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SECURE GROUP MANAGEMENT FOR PRIVACY-PRESERVING PUBLIC AUDITING OF SHARED CLOUD DATA

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ABSTRACT:
With the increasing adoption of cloud storage services for data sharing and collaboration, ensuring the privacy and integrity of shared data has become a critical concern. In this context, secure group management techniques play a crucial role in facilitating privacy-preserving public auditing of shared cloud data. This paper presents a novel framework for secure group management, specifically tailored for enabling privacy-preserving public auditing of shared cloud data. The framework leverages cryptographic primitives and access control mechanisms to ensure that only authorized group members can access and audit the shared data while preserving the privacy of individual users. Additionally, the proposed framework incorporates efficient data verification techniques to enable public auditing of cloud data integrity without revealing the underlying content to unauthorized parties. Through extensive experimentation and evaluation, the effectiveness and scalability of the proposed framework are demonstrated, offering a robust solution for secure group management in the context of privacy-preserving public auditing of shared cloud data.

Keywords: adoption, cloud storage, data sharing, collaboration, integrity.

INTRODUCTION :

In the era of cloud computing, the sharing and collaboration of data among multiple users have become increasingly prevalent. However, this trend brings forth significant challenges related to data privacy, integrity, and security. Particularly in scenarios where sensitive information is shared among multiple parties in the cloud, ensuring secure group managementbecomes paramount. Additionally, the need for public auditing of shared cloud data to verify its integrity further complicates the matter, as traditional access control mechanisms may not suffice to protect user privacy while enabling transparent data verification. Addressing these challenges requires innovative solutions that can facilitatesecure group management while preserving the privacy of individual users and ensuring the integrity of shared data.

The concept of secure group management for privacy-preserving public auditing of shared cloud data aims to address these challenges by providing a comprehensive framework for managing group access and facilitating transparent data verification in the cloud. This framework encompasses various components, including cryptographic techniques, access control mechanisms, and efficient data verification methods, to ensure the confidentiality, integrity, and privacy of shared data. By leveraging advanced cryptographic primitives such as attribute-based encryption (ABE) and homomorphic encryption, the framework enables fine-grained access control and secure data encryption while preserving user privacy.Furthermore, the framework incorporates efficient data verification techniques such as proofs of retrievability (POR) and zero-knowledge proofs (ZKP) to enable auditors to verify the integrity of shared cloud data without accessing the actual content. This ensures that data integrity is maintained while preserving user privacy and confidentiality. Additionally, the decentralized nature of group management in the framework enhances scalability and resilience, as it allows for distributed identity management and access control across multiple cloud environments and decentralized systems. This reduces the risk of single points of failure and unauthorized access, enhancing the overall security posture of the system.

In this paper, we present a comprehensive overview of secure group management for privacy-preserving public auditing of shared cloud data, highlighting the challenges, existing approaches, and future directions in this area. We discuss the key components and techniques involved in the proposed framework and explore its implications for enhancing data privacy, integrity, and security in collaborative cloud environments. Through this exploration, we aim to contribute to the ongoing research efforts in secure cloud computing and provide insights into the design and implementation of effective solutions for managing group access and ensuring transparent data verification in shared cloud environments. Auditing and group management solutions in shared cloud environments.

SYSTEM ARCHITECTURE

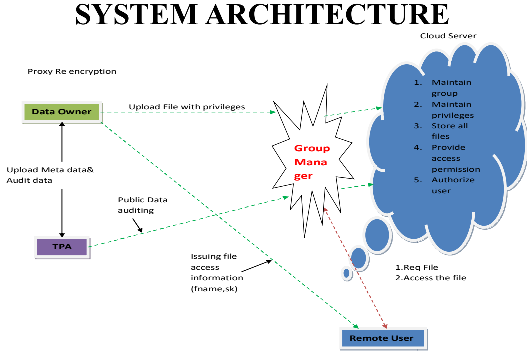

Fig1:System Architecture

METHODOLOGY :

Let groups G_1 and G_T be multiplicative cyclic groups with prime order p,and let $e{:}G_1\times G_1\rightarrow G_T$ be a bilinear map. In addition, g and u are the generators of G_1.Moreover, $H_1{:}\{0,1\}^*\rightarrow G_1$ and $H_2{:}G_T\rightarrow Z^*_p$ are collision-resistant hash functions. Assume that a file F is divided into n data blocks F= $\{m_1\ldots, m_n\}$ and there are w users in the user group U= $\{u_1, u_2,\ldots, u_w\}$,where the user u_1 acts as a group manager (GM) and the others are common users. Let U_L be the set of all legal users, and U_R be the set of all revoked users in the group. Our proposed scheme consists of six probabilistic polynomial-time algorithms: **KeyGen**, **TagGen**, **Update**, **Challenge**, **Prove**, **Verify**, and **Revocation**.

KeyGen. The group manager randomly chooses $a_1\leftarrow Z^*_p$ and calculates $y_1=g^{a1}$ as the manager's secret/public key pair and randomly chooses $a_i\leftarrow Z^*_p$ as the secret key of u_i and calculates $y_i=y_1^{1/ai}$ as the public key of ui.

TagGen. User u_j generates an authenticated tag σ_i on the message block m_i of F as

$\sigma_i=(h_{i,j}\cdot u^{mi})^{aj}$,

where $h_{i,j}=H_1(ID||i||j||v_i||t_i)$, ID is the file identifier of F, v_i is the version number, and ti is the time stamp.User u_j uploads $\{m_i, \sigma_i\}$ to the CSP, and records additional information to the EDHT. When a data block is modified, the group manager adds the operation information into the MRT and asks the TPA to update the additional information of the block in the EDHT.

Update. Suppose that the valid group user u_k modifies the i -thblock m_i to m'_i.Then, u_k computes the authenticated tag σ'_i on the modified block m'_i as

$\sigma'_i=(h_{i,k}\cdot u^{m'i})^{ak}$,

where $h_{i,k}=H_1(ID||i||k||v'_i||t'_i)$,and v'_i and t'_i denote the updated version number and time stamp, respectively. User u_k uploads (m'_i, σ'_i) to the CSP and asks the group manager to update the additional information of the block in the EDHT and MRT.

Challenge. Because the challenge process is the same as that of Tian *et al.*'s scheme, a detailed description is omitted here.

Prove. After receiving the challenge message for the challenged blocks. For the challenge blocks, the CSP calculates the tag proof Φ as

$$\Phi = \prod_{i\in IDX} e(\sigma_i, \gamma_j)^{s_i},$$

where $j\in U_L$ and the i -thblock is modified by the j -thuser. The CSP then calculates the data proof ν1 as

$$\nu_1 = \sum_{i \in IDX} m_i \cdot s_i \cdot H_2(\Theta_1) + r_1,$$

where $r_1 \in Z^*_p$ is a random number, and Θ_1=e (u, y1)^{r1}. These values are used to protect data privacy against the TPA.

For all RU-blocks, the CSP calculates the tag proof T as follows:

$$T = \prod_{i \in D} (e(\sigma_i, \tau_j))^{\beta_i},$$

where $j \in U_R$ and the i -thblock is modified by the j -thuser. The CSP then calculates the data proof ν2 as

$$\nu_2 = \sum_{i \in D} m_i \cdot \beta_i \cdot H_2(\Theta_2) + r_2,$$

where $r_2 \in Z^*_p$ is a random number, and Θ_2=e (u, y_1) ^{r2}.These values are used to protect data privacy against the TPA.

Finally, the CSP sends the proof P= {Φ, T, Λ, ν_1, ν_2, Θ_1, Θ_2} to the TPA.

Verify. With the proofthat P= {Φ, T, Λ, ν_1, ν_2, Θ_1, Θ_2},the TPA verifies the integrity of the chosen blocks. If there is no revoked user or all RU-blocks have been modified by the other users in U_L, the TPA can then verify the correctness of the data file; otherwise, the TPA verifies the post-revocation authenticator by computing the following equation:

$\Lambda = T^{\eta.\epsilon/w}$.

If does not hold, the TPA outputs Reject; otherwise, it can be verified as

$$\Theta_1{}^{w} \cdot \Phi^{H_2(\Theta_1)} = e(\prod_{i \in IDX} h_{i,j}^{s_i \cdot H_2(\Theta_1)} \cdot u^{\nu_1}, y_1)^{w},$$

$$\Theta_2{}^{\eta \cdot w} \cdot T^{\eta \cdot \epsilon \cdot H_2(\Theta_2)} = e(\prod_{i \in D} h_{i,j}^{\lambda_i \cdot H_2(\Theta_2)} \cdot u^{\nu_2 \cdot \eta}, y_1)^{w},$$

where $h_{i,\ j}=H_1(ID||i||j||v_i||t_i)$. If hold, the TPA outputs Accept; otherwise, it outputs Reject.

Revocation. Our scheme provides two types of revocation: lazy revocation (LR) and active revocation (AR). With the LR method, when user uk needs to be revoked, the group manager sends a revocation message to the CSP as follows:

Ψ= {$y_k{}^q$, {θ_i|i∈D}},

where D is the index set of the blocks modified by the revoked user u_k,and $q \in Z^*_q$ and $\theta_i \in Z^*_q$(i∈D) are random numbers. Upon receiving the revocation message, the CSP aggregates the tags corresponding to index set D as

$$\Lambda' = \prod_{i \in D} e(\sigma_i, y_k^{q})^{\theta_i},$$

and sends Λ' to the group manager. The group manager then generates thepost-revocationauthenticator Λ and its parameter λ_i as

$\Lambda = \Lambda'^{\rho}$,

$\lambda i = q \cdot \rho \cdot \theta_i$, i∈D,

where ρ is a random number. Finally, the group manager sends (R, {λ_i|i∈D}),where R is the index set of the RU-blocks to the TPA.

When a data block m_i modified by the revoked user u_k is modified by another legal user, the TPA updates the post-revocation authenticator as

$\Lambda = \Lambda / e\ (\sigma_i, y_k)^{\lambda i}$.

Finally, the TPA sends the post-authenticator Λ to the CSP.

With the AR method, when user u_k needs to be revoked, the process of creating the post-revocation authenticator Λ is the same as in the LR method, but the subsequent process is different. First, the group manager chooses the revocation parameters z_{0i}, z_{1i} for all i∈D,computes the revocationfactor z_i as $z_i = z_{0i}/z_{1i}$,and updates the public key y_k of user u_k as $y^{z1i}{}_k$. The group manager also generates the challenge message chal and sends all revocation factors z_i with the challenge message chal to the CSP. Then, the CSP re-computes the tag for the data block handled by the revoked user $\sigma_i = \sigma^{zi}{}_i$ and the proof P for the challenge message chal, and sends the proof P to the group manager. With proof P, the group manager verifies the integrity of the chosen blocks.

If it is valid, the group manager sends the revocation factor z_{0i} to the TPA. The TPA then updates the revocation factor in the EDHT and the post-authenticator Λ as

$$\Lambda = \Lambda / \prod_{i \in D} e(\sigma_i, y_k)^{\lambda_i / z_{0i}}.$$

Finally, the TPA sends the post-authenticator Λ to the CSP.

A. CORRECTNESS

The correctness of our scheme can be proved as follows:

$$\Theta_1{}^{w} \cdot \Phi^{H_2(\Theta_1)}$$
$$= e(u, y_1)^{r_1 w} \cdot \prod_{i \in IDX} ((e(\sigma_i, \gamma_j))^{s_i})^{H_2(\Theta_1)},$$
$$= e(u, y_1)^{r_1 w} \cdot \prod_{i \in IDX} e((h_{i,j} \cdot u^{m_i})^{a_j}, g^{w \cdot a_1 / a_j})^{s_i H_2(\Theta_1)}$$
$$= e(u, y_1)^{r_1 w} \cdot \prod_{i \in IDX} e((h_{i,j} \cdot u^{m_i}), y_1{}^{w})^{s_i H_2(\Theta_1)},$$
$$= e(u, y_1)^{r_1 w} \cdot (\prod_{i \in IDX} e(h_{i,j}, y_1{}^{w})^{s_i H_2(\Theta_1)}),$$
$$\cdot \prod_{i \in IDX} e(u^{m_i s_i H_2(\Theta_1)}, y_1{}^{w})$$
$$= (\prod_{i \in IDX} e(h_{i,j}^{s_i H_2(\Theta_1)}, y_1{}^{w})) \cdot e(u^{\Sigma m_i s_i H_2(\Theta_1)}, y_1{}^{w})$$
$$\cdot e(u^{r_1}, y_1{}^{w})$$
$$= (\prod_{i \in IDX} e(h_{i,j}^{s_i H_2(\Theta_1)}, y_1{}^{w})) \cdot e(u^{\Sigma m_i s_i H_2(\Theta_1) + r_1}, y_1{}^{w})$$

$$= (\prod_{i \in IDX} e(h_{i,j}^{s_i H_2(\Theta_1)}, y_1{}^{w})) \cdot e(u^{v_1}, y_1)^{w}$$
$$= e(\prod_{i \in IDX} h_{i,j}^{s_i H_2(\Theta_1)} \cdot u^{v_1}, y_1)^{w}$$

$$\Theta_2{}^{\eta \cdot w} \cdot T^{\eta \cdot \epsilon \cdot H_2(\Theta_2)}$$
$$= e(u, y_1)^{r_2 \cdot \eta \cdot w} \cdot \prod_{i \in D} ((e(\sigma_i, \tau_j))^{\beta_i})^{\eta \cdot \epsilon \cdot H_2(\Theta_2)}$$
$$= e(u, y_1)^{r_2 \cdot \eta \cdot w}$$
$$\cdot \prod_{i \in D} e((h_{i,j} \cdot u^{m_i})^{a_j}, g^{(w \cdot a_1)/(a_j \cdot \epsilon)})^{\beta_i \cdot \eta \cdot \epsilon \cdot H_2(\Theta_2)}$$
$$= e(u, y_1)^{r_2 \cdot \eta \cdot w} \cdot \prod_{i \in D} e((h_{i,j} \cdot u^{m_i}), y_1{}^{w})^{\beta_i \cdot \eta \cdot H_2(\Theta_2)}$$
$$= e(u, y_1)^{r_2 \cdot \eta \cdot w} \cdot (\prod_{i \in D} e(h_{i,j}, y_1{}^{w})^{\beta_i \cdot \eta \cdot H_2(\Theta_2)})$$
$$\cdot \prod_{i \in D} e(u^{m_i \cdot \beta_i \cdot \eta \cdot H_2(\Theta_2)}, y_1{}^{w})$$
$$= e(u, y_1)^{r_2 \cdot \eta \cdot w} \cdot (\prod_{i \in D} e(h_{i,j}, y_1{}^{w})^{\lambda_i H_2(\Theta_2)}),$$
$$\cdot \prod_{i \in D} e(u^{m_i \cdot \beta_i \cdot \eta \cdot H_2(\Theta_2)}, y_1{}^{w})$$
$$= (\prod_{i \in D} e(h_{i,j}^{\lambda_i H_2(\Theta_2)}, y_1{}^{w})) \cdot e(u^{\Sigma m_i \beta_i H_2(\Theta_2)}, y_1{}^{w})^{\eta}$$
$$\cdot e(u, y_1)^{r_2 \cdot \eta \cdot w}$$
$$= (\prod_{i \in D} e(h_{i,j}^{\lambda_i H_2(\Theta_2)}, y_1{}^{w})) \cdot e(u^{\Sigma m_i \beta_i H_2(\Theta_2) + r_2}, y_1{}^{\eta w})$$
$$= (\prod_{i \in D} e(h_{i,j}^{\lambda_i H_2(\Theta_2)}, y_1{}^{w})) \cdot e(u^{v_2 \cdot \eta}, y_1)^{w}$$
$$= e(\prod_{i \in D} h_{i,j}^{\lambda_i H_2(\Theta_2)} \cdot u^{v_2 \cdot \eta}, y_1)^{w}$$

System Model and Initialization

Entities Involved Data Owner the entity that generates and uploads the data to the cloud. Cloud Server (CS)the entity that stores the data and responds to audit requests. Third-Party Auditor (TPA) The entity that performs audits to verify data integrity.Group Members Users who have shared access to the data. Setup Phase the DO initializes the system by generating cryptographic keys.A public key and a private key pair are generated using a secure key generation algorithm.Public parameters necessary for auditing are shared with the CS and TPA.

Data Upload and Integrity Tags

Data Division the DO divides the data into multiple blocks and generates a unique tag for each block using cryptographic hash functions. Homomorphic authenticator schemes (e.g., homomorphic signatures) are used to generate integrity tags that allow computation on encrypted data.

Privacy-Preserving Auditing Protocol

Audit Initiation the TPA initiates an audit by sending a challenge request to the CS. The challenge typically includes random indices of the data blocks to be verified. Proof Generationthe CS computes a proof of data possession by combining the requested data blocks and their corresponding tags using homomorphic properties.The proof is then sent to the TPA. Proof Verification the TPA verifies the proof without needing to access the actual data. Techniques such as bilinear pairings or zero-knowledge proofs can be used for verification. If the proof is valid, it indicates that the data is intact.

Secure Group Management

Group Key Managementa group key is established for secure communication among group members.Techniques such as group key agreement protocols or hierarchical key management schemes are employed to securely distribute and update group keys. Access ControlAttribute-based access control (ABAC) or role-based access control (RBAC) mechanisms are implemented to manage permissions and access rights of group members.Member RevocationWhen a member leaves the group, the group key is updated to prevent the revoked member from accessing the data.Efficient key update mechanisms, such as proxy re-encryption or broadcast encryption, are used to ensure forward and backward secrecy.

Data Integrity and Security Measures

Merkle trees are used to efficiently verify the integrity of data blocks. The root hash of the Merkle tree is used as a commitment to the data set. Batch auditing techniques allow the TPA to handle multiple audit requests simultaneously, reducing computational overhead**.** Dynamic Data Operations The system supports dynamic operations such as data insertion, deletion, and modification while maintaining data integrity. Index structures, such as authenticated skip lists or hash tables, can be used to manage dynamic data.

Security Analysis and Optimization

Resistance to Attacksthe system is designed to resist various attacks, including replay attacks, collusion attacks, and insider threats. Techniques such as random masking, challenge-response protocols, and secure key management help mitigate these threats. Performance Optimizationthe methodology focuses on optimizing performance by reducing communication and computation costs. Efficient cryptographic operations, parallel processing, and lightweight protocols are implemented to enhance system performance.

OUTPUTS

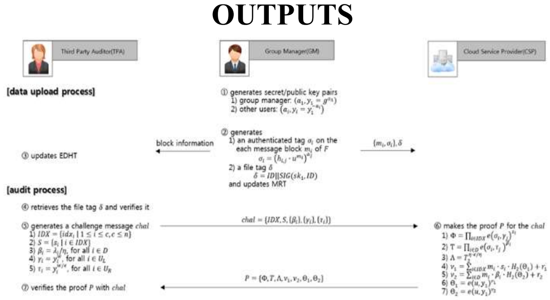

Fig2:Data upload and audit process

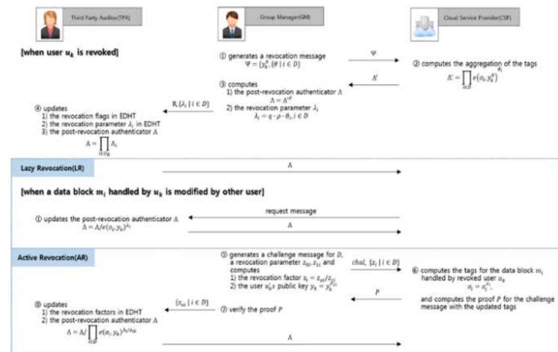

Fig3:Lazy revocation (LR) and active revocation (AR) processes.

FUTURE ENHANCEMENT :

Looking ahead, the future of secure group management for privacy-preserving public auditing of shared cloud data holds significant promise for further innovation and advancement. One key direction for future research involves the exploration and development of more efficient and scalable cryptographic techniques for access control and data verification. Advancements in areas such as attribute-based encryption (ABE), homomorphic encryption, and zero-knowledge proofs (ZKP) could lead to more robust and flexible solutions for enforcing fine-grained access control policies while preserving user privacy and data confidentiality. Additionally, research efforts aimed at enhancing the usability and practicality of secure group management systems through improved user interfaces, access control policies, and decentralized identity management mechanisms could further accelerate the adoption and deployment of these solutions in real-world cloud environments.

Moreover, the integration of emerging technologies such as blockchain and federated learning holds great promise for enhancing the security and privacy of group management systems in shared cloud environments. By leveraging blockchain technology to establish decentralized and tamper-proof ledgers of access control policies and user identities, organizations can enhance the transparency and integrity of group management operations while mitigating the risk of unauthorized access and data exposure. Similarly, federated learning techniques enable organizations to collaboratively train machine learning models on encrypted user data without compromising individual privacy, offering a scalable and privacy-preserving approach to group management and data analysis in cloud environments. Overall, the future of secure group management for privacy-preserving public auditing of shared cloud data is characterized by ongoing innovation and collaboration, driven by the goal of ensuring confidentiality, integrity, and privacy in collaborative cloud environments.

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