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Pecking Order Attribute Based Encryption

Vishal Shrinivas Revadi
B.Tech Student,
Dept. of Computer Science,
Ballari Institute of Technology & Management,
vishalrevadi24@gmail.com.

Priyanka Pal
B.Tech Student,
Dept. of Computer Science,
Ballari Institute of Technology & Management,
preciouspriyanka11@gmail.com

Shamshad Begum
B.Tech Student,
Dept. of Computer Science,
Ballari Institute of Technology & Management,
shamshadbegum1212b@gmail.com.

Sri Nikitha Reddy
B.Tech Student,
Dept. of Computer Science,
Ballari Institute of Technology & Management,
srinikithareddy1996@gmail.com.

Azhar Baig
Assistant Professor,
Dept. of Computer Science,
Ballari Institute of Technology & Management,
azharbaig.mab@gmail.com.

Abstract

Cloud computing has emerged as one of the most influential paradigms in the IT industry in recent years. Since this new computing technology requires users to entrust their valuable data to cloud providers, there have been increasing security and privacy concerns on outsourced data. Several schemes employing attribute-based encryption (ABE) have been proposed for access control of outsourced data in cloud computing; however, most of them suffer from inflexibility in implementing complex access control policies. In order to realize scalable, flexible, and fine-grained access control of outsourced data in cloud computing, in this paper, we propose pecking order attribute-set-based encryption (PASBE) by extending cipher text-policy attribute-set-based encryption (ASBE) with a hierarchical structure of users. The proposed scheme not only achieves scalability due to its hierarchical structure, but also inherits flexibility and fine-grained access control in supporting compound attributes of ASBE. In addition, PASBE employs multiple value assignments for access expiration time to deal with user revocation more efficiently than existing schemes. We formally prove the security of PASBE based on security of the cipher text-policy attribute-based encryption (CP-ABE) scheme by Bettencourt et al. and analyze its performance and computational complexity. We implement our scheme and show that it is both efficient and flexible in dealing with access control for outsourced data in cloud computing with comprehensive experiments.

*Keywords***— *PASBE, ASBE, Cipher text-policy, ABE, access control;***

INTRODUCTION

To achieve flexible and fine-grained access control, a number of schemes have been proposed more recently. Unfortunately, these schemes are only applicable to systems in which data owners and the service providers are within the same trusted domain. Since data owners and service providers are usually not in the same trusted domain in cloud computing, a new access control scheme employing attributed-based encryption is proposed, which adopts the so-called key-policy attribute-based encryption (KP-ABE) to enforce fine-grained access control. However, this scheme falls short of flexibility in attribute management and lacks scalability in dealing with multiple-levels of attribute authorities.

Cloud computing is a new computing paradigm that is built on virtualization, parallel and distributed computing, utility computing, and service-oriented architecture. In the last several years, cloud computing has emerged as one of the most influential paradigms in the IT industry, and has attracted extensive attention from both academia and industry. Cloud computing holds the promise of providing computing as the fifth utility [1] after the other four utilities (water, gas, electricity, and telephone). The benefits of cloud computing include reduced costs and capital expenditures, increased operational efficiencies, scalability, flexibility, immediate time to market, and so on. Different service-oriented cloud computing models have been proposed, including Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). Numerous commercial cloud computing systems have been built at different levels, e.g., Amazon's EC2 [2], Amazon's S3 [3], and IBM's Blue Cloud [4] are IaaS systems, while Google App Engine [5] and Yahoo Pig are representative PaaS systems, and Google's Apps [6] and Sales force's Customer Relation Management (CRM) System [7] belong to SaaS systems. With these cloud computing systems, on one hand, enterprise users no longer need to invest in hardware/software systems or hire IT professionals to maintain these IT systems, thus they save cost on IT infrastructure and human resources; on the other hand, computing utilities provided by cloud computing are being offered at a relatively low price in a pay-as-you-use style. For example, Amazon's S3 data storage service with 99.99% durability charges only $0.06 to $0.15 per gigabyte-month, while traditional storage cost ranges from $1.00 to $3.50 per gigabyte-month according to Zetta Inc. [8].

Although the great benefits brought by cloud computing paradigm are exciting for IT companies, academic researchers, and potential cloud users, security problems in cloud computing become serious obstacles which, without being appropriately addressed, will prevent cloud computing extensive applications and usage in the future. One of the prominent security concerns is data security and privacy in cloud computing due to its Internet- based data storage and management. In cloud computing, users have to give up their data to the cloud service provider for storage and business operations, while the cloud service provider is usually a commercial enterprise which cannot be totally trusted. Data represents an extremely important asset for any organization, and enterprise users will face serious consequences if its confidential data is disclosed to their business competitors or the public. Thus, cloud users in the first place want to make sure that their data are kept confidential to outsiders, including the cloud provider and their potential competitors. This is the first data security requirement. Data confidentiality is not the only security requirement. Flexible and fine-grained access control is also strongly desired in the service-oriented cloud computing model. A health-care information system on a cloud is required to restrict access of protected medical records to eligible doctors and a customer relation management system running on a cloud may allow access of customer information to high-level executives of the company only. In these cases, access control of sensitive data is either required by legislation (e.g., HIPAA) or company regulations.

Access control is a classic security topic which dates back to the 1960s or early 1970s [9], and various access control models have been proposed since then. Among them, Bell-La Padula (BLP) [10] and BiBa [11] are two famous security models. To achieve flexible and fine-grained access control, a number of schemes [12]–[15] have been proposed more recently. Unfortunately, these schemes are only applicable to systems in which data owners and the service providers are within the same trusted domain. Since data owners and service providers are usually not in the same trusted domain in cloud computing, a new access control scheme employing attributed-based encryption [16] is proposed by Yu et al. [17], which adopts the so-called key-policy attribute-based encryption (KP-ABE) to enforce fine-grained access control. However, this scheme falls short of flexibility in attribute management and lacks scalability in dealing with multiple-levels of attribute authorities.

We note that in contrast to KP-ABE, cipher text-policy ABE (CP-ABE) [18] turns out to be well suited for access control due to its expressiveness in describing access control policies. In this paper, we propose a pecking order attribute-set-based encryption (PASBE) scheme for access control in cloud computing. PASBE extends the ciphertext-policy attribute- set-based encryption (CP-ASBE, or ASBE for short) scheme by Bobba et al. [19] with a hierarchical structure of system users, so as to achieve scalable, flexible and fine-grained access control. The contribution of the paper is multifold. First, we show how PASBE extends the ASBE algorithm with a hierarchical structure to improve scalability and flexibility while at the same time inherits the feature of fine-grained access control of ASBE.

Second, we demonstrate how to implement a full-fledged access control scheme for cloud computing based on PASBE. The scheme provides full support for hierarchical user grant, file creation, file deletion, and user revocation in cloud computing. Third, we formally prove the security of the proposed scheme based on the security of the CP-ABE scheme by Bettencourt et al. [18] and analyze its performance in terms of computational overhead. Lastly, we implement PASBE and conduct comprehensive experiments for performance evaluation, and our experiments demonstrate that PASBE has satisfactory performance.

LITERATURE SURVEY

1) Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility

With the significant advances in Information and Communications Technology (ICT) over the last half century, there is an increasingly perceived vision that computing will one day be the 5th utility (after water, electricity, gas, and telephony). This computing utility, like all other four existing utilities, will provide the basic level of computing service that is considered essential to meet the everyday needs of the general community. To deliver this vision, a number of computing paradigms have been proposed, of which the latest one is known as Cloud computing. Hence, in this paper, we define Cloud computing and provide the architecture for creating Clouds with market-oriented resource allocation by leveraging technologies such as Virtual Machines (VMs). We also provide insights on market-based resource management strategies that encompass both customer-driven service management and computational risk management to sustain Service Level Agreement (SLA)-oriented resource allocation. In addition, we reveal our early thoughts on interconnecting Clouds for dynamically creating global Cloud exchanges and markets. Then, we present some representative Cloud platforms, especially those developed in industries, along with our current work towards realizing market-oriented resource allocation of Clouds as realized in Aneka enterprise Cloud technology. Furthermore, we highlight the difference between High Performance Computing (HPC) workload and Internet-based services workload. We also describe a meta-negotiation infrastructure to establish global Cloud exchanges and markets, and illustrate a case study of harnessing 'Storage Clouds' for high performance content delivery. Finally, we conclude with the need for convergence of competing IT paradigms to deliver our 21st century vision.

2) Methods and limitations of security policy reconciliation

A security policy is a means by which participant session requirements are specified. However, existing frameworks provide limited facilities for the automated reconciliation of participant policies. This paper considers the limits and methods of reconciliation in a general-purpose policy model. We identify an algorithm for efficient two-policy reconciliation, and show that, in the worst-case, reconciliation of three or more policies is intractable. Further, we suggest efficient heuristics for the detection and resolution of intractable reconciliation. Based upon the policy model, we describe the design and implementation of the Ismene policy language. The expressiveness of Ismene, and indirectly of our model, is demonstrated through the representation and exposition of policies supported by existing policy languages. We conclude with brief notes on the integration and enforcement of Ismene policy within the Antigone communication system.

3) A unified scheme for resource protection in automated trust negotiation

Automated trust negotiation is an approach to establishing trust between strangers through iterative disclosure of digital credentials. In automated trust negotiation, access control policies play a key role in protecting resources from unauthorized access. Unlike in traditional trust management systems, the access control policy for a resource is usually unknown to the party requesting access to the resource, when trust negotiation starts. The negotiating parties can rely on policy disclosures to learn each other's access control requirements. However a policy itself may also contain sensitive information. Disclosing policies' contents unconditionally may leak valuable business information or jeopardize individuals' privacy. In this paper we propose UniPro, a unified scheme to model protection of resources, including policies, in trust negotiation. UniPro improves on previous work by modeling policies as first-class resources, protecting them in the same way as other resources, providing fine-grained control over policy disclosure, and clearly distinguishing between policy disclosure and policy satisfaction, which gives users more flexibility in expressing their authorization requirements. We also show that UniPro can be used with practical negotiation strategies without jeopardizing autonomy in the choice of strategy, and present criteria under which negotiations using UniPro are guaranteed to succeed in establishing trust.

4) Cipher text-policy attribute based encryption

In several distributed systems a user should only be able to access data if a user posses a certain set of credentials or attributes. Currently, the only method for enforcing such policies is to employ a trusted server to store the data and mediate access control. However, if any server storing the data is compromised, then the confidentiality of the data will be compromised. In this paper we present a system for realizing complex access control on encrypted data that we call Ciphertext-Policy Attribute-Based Encryption. By using our techniques encrypted data can be kept confidential even if the storage server is untrusted; moreover, our methods are secure against collusion attacks. Previous Attribute- Based Encryption systems used attributes to describe the encrypted data and built policies into user's keys; while in our system attributes are used to describe a user's credentials, and a party encrypting data determines a policy for who can decrypt. Thus, our methods are conceptually closer to traditional access control methods such as Role-Based Access Control (RBAC). In addition, we provide an implementation of our system and give performance measurements.

5) Fuzzy identity based encryption

We introduce a new type of Identity Based Encryption (IBE) scheme that we call Fuzzy Identity Based Encryption. A Fuzzy IBE scheme allows for a private key for an identity id to decrypt a ciphertext encrypted with another identity id # if and only if the identities id and id # are close to each other as measured by some metric (e.g. Hamming distance). A Fuzzy IBE scheme can be applied to enable encryption using biometric measurements as identities. The error-tolerance of a Fuzzy IBE scheme is precisely what allows for the use of biometric identities, which inherently contain some amount of noise during each measurement.

EXISTING SYSTEM

Our existing solution applies cryptographic methods by disclosing data decryption keys only to authorize users. These solutions inevitably introduce a heavy computation overhead on the data owner for key distribution and data management when fine grained data access control is desired, and thus do not scale well.

Disadvantages:

- Software update/patches- could change security settings, assigning privileges too low, or even more alarmingly too high allowing access to your data by other parties.
- Security concerns- Experts claim that their clouds are 100% secure - but it will not be their head on the block when things go awry. It's often stated that cloud computing security is better than most enterprises. Also, how do you

decide which data to handle in the cloud and which to keep to internal systems once decided keeping it secure could well be a full-time task?

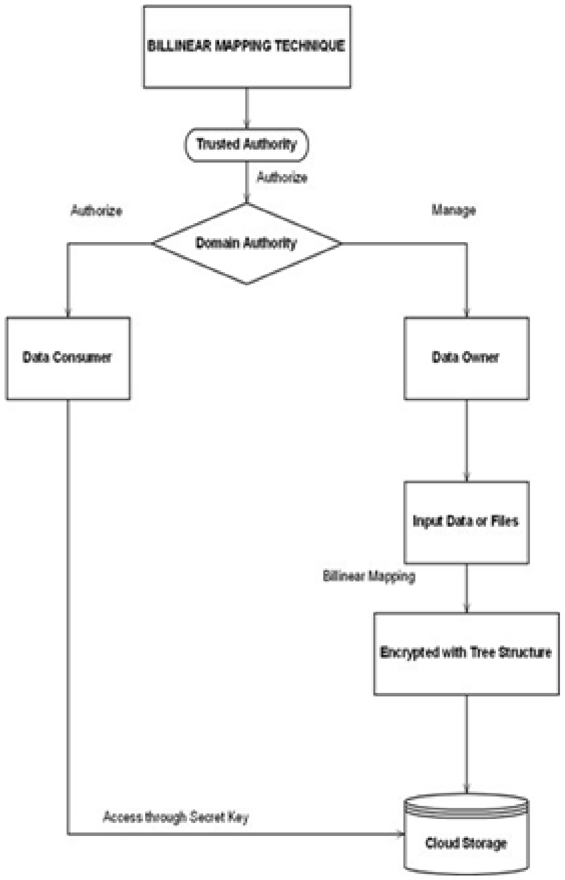
- Control- Control of your data/system by third-party. Data - once in the cloud always in the cloud! Can you be sure that once you delete data from your cloud account will it not exist any more......or will traces remain in the cloud

PROPOSED SYSTEM

This proposed system addresses this challenging open issue by, on one hand, defining and enforcing access policies based on data attributes, and, on the other hand, allowing the data owner to delegate most of the computation tasks involved in fine grained data access control to un-trusted cloud servers without disclosing the underlying data contents.

We propose a pecking order attribute-set-based encryption (PASBE) scheme for access control in cloud computing. PASBE extends the cipher text-policy attribute- set-based encryption (CP-ASBE, or ASBE for short) scheme with a hierarchical structure of system users, so as to achieve scalable, flexible and fine-grained access control.

More specifically, we associate each data file with a set of attributes, and assign each user an expressive access structure which is defined over these attributes. To enforce this kind of access control, we utilize KP-ABE to escort data encryption keys of data files. Such construction enables us to immediately enjoy fine-grainedness of access control. However, this construction, if deployed alone, would introduce heavy computation overhead and cumbersome online burden towards the data owner, as he is in charge of all the operations of data/user management. Specifically, such an issue is mainly caused by the operation of user revocation, which inevitably requires the data owner to re-encrypt all the data files accessible to the leaving user, or even needs the data owner to stay online to update secret keys for users.



To resolve this challenging issue and make the construction suitable for cloud computing, we uniquely combine PRE with KP-ABE and enable the data owner to delegate most of the computation intensive operations to Cloud Servers without disclosing the underlying file contents. Such a construction allows the data owner to control access of his data files with a minimal overhead in terms of computation effort and online time, and thus fits well into the cloud environment. Data confidentiality is also achieved since Cloud Servers are not able to learn the plaintext of any data file in our construction. For further reducing the computation overhead on Cloud Servers and thus saving the data owner's investment, we take advantage of the lazy re-encryption technique and allow Cloud Servers to "aggregate "computation tasks of multiple system operations.

As we will discuss in section V-B, the computation complexity on Cloud Servers is either proportional to the number of system attributes, or linear to the size of the user access structure/tree, which is independent to the number of users in the system. Scalability is thus achieved. In addition, our construction also protects user access privilege information against Cloud Servers. Accountability of user secret key can also be achieved by using an enhanced scheme of KP-ABE.

Advantages:

- Low initial capital investment
- Shorter start-up time for new services
- Lower maintenance and operation costs
- Higher utilization through virtualization
- Easier disaster recovery

MODULES DESCRIPTION

Data Owner Module

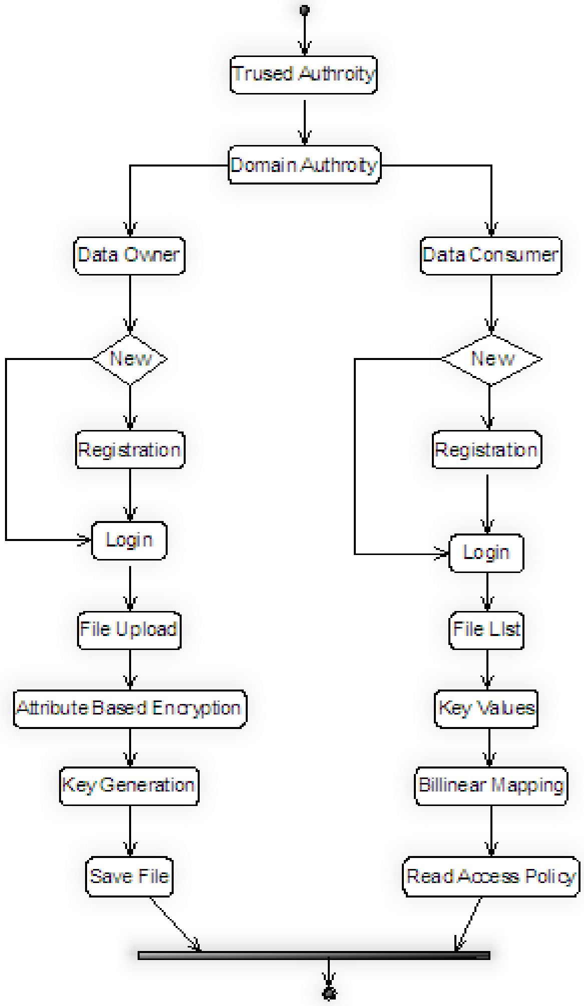
In this module, the data owner uploads their data in the cloud server. For the security purpose the data owner encrypts the data file and then store in the cloud. The data owner can change the policy over data files by updating the expiration time. The Data owner can have capable of manipulating the encrypted data file. And the data owner can set the access privilege to the encrypted data file.

Data Consumer Module

In this module, the user can only access the data file with the encrypted key if the user has the privilege to access the file. For the user level, all the privileges are given by the Domain authority and the Data user's are controlled by the Domain Authority only. Users may try to access data files either within or outside the scope of their access privileges, so malicious users may collude with each other to get sensitive files beyond their privileges.

Cloud Server Module

The cloud service provider manages a cloud to provide data storage service. Data owners encrypt their data files and store them in the cloud for sharing with data consumers. To access the shared data files, data consumers download encrypted data files of their interest from the cloud and then decrypt them.



Attribute based key generation Module

The trusted authority is responsible for generating and distributing system parameters and root master keys as well as authorizing the top-level domain authorities. A domain authority is responsible for delegating keys to subordinate domain authorities at the next level or users in its domain. Each user in the system is assigned a key structure which specifies the attributes associated with the user's decryption key. The trusted authority calls the algorithm to create system public parameters PK and master key MK. PK will be made public to other parties and MK will be kept secret. When a user sends request for data files stored on the cloud, the cloud sends the corresponding cipher texts to the user. The user decrypts them by first calling decrypt(CT,SK) to obtain DEK and then decrypt data files using DEK.

CONCLUSION

In this paper, we introduced the PASBE scheme for realizing scalable, flexible, and fine-grained access control in cloud computing. The PASBE scheme seamlessly incorporates a hierarchical structure of system users by applying a delegation algorithm to ASBE. PASBE not only supports compound attributes due to flexible attribute set combinations, but also achieves efficient user revocation because of multiple value assignments of attributes. We formally proved the security of PASBE based on the security of CP-ABE by Bethen court et al.. Finally, we implemented the proposed scheme, and conducted comprehensive performance analysis and evaluation, which showed its efficiency and advantages over existing schemes.

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