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Design & Development of an Economical and Efficient Protocol for Enhanced Privacy and Security in Distributed Databases

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ABSTRACT:

We propose a protocol for secure mining of association rules in horizontally distributed databases. The current leading protocol is that of Kantarcioglu and Clifton. Our protocol, like theirs, is based on the Fast Distributed Mining (FDM) algorithm of Cheung et al. which is an unsecured distributed version of the Apriori algorithm. The main ingredients in our protocol are two novel secure multi-party algorithms — one that computes the union of private subsets that each of the interacting players hold and another that tests the inclusion of an element held by one player in a subset held by another. Our protocol offers enhanced privacy with respect to the protocol. In addition, it is simpler and is significantly more efficient in terms of communication rounds, communication cost and computational cost.

KEYWORDS: Classification and Regression Trees (CART); and Chi Square Automatic Interaction Detection (CHAID); Beaver-Micali-Rogaway (BMR); Ben-Or-Goldwasser-Wigderson (BGW); Fast Distributed Mining (FDM)

INTRODUCTION

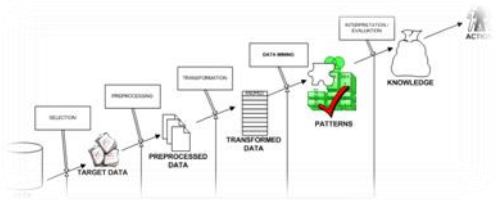


Figure 1: Structure of Data Mining

Generally, data mining (sometimes called data or knowledge discovery) is the process of analyzing data from different perspectives and summarizing it into useful information - information that can be used to increase revenue, cuts costs, or both. Data mining software is one of a number of analytical tools for analyzing data. It allows users to analyze data from many different dimensions or angles, categorize it, and summarize the relationships identified. Technically, data mining is the process of finding correlations or patterns among dozens of fields in large relational databases.

While large-scale information technology has been evolving separate transaction and analytical systems, data mining provides the link between the two. Data mining software analyzes relationships and patterns in stored transaction data based on open-ended user queries. Several types of analytical software are available: statistical, machine learning, and neural networks.[1] **Generally, any of four types of relationships are sought:**

- **Classes**: Stored data is used to locate data in predetermined groups. For example, a restaurant chain could mine customer purchase data to determine when customers visit and what they typically order. This information could be used to increase traffic by having daily specials.

- **Clusters**: Data items are grouped according to logical relationships or consumer preferences. For example, data can be mined to identify market segments or consumer affinities.
- **Associations**: Data can be mined to identify associations. The beer-diaper example is an example of associative mining.
- **Sequential patterns**: Data is mined to anticipate behavior patterns and trends. For example, an outdoor equipment retailer could predict the likelihood of a backpack being purchased based on a consumer's purchase of sleeping bags and hiking shoes.[2]

Data mining consists of five major elements:

1) Extract, transform, and load transaction data onto the data warehouse system.
2) Store and manage the data in a multidimensional database system.
3) Provide data access to business analysts and information technology professionals.
4) Analyze the data by application software.
5) Present the data in a useful format, such as a graph or table.[3]

Different levels of analysis are available:

- **Artificial neural networks**: Non-linear predictive models that learn through training and resemble biological neural networks in structure.
- **Genetic algorithms**: Optimization techniques that use process such as genetic combination, mutation, and natural selection in a design based on the concepts of natural evolution.
- **Decision trees**: Tree-shaped structures that represent sets of decisions. These decisions generate rules for the classification of a dataset. Specific decision tree methods include Classification and Regression Trees (CART) and Chi Square Automatic Interaction Detection (CHAID). CART and CHAID are decision tree techniques used for classification of a dataset. They provide a set of rules that you can apply to a new (unclassified) dataset to predict which records will have a given outcome. CART segments a dataset by creating 2-way splits while CHAID segments using chi square tests to create multi-way splits. CART typically requires less data preparation than CHAID.
- **Nearest neighbor method**: A technique that classifies each record in a dataset based on a combination of the classes of the *k* record(s) most similar to it in a historical dataset (where *k*=1). Sometimes called the *k*-nearest neighbor technique.
- **Rule induction**: The extraction of useful if-then rules from data based on statistical significance.
- **Data visualization**: The visual interpretation of complex relationships in multidimensional data. Graphics tools are used to illustrate data relationships.[4]

Characteristics of Data Mining:

- **Large quantities of data**: The volume of data so great it has to be analyzed by automated techniques e.g. satellite information, credit card transactions etc.
- **Noisy, incomplete data**: Imprecise data is the characteristic of all data collection.
- **Complex data structure**: conventional statistical analysis not possible
- **Heterogeneous data stored in legacy systems[5]**

Benefits of Data Mining:

1) It's one of the most effective services that are available today. With the help of data mining, one can discover precious information about the customers and their behavior for a specific set of products and evaluate and analyze, store, mine and load data related to them
2) An analytical CRM model and strategic business related decisions can be made with the help of data mining as it helps in providing a complete synopsis of customers

3) An endless number of organizations have installed data mining projects and it has helped them see their own companies make an unprecedented improvement in their marketing strategies (Campaigns)
4) Data mining is generally used by organizations with a solid customer focus. For its flexible nature as far as applicability is concerned is being used vehemently in applications to foresee crucial data including industry analysis and consumer buying behaviors
5) Fast paced and prompt access to data along with economic processing techniques have made data mining one of the most suitable services that a company seek[6]

Advantages of Data Mining:

1. Marketing / Retail:

Data mining helps marketing companies build models based on historical data to predict who will respond to the new marketing campaigns such as direct mail, online marketing campaign…etc. Through the results, marketers will have appropriate approach to sell profitable products to targeted customers.

Data mining brings a lot of benefits to retail companies in the same way as marketing. Through market basket analysis, a store can have an appropriate production arrangement in a way that customers can buy frequent buying products together with pleasant. In addition, it also helps the retail companies offer certain discounts for particular products that will attract more customers.

2. Finance / Banking

Data mining gives financial institutions information about loan information and credit reporting. By building a model from historical customer's data, the bank and financial institution can determine good and bad loans. In addition, data mining helps banks detect fraudulent credit card transactions to protect credit card's owner.

3. Manufacturing

By applying data mining in operational engineering data, manufacturers can detect faulty equipments and determine optimal control parameters. For example semi-conductor manufacturers has a challenge that even the conditions of manufacturing environments at different wafer production plants are similar, the quality of wafer are lot the same and some for unknown reasons even has defects. Data mining has been applying to determine the ranges of control parameters that lead to the production of golden wafer. Then those optimal control parameters are used to manufacture wafers with desired quality.

4. Governments

Data mining helps government agency by digging and analyzing records of financial transaction to build patterns that can detect money laundering or criminal activities.

5. Law enforcement:

Data mining can aid law enforcers in identifying criminal suspects as well as apprehending these criminals by examining trends in location, crime type, habit, and other patterns of behaviors.

6. Researchers:

Data mining can assist researchers by speeding up their data analyzing process; thus, allowing those more time to work on other projects.[7]

LITERATURE SURVEY

The use of cryptographic hash functions like MD5 or SHA-1 for message authentication has become a standard approach in many applications, particularly Internet security protocols. Though very easy to implement, these mechanisms are usually based on ad hoc techniques that lack a sound security analysis.

We present new, simple, and practical constructions of message authentication schemes based on a cryptographic hash function. Our schemes, NMAC and HMAC, are proven to be secure as long as the underlying hash function has some reasonable cryptographic strengths. Moreover we show, in a quantitative way, that the schemes retain almost all the security of the underlying hash function. The

performance of our schemes is essentially that of the underlying hash function. Moreover they use the hash function (or its compression function) as a black box, so that widely available library code or hardware can be used to implement them in a simple way, and replaceability of the underlying hash function is easily supported.[8]

We present FairplayMP (for "Fairplay Multi-Party"), a system for secure multi-party computation. Secure computation is one of the great achievements of modern cryptography, enabling a set of untrusting parties to compute any function of their private inputs while revealing nothing but the result of the function. In a sense, FairplayMP lets the parties run a joint computation that emulates a trusted party which receives the inputs from the parties, computes the function, and privately informs the parties of their outputs. FairplayMP operates by receiving a high-level language description of a function and a configuration file describing the participating parties.[9] The system compiles the function into a description as a Boolean circuit, and perform a distributed evaluation of the circuit while revealing nothing else. FairplayMP supplements the Fairplay system , which supported secure computation between two parties. The underlying protocol of FairplayMP is the Beaver-Micali-Rogaway (BMR) protocol which runs in a constant number of communication rounds (eight rounds in our implementation). We modified the BMR protocol in a novel way and considerably improved its performance by using the Ben-Or-Goldwasser-Wigderson (BGW) protocol for the purpose of constructing gate tables.[10] We chose to use this protocol since we believe that the number of communication rounds is a major factor on the overall performance of the protocol. We conducted different experiments which measure the effect of different parameters on the performance of the system and demonstrate its scalability. (We can now tell, for example, that running a second-price auction between four bidders, using five computation players, takes about 8 seconds.)[11]

lackley and Shamir independently proposed schemes by which a secret can be divided into many shares which can be distributed to mutually suspicious agents. This paper describes a homomorphism property attained by these and several other secret sharing schemes which allows multiple secrets to be combined by direct computation on shares.[12] This property reduces the need for trust among agents and allows secret sharing to be applied to many new problems. One application described gives a method of verifiable secret sharing which is much simpler and more efficient than previous schemes. A second application is described which gives a fault-tolerant method of holding verifiable secret-ballot elections.

We consider scenarios in which two parties, each in possession of a graph, wish to compute some algorithm on their *joint graph* in a privacy-preserving manner, that is, without leaking any information about their inputs except that revealed by the algorithm's output.[13]

Working in the standard secure multi-party computation paradigm, we present new algorithms for privacy-preserving computation of APSD (all pairs shortest distance) and SSSD (single source shortest distance), as well as two new algorithms for privacy-preserving set union. Our algorithms are significantly more efficient than generic constructions. As in previous work on privacy-preserving data mining, we prove that our algorithms are secure provided the participants are "honest, but curious.[14]

With the existence of many large transaction databases, the huge amounts of data, the high scalability of distributed systems, and the easy partitioning and distribution of a centralized database, it is important to investigate efficient methods for distributed mining of association rules. The study discloses some interesting relationships between locally large and globally large item sets and proposes an interesting distributed association rule mining algorithm, FDM (fast distributed mining of association rules), which generates a small number of candidate sets and substantially reduces the number of messages

to be passed at mining association rules. A performance study shows that FDM has a superior performance over the direct application of a typical sequential algorithm. Further performance enhancement leads to a few variations of the algorithm.[15]

SYSTEM STUDY

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.

SYSTEM DESIGN

DATA FLOW DIAGRAM:

1. The DFD is also called as bubble chart. It is a simple graphical formalism that can be used to represent a system in terms of input data to the system, various processing carried out on this data, and the output data is generated by this system.
2. The data flow diagram (DFD) is one of the most important modeling tools. It is used to model the system components. These components are the system process, the data used by the process, an external entity that interacts with the system and the information flows in the system.
3. DFD shows how the information moves through the system and how it is modified by a series of transformations. It is a graphical technique that depicts information flow and the transformations that are applied as data moves from input to output.
4. DFD is also known as bubble chart. A DFD may be used to represent a system at any level of abstraction. DFD may be partitioned into levels that represent increasing information flow and functional detail.

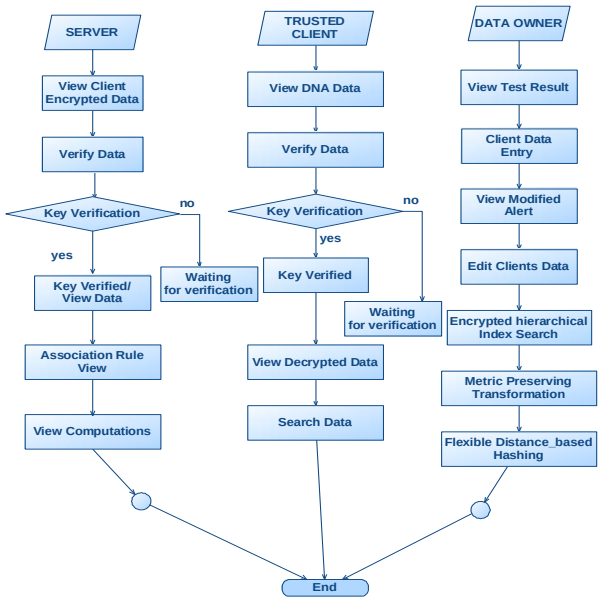


Figure 2 : Data Flow Diagram

UML DIAGRAMS

UML stands for Unified Modeling Language. UML is a standardized general-purpose modeling language in the field of object-oriented software engineering. The standard is managed, and was created by, the Object Management Group.

The goal is for UML to become a common language for creating models of object oriented computer software. In its current form UML is comprised of two major components: a Meta-model and a notation. In the future, some form of method or process may also be added to; or associated with, UML.

The Unified Modeling Language is a standard language for specifying, Visualization, Constructing and documenting the artifacts of software system, as well as for business modeling and other non-software systems.

The UML represents a collection of best engineering practices that have proven successful in the modeling of large and complex systems.

The UML is a very important part of developing objects oriented software and the software development process. The UML uses mostly graphical notations to express the design of software projects.

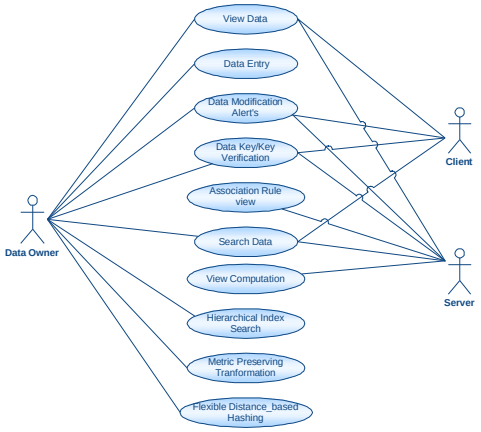
GOALS:

The Primary goals in the design of the UML are as follows:

1. Provide users a ready-to-use, expressive visual modeling Language so that they can develop and exchange meaningful models.
2. Provide extendibility and specialization mechanisms to extend the core concepts.
3. Be independent of particular programming languages and development process.
4. Provide a formal basis for understanding the modeling language.
5. Encourage the growth of OO tools market.
6. Support higher level development concepts such as collaborations, frameworks, patterns and components.
7. Integrate best practices.

USE CASE DIAGRAM:

A use case diagram in the Unified Modeling Language (UML) is a type of behavioral diagram defined by and created from a Use-case analysis. Its purpose is to present a graphical overview of the functionality provided by a system in terms of actors, their goals (represented as use cases), and any dependencies between those use cases. The main purpose of a use case diagram is to show what system functions are performed for which actor. Roles of the actors in the system can be depicted.



sFigure 3 : Use case Diagram

CLASS DIAGRAM:

In software engineering, a class diagram in the Unified Modeling Language (UML) is a type of static structure diagram that describes the structure of a system by showing the system's classes, their attributes, operations (or methods), and the relationships among the classes. It explains which class contains information.

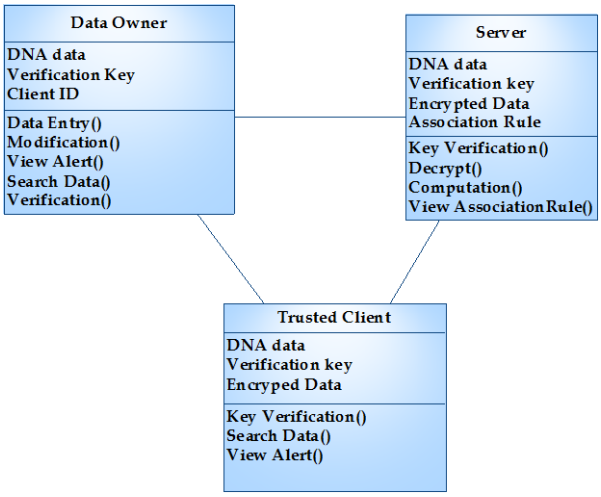


Figure 4 : Class Diagram

SEQUENCE DIAGRAM:

A sequence diagram in Unified Modeling Language (UML) is a kind of interaction diagram that shows how processes operate with one another and in what order. It is a construct of a Message Sequence Chart. Sequence diagrams are sometimes called event diagrams, event scenarios, and timing diagrams.

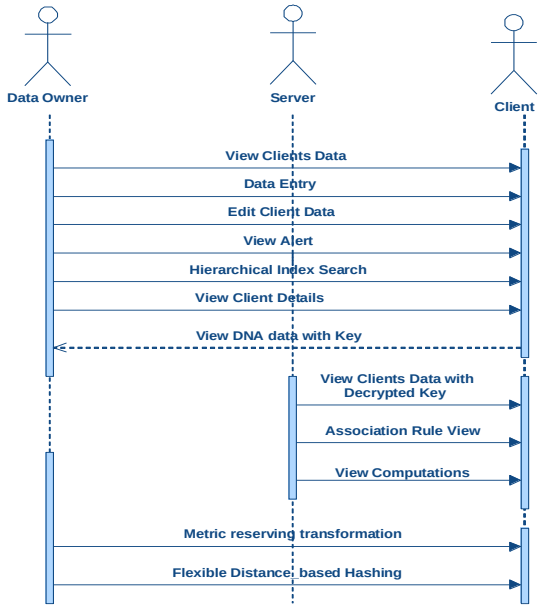


Figure 5: Sequence Diagram

ACTIVITY DIAGRAM:

Activity diagrams are graphical representations of workflows of stepwise activities and actions with support for choice, iteration and concurrency. In the Unified Modeling Language, activity diagrams can be used to describe the business and operational step-by-step workflows of components in a system. An activity diagram shows the overall flow of control.

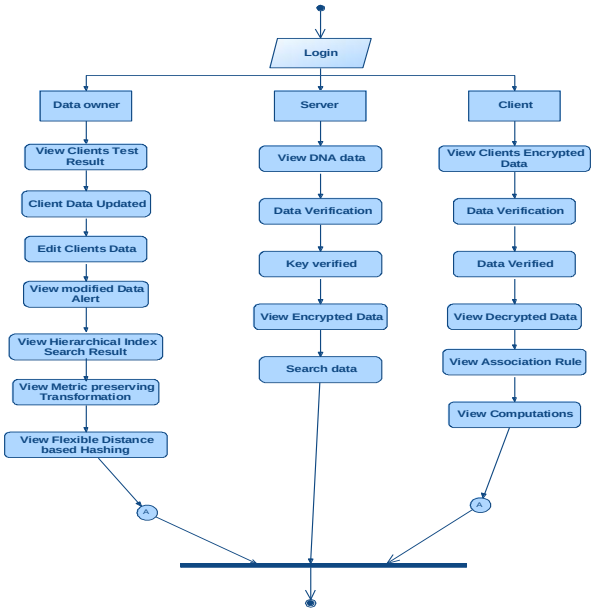


Figure 6 : Activity Diagram

INPUT DESIGN

The input design is the link between the information system and the user. It comprises the developing specification and procedures for data preparation and those steps are necessary to put transaction data in to a usable form for processing can be achieved by inspecting the computer to read data from a written or printed document or it can occur by having people keying the data directly into the system. The design of input focuses on controlling the amount of input required, controlling the errors, avoiding delay, avoiding extra steps and keeping the process simple. The input is designed in such a way so that it provides security and ease of use with retaining the privacy. Input Design considered the following things:

- What data should be given as input?
- How the data should be arranged or coded?
- The dialog to guide the operating personnel in providing input.
- Methods for preparing input validations and steps to follow when error occur.

OBJECTIVES

1. Input Design is the process of converting a user-oriented description of the input into a computer-based system. This design is important to avoid errors in the data input process and show the correct direction to the management for getting correct information from the computerized system.

2. It is achieved by creating user-friendly screens for the data entry to handle large volume of data. The goal of designing input is to make data entry easier and to be free from errors. The data entry screen is designed in such a way that all the data manipulates can be performed. It also provides record viewing facilities.

3. When the data is entered it will check for its validity. Data can be entered with the help of screens. Appropriate messages are provided as when needed so that the user will not be in maize of instant. Thus the objective of input design is to create an input layout that is easy to follow

OUTPUT DESIGN

A quality output is one, which meets the requirements of the end user and presents the information clearly. In any system results of processing are communicated to the users and to other system through outputs. In output design it is determined how the information is to be displaced for immediate need and also the hard copy output. It is the most important and direct source information to the user. Efficient and intelligent output design improves the system's relationship to help user decision-making.

1. Designing computer output should proceed in an organized, well thought out manner; the right output must be developed while ensuring that each output element is designed so that people will find the system can use easily and effectively. When analysis design computer output, they should Identify the specific output that is needed to meet the requirements.

2.Select methods for presenting information.

3.Create document, report, or other formats that contain information produced by the system.

The output form of an information system should accomplish one or more of the following objectives.

- Convey information about past activities, current status or projections of the
- Future.
- Signal important events, opportunities, problems, or warnings.
- Trigger an action.
- Confirm an action.

SYSTEM ANALYSIS

EXISTING SYSTEM:

Kantarcioglu and Clifton studied that problems and devised a protocol for its solution. The main part of the protocol is a sub-protocol for the secure computation of the union of private subsets that are held by the different players. (The private subset of a given player, as we explain below, includes the item sets that are s-frequent in his partial database. That is the most costly part of the protocol and its implementation relies upon cryptographic primitives such as commutative encryption, oblivious transfer, and hash functions. This is also the only part in the protocol in which the

players may extract from their view of the protocol information on other databases, beyond what is implied by the final output and their own input. While such leakage of information renders the protocol not perfectly secure, the perimeter of the excess information is explicitly bounded and it is argued there that such information leakage is innocuous, whence acceptable from a practical point of view.

DISADVANTAGES OF EXISTING SYSTEM:

- Insufficient security, simplicity and efficiency are not well in the databases, not sure in privacy in an existing system.
- While our solution is still not perfectly secure, it leaks excess information only to a small number (three) of possible coalitions, unlike the protocol of that discloses information also to some single players.
- Our protocol may leak is less sensitive than the excess information leaked by the protocol.

PROPOSED SYSTEM:

The protocol that we propose here computes a parameterized family of functions, which we call threshold functions, in which the two extreme cases correspond to the problems of computing the union and intersection of private subsets. Those are in fact general-purpose protocols that can be used in other contexts as well. Another problem of secure multiparty computation that we solve here as part of our discussion is the set inclusion problem; namely, the problem where Alice holds a private subset of some ground set, and Bob holds an element in the ground set, and they wish to determine whether Bob's element is within Alice's subset, without revealing to either of them information about the other party's input beyond the above described inclusion.

ADVANTAGES OF PROPOSED SYSTEM:

- We proposed a protocol for secure mining of association rules in horizontally distributed databases that improves significantly upon the current leading protocol in terms of privacy and efficiency.
- The main ingredient in our proposed protocol is a novel secure multi-party protocol for computing the union (or intersection) of private subsets that each of the interacting players holds.

SYSTEM TESTING

The purpose of testing is to discover errors. Testing is the process of trying to discover every conceivable fault or weakness in a work product. It provides a way to check the functionality of components, sub assemblies, assemblies and/or a finished product It is the process of exercising software with the intent of ensuring that the Software system meets its requirements and user expectations and does not fail in an unacceptable manner. There are various types of test. Each test type addresses a specific testing requirement.

TYPES OF TESTS

Unit testing

Unit testing involves the design of test cases that validate that the internal program logic is functioning properly, and that program inputs produce valid outputs. All decision branches and internal code flow should be validated. It is the testing of individual software units of the application .it is done after the completion of an individual unit before integration. This is a structural testing, that relies on knowledge of its construction and is invasive. Unit tests perform basic tests at component level and test a specific business process, application, and/or system configuration. Unit tests ensure that each unique path of a business process performs accurately to the documented specifications and contains clearly defined inputs and expected results.

Integration testing

Integration tests are designed to test integrated software components to determine if they actually run as one program. Testing is event driven and is more concerned with the basic outcome of screens or fields. Integration tests demonstrate that although the components were individually satisfaction, as shown by successfully unit testing, the combination of components is correct and consistent. Integration

testing is specifically aimed at exposing the problems that arise from the combination of components.

Functional test

Functional tests provide systematic demonstrations that functions tested are available as specified by the business and technical requirements, system documentation, and user manuals.

Functional testing is centered on the following items:

Valid Input : identified classes of valid input must be accepted.

Invalid Input : identified classes of invalid input must be rejected.

Functions : identified functions must be exercised.

Output : identified classes of application outputs must be exercised.

Systems/Procedures: interfacing systems or procedures must be invoked.

Organization and preparation of functional tests is focused on requirements, key functions, or special test cases. In addition, systematic coverage pertaining to identify Business process flows; data fields, predefined processes, and successive processes must be considered for testing. Before functional testing is complete, additional tests are identified and the effective value of current tests is determined.

System Test

System testing ensures that the entire integrated software system meets requirements. It tests a configuration to ensure known and predictable results. An example of system testing is the configuration oriented system integration test. System testing is based on process descriptions and flows, emphasizing pre-driven process links and integration points.

White Box Testing

White Box Testing is a testing in which in which the software tester has knowledge of the inner workings, structure and language of the software, or at least its purpose. It is purpose. It is used to test areas that cannot be reached from a black box level.

Black Box Testing

Black Box Testing is testing the software without any knowledge of the inner workings, structure or language of the module being tested. Black box tests, as most other kinds of tests, must be written from a definitive source document, such as specification or requirements document, such as specification or requirements document. It is a testing in which the software under test is treated, as a black box .you cannot "see" into it. The test provides inputs and responds to outputs without considering how the software works.

Unit Testing:

Unit testing is usually conducted as part of a combined code and unit test phase of the software lifecycle, although it is not uncommon for coding and unit testing to be conducted as two distinct phases.

Test strategy and approach

Field testing will be performed manually and functional tests will be written in detail.

Test objectives

- All field entries must work properly.
- Pages must be activated from the identified link.
- The entry screen, messages and responses must not be delayed.

Features to be tested

- Verify that the entries are of the correct format
- No duplicate entries should be allowed
- All links should take the user to the correct page.

Integration Testing

Software integration testing is the incremental integration testing of two or more integrated software components on a single platform to produce failures caused by interface defects.

The task of the integration test is to check that components or software applications, e.g. components in a software system or – one step up – software applications at the company level – interact without error.

Test Results: All the test cases mentioned above passed successfully. No defects encountered.

Acceptance Testing

User Acceptance Testing is a critical phase of any project and requires significant participation by the end user. It also ensures that the system meets the functional requirements.

Test Results: All the test cases mentioned above passed successfully. No defects encountered.

IMPLEMENTATION

MODULES:

1. Privacy Preserving Data Mining
2. Distributed Computation
3. Frequent Itemsets
4. Association Rules

MODULES DESCRIPTION:

1. Privacy Preserving Data Mining:

One, in which the data owner and the data miner are two different entities, and another, in which the data is distributed among several parties who aim to jointly perform data mining on the unified corpus of data that they hold. In the first setting, the goal is to protect the data records from the data miner. Hence, the data owner aims at anonym zing the data prior to its release. The main approach in this context is to apply data perturbation. The idea is that. Computation and communication costs versus the number of transactions *N* the perturbed data can be used to infer general trends in the data, without revealing original record information. In the second setting, the goal is to perform data mining while protecting the data records of each of the data owners from the other data owners. This is a problem of secure multiparty computation. The usual approach here is cryptographic rather than probabilistic.

2. Distributed Computation:

We compared the performance of two secure implementations of the FDM algorithm Section In the first implementation (denoted FDM-KC), we executed the unification step using Protocol UNIFI-KC, where the commutative cipher was 1024-bit RSA in the second implementation (denoted FDM) we used our Protocol UNIFI, where the keyed-hash function was HMAC. In both implementations, we implemented Step 5 of the FDM algorithm in the secure manner that was described in later. We tested the two implementations with respect to three measures:

1) Total computation time of the complete protocols (FDMKC and FDM) over all players. That measure includes the Apriori computation time, and the time to identify the globally *s*-frequent item sets, as described in later.

2) Total computation time of the unification protocols only (UNIFI-KC and UNIFI) over all players. 3) Total message size. We ran three experiment sets, where each set tested the dependence of the above measures on a different parameter: • *N* — the number of transactions in the unified database,

3. Frequent Itemsets:

We describe here the solution that was proposed by Kantarcioglu and Clifton. They considered two possible settings. If the required output includes all globally *s*-frequent item sets, as well as the sizes of their supports, then the values of $\Delta(x)$ can be revealed for all. In such a case, those values may be computed using a secure summation protocol, where the private addend of *Pm* is $suppm(x) - sNm$. The more interesting setting, however, is the one where the support sizes are not part of the required output. We proceed to discuss it.

4. Association Rules:

Once the set *Fs* of all *s*-frequent itemsets is found, we may proceed to look for all (*s*, *c*)-association rules (rules with support at least *sN* and confidence at least *c*). In order to derive from *Fs* all (*s*, *c*)-association rules in an efficient manner we rely upon the straightforward lemma.

RESULTS & CONCLUSION

We proposed a protocol for secure mining of association rules in horizontally distributed databases that improves significantly upon the current leading protocol [18] in terms of privacy and efficiency. One of the main ingredients in our proposed protocol is a

novel secure multi-party protocol for computing the union (or intersection) of private subsets that each of the interacting players hold. Another ingredient is a protocol that tests the inclusion of an element held by one player in a subset held by another. Those protocols exploit the fact that the underlying problem is of interest only when the number of players is greater than two.

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