

Purdue University

Center for Education and Research in Information Assurance and Security

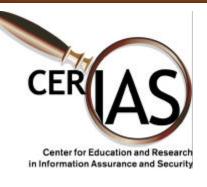


Association Rule Hiding

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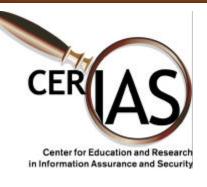
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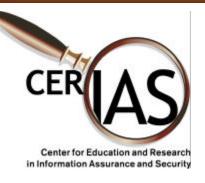
Introduction

- Restricting access to sensitive data and the "inference" problem.
- Security risks due to recent advances in data mining techniques.
- Association Rules (i.e., "90% of air-force basis having super-secret plane A, also have helicopters of type B").



Introduction(Contd.)

- Security and privacy threats from data mining and similar applications.
- Possible solutions to prevent data mining of significant knowledge:
 - Releasing only subsets of the source database
 - Augmenting the database
 - Disclosing an aggregated but not individual value



Association Rule Discovery

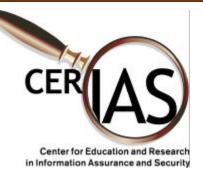
Let $I = \{i_1, i_2, \dots, i_m\}$ be a set of literals, called items.

A set of items $X \subset I$ is called an itemset.

Let D be a set of transactions, where each

transaction T is an itemset such that $T \subseteq I$.

A transaction T contains an itemset X, if $X \subseteq T$.



Association Rule Discovery

An association rule is an implication of the form

$$X \Longrightarrow Y \text{ where } X \subset I, Y \subset I, \text{ and } X \cap Y = 0.$$

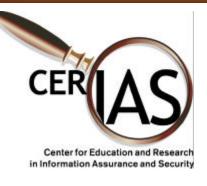
confidence=
$$\frac{|X \cup Y|}{|X|}$$
, and support= $\frac{|X \cup Y|}{N}$

Example Database

TID	Items
T1	ABCD
T2	ABC
T3	ACD

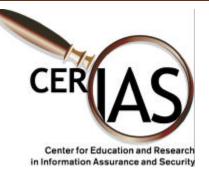


Frequent Itemsets	Support
AB	2
AC	3
AD	2
BC	2
CD	2
ABC	2
ACD	2



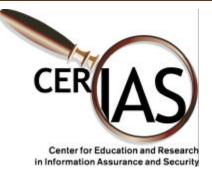
Optimal Sanitization is NP-hard

- Let D be the source database.
- Let R be a set of "significant" association rules that are mined from D.
- Let r_i be a "sensitive" rule in R.
- Transform D into D' so that all rules in R can still be mined from D' but r_{i.}
- Optimal sanitization is NP-Hard.
- Reduction from the NP-Hard problem of Hitting Set.



Hiding Methods

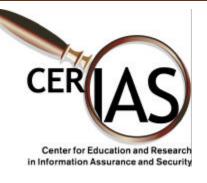
- Reduce the support of frequent itemsets containing sensitive rules
 - Cyclic Method
 - -Greedy Method
 - Isolated items and safe transactions
- Reduce the confidence or support of rules



Hiding Association Rules by using Confidence and Support

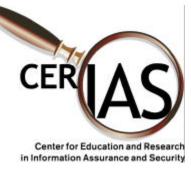
Assumptions

- We hide a rule by decreasing either its confidence or its support
- We decrease either the support or the confidence one unit at a time (we modify the value of one transaction at a time)
- We hide one rule at a time
- We consider only set of disjoint rules (rules supported by large itemsets that do not have any common item)



Hiding a rule X→Y by using Confidence and Support

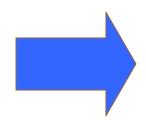
- Conf(X→Y) = Supp(XY) / Supp(X)
- Strategies
 - Decreasing confidence of rule
 - Increasing the support of X in transactions not supporting Y
 - Decreasing the support of Y in transactions supporting both X and Y
 - Decreasing support of rule
 - Decreasing the support of the corresponding large itemset (XY)



Strategies: basic idea

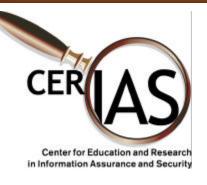
- Transactions viewed as lists
- One element for each item in DB

TID	Items
T1	ABC
T2	A



TID	A	В	С
T1	1	1	1
T2	1	0	0

- Decreasing support of S = turning to 0 one item in one transaction supporting S
- Increasing support of S = turning to 1 one item in one transaction partially supporting S

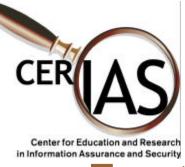


Example

TID	Items
T1	ABC
T2	ABC
T3	A C
T4	A
T5	В

MIN_SUPP = 1/5=20% MIN_CONF = 80%

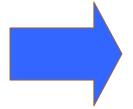
AR	Conf
AB→C	100%
BC→A	100%



Example:hiding AB > C by increasing support of AB

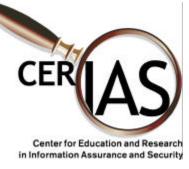
Turn to 1 the item B in transaction T4

TID	Items
T1	ABC
T2	ABC
T3	A C
T4	A
T5	В



TID	Items
T1	ABC
T2	ABC
T3	A C
T4	AB
T 5	В

AR	Conf
$AB \rightarrow C$	66%
BC→A	100%



Example: hiding AB \rightarrow C by decreasing support of C

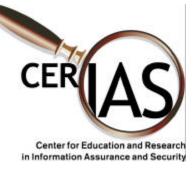
Turn to 0 the itemC in T1

TID	Items
T1	ABC
T2	ABC
T3	A C
T4	A
T5	В



TID	Items
T1	AB
T2	ABC
T3	A C
T4	A
T5	В

AR	Conf
$AB \rightarrow C$	50%
BC→A	100%



Example: hiding AB \rightarrow C by decreasing support of ABC

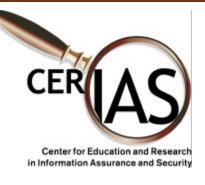
- Turn to 0 the item B in T1
- Turn to 0 the item C in T2

TID	Items
T1	ABC
T2	ABC
T3	A C
T4	A
T5	В



TID	Items
T1	A C
T2	AB
T3	A C
T4	A
T5	В

AR	Conf
$AB \rightarrow C$	0%
$BC \rightarrow A$	0%



Conclusions

- DM as a threat to DB security
- Need to limit the disclosure of sensitive information
- Optimal sanitization is NP-hard
- Developed heuristics to solve the problem
- The proposed methods are implemented and tested
- We plan to extend the problem of limiting the disclosure of sensitive information for different data mining techniques