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An Effective Aggressive Multi-Keyword Ranked Search Procedure over Encrypted Cloud Data with Enhanced Protection

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Abstract:

Due to the increasing popularity of cloud computing, more and more data owners are motivated to outsource their data to cloud servers for great convenience and reduced cost in data management. However, sensitive data should be encrypted before outsourcing for privacy requirements, which obsoletes data utilization like keyword-based document retrieval. In this paper, we present a secure multi-keyword ranked search scheme over encrypted cloud data, which simultaneously supports dynamic update operations like deletion and insertion of documents. Specifically, the vector space model and the widely-used TF_IDF model are combined in the index construction and query generation. We construct a special tree-based index structure and propose a “Greedy Depth-first Search” algorithm to provide efficient multi-keyword ranked search. The secure kNN algorithm is utilized to encrypt the index and query vectors, and meanwhile ensure accurate relevance score calculation between encrypted index and query vectors. In order to resist statistical attacks, phantom terms are added to the index vector for blinding search results. Due to the use of our special tree-based index structure, the proposed scheme can achieve sub-linear search time and deal with the deletion and insertion of documents flexibly. Extensive experiments are conducted to demonstrate the efficiency of the proposed scheme.

1. INTRODUCTION

CLOUD computing has been considered as a new model of enterprise IT infrastructure, which can organize huge resource of computing, storage and applications, and enable users to enjoy ubiquitous, convenient and on-demand network access to a shared pool of configurable computing resources with great efficiency and minimal economic overhead [1]. Attracted by these appealing features, both individuals and enterprises are motivated to outsource their data to the cloud, instead of purchasing software and hardware to manage the data themselves. Despite of the various advantages of cloud services, outsourcing sensitive information (such as e-mails, personal health records, company finance data, government documents, etc.) to remote servers brings privacy concerns. The cloud service providers (CSPs) that keep the data for users may access users' sensitive information without authorization. A general approach to protect the data confidentiality is to encrypt the data before outsourcing [2]. However, this will cause a huge cost in terms of data usability. For example, the existing techniques on keyword-based information retrieval, which are widely used on the plaintext data, cannot be directly applied on the encrypted data. Downloading all the data from the cloud and decrypt locally is obviously impractical. In order to address the above problem, researchers have designed some general-purpose solutions with fully-homomorphic encryption [3] or oblivious RAMs [4]. However, these methods are not practical due to their high computational overhead for both the cloud sever and user. On the contrary, more practical specialpurpose solutions, such as searchable encryption (SE) schemes have made specific contributions in terms of efficiency, functionality and security.

Searchable encryption schemes enable the client to store the encrypted data to the cloud and execute keyword search over ciphertext domain. So far, abundant works have been proposed under different threat models to achieve various search functionality, such as single keyword search, similarity search, multi-keyword boolean search, ranked search, multi-keyword ranked search, etc. Among them, multi keyword ranked search achieves more and more attention for its practical applicability. Recently, some *dynamic* schemes have been proposed to support inserting and deleting operations on document collection. These are significant works as it is highly possible that the data owners need to update their data on the cloud server. But few of the dynamic schemes support efficient multi keyword ranked search.

This paper proposes a secure tree-based search scheme over the encrypted cloud data, which supports multi keyword ranked search and dynamic operation on the document collection. Specifically, the vector space model and the widely-used "term frequency (TF) × inverse doc ument frequency (IDF)" model are combined in the index construction and query generation to provide multikeyword ranked search. In order to obtain high search efficiency, we construct a tree-based index structure and propose a "Greedy Depth-first Search" algorithm based on this index tree. Due to the special structure of our tree-based index, the proposed search scheme can flexibly achieve sub-linear search time and deal with the deletion and insertion of documents. The secure kNN algorithm is utilized to encrypt the index and query vectors, and meanwhile ensure accurate relevance score calculation between encrypted index and query vectors. To resist different attacks in different threat models, we construct two secure search schemes: the basic dynamic multi-keyword ranked search (BDMRS) scheme in the known cipher text model, and the enhanced dynamic multi-keyword ranked search (EDMRS) scheme in the known background model.

Our contributions are summarized as follows:

1) We design a searchable encryption scheme that supports both the accurate multi-keyword ranked search and flexible dynamic operation on document collection.

2) Due to the special structure of our tree-based index, the search complexity of the proposed scheme is fundamentally kept to logarithmic. And in practice, the proposed scheme can achieve higher search efficiency by executing our "Greedy Depth-first Search" algorithm. Moreover, parallel search can be flexibly performed to further reduce the time cost of search process. The reminder of this paper is organized as follows.

Related work is discussed in Section 2, and Section 3 gives a brief introduction to the system model, threat model, the design goals, and the preliminaries. Section 4 describes the schemes in detail. Section 5 presents the experiments and performance analysis. And Section 6 covers the conclusion.

2. SYSTEM STUDY

2.1 FEASIBILITY STUDY

The feasibility of the project is analyzed in this phase and business proposal is put forth with a very general plan for the project and some cost estimates. During system analysis the feasibility study of the proposed system is to be carried out. This is to ensure that the proposed system is not a burden to the company. For feasibility analysis, some understanding of the major requirements for the system is essential. Three key considerations involved in the feasibility analysis are

- ECONOMICAL FEASIBILITY
- TECHNICAL FEASIBILITY
- SOCIAL FEASIBILITY

ECONOMICAL FEASIBILITY

This study is carried out to check the economic impact that the system will have on the organization. The amount of fund that the company can pour into the research and development of the system is limited. The expenditures must be justified. Thus the developed system as well within the budget and this was achieved because most of the technologies used are freely available. Only the customized products had to be purchased.

TECHNICAL FEASIBILITY

This study is carried out to check the technical feasibility, that is, the technical requirements of the system. Any system developed must not have a high demand on the available technical resources. This will lead to high demands on the available technical resources. This will lead to high demands being placed on the client. The developed system must have a modest requirement, as only minimal or null changes are required for implementing this system.

SOCIAL FEASIBILITY

The aspect of study is to check the level of acceptance of the system by the user. This includes the process of training the user to use the system efficiently. The user must not feel threatened by the system, instead must accept it as a necessity. The level of acceptance by the users solely depends on the methods that are employed to educate the user about the system and to make him familiar with it. His level of confidence must be raised so that he is also able to make some constructive criticism, which is welcomed, as he is the final user of the system.

3. SYSTEM ANALYSIS

3.1 EXISTING SYSTEM

A general approach to protect the data confidentiality is to encrypt the data before outsourcing. Searchable encryption schemes enable the client to store the encrypted data to the cloud and execute keyword search over cipher text domain. So far, abundant works have been proposed under different threat models to achieve various search functionality, such as single keyword search, similarity search, multi-keyword boolean search, ranked search, multi-keyword ranked search, etc. Among them, multi-keyword ranked search achieves more and more attention for its practical applicability. Recently, some *dynamic* schemes have been proposed to support inserting and deleting operations on document collection. These are significant works as it is highly possible that the data owners need to update their data on the cloud server.

3.1.1 DISADVANTAGES OF EXISTING SYSTEM

Huge cost in terms of data usability. For example, the existing techniques on keyword-based information retrieval, which are widely used on the plaintext data, cannot be directly applied on the encrypted data. Downloading all the data from the cloud and decrypt locally is obviously impractical. Existing System methods not practical due to their high computational overhead for both the cloud sever and user

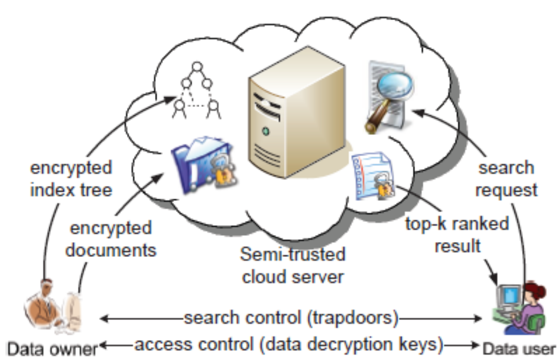
3.2 PROPOSED SYSTEM

This paper proposes a secure tree-based search scheme over the encrypted cloud data, which supports multi-keyword ranked search and dynamic operation on the document collection. Specifically, the vector space model and the widely-used "term frequency (TF) $\times$ inverse document frequency (IDF)" model are combined in the index construction and query generation to provide multi-keyword ranked search. In order to obtain high search efficiency, we construct a tree-based index structure and propose a "Greedy Depth-first Search" algorithm based on this index tree. The secure kNN algorithm is utilized to encrypt the index and query vectors, and meanwhile ensure accurate relevance score calculation between encrypted index and query vectors. To resist different attacks in different threat models, we construct two secure search schemes: the basic dynamic multi-keyword ranked search (BDMRS) scheme in the known cipher text model, and the enhanced dynamic multi-keyword ranked search (EDMRS) scheme in the known background model.

3.2.1 ADVANTAGES OF PROPOSED SYSTEM

Due to the special structure of our tree-based index, the proposed search scheme can flexibly achieve sub-linear search time and deal with the deletion and insertion of documents. We design a searchable encryption scheme that supports both the accurate multi-keyword ranked search and flexible dynamic operation on document collection. Due to the special structure of our tree-based index, the search complexity of the proposed scheme is fundamentally kept to logarithmic. And in practice, the proposed scheme can achieve higher search efficiency by executing our "Greedy Depth-first Search" algorithm. Moreover, parallel search can be flexibly performed to further reduce the time cost of search process.

4. SYSTEM ARCHITECTURE



4.1 MODULES

Index Module:

Index structures for huge datasets cannot be stored in main memory. Disk is a possible alternative. Storing it on disk requires different approach. The solution is to use more branches to reduce the height of the tree. For this we used B-tree data structure for each document. B-tree is a data structure of order n. The nodes are filled from n to 2n keys. Nodes are always at least half full of keys. The keys are within each node. A list of pointers is inserted between keys. These pointers help to navigate through tree. In general, a node with k keys has (k+1) pointers.

Search Module:

Searching a B-tree is like searching a binary tree. Here instead of making a binary branching decision at each node, we make a multiday branching decision according to the number of the node's children.

Ranking Module:

In large databases, it is quite likely that the keyword might be matching with more number of documents. It is cumbersome for a user to decrypt and go through all the documents. Therefore there is a need for ranking the documents based on their relevance to the keywords. In our scheme we used (TF * IDF) to rank the documents. TF is the term frequency i.e. occurrence of keywords in a document and IDF is inverse document frequency i.e. total number of documents divided by number of documents containing the keyword. Similarity measure is used to find the rank based on relevance. For this, we maintain two vectors one for storing TF weight and other to store IDF weight.

Result Analysis:

The privacy preserved multi-keyword search based on the encrypted cloud data has been designed. The system model presented has been developed on Visual Studio 2010 framework 4.0 with C#. The overall system has been developed and implemented with Microsoft Azure cloud platform.

5. CONCLUSION

In this paper, a secure, efficient and dynamic search scheme is proposed, which supports not only the accurate multi-keyword ranked search but also the dynamic deletion and insertion of documents. We construct a special keyword balanced binary tree as the index, and propose a "Greedy Depth-first Search" algorithm to obtain better efficiency than linear search. In addition, the parallel search process can be carried out to further reduce the time cost. The security of the scheme is protected against two threat models by using the secure kNN algorithm. Experimental results demonstrate the efficiency of our proposed scheme. There are still many challenge problems in symmetric SE schemes. In the proposed scheme, the data owner is responsible for generating updating information and sending them to the cloud server. Thus, the data owner needs to store the unencrypted index tree and the information that are necessary to recalculate the IDF values. Such an active data owner may not be very suitable for the cloud computing model. It could be a meaningful but difficult future work to design a dynamic searchable encryption scheme whose updating operation can be completed by cloud server only, meanwhile reserving the ability to support multi-keyword ranked search. In addition, as the most of works about searchable encryption, our scheme mainly considers the challenge from the cloud server. Actually, there are many secure challenges in a multi-user scheme. Firstly, all the users usually keep the same secure key for trapdoor generation in a symmetric SE scheme. In this case, the revocation of the user is big challenge. If it is needed to revoke a user in this scheme, we need to rebuild the index and distribute the new secure keys to all the authorized users. Secondly, symmetric SE schemes usually assume that all the data users are trustworthy.

6. Results

It is not practical and a dishonest data user will lead to many secure problems. For example, a dishonest data user may search the documents and distribute the decrypted documents to the unauthorized ones. Even more, a dishonest data user may distribute his/her secure keys to the unauthorized ones. In the future works, we will try to improve the SE scheme to handle these challenge problems.

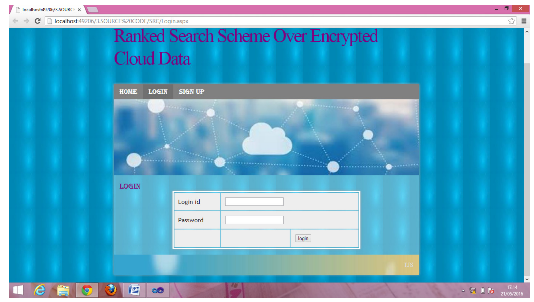


Fig 6.1

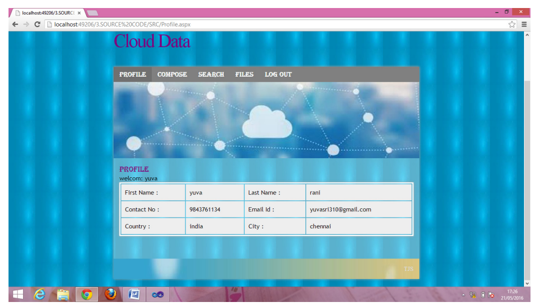


Fig 6.2

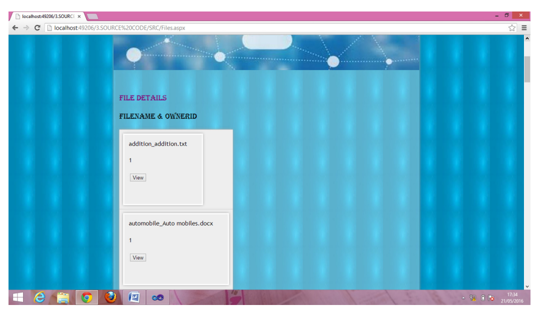


Fig 6.3

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