A Multi-dimensional Evidence-based Trust Evaluation Model

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Abstract. Trust evaluation is increasingly important for collaboration in Internet today. We propose a multi-dimensional evidence-Based trust evaluation model named EBTrust model, which expands the types and sources of evidence. We put both transaction feedback and the network operating behavior information into this model. We analyze and design an EBtrust model which is based on multi-dimensional evidence including the evidence collection module, evidence formal processing module and trust calculation and management module. The EBTrust model can resist conspiracy and malicious comment behavior.

Key words: trust management; D-S evidence theory; multi-dimensional evidence

1   Introduction

Trust Management is presented as a new security mechanism for all open and distributed environments, and trust evaluation is one of the most important issues in Trust Management. There is a demand for trust evaluation from P2P networks, e-commerce applications, service oriented computing and multi-agent systems, in which it is important to evaluate the trustworthiness of participating entities since trust is the major driving force for collaboration.

Currently, there are some models and methods of trust evaluation. Yu[1] proposes that local experience (local evidence) and the assessment from other nodes are both to be considered, he used the D-S evidence theory to spread and merge the trust evaluation from a agent to other agents. Luolai Yuan and Guosun Zeng[2] propose a trust evaluation model based on transaction feedback and the original D-S evidence theory. In order to solve the problem of the synthesis rules and confliction information in the actual application of D-S evidence theory, Matsuyama[3], Yager[4], Xiaoxia Wang [6] and Murphy[5] have done some researches on the evidence synthesis and put forward their own improvement method.

This paper proposes a multi-dimensional evidence based trust evaluation model called EBTrust model. We use multi-dimensional evidence to expand the types of evidence and the sources of evidence, meanwhile we improved D-S evidence synthesis rule to synthesize the multi-dimensional evidence, which can solve the problem of uncertainty better in the process of trust evaluation. The rest of the paper is

organized as follows. Firstly, we describe the framework of EBTrust model in Section II.Then we introduce Evidence preprocessing in Section III. Further, Section IV gives the construction of basic trust function. Finally, the conclusions are drawn in section V.

2 Framework of EBTrust Model

EBTrust is a new trust evaluation model based on multi-dimensional evidence, which not only expands the types of evidence and evidence sources, but also solves the problem of uncertainty better in the process of trust evaluation. The Figure 1 shows the structure of EBTrust model.

In this paper, the design of EBTrust model is similar to a centralized trust model. This model is dividing into three main modules: the evidence collection module, evidence formal processing module and trust calculation and management module.
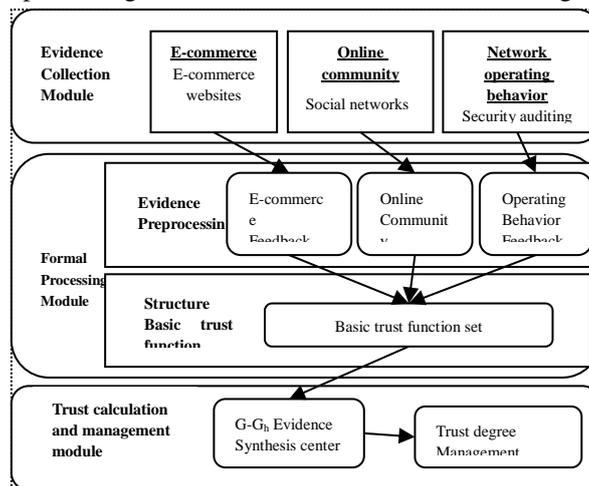

Fig.1 Framework of EBtrust model

Evidence collection module collect the multi-dimensional evidence mainly , this multi-dimensional evidence includes three sections: e-commerce feedback, online community feedback and network operating behavior feedback.

Evidence formal processing module is responsible to process the original evidence that have various forms and complex structure in order to achieve a formal expression. This module will be dividing into two small modules. One is evidence preprocessing, which is process three types of evidence and construct data structure. The other is structure basic trust function module, which constructs three types of evidence's trust function.

Trust calculation and management module responsible to the final calculation of trust, as well as to store, update, retrieve and release the data of trust degree. It contains the trust degree management center.

3   Evidence Preprocessing

The original evidences from the evidence collection module are expressed as natural language or other non-mathematical language, and the same type of evidence from different sources of evidence may have different complex structures. So it is important to preprocessing the original evidence.

The existing trust evaluation mainly includes trading volume, trading volume, transaction time, transaction results and transaction evaluation etc.. But most of these evidences can be classified as business feedback based evidence. These evidences have obvious limitations. It ignores the impact of network operating activities related to transactions to transactions. And it only consider the performance of the subject in a specific type of transaction.

In view of the above limitations, we put forward the concept of multidimensional evidence to evaluate the subject of network reliability. Multidimensional refers to the different types of evidence. Multidimensional evidence involved in our proposed model including electronic commerce feedback evidence, the community network service feedback evidence, network operation behavior evidence.

3.1 Preprocessing of e-commerce feedback evidence

The data structure of e-commerce feedback evidence after preprocessing can be describe as: Evi(Cla，Ide，T，Val，Res，Asse), and we defined:
-   Cla is the variable of the type of evidence and the value is 1.
-   Ide is the variable of network subjective identity, and $Ide \in \{-1,1\}$, Ide=1 shows that the current subject is the seller, Ide=-1 shows that the current subject is buyer.
-   The time variable T is equal to the time of the current evidence, that means the current online transaction occurred time.
-   Val is the variable of the transaction value, Val equal to the value of the transaction of the current evidence, measured in monetary currency.
-   Res is the variable of the result of transaction, Res=-1 indicate that the responsibility for itself when the current transaction is failed. Res=0 indicates that the responsibility for other side when the current transaction is failed. Res=1 indicates that the current transaction complete successfully.
-   The variable of transaction evaluation and Asse=-1 shows that the other side give a negative assessment to own side. Asse=0 shows that the other side give a medium evaluation or fails to make an assessment. Aesse=1 shows that the other side made a positive assessment.

3.2 Preprocessing of online community feedback evidence

The data structure of online community feedback evidence after preprocessing can be described as: Evi (Cla，Eve，T，Disti), the variable of it will defined as:
-   Cla is the variable of the type of evidence and the value is 2.
-   Eve is the variable of event, Eve=1 shows that the home page that the current evidence point to was browsed. Eve=2 shows that the original posts were browsed. Eve=3 shows that the posts were deleted by administrator. Eve=4

shows that the posts were prohibited by the administrator.
- The time variable T is the time of the current evidence accrues.
- Disti is the variable of the event judgment, the value of Disti associated with the variable of event Eve, so the specific value will be showed in Table I.

Table 1. The specific value of Disti

Eve	Disti
1	The times of browsed
2	The times of browsed
3	Disti=1, the object is poster. Disti=-1, the object is commentator
4	Disti=1, the object was temporarily prohibited posting. Disti=-1 the object was permanently prohibited posting or delete the id of object.

3.3 Preprocessing of operating behavior feedback evidence

The data structure of operating behavior feedback evidence after preprocessing can be described as: Evi (Cla，T，Lev), and the variable will describe as:
- Cla is the variable of the type of evidence and the value is 3.
- The time variable T is the time of the current evidence behavior accrues.
- Lev is the level of act endangers(or attack level), the classification of the attack level will be shown in Table II.

Table 2. The Attack Level

Attack level	The type of attack	Attack listed
1	Information disclosure	Read files, memory data, registry, port and so on.
2	Refuse service	Cpu consumption, memory consumption, decreased quality of service, disk space consumption and so on.
3	Data destruction and deception	Tampered with the file system, memory data, system kernel, database configuration and so on.
4	Intrusion control	Illegal execution, unauthorized access to the file system, illegal acquisition of shell and so on.
5	Antagonistic	Bypass virus detection, penetrate the firewall, communication hidden functions and so on

4 Construction of Basic Trust Function

For any subject of one network, it is assumed that the evidence is sufficient, so determine its trust only have two cases: trust and distrust. Therefore we can construct

the identification framework: $\Theta = \{trust, distrust\}$, it can abbreviated as: $\Theta = \{t, d\}$,

So, $2^{\Theta} = \{\phi, \{t\}, \{d\}, \Theta\}$.

Then possible focus elements of Θ are {t}、{d}、Θ, this paper will represent these focus element as proposition T、D、Θ, so $T = \{t\}$, $D = \{d\}$, Θ

Therefore, we construct the basic trust distribution function in the form of: $m(T, D, \Theta)$

We assume that a network subject A. when construct a basic trust function of e-commerce feedback evidence, we consider the results and the effect of evaluation of the actual e-commerce and constructs a basic trust function of feedback evidence. Whatever the network subject A is seller or buyer, the specific structure of a basic trust function of feedback evidence can be shown in Table III. When construct a basic trust function of online community feedback evidence, we also consider the effect of behavior of subject on the trust, so the trust function of online community feedback can be describe as Table IV. We construct the basic trust function of operating behavior feedback evidence based on the effect of operate behavior on the subject A, so the trust function of operating behavior feedback can be describe as Table V.

Table 3. The Trust Function of e-Commerce Feedback Evidence

Id	$Evi(Cla, Tde, T, Val, Res, Asse)$	$m(T, D, \Theta)$	Instruction
1	$(1, Tde, T, Val, 1, 1)$	$(1, 0, 0)$	Transaction is successfully, and get a positive assessment, so A is trusted
2	$(1, Tde, T, Val, 1, 0)$	$(0.5, 0, 0.5)$	Transaction is successfully, and gets a medium assessment or missing assessment, so A is not completely trusted.
3	$(1, Tde, T, Val, 1, -1)$	$(0, 1, 0)$	Transaction is successfully, and gets a negative evaluation, so A is distrust.
4	$(1, Tde, T, Val, 0, 1)$	$(0.5, 0, 0.5)$	Transaction failed because of the problem of other side and gets a positive assessment, so A is not completely trusted.
5	$(1, Tde, T, Val, 0, 0)$	$(0, 0, 1)$	Transaction failed because of the problem of other side and gets a medium assessment or missing assessment, so we can't judge A trust or not.
6	$(1, Tde, T, Val, 0, -1)$	$(0, 1, 0)$	Transaction failed because of the problem of other side and gets a negative evaluation, so A is distrust.
7	$(1, Tde, T, Val, -1, 1)$	$(0.5, 0, 0.5)$	Transaction failed because of the problem of A and gets a positive evaluation, so A is not completely trusted.

| 8 | $(1, Tde, T, Val, -1, 0)$ | $(0, 0.5, 0.5)$ | Transaction failed because of the problem of A and gets a medium assessment or missing assessment, so A is not completely distrusted. |
| 9 | $(1, Tde, T, Val, -1, -1)$ | $(0, 1, 0)$ | Transaction failed because of the problem of A and gets a negative evaluation, so A is distrust. |

Table 4. The trust function of online community feedback evidence

Id	$Evi(Cla, Eve, T, Disti)$	$m(T, D, \Theta)$	**Instruction**
1	$(2, 1, T, Disti)$	$(1, 0, 0)$	The home page of A was browsed，so A is trust.
2	$(2, 2, T, Disti)$	$(1, 0, 0)$	A post was browsed, so A is trust.
3	$(2, 3, T, Disti)$	$(0, 1, 0)$	A post was deleted by administrator, so A is distrust.
4	$(2, 4, T, Disti)$	$(0, 1, 0)$	Subject A has disabled a post, so A is distrust.

Table 5. The trust function of operating behavior feedback evidence

Id	$Evi(Cla, T, Lev)$	$m(T, D, \Theta)$	**Instruction**
1	$(3, T, Lev)$	$(0, 1, 0)$	Network operating behavior has produced, that means A makes the danger operating behavior, so A is distrust.

5   Conclusions

Although many trust evaluation models have previously been proposed, precise security goals and properties are lacking. In this paper, we analyze and design an EBtrust model which is based on multi-dimensional evidence. We expanded the types of evidence and evidence sources. All the work makes EBtrust model can solves the problem of uncertainty in the process of trust evaluation.

The theoretical analysis and test results reveal that EBtrust model has high efficiency on Resistance of collusion behavior and malicious evaluation behavior. The work of this paper will contribute strong theoretical and academic significance to the trust evaluation.

EBtrust model is the expansion of NBTEM (network behavior based trust evaluation model) [10] proposed by our group in 2010. This model didn't deep study in the collection of evidence and the evidence synthesis rule not very satisfied, which need study in the future work.

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