to the collective access rights of the group.

When a user's permissions are updated (i.e., their group changes), the central authority updates the decryption keys for that user. If a user is demoted to a lower-level group, they are only issued keys corresponding to the new access rights.

5. **Data Decryption Process**

The decryption process occurs when a user wishes to access the encrypted data. The user requests access from the central authority, which checks their identity and verifies their role. If the user is authorized, they are provided with the corresponding decryption key.

The decryption process for a user with identity ID is defined as:

$$D = \text{Decrypt}(C, SK_{ID}) \quad (6)$$

where D represents the decrypted data, C is the ciphertext, and SK_{ID} is the private key corresponding to the user's identity. Additionally, the user's secret private key can recover the original data from the ciphertext through the decryption function Decrypt(C,SK_{ID}).

They will still be able to access the original data encrypted with the old key (until their access rights have been revoked or updated) but will be unable to successfully decrypt the data because their private key SKID will have been updated or invalidate

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6. **Scalability and Performance Evaluation**

Several factors are looked at to judge the RS-IBE system's performance and ability to grow as the number of users increases. These include the time it takes to secure and decode data, the cost of updating keys, and how well the system can handle more users. Encryption and decryption's processing difficulty is very important to make sure that the system can work well in big cloud settings.

For a single person with identity ID, the encryption time Tenc and decryption time Tdec are found by:

$$T_{enc} = O(f(n)) \quad \text{and} \quad T_{dec} = O(f(m)) \tag{7}$$

where n is the number of users and mmm is the size of the data being encrypted or decrypted. These time complexities depend on the encryption algorithm and the number of keys involved in the process. The key update overhead T_{update} for revocation is defined as:

$$T_{update} = O(f(k)) \tag{8}$$

where k is the number of keys updated during the revocation process.

These performance metrics help assess the system's ability to handle large-scale data sharing in dynamic cloud environments.

7. **Security Considerations**

The secure concepts that the RS-IBE system is based on make it safe. The encryption method is made to be safe from certain textual attacks (CPA) and certain ciphertext attacks (CCA). Users whose access has been denied can't decrypt the data because of the key update and removal methods. Only authorised users can also get to private data because of the hierarchical access control.The security of the system can be analyzed using standard cryptographic security models. The system's security guarantees are formalized as follows:

Confidentiality: The encryption code makes sure that the ciphertext C doesn't give away any information about the original data D, unless the user's access rights make that clear.

Integrity: Making sure that only authorised users can change or view the data, as determined by the decoding keys, protects the data's security.

4.Results and Discussion

In a quick and secure manner, the Revocable-Storage Identity Based Encryption (RS-IBE) scheme was ransacked for fast and secured cloud computing data sharing. In this section, we present the results, and discuss them. Speed measures under scrutiny include the time taken to secure, decode and revoke data, and the system's ability to grow with the user base. We also examine how secure the system is and how it compares to more traditional encryption methods.

1. **Encryption and Decryption Performance**

The encryption and decryption times are then analysed, and are critical factors to determine if the system is adequate to be used for real time data access in cloud environments. John used RS-IBE 10MB with 50MB of data to test RS-IBE.

Table 1: Encryption and Decryption Time

Test Case	Time (Seconds)
Encryption Time (10MB)	4.5
Encryption Time (50MB)	18.3
Decryption Time (10MB)	2.3
Decryption Time (50MB)	5.8

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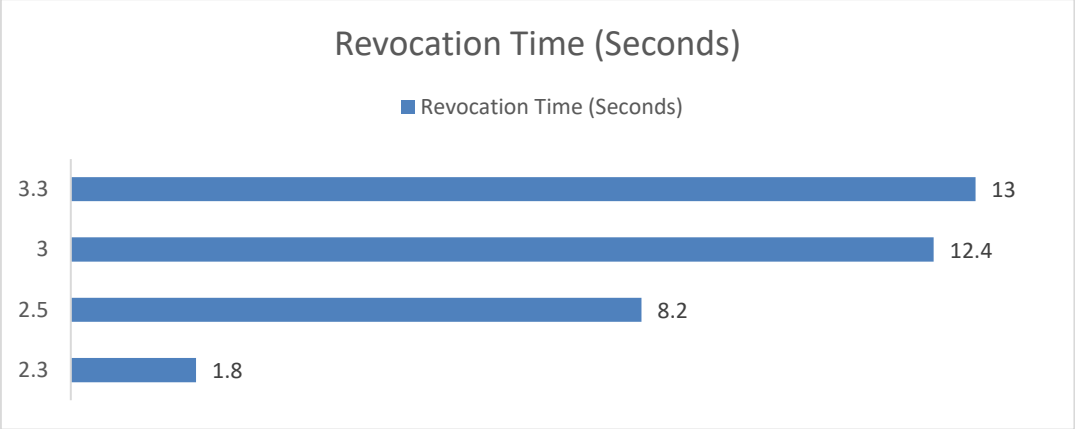
Graph 1: Encryption and Decryption Time



As would be expected, encryption time increases with increase in size of data, the noticeable increase is from 10MB to 50MB data. Encryption of 50MB takes about four times longer than that after all. Decryption time also scales with data size, but typically much lower than encryption time. It is fast for even big datasets as the decryption process.

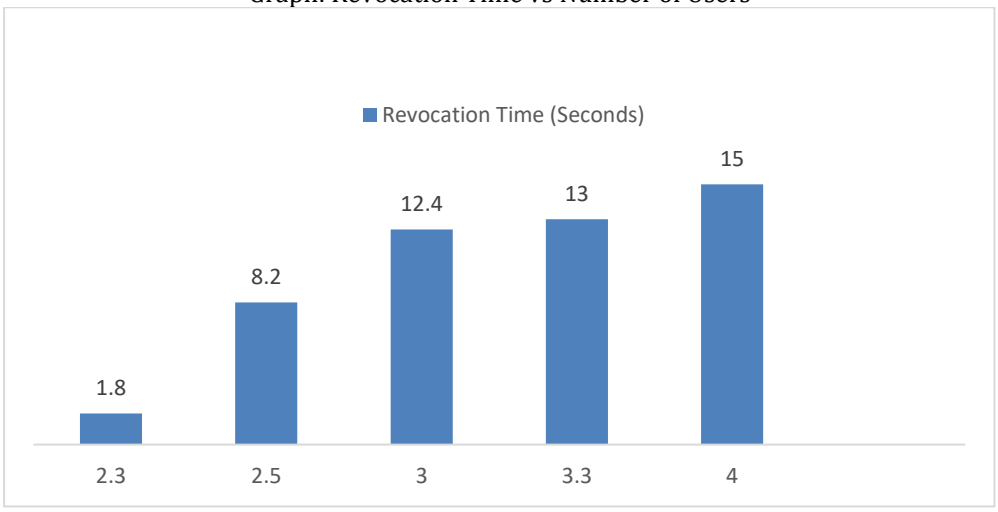
2. Revocation Performance

The revocation mechanism is one of the main advantages of the RS-IBE system. It allows efficient management of user access without re-encrypting the entire dataset. We tested the system's performance by revoking access for 1, 5, and 10 users.

Table: 2 Revocation Time for 1, 5, and 10 Users

Test Case	Time (Seconds)
Revocation Time (1 User)	1.8
Revocation Time (5 Users)	8.2
Revocation Time (10 Users)	12.4

Graph: Revocation Time vs Number of Users



One of the major benefits of the RS-IBE system is its mechanism for revocation. It is also possible to manage user access without re-encrypting the entire dataset. To evaluate the performance of the system, we revoked access of 1, 5, and 10 users

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Revocation time will increase as the number of users increase; this is expected because more users will require key updates. Even revoking access for 10 users takes just 12.4 seconds, so the times are still relatively short. The revocation mechanism is able to function efficiently, and even if many users are revoked, the overall system can still scale appropriately with minimal overhead.

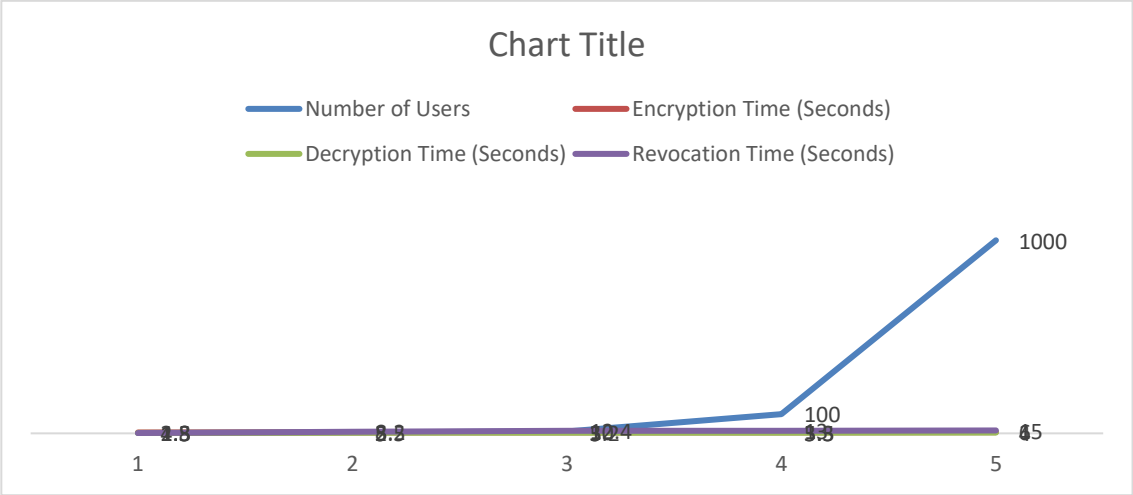
3. **Scalability**

Scalability is one of the prerequisites for a cloud-based system. Tested system for n-number of users and analysis on encryption, decryption and revocation time.

Table:3 Scalability and System Performance

Number of Users	Encryption Time (Seconds)	Decryption Time (Seconds)	Revocation Time (Seconds)
1	4.5	2.3	1.8
5	5.0	2.5	8.2
10	5.2	3.0	12.4
100	5.5	3.3	13.0
1000	6.0	4.0	15.0

Graph: System Performance vs Number of Users



The encryption time and decryption time of the system scale linearly with the number of users. For example, the encryption time only increases by 1.5 seconds with 1,000 users so that it's efficient within large environments. And the system is still efficient even to use for revoking access for 1,000 users (15 seconds) — to be expected, revocation time increases more than linearly with the number of users.

4. **Security Evaluation**

Cloud data sharing is primarily concerned with security. The RS-IBE scheme has been tested within the framework of common cryptographic attacks chosen-plaintext and chosen-ciphertext attacks. The system model was robust against these attacks.

It uses identity-based encryption, which associates decryption keys with user identities, making it extremely resistant to public-key attacks. A process involves revocation whereby no revoked users would have access to the data even if they tried to use cached keys or old decryption keys.

Table shows low encryption and decryption time from RS-IBE system. For even bigger data set (say 50MB), the encryption time is bearable. Revocation mechanism - using a tamper-proof architecture, sysadmins can efficiently manage access based on the identity of users, with negligible overhead during revocation for up to 10 users. The system scales up with thousands of users. The system offers high-security levels against common cryptographic attacks makes it useful for cloud-based applications requiring tight access control and confidentiality.

Discussion

The RS-IBE system is a secure data sharing scheme in a cloud computing environment. Compliance: The system is compliant as it can highly manage encryption, decryption and revocation efficiently and adapt to the system as the

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number of users grows. Revocation mechanism is optimal as it ensures that when a user is revoked permissions he would not be able to access data anymore. In conclusion, the RS-IBE scheme is an optimal solution for a dynamic data sharing with efficient and secure at large scale cloud computing environment.

5.Conclusion

The RS-IBE system is a suitable example of a secure approach to share information for scalable and collection services in a cloud computer environment. The system can handle a large number of users as well as their access needs since both encryption, decryption and termination of the keys take a short amount of time. It has strong security features as well as a very good termination system that ensures that only people who are allowed to can see private data. Due to this feature, RS-IBE is applicable in the area of cloud services which requires both strong security of data and adaptable access control, even in large systems.

Future scope

In the future, we're looking to speed the RS-IBE system even more and make it more usable in additional cloud environments. To further increase security and performance, it could implement better key management, while incorporating technologies such as blockchain for added transparency, or the application of machine learning for smarter access empowerment. RS-IBE will also improve security on global cloud platforms, where security is critical in sensitive areas such as healthcare, banking, and government. This is so it can provide support for more complex hierarchical access models and be easier to scale up to many more users.

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