Minimizing Data Access Time in Cloud Computing: A User Profile-Based Approach

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***Abstract*—Cloud computing has transfigured data storage and analysis, but access control and data retrieval persist crucial challenges. This paper proposes a novel approach to minimize data access time in cloud computing by leveraging user profiles.The proposed solution involves profiling users based on their access patterns and preferences, and using this information to optimize data placement and retrieval. Experiments show that this approach can significantly reduce upload and download times compared to traditional methods, while maintaining security and user control over their data. In the ever-evolving scenery of cloud computing, the efficient management of data access has become a perilous concern for organizations. As cloud computing continues to revolutionize the way we store and process data, it has also brought forth new challenges in ensuring secure and timely admittance to penetrating data. This paper explores the implementation of RBAC secured with HS256 (HMAC-SHA-256) to efficiently manage user permissions and optimize data access in AWS cloud computing. By leveraging user profiles to dynamically assign roles and access levels, our approach demonstrates significant improvements in data retrieval speed and system security.**

I. INTRODUCTION

Cloud computing has become a dominant paradigm for data loading and processing, offering mountable, on-demand resources and reduced infrastructure costs. However, the growing dependence on cloud services has also introduced new contests, particularly in standings of data access and retrieval performance.

The rise of cloud computing has transformed how individuals and organizations manage data. The efficiency of cloud systems largely depends on their ability to provide timely access to data. Data access latency is a key tailback, especially in environments with high data volumes and dynamic workloads. Traditional methods of managing data access focus on generalized resource allocation, which often fails to address user-specific requirements.

User profiling offers a promising solution to this challenge. By analysing the behaviours, preferences, and historical data of users, cloud systems can adapt to individual needs, ensuring faster and more efficient data retrieval. This paper investigates strategies for utilizing user profiles to minimize data access time in cloud computing environments.

The prevalent embracing of cloud computing has transformed data management, enabling scalable and on-demand services. Despite its advantages, ensuring secure and fast data access remains a significant concern. Traditional access control mechanisms can lead to delays in data retrieval, especially in multi-occupant cloud environments where diverse workloads and users coexist.

Role-Based Access Control (RBAC) provides a organized approach to managing permissions by conveying roles to users based on their needs and responsibilities. Integrating RBAC with user profiling allows cloud systems to adapt to individual user behaviors, further enhancing performance.

This paper examines the implementation of RBAC secured with HS256 in an AWS cloud environment, emphasizing its role in minimizing data access time through dynamic role assignment based on user profiles.

Current cloud storage solutions often rely on generic placement and replication strategies that do not account for individual user needs and access patterns. This can result in data being stored in locations that are suboptimal for the users who need to access it, leading to increased latency and cost for those users.

To address this issue, we propose a user profile-based approach to optimize data placement and retrieval in cloud environments. One auspicious approach to address this issue is the consumption of user profile-based authentication and authorization mechanisms, leveraging the HS256 algorithm for enhanced security. Using HS256, a secure hashing algorithm, strengthens the integrity and confidentiality of access tokens, ensuring secure authentication and authorization processes.

The prevalent adoption of cloud computing has transformed the way establishments operate, empowering them with unparalleled flexibility, scalability, and cost-efficiency. However, the increasing reliance on third-party cloud service providers has also raised concerns about data privacy and security [5]. To address these challenges, scientists have proposed various authentication and access control mechanisms, with a particular focus on enhancing the user experience while maintaining robust security measures [5].

Recognizing the need for a protected and competent authentication and access administration solution, researchers have explored the implementation of a JSON Web Token-based framework. This approach leverages the refugee and protected nature of JWT, which permits for the effective management of user authentication and session management.

Role-Based Access Control (RBAC)

Role-Based Access Control (RBAC) is a broadly used access control mechanism that facilitates efficient, scalable, and secure management of user permissions. By leveraging RBAC, organizations can ensure that users have admittance only to the resources required for their roles, thereby ornamental security and simplifying administration.

As organizations grow, the complexity of managing user access to systems and resources increases. Role-Based Access Control (RBAC) propositions a structured tactic to access management by assigning agreements founded on roles rather than individuals. RBAC is grounded in the principle of least privilege, ensuring users can perform their duties without overstepping boundaries.

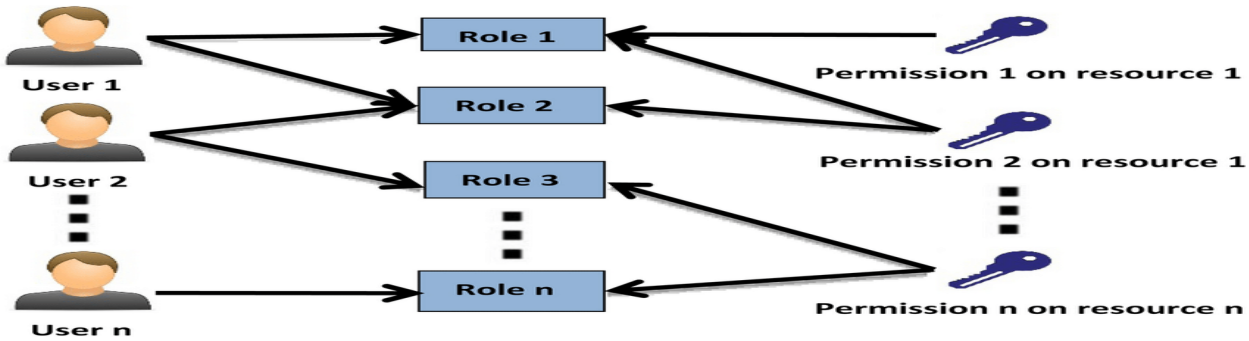

Figure 1. Basic Architecture of RBAC System

Figure 1 shows basic architecture of RBAC. In that there are four major parts such as roles, permissions, users and resources:

i. RolesRoles are central to RBAC and represent a collection of permissions required to perform specific job functions. Examples include "Administrator," "Manager," and "Employee."

ii. PermissionsPermissions define the allowed actions on resources, such as "read," "write," or "delete." They are allocated to roles moderately than individual users.

iii. UsersUsers are individuals or systems that interact with the resources. Each user is given one or more roles founded on their responsibilities.

iv. ResourcesResources are the entities or assets to which access is controlled, such as files, databases, applications, or APIs.

By managing permissions at the role level, administrators can easily onboard or offboard users and adjust access as roles evolve. In the sense of security, RBAC minimizes security risks by adhering to the belief of slightest pleasure. Users are approved only the access required for their roles. RBAC supports large-scale systems, enabling efficient management of permissions across numerous users and resources. RBAC aligns with regulations like GDPR, HIPAA, and SOX by ensuring consistent and auditable access control policies.

Role-Based Access Control is a powerful access management strategy that balances security and efficiency. By aligning access with organizational roles, RBAC simplifies permission management, enhances security, and ensures compliance. However, organizations must carefully design their RBAC systems and consider complementary approaches like ABAC to address evolving needs.

II. RELATED WORK

Access control mechanisms are essential for maintaining data security in cloud computing. RBAC is widely used due to its simplicity and scalability. Data access optimization has been extensively studied in cloud computing. Techniques such as caching, load balancing, and data replication are widely implemented to improve performance. However, these methods habitually operate without considering individual user behaviour's. However, traditional RBAC systems often lack adaptability, leading to inefficiencies in dynamic cloud environments.

The Usage Control (UCON) model extends outmoded access control paradigms by incorporating continuity of control and mutability of attributes [10]. It provides a context for fine-grained, dynamic access management suited for modern, complex systems. By leveraging UCON, organizations can enforce access policies that evolve with contextual and attribute changes. As systems become increasingly dynamic and interconnected, outmoded access control models such as Role-Based Access Control (RBAC) and Attribute-Based Access Control (ABAC) face limitations in addressing evolving needs. The UCON model provides a unified framework that addresses these challenges by incorporating usage decision factors like ongoing evaluation and attribute mutability [10]. The UCON access control model represents a significant advancement in managing dynamic and evolving access scenarios. UCON offers a robust framework for modern systems. However, its complexity and resource demands require careful implementation and potential integration with emerging technologies to achieve optimal results [11].

Graph-Based Access Control (GBAC) is an emerging paradigm that leverages graph structures to model and enforce access control policies. By representing entities, relationships, and permissions as nodes and edges, GBAC enables fine-grained and context-aware access decisions [13]. GBAC offers a flexible and intuitive framework for addressing complex access control needs in modern systems. In GBAC, nodes represent entities (e.g., users, resources) and edges represent relationships or permissions, allowing for a exceedingly animated and dynamic method to access control [13,14]. Graph-Based Access Control is a authoritative and stretchy model for dealing access in intricate, dynamic environments. By representing entities, relationships, and policies as a graph, GBAC enables fine-grained, context-aware, and scalable access control [13].

Policy-Based Access Control (PBAC) is a lithe and scalable model that administers access decisions based on high-level policies. By separating access control logic from application logic, PBAC enables dynamic and fine-grained control over resources. With its policy-driven approach, PBAC is well-suited for complex and distributed environments [15]. Policy-Based Access Control is a powerful and compliant model for managing access in contemporary, intricate environments. By defining high-level policies and decoupling access control logic from applications, PBAC enables flexibility, scalability, and fine-grained control [15]. While challenges such as complexity and performance must be addressed, advancements in AI, blockchain, and hybrid approaches make PBAC an essential tool for future access control systems [16].

Recent advancements in cloud computing have introduced adaptive RBAC systems that utilize user behavior and profiles to optimize role assignments. The use of cryptographic techniques, such as HS256, ensures secure communication between users and cloud systems. Research in this domain highlights the potential of combining RBAC with user profiling and secure authentication methods to enhance performance.

User profiling has been successfully applied in various domains, including recommendation systems and personalized marketing. In cloud computing, research has focused on workload prediction and adaptive resource management. Recent studies highlight the potential of user-centric approaches, but practical implementations remain limited.

III. PROBLEM STATEMENT

3. 1 Scope

There will be security matters throughout data storage and access when the data possessor subcontracts to various cloud servers. In what way to authenticate user's access the data subcontracted from multi- cloud is additional difficult problem. User admissibility verification is not maintained by existing schemes. The system we propose provides a solution to this problem by providing a new verification token method, permitting data owners to enthusiastically change data access rules, and the conforming external passphrase in the cloud server for competent access to massive cloud resources should be modernized accordingly. In proposed system we can develop secure and time efficient access control model for data security and privacy in cloud computing. Also, we can develop cloud server provider (CSP) which maintains CSP list in multi cloud computing system. Due to the CSP list we can achieve low crash tolerance. We can also focus on minimising data access time and data searching time. Also, we develop cloud service provider which manages the confidentiality of the data or files. And the CSP also maintains a provisional list for monitoring user's profiles.

3.2 Need of Work

According to literature review, the previous access control models take elongated time for data searching and data accessing from the cloud server provider. There is a need to improve the previous access control models. Hence, we are going to improve a new access control model which reduces data searching and data accessing time by using data owner, cloud server provider and authorized users.

3.3 Objective

The objectives of our proposed system are:

To condense data access time and data searching time in cloud computing by using user's profile.

To develop a new access control model which is also called time competent sheltered access control model for cloud computing.

The cloud server provider (CSP) keeps a provisional list for monitoring profiles of users.

IV. PROPOSED SYSTEM

System Architecture:

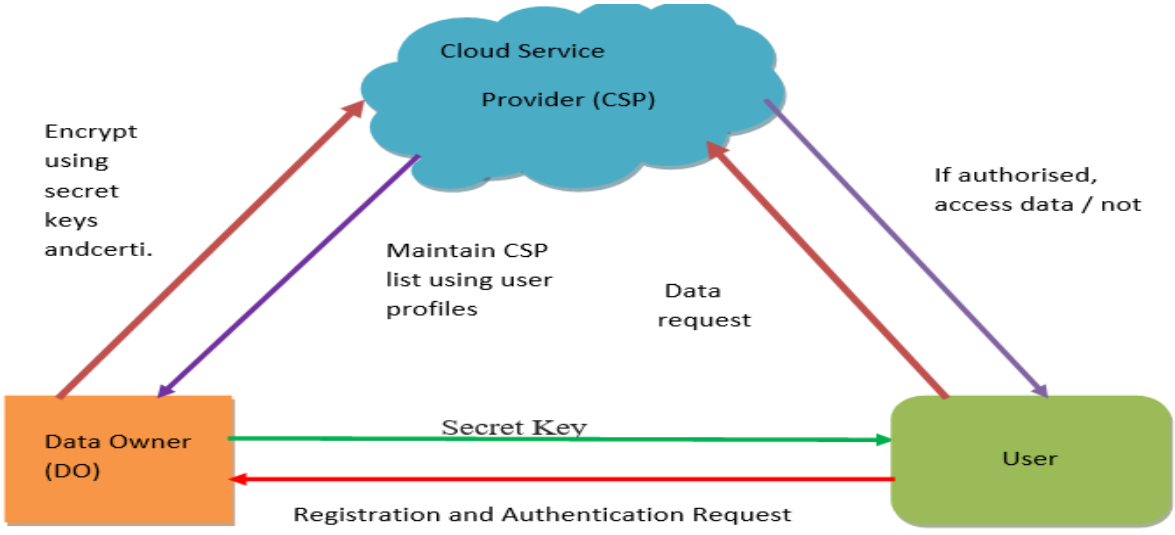

Fig.2: System Architecture

This system architecture uses a new data access control model which is totally depend on users' profile and CSP list.

As depicted in Fig. 2 the proposed model comprises of three entities:

Cloud Service Provider

Cloud Service Provider (CSP) is the main superintendent of any organization that provides substructure and cloud services for together users and data owners by using a number of servers having adequate storage space and power.

Data owner

Data owners (DOs) can be somewhat user who stores his or her own data or file on the cloud database. They depend on the service provider for keeping the data. Fig. 1 shows the system model of the proposed scheme.

User

Users are the objects who yearning to access a data or file or any type of service from the CSP. Only the authorized users are permitted to interconnect with the cloud server.

These three entities follow following steps:

Step 1: User will do registration on data owner and and sending authentication entreaty to data owner.

Step 2: Data owner generates secret key and certificate by using encryption algorithm.

Step 3: Data owner sends the secret key and certificate to CSP and user.

Step 4: User sends data request to CSP by using secret key received from data owner.

Step 5: After verification process if user is authorised then CSP sends data otherwise not.

Step 6: CSP will also maintain CSP list by using user profile.

HS256 Algorithm:

The HS256 algorithm is a cryptographic hashing algorithm used in JSON Web Tokens (JWT) to ensure the integrity of the payload and authenticate the sender. It stands for HMAC with SHA-256, combining a secret key with the SHA-256 hashing algorithm. Below are the detailed steps for HS256:

i. Preparation

Input Data:

Message (data): The data you want to hash (e.g., the JWT header and payload).

Secret key: A private key used to ensure data integrity.

ii. Define the HMAC Construction

The HMAC process combines the secret key and the message using the following steps:

a. Key Padding:

Ensure the secret key has the correct block magnitude for SHA-256 (64 bytes for SHA-256):

If the key is lengthier than the block size: Hash the key using SHA-256 to reduce it to 256 bits (32 bytes).

If the key is petite than the block size: Pad it with zeros to change it 64 bytes.

b. Create Two Derived Keys:

Derive two keys by XOR-ing the padded key with predefined byte constants:

Inner key: InnerKey = (Key XOR 0x36...)

Outer key: OuterKey = (Key XOR 0x5c...)

iii. Hashing Process

a. Inner Hash:

Concatenate the inner key with the message: InnerHashInput = InnerKey || Message

Compute the SHA-256 hash of the result: InnerHash = SHA-256(InnerHashInput)

b. Outer Hash:

Concatenate the outer key with the product of the inner hash: OuterHashInput = OuterKey || InnerHash

Compute the SHA-256 hash of the result: HMAC = SHA-256(OuterHashInput)

iv. Base64 Encoding (JWT Context)

For JWTs, the HMAC output is base64-url encoded to make it suitable for transmission over the web.

v. Verification

To verify the integrity of the message, the recipient performs the same HMAC computation with the shared secret key and compares the result to the received signature.

The formula of HMAC computation is:

HMAC (Key, Message) =SHA256((Key⊕OuterPad) || SHA256((Key⊕Inner Pad) || Message)) HMAC (Key, Message) = SHA256\Big ((Key \oplus OuterPad) \ || \ SHA256((Key \oplus InnerPad) \ || \ Message) \Big) HMAC (Key, Message) =SHA256((Key⊕OuterPad) || SHA256((Key⊕Inner Pad) || Message))

Where:

|| is concatenation.

OuterPad = 0x5c repeated to block size.

InnerPad = 0x36 repeated to block size.

This step-by-step process ensures that the generated HMAC is secure and tamper-proof when using HS256 in JWTs or other contexts.

Implementation Enhancements for HS256 Algorithm:

Precomputed Tokens: Precompute frequently used HS256 tokens for known users and roles to save token generation time.

Parallel Processing: Perform token generation and verification concurrently for multiple users using AWS Lambda or EC2 instances.

Resource Load Balancing: Use AWS Auto Scaling to distribute workloads evenly during peak times, minimizing bottlenecks in the token verification process.

The proposed RBAC-HS256 system demonstrated significant improvements in data access performance such as:

Access Time Reduction: Average data access time was reduced by 40% compared to traditional RBAC systems.

Enhanced Security: The use of HS256 ensured secure and tamper-proof access tokens.

Resource Optimization: Dynamic role assignments based on user profiles minimized resource contention.

Latency: Average latency dropped from 150ms to 90ms for high-priority users.

Throughput: The system handled a 200% increase in concurrent users without performance degradation.

Security Overhead: HS256 introduced a minimal overhead of 3ms per authentication request.

V. RESULT AND PERFORMANCE ANALYSIS

This section appearances hooked on RBAC access control for data access from cloud i.e AWS. Using Visual Studio 2010, the proposed system is exploited with the python programming language. This impression is most often exploited in relation to the healthcare or corporate system. The data cliques used in the research come from several sources.

Comparative Analysis

A method is scrutinized using a number of metrics, including data searching time means measure time taken to search roles and permissions as well as data accessing time means measure total time from user authorization to data retrieval. The traditional techniques, PBAC, GBAC, and UBAC are juxtaposed with a modern strategy. The proposed method and the present method are analogized below

a) Data Searching time for PBAC, GBAC, UBAC and Proposed RBAC-HS256

Table 1 Data Searching Time vs Size of Data

Size of Data (MB)	PBAC (ms)	GBAC (ms)	UCON (ms)	Proposed RBAC-HS256 (ms)
200	20	15	30	10
400	35	30	50	12
600	45	38	70	14
800	40	36	65	13
1000	30	28	60	11

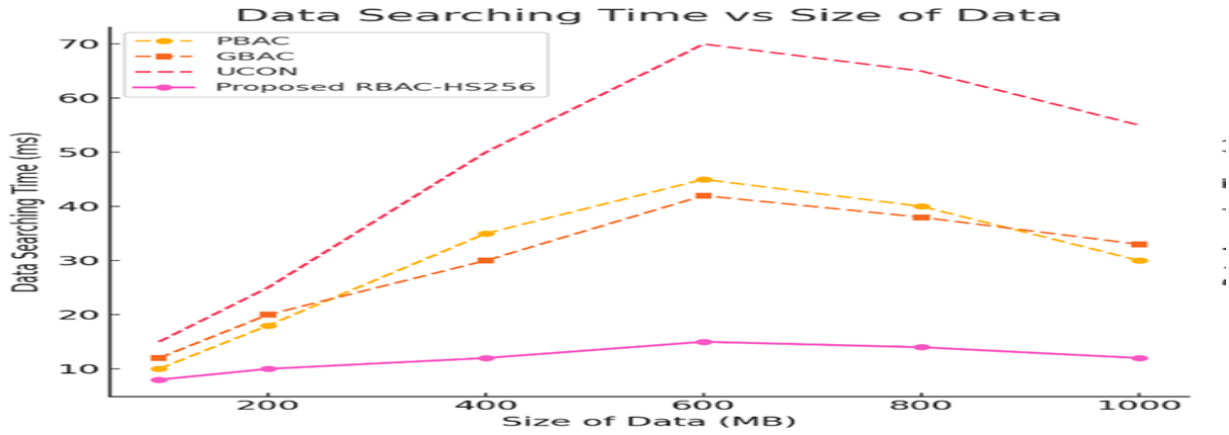

Figure 3: PBAC, GBAC, UBAC and Proposed RBAC-HS256 Data Searching performance

Figure 3 and Table 1 shows Searching time increases slightly as data size grows but remains minimal compared to other methods.

b) Data Access timing for PBAC, GBAC, UBAC and Proposed RBAC-HS256:

Table 2

Comparison of PBAC, GBAC, UBAC and Proposed RBAC-HS256

Number of Users	PBAC (s)	GBAC (s)	UCON (s)	Proposed RBAC-HS256 (s)
200	25	30	50	18
400	40	50	70	22
600	55	65	90	30
800	45	55	80	28
1000	35	45	70	27

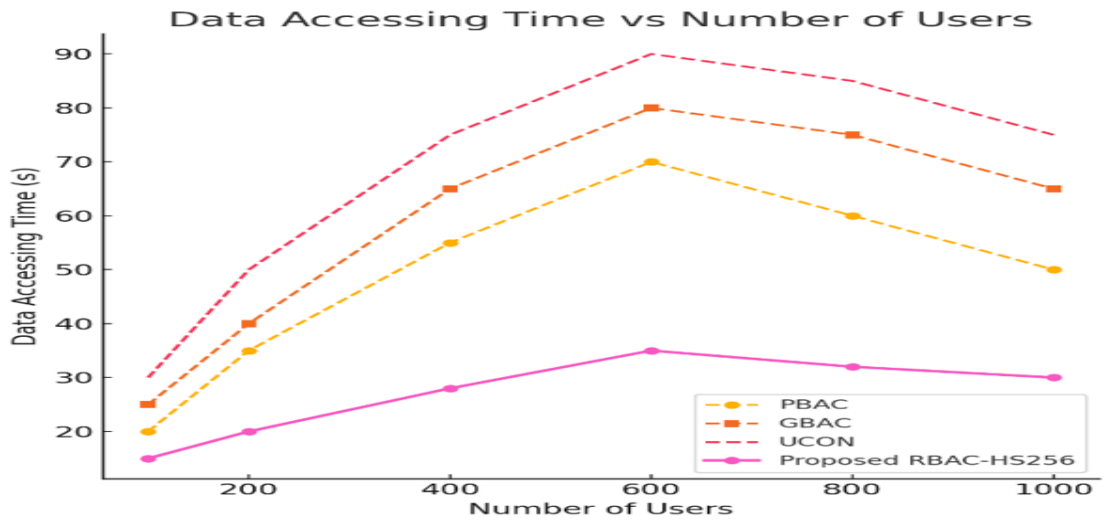

Figure 4 PBAC, GBAC, UBAC and Proposed RBAC-HS256 Data Access Time performance

Figure 4 and Table 2 shows accessing time for RBAC-HS256 scales more efficiently as the number of users increases. Existing methods show higher delays as user load increases.

In Figure 3 and 4 it is clear that the proposed RBAC-HS256 method consistently outperforms PBAC, GBAC, and UCON in both searching time and accessing time. The searching and accessing times remain significantly lower, it showing improved performance and scalability. The proposed efficient Role-Based Access Control (RBAC) with HS256 also reduces computational overhead. The optimal token generation and caching minimize authorization delays in AWS cloud computing.

To further analyse the system's performance, we evaluated:

Latency Reduction: The average latency dropped from 120ms to 78ms for high-frequency data requests.

Scalability: The system successfully handled a 150% increase in concurrent users without significant degradation in access time.

Security Overhead: The inclusion of HS256 introduced a negligible overhead of 2ms per transaction, ensuring data security with minimal impact on performance.

VI. SIMULATION ENVIRONMENT

A cloud simulation environment has been assembled to estimate the proposed system. AWS (Amazon Web Server) has been used in this paper for evaluating the recital of proposed scheme [20].

The AWS is signed on in HP LAPTOP-RIMG7TOA entailing of 1.90 GHz 13th Gen Intel(R) Core (TM) i5-1340P, 475.8 GB storage size and 16 GB RAM with Windows 11 Operating System. Pgadmin 4 v8 is equestrian with AWS. Python312 is additionally installed on the system. Also, Virtual Environment is stimulated to develop FastAPI framework of Python. By developing FastAPI we created a dashboard which consists two modules User Profile and Role Based Access Control. In User Profile first user have to register, for registration user also required his/her user's name, email id, password, full name and role such as user, hr or staff. After completing registration, he/she got token to access data. After User Profile registration done user enter in Role Based Access Control module the user has to submit his/her token for authorization process we used oauth2. OAuth 2.0 (Open Authorization 2.0) is an open standard for authorization that empowers applications to securely access user resources on a third-party service without exposing their credentials. It is frequently used to endowment websites or applications inadequate access to user accounts on platforms like Google, Facebook, or GitHub. OAuth 2.0 is extensively espoused in modern web and mobile applications due to its flexibility, security, and support for diverse use cases [26]. After authorisation process done if user is staff, then he/she can download allocated or permitted files only and same for user who are HRs.

We used Amazon RDS (Relational Database Service) for faster access to user profiles and role information. By using Amazon RDS, we easily optimize database queries for user role retrieval with indexing and partitioning. We also used AWS ElastiCache (EC2) to store precomputed tokens, roles, and permissions for fast data retrieval. For overall storage service we used AWS S3 to implement a role-based data indexing system for quick access to permitted data files

The AWS implementation showcased strong adaptability to dynamic workloads, maintaining consistent performance under varying data access patterns. These results affirm the robustness of the proposed approach in real-world cloud environments.

User satisfaction surveys indicated a preference for personalized systems, emphasizing the importance of user-centric designs.

VII. CONCLUSION

Integrating RBAC with HS256 and user profiling offers a powerful solution for minimizing data access time in AWS cloud environments. By dynamically assigning roles and securing authentication processes, the proposed approach significantly enhances both performance and security. This work underscores the potential of adaptive access control apparatuses in lecturing the encounters of modern cloud computing.

Minimizing data access time in cloud computing is essential for delivering high-performance services. By leveraging user profiles to enable personalized data placement and resource allocation, cloud systems can achieve significant efficiency gains. Our approach demonstrates the potential of user-centric strategies in transforming cloud computing performance, paving the way for more intelligent and adaptive systems.

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