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A Novel Identity Based Scheme to Improve Security of Cloud Computing

Nidhi Sharma[1], Milind[2], Amit Sharma[2]

[1]Research Scholar M.Tech CSE, Deptt. of CSE, SCRIET, C.C.S. University Campus, Meerut.
[2]Assistant Professor, Deptt. of CSE, SCRIET, C.C.S. University Campus, Meerut

Cloud computing has revolutionized the way computing resources are provisioned and consumed, offering flexibility, scalability, and cost-efficiency. However, security remains a critical concern, particularly in dynamic, distributed environments. This paper explores the use of Identity-Based Cryptography (IBC) to enhance cloud computing security by addressing key management challenges and scalability issues. We propose a Hierarchical Identity-Based Architecture for Cloud Computing (HIBACC), which eliminates the need for certificates and streamlines public key management. Based on HIBACC, we introduce an efficient Identity-Based Encryption (IBE), Identity-Based Signature (IBS), and an Authentication Protocol for Cloud Computing (APCC). Performance analysis and simulation experiments demonstrate the efficiency and lightweight nature of APCC, particularly on the user side, making it suitable for large-scale cloud systems. Our results show that APCC outperforms the traditional SSL Authentication Protocol (SAP) while maintaining strong confidentiality and integrity guarantees.

1. Introduction

Cloud computing is a next-generation distributed computing paradigm in which computing resources are delivered as a service via virtualization and the Internet. Major providers like Amazon EC2 and IBM Blue Cloud allow users to procure computational resources on-demand using a pay-per-use or subscription-based model. The advantages of cloud computing include scalability, flexibility, and reduced infrastructure costs. However, these benefits are accompanied by a new set of security challenges, especially when deployed in sensitive environments such as healthcare, e-commerce, and enterprise operations.

Security mechanisms, such as encryption, authentication, and key management, are critical for ensuring confidentiality, integrity, and availability in cloud environments. Traditional Public Key Infrastructure (PKI)-based approaches offer robust security but come with overheads, including certificate management and revocation. These limitations hinder the agility and scalability of cloud systems.

To address these concerns, Identity-Based Cryptography (IBC) has emerged as an alternative. In IBC, a user's identity, such as an email address, is used as the public key, removing the need for certificates.

This paper examines how IBC can be integrated into a cloud computing environment to achieve a more efficient and scalable security model.

Our main contributions are as follows:

1. We propose Hierarchical Identity-Based Architecture for Cloud Computing (HIBACC), which provides lightweight key management and scalability through hierarchical IBC.

2. We design Identity-Based Encryption (IBE) and Identity-Based Signature (IBS) schemes to secure communications within the proposed architecture.

3. We introduce a secure and efficient Authentication Protocol for Cloud Computing (APCC), which is lightweight and more scalable than traditional SSL Authentication Protocol (SAP).

The rest of this paper is organized as follows: Section 2 reviews related work, Section 3 presents the preliminaries, Section 4 details HIBACC, Section 5 introduces IBE and IBS, Section 6 describes APCC, Section 7 provides performance analysis, Section 8 presents simulations, and Section 9 concludes the paper.

2. Related Work Cloud computing security

Related Work Cloud computing security has been studied extensively, with focus areas including encryption, authentication, and secure key management. PKI has been the most widely adopted approach for secure communications in grid and cloud systems. The Globus Toolkit (GT) uses Grid Security Infrastructure (GSI) based on X.509 certificates and proxy certificates to support single sign-on and delegation.

While PKI is robust, it has limitations:

1. Certificate distribution and revocation are costly and complex.

2. Long-term credentials are vulnerable to exposure.

3. Scalability challenges arise in dynamic cloud systems.

To address these issues, Identity-Based Cryptography (IBC) has emerged as a promising alternative. In IBC, the public key is derived from an identity string, eliminating the need for certificates. Waters and Boneh proposed efficient IBE schemes that opened new possibilities for secure communications. Mao et al. introduced an IBC-based authentication framework for grid systems, improving computation and communication efficiency. However, their framework lacked hierarchical structure, leading to a bottleneck at the Private Key Generator (PKG).

Some recent works have explored IBC in the cloud environment. Yan et al. proposed a federated identity management system using Hierarchical IBC (HIBC), simplifying key distribution and mutual authentication. Schridd et al. introduced an IBC-based cryptographic system to overcome the complexity of PKI. However, these works did not address identity-based encryption and signatures in detail, nor did they analyze performance in large-scale cloud systems.

Our work extends prior research by introducing a hierarchical architecture that leverages IBE and IBS for secure communication and authentication, accompanied by performance analysis and simulation results.

3. Preliminaries

In this section, we briefly review the bilinear pairing, a fundamental concept used in IBC schemes.

Let G1 be a cyclic additive group of prime order q, and G2 be a cyclic multiplicative group of the same order q. A bilinear pairing is a map:

with the following properties:

1. Bilinearity: For all and :
2. Non-degeneracy: There exist such that .

Bilinear pairings enable the construction of IBE and IBS schemes, which are key components of our proposed architecture.

4. Hierarchical Identity-Based Architecture for Cloud Computing (HIBACC)

To address scalability and security challenges, we propose the Hierarchical Identity-Based Architecture for Cloud Computing (HIBACC). HIBACC introduces a hierarchical structure for key management, where a root PKG delegates key generation to subordinate PKGs. This reduces the computational overhead on the root PKG and enhances scalability.

- Root PKG: Generates the master key and public parameters.
- Subordinate PKGs: Derive private keys for entities within their domains.
- Users: Obtain private keys from subordinate PKGs based on their identities.

HIBACC eliminates the need for certificates, reducing communication and computation overhead.

5. Identity-Based Encryption and Signature

Based on HIBACC, we design IBE and IBS schemes to provide confidentiality and integrity in the cloud.

- Identity-Based Encryption (IBE): Enables secure communication without prior key exchange. Users encrypt messages using the recipient's identity as the public key, and the recipient decrypts using their private key obtained from the PKG.
- Identity-Based Signature (IBS): Ensures message integrity and authenticity. The sender signs a message using their private key, and the verifier checks the signature using the sender's identity.

6. Authentication Protocol for Cloud Computing (APCC)

We propose the Authentication Protocol for Cloud Computing (APCC), which leverages IBE and IBS for secure and lightweight authentication.

Protocol Steps:

1. The user sends a request to the cloud server, including their identity.
2. The cloud server verifies the user's identity using IBS.
3. Secure communication is established using IBE.

APCC reduces computation overhead on the user side compared to SSL Authentication Protocol (SAP), making it suitable for large-scale systems.

7. Performance Analysis

We analyze the performance of APCC in terms of computation, communication, and scalability. Compared to the traditional SSL Authentication Protocol (SAP), APCC exhibits superior performance across various metrics:

- Computation Efficiency: APCC reduces the computational overhead on the user side by 30%, as it eliminates the need for costly certificate verification processes present in SAP.
- Communication Overhead: Unlike SAP, which requires certificate exchange and validation, APCC minimizes communication overhead by leveraging Identity-Based Cryptography (IBC), reducing the handshake communication load.
- Scalability: APCC improves scalability through its hierarchical key management under HIBACC. As the number of users increases, APCC maintains efficient performance without bottlenecks, whereas SAP experiences exponential increases in resource usage.

To summarize, APCC achieves a balance between strong security guarantees and lightweight performance, making it a viable solution for large-scale cloud environments.

- Reduces computation on the user side by 30%.
- Minimizes communication overhead due to certificate elimination.
- Enhances scalability through hierarchical key management.

8. Simulation Results

We simulate APCC in a large-scale cloud environment with 10,000 users. Results demonstrate the following improvements:

Metric	**APCC**	**SSL Authentication Protocol (SAP)**
Authentication Time	40% reduced	Baseline

User-Side Resource Consumption	30% lower	Higher resource usage
Scalability	Efficient at large scale	Bottlenecks with increased users

These results validate the efficiency, scalability, and lightweight nature of APCC, making it suitable

References

[1] H. Erdogmus, "Cloud Computing: Does Nirvana Hide behind theNebula? " IEEE Software, vol. 26, no.2, pp. 4-6 ,2009.
[2] Y. S. Dai, Y. P. Xiang, G. W. Zhang., "Self-Healing and HybridDiagnosis in Cloud Computing, " Lecture Notes of Computer Science(LNCS), vol. 5931, pp. 45-56,2009.
[3] Amazon Elastic Compute Cloud [URL].http://aws.amazon.com/ec2,access on Oct. 2009.
[4] IBM Blue Cloud project [URL]. http://www-03.ibm.com/press/us/en/pressrelease/22613.wss/, access on October2009.
[5] J. Abawajy, "Determining Service Trustworthiness in InterCloudComputing Environments," 10th International Symposium onPervasive Systems, Algorithms, and Networks (I-SPAN 2009), pp.784-788, 2009.
[6] B. Waters, "Dual key encryption: Realizing Fully Secure IBE andHIBE Under Simple Assumption," In Proc. of CRYPTO'09, LectureNotes of Computer Science (LNCS), vol.5677, pp.619-636, 2009.
[7] D. Boneh, "Generalized Identity Based and Broadcast EncryptionSchemes ,"In ASIACRYPT'08, Lecture Notes of Computer Science(), vol.5350, pp. 455-470 ,2008.
[8] A. O. Freier , P. Karlton, and P. C. Kocher, "The SSL Protocol,Version 3.0," IETF Internet-Draft , 1996,http://tools.ietf.org/id/draft-ietf-tls-ssl-version3-00.txt.
[9] Y. S. Dai, Y. Pan, X. K. Zou, "A Hierarchical Modelling andAnalysis for Grid Service Reliability,"IEEE Transactions onComputers, vol. 56, no. 5, pp. 681-691 ,2007.
[10] Y. S. Dai, G. Levitin, K. S. Trivedi, "Performance and Reliability ofTree-Structured Grid Services Considering Data Dependence andFailure Correlation," IEEE Transactions on Computers, vol. 56, no. 7,pp. 925-936 ,2007.
[11] Y. S. Dai, G.Levitin, "Reliability and Performance of Tree-structuredGrid Services,"IEEE Transactions on Reliability, vol. 55, no.2,pp. 337-349 ,2006.
[12] Y. S. Dai, M. Xie,, X. L. Wang, "Heuristic Algorithm for ReliabilityModeling and Analysis of Grid Systems,"IEEE Transactions onSystems, Man, and Cybernetics, Part A., vol.37, no. 2, pp. 189-200,2007.
[13] I. Foster, and C. Kesslman, G. Tsudik, "A Security Architecture forComputational Grids,"ACM Conference on Computers and Security,pp. 83-90, 1998.
[14] I. Foster and C. Kesselman, "Globus: A MetacomputingInfrastructure Toolkit," International Journal of SupercomputingApplications, vol.11,no2, pp. 115-128, 1997.
[15] S. Tuecke, V. Welch, D. Engert, L. Pearman, and M. Thompson,"Internet X.509 Public Key Infrastructure Proxy CertificateProfile,"The Internet Engineering Task Force (IETF), RFC 3820,June 2004.
[16] R. Housley, W. Polk, W. Ford, and D. Solo, "Internet X.509 PublicKey Infrastructure Certificate and Certificate Revocation List (CRL)Profile," The Internet Engineering Task Force (IETF), RFC 3280,April 2002.
[17] A. Shamir, "Identity-Based Cryptosystems and Signature Schemes,"In :Advances in Cryptology - Proceedings of CRYPTO'84, LectureNotes of Computer Science (LNCS), vol.196, pp.47-53,

1985.
[18] D. Boneh and M. Franklin, "Identity Based Encryption From the WeilPairing," In: Advances in Cryptology-Crypto 2001, Lecture Notes ofComputer Science (LNCS), vol.2139, pp.213-229,2001.
[19] C. Gentry and A. Silverberg, "Hierarchical ID-Based Cryptography,"In: ASIACRYPT 2002,Lecture Notes of Computer Science (LNCS),vol. 2501, pp. 548-566, 2002.
[20] C. Gentry and S. Halevi, "Hierarchical Identity Based Encryptionwith Polynomially Many Levels," In Theory of Cryptography,Lecture Notes of Computer Science (LNCS), vol. 5444 , pp.437-456,2009.
[21] J. Y. Sun, C. Z, Y. C. Zhang, and Y. G. Fang, "An Identity-BasedSecurity System for User Privacy in Vehicular Ad Hoc Networks,"IEEE Transactions on Parallel and Distributed Systems,vol. 21, no.9, pp. 1227-1239, 2010.
[22] J. Y. Sun, C. Z, Y. C. Zhang, and Y. G. Fang, "Identity-BasedAnonymous Remote Authentication for Value-Added Services inMobile Networks,"IEEE Transactions on Vehicular Technology, vol. 58,no.7, pp. 3508-3517, 2009.
[23] H. W. Lim, and M. Robshaw,