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RESEARCH ARTICLE

DYNAMIC NON-COOPERATIVE COMPUTATION FOR PRIVACY PRESERVING DATA ANALYSIS

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*Abstract: Data mining has been around for many years that can help organizations to discover actionable knowledge. When data is available with multiple data providers, it is useful practice to have privacy preserving collaborative data analysis in distributed environment. Many techniques came into existence in order to achieve this. Recently Kantarcioglu *et al.* proposed incentive compatible approach that motivates competing parties to provide genuine data instead of giving less than ideal or incompatible data. In this paper we implement a mechanism and built a prototype application that allows multiple parties to have secure communication in distributed environment. The parties are able to log into the system and provide data. It does mean that multiple parties can provide compatible data. The system verifies the data and comes to know whether it is genuine or not. When data provided is not compatible the system deducts the incentives and informs the party to provide data again. When valid data is provided, the incentives will be increased again. This technique along with secure multi-party computations makes the proposed system very useful for privacy preserving collaborative data analysis. The empirical results are encouraging.*

Index Terms – Security, privacy-preserving data mining, horizontally partitioned data, vertically partitioned data

RELATED WORKS

This section reviews the literature on related works. Privacy preserving data mining is very important as the data mining should not disclose sensitive details. The researchers in [6], [5] and [7] focused on horizontally partitioned data. Other researches in [2] and [4] focused on vertically partitioned data. Many privacy preserving data mining solutions [1] assumed that the participants provide data truthfully. Horizontal partitioning is done through distributed partition of data. The

data is horizontally split into various sites. It does mean that the data is saved in various locations. The collaborative data mining where multiple participants or competing parties provide compatible data in a distributed environment it is important that all parties provide genuine data. The vertical data is split into multiple databases and that can be used as and when required. Non cooperative computation models and other related models were explored in [9]. More details are provided on NCC model in [8].

Another important research area explored in literature was about Secure Multi-Party Computations (SMC) that helps multiple competing parties to contribute in providing data in secure manner. The competing parties are supposed to give genuine data as explored in [3]. SMC protocols take care of the secure communications among multiple parties who involve in the data mining process. In this paper we follow an approach that provides incentives to the genuine data givers. Among the competing parties, it is observed for any incompatible data. When incompatible data is provided by any party, the incentives are reduced otherwise the incentives are increased. The idea is to ensure that competing parties are encouraged to provide genuine data.

PROTOTYPE IMPLEMENTATION

We built a prototype application that facilitates collaborative data mining. Multiple parties can collaborate and provide data for mining in distributed environment. Privacy preserving data mining is the important research area. In this paper we focused on building a data mining application that allows multiple parties to give compatible inputs in order to mine the data to produce business intelligence. Association rule mining is demonstrated with the application. However, it can be extended to support all mining operations. The collaborative data mining along with privacy preserving data analysis is possible with the help of the prototype application. The application has the notion of incentives. Incentives allow the competing parties to behave well. When they misbehave, the incentives will be decreased that will affect the credibility of that party for participating collaborative computing. This is the motivation the competing parties get so as to provide genuine inputs to the system.

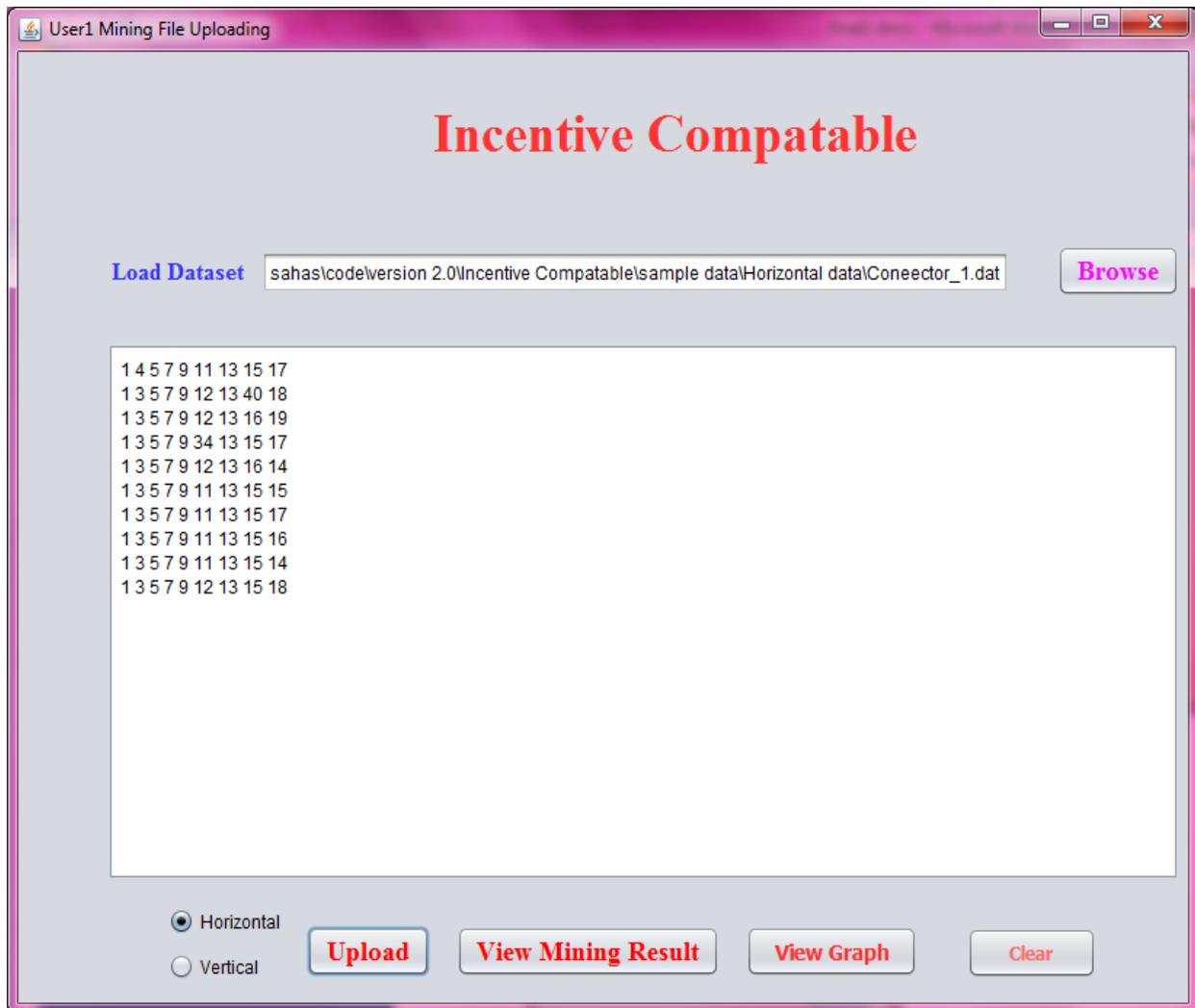


Figure 3 – User 1 loads either horizontal or vertically partitioned data

As can be seen in Figure 3, it is evident that the ends user is capable of providing inputs. This way multiple parties can provide inputs for collaborative data mining. In this application three users are considered for experiments. The UI for uploading data also provide functionalities for viewing data mining results and have a graph to understand the data analysis details just by a glance. In the same fashion, three users can provide inputs that are compatible. On clicking view mining results, the application generates the association rules as presented in Figure 4.

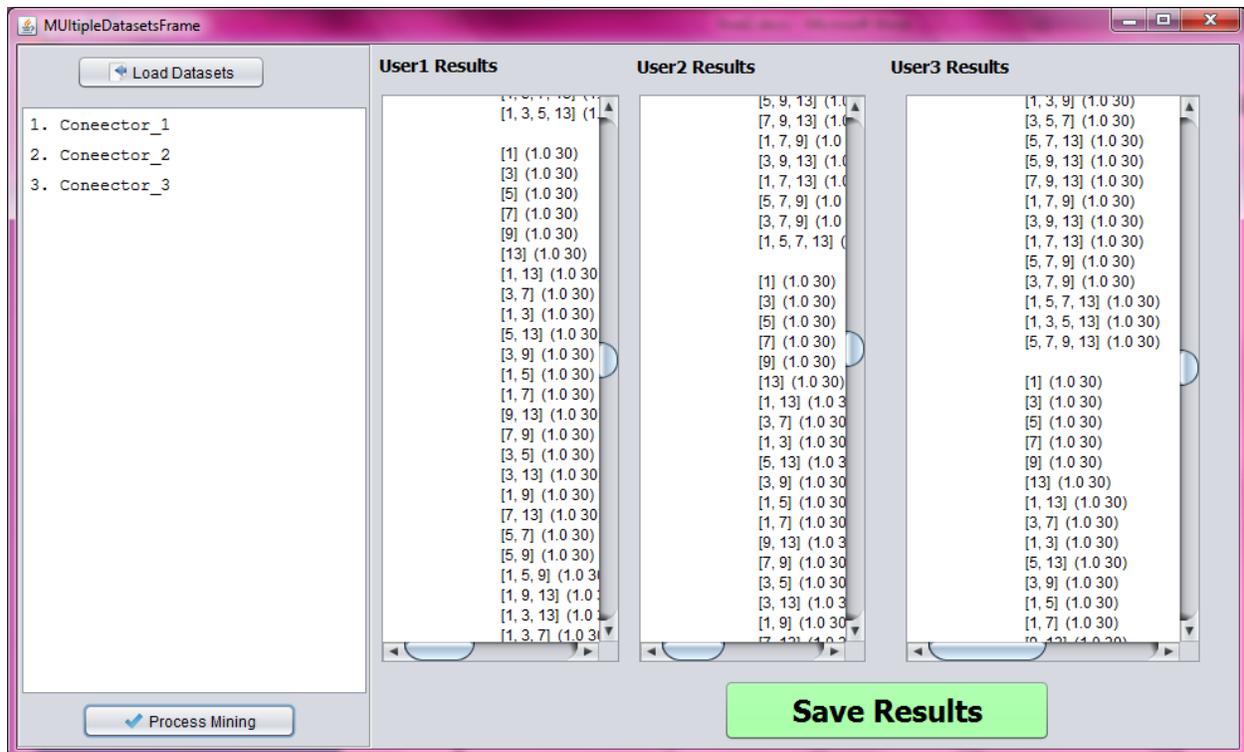


Figure 4 – The results of collaborative data mining

As can be seen in Figure 4 it is evident that the mining results are presented. However before mining results the data given by the competing parties is revived for compatibility. If any inconsistency with respect to given values is suspected, that particular party is notified besides reducing incentives. Then one more chance is given to provide correct data. When the party gives correct data again the incentives will be restored and the process of mining gets completed. The consolidated results along with incentives are provided as shown in Figure 5.

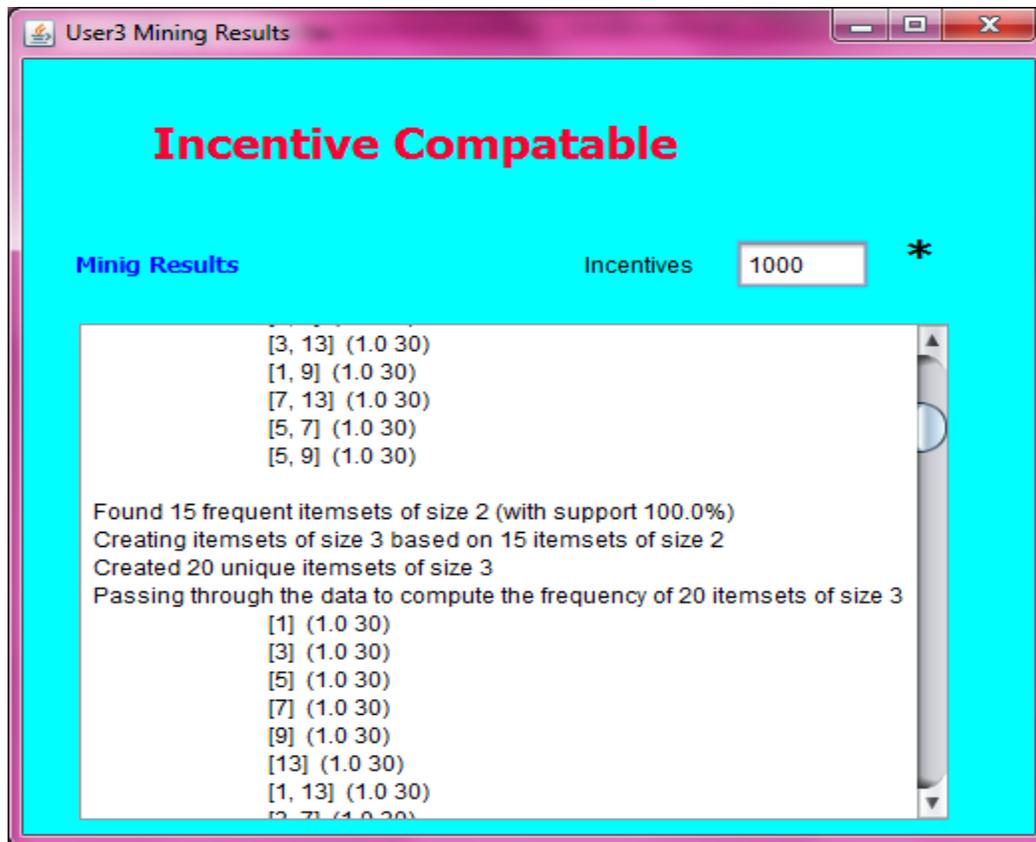


Figure 5 – Consolidated results of collaborative and privacy preserving data analysis

While performing the data mining after taking data from competing parties, the security is applied and each party needs to provide pre-distributed key so as to validate users in a secure distributed environment. Figure 6 presents the results of incompatible data provided by one of the parties. Then the incentives are reduced so as to encourage the party to give correct input. This will reduce the chances of misbehavior on parties thus achieving privacy preserving collaborative data analysis.

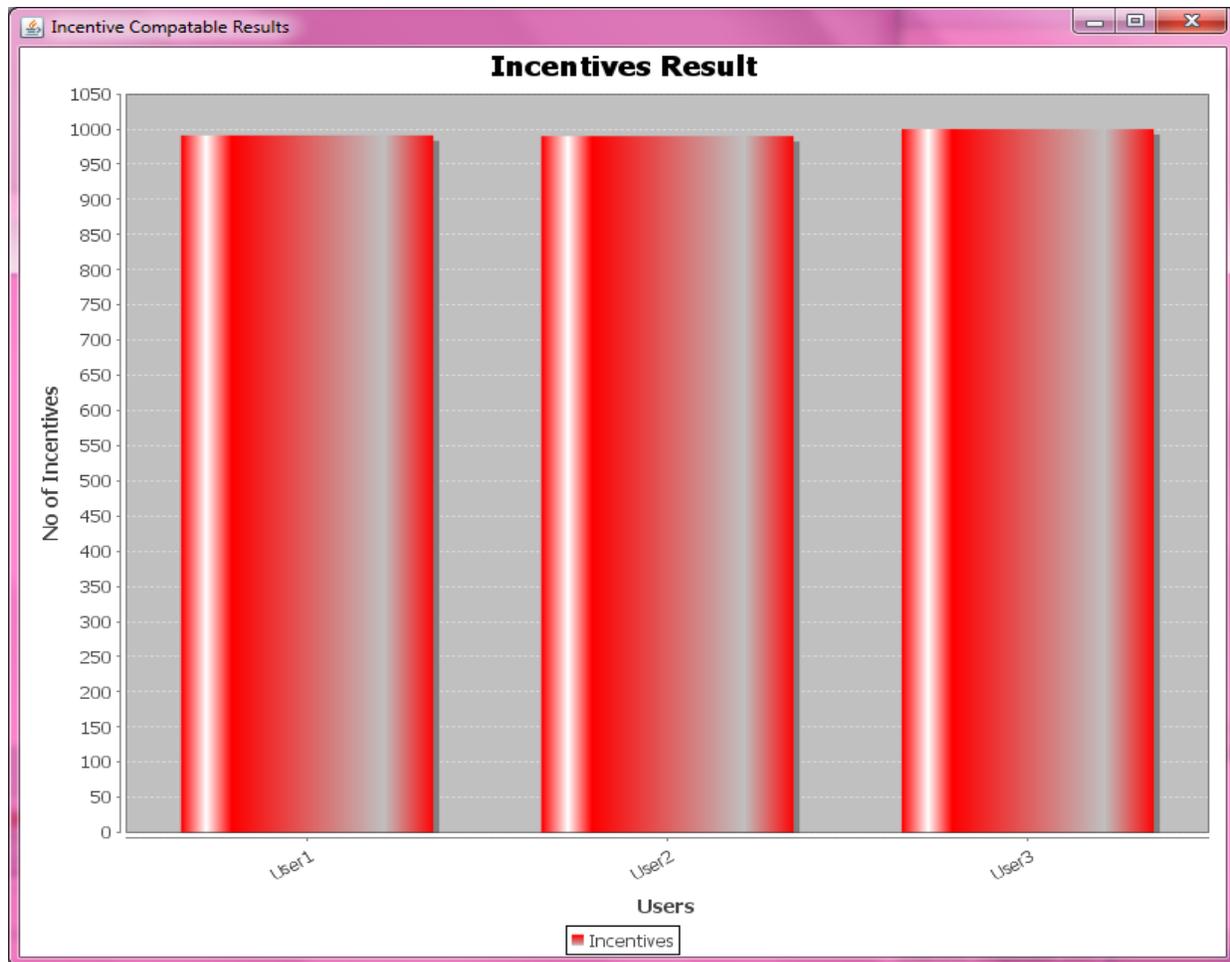


Figure 6 – Incentives of different competing parties

As can be seen in Figure 6, it is evident that the parties involved in the privacy preserving collaborative data analysis are given incentives for every genuine act. For every misbehaving act, incentives are reduced. This makes them get motivated to provide genuine results so as to achieve the purpose of collaborative data analysis in distributed environment.

CONCLUSIONS AND FUTURE WORK

In this paper, we studied the problem of collaborative data analysis. When multiple competing parties are involved in providing data for privacy preserving data analysis, the parties might provide either genuine data or they provide incompatible data. In this paper we explored the possibilities to encourage all competing parties to provide genuine data so as to serve the purpose of collaborative data mining in order to acquire new business intelligence and device new

business models. We presented secure and incentive compatible approach that lets competing parties to get incentives for genuine data. When incompatible data is suspected, the incentives are reduced. This is the motivation for the competing parties to behave well and provide genuine data. We built a prototype application that demonstrates the proof of concept. The empirical results revealed that the proposed solution is good for collaborative and privacy preserving data analysis in distributed environment. In future we extend this research into other aspects such as Big Data mining with MapReduce programming using distributed programming frameworks like Hadoop.

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