Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2014, 6(9):449-455

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

The study of history aging model in network trust evaluation

Liu Xiaojun

School of Electronic & Information, Huanggang Normal University, Hubei Huanggang, China

---

ABSTRACT

The history aging model, followed trust natural quality of attenuation and dynamic, utilized time quantity to quantify the important degree of historical reference value. Combined with trust assessment and its history occurred moments, it gave the objective description on history trust evaluation by the methods of threshold space and induce ordered weighted averaging (IOWA) operators. History aging model transparentized trust evaluation content, and calculated the value of dynamic degree to network objects. It also improved the trust assessment accuracy of network security applications. Through historical aging model's design rules, method, and experimental analysis, it pointed its limitation, flaws and future research direction.

Key words: History aging model; Trust evaluation; Induced ordered weighted average operator (IOWA); Network

---

INTRODUCTION

With the increasing globalization of the world economy and the continuous development of information technology, network application is developing from the closed to the open. The network-based trust applications of electronic shopping, network transactions, business electronics has become increasingly diverse, but at the same time the opening of the Internet network environment also increases the complexity of the interaction between network objects and the lost trust rate. Therefore, the establishment of trust evaluation mechanism and network node trust acquisition is particularly important.

Since last century, scholars have done a large amount of researches concerning credibility and trust model, in foreign countries, T.Beth [1] and some other scholars offered a trust evaluation model based on experience and probabilistic interpretation aiming at the safety certification problem of open network. This model explains the relationship between credibility and probability number using accurate math metrics method, but it hasn't considered the problem of initial trust acquisition. Josang[2,3] has also offered subjective logic model, and he redefined opinion space and evidence space, which can describe and measure subjective credible in many different ways. When acquiring credibility in this model, we emphasis the randomness of credibility but didn't involve the timeless of credibility. Wong Shouxin [4]and other people use cloud model theory to model according to trust management problems, they also offered the timeless of credibility question. But this model describes the timeless of credibility only by geometric decay sequence simply. Li Xiaoyong [5]and other people offered multidimensional trust evaluation model and timeless problems at the same time, but the timeless function they offered is much too simple.

In the open networking interactive applications, the credibility will change according to the change of time. So the credibility evaluation data must have the characteristics of timeless. To evaluate the object's current credibility accurately, this paper offered a history aging model and its function is: obtain the current trust value. The model in this paper gained the accuracy of network object trust prediction.

This paper presents a credit history aging model. Its role is to get the trust value of the current evaluation moment based on the validity and importance of the historical evaluation data. To some extent, it improves the accuracy of the forecast of network object trust.

THE DEFINITION OF HISTORY AGING MODEL

Credibility itself has the characteristics of dynamic attenuation; therefore, time to build trust in the history of the model should consider the following points:

History aging model object must be unrelated with evaluation (such as subjective evaluation and objective evaluation), it only reflects the relationship between trust evaluation values and time. In history evaluation, due to the long time, some evaluation will be inefficiency. Because of the time characteristics of the evaluation, the more recent the evaluation time of the trust evaluation from the current, the higher for the current reference value. History aging model can change the degree of importance of the history evaluation data based on objective requirements. History aging model needs to reflect the importance of the time in evaluating network and the relationship between them. According to the considerations above, combining with the characteristics of trust evaluation of the network platform transaction, history aging model can be defined as follows: Set $k=\{x(1),x(2),\ldots x(k)\}$,Where k is the set of history trust evaluation, $x(i)$ is the $(i-th)$ historical evaluation of the set, where $x(i)\in k, 1\le i\le k$. Another function $Time(x_i)$, $Time(x_i)$ represents the time of the i-th trust evaluation, then those evaluate data of the set K follow:

$$\forall x_i,\ x_j(1\le i\le j\le k);\quad 0\le Time(x_i)\le Time(x_j)\le Time(k)$$

That means the time scale of the evaluation data in set K follows the strict time order. Assuming the current time is T_N, then $0\le Time(x_i)\le Time(x_k)\le T_N$.The definitions of the history aging model are as follows:

Definition 1：Here is the trust history aging model H，

$$H=\begin{cases}\sum_{i=1}^{k}x(i)*A[Time(x_i)] & 1\le i\le k\\ 0 & i=0\end{cases},$$

where $F=A[Time(x_i)]$ represents history aging amplitude, and $0\le A[Time(x_i)]\le 1$.

THE BASIC RULE OF HISTORY AGING MODEL

The history aging model is closely related to time, so it has strict constraint rules in selecting the time scale. According to the definition mentioned in the last section, the history aging model can be described by three basic rules:

a) Set start time S as the time origin, marked as $Time(s)=0$,assuming $Time(now)=T_N$,and T_y as a judgment of history aging model, then the three values have the following relationship: $0\le T_y\le T_N$.According to the characteristics of aging, the set K breaks into two subsets K_a and K_{una}, representing the history effective evaluation set and history failure evaluation set respectively, then they follow that:

$K_{una}\cup K_a=K$, and $K_{una}\cap K_a=\varnothing$。

$\forall x_m\in K_a(1\le m\le k)\quad 0\le Time(x_i)-T_y\le T_N-T_y$；

$\forall x_n\in K_{una}(1\le n\le k)\ Time(x_i)-T_y<0\le T_N-T_y$；

b) For the history effective evaluation set K_a, the history evaluation data are in the time period T_N-T_y.If we divided the time period T_N-T_y into m subintervals, then mark these subintervals time window W, the time windows can divide the history effective evaluation set K_a into m history evaluation data subsets $K_{W1},K_{W2},\cdots K_{Wm}$,and they follow:

$W_1=W_2=\ldots=W_m=(T_N-T_y)/m$；

$K_a=K_{W1}\cup K_{W2}\cup\ldots\cup K_{Wm},\quad \forall K_{Wi},K_{Wj}(1\le i\le m,1\le j\le m), K_{Wi}\cap K_{Wj}=\varnothing$

c) The function $F = A[Time(x_i)]$ is not only for the weighted calculation of time window $K_a = \{K_{W1}, K_{W2}, ..., K_{Wm}\}$, but it must calculate every $x(i)$ which is larger than the time threshold .And it must meet the following conditions:

$$\forall x(i), x(j) \in K_{Wz} (1 \le z \le m) \quad A[Time(x_i)] = A[Time(x_j)];$$
$$\forall x(i) \in K_{Wl}, x(j) \in K_{Wz} (1 \le l < z \le m) \; A[Time(x_i)] < A[Time(x_j)]$$
$$\left(\sum_{i=1}^{k} A[Time(x_i)] \right) = 1$$

THE DESIGN STEPS OF HISTORY AGING MODEL

Five establishing steps can be introduced by the history aging model rules mentioned above:

a) Set T_y, break the history evaluation data set into K_a which can meet the threshold requirements.

b) According to the design rules, discarding the data set K_{una} which does not meet the conditions set and further processing history evaluation data in K_a.

c) Dividing the time window reasonably according to the length of the time interval $T_N - T_y$, then K_a will be divided into m time window intervals $K_a = \{K_{W1}, K_{W2}, ..., K_{Wm}\}$, and they follow the strict time order.

d) We should calculate history aging amplitude to deal with different time window history data and use the same weight value on aging history evaluation data of the same time window.

e) Determine the rules demand of $F = A[Time(x_i)]$, calculate $F = A[Time(x_i)]$ according to the definition. This paper use Induced Ordered Weighted Average Operator, IOWA and combined with the dynamic and aging characteristics of the trust evaluation data to come to the result that the history aging amplitude $F = A[Time(x_i)]$.

In 1988, the famous American scholar Ronald R.Yager has put forward Ordered Weighted Averaging Operator and Induced Ordered Weighted Averaging Operator, it is an information integration method [6] between the maximum and minimum operator. Induced Ordered Weighted Averaging Operator can be defined as follows:

Definition 2 .Set $< v_1, a_1 >, < v_2, a_2 >, ..., < v_m, a_m >$ are m two-dimension array and

$$f_w(< v_1, a_1 >, < v_2, a_2 >, ..., < v_m, a_m >) = \sum_{i=1}^{m} w_i a_{v-index(i)} \quad (1)$$

then we call function f_w m-dimension induced ordered weighted averaging operator(IOWA operator) produced by $v_1, v_2, ..., v_m$. v_i is called the induced value a_i, in which $v - index(i)$ is the i-th number subscript arranged in descending order of $v_1, v_2, ..., v_m$, $W = (w_1, w_2, ..., w_m)^T$ is the weighting vector of OWA, and $\sum_{i=1}^{m} w_i = 1, w_i \ge 0, i = 1, 2, ..., m$.

We can know from the history aging model definition rule that $H = \sum_{i=1}^{k} x(i) * A[Time(x_i)]$. History aging amplitude $F = A[Time(x_i)]$ follows the strict time order within the m time-scale values of the time interval $T_N - T_y$, with the passage of time, the aging value in descending order, so we order $\sum_{i=1}^{k} x(i) * A[Time(x_i)] = \sum_{j=1}^{m} y_W(j) * w_{Wj}$,where $y_W(j)$ is the weighted averaging value of the history evaluation data of each time window W, w_{Wj} is the history aging amplitude for each time window. Similarly, we give a similar definition, set $< T_{W1}, y_W(1) >, < T_{W2}, y_W(2) >, ..., < T_{Wm}, y_W(m) >$ as m two-dimension array, so that

$$f_w(<T_{W1}, y_W(1)>, <T_{W2}, y_W(2)>, ..., <T_{Wm}, y_W(m)>) = \sum_{i=1}^{m} w_{Wi} y_{T-index(i)} \quad (2)$$

where T_{Wi} is the time scale mark of set $K_a = \{K_{W1}, K_{W2}, ..., K_{Wm}\}$, we called T_{Wi} the induced value of $y_W(i)$, which $T-index(i)$ is the subscript of i-th number of T_{Wi} which in descending order of the window period (i.e. the distance sequence that away from the current time), $W = (w_{W1}, w_{W2}, ..., w_{Wm})^T$ is the history aging amplitude of each time window, and $\sum_{i=1}^{m} w_{Wi} = 1;\ w_{Wi} \geq 0;\ i = 1, 2, ..., m$.

According to the maximum entropy induced ordered weighted averaging operator method mentioned by Fuller in the literature [7-10], using maximum entropy can calculate the following formula:

$$orness(W) = \frac{1}{m-1}\sum_{j=1}^{m}(m-j)w_{Wj} = \alpha;\ 0 \leq \alpha \leq 1 \quad (3)$$

$$w_{W1}[(m-1)\alpha + 1 - mw_{W1}]^m = [(m-1)\alpha]^{m-1} * [((m-1)\alpha - m)w_{W1} + 1] \quad (4)$$

$$w_{Wm} = \frac{((m-1)\alpha - m)w_{W1} + 1}{(m-1)\alpha + 1 - mw_{W1}} \quad (5)$$

$$w_{Wj} = \sqrt[m-1]{w_{W1}^{(m-j)} w_{Wm}^{(j-1)}};\ 1 \leq j \leq m \quad (6)$$

By history aging amplitude rules, in the set $K_a = \{K_{W1}, K_{W2}, ..., K_{Wm}\}$, all the history evaluation data of time window $K_{Wi} \in K_a$ has the same history aging amplitude. Assuming set K_{Wi} contains n history evaluation data, we will have $F = A[Time(x_i)] = \frac{w_{Wj}}{n}$ .According to $\sum_{i=1}^{k} x(i) * A[Time(x_i)] = \sum_{j=1}^{m} y_W(j) * w_{Wj}$, history aging model can be introduced as follows[11-13]:

$$H = \begin{cases} \sum_{i=1}^{k} x'(i) * \frac{\sqrt[m-1]{w_{W1}^{(m-j)} w_{Wm}^{(j-1)}}}{n}, & 1 \leq i \leq k \\ 0 & i = 0 \end{cases} \quad (7)$$

$$w_{W1}[(m-1)\alpha + 1 - mw_{W1}]^m = [(m-1)\alpha]^{m-1} * [((m-1)\alpha - m)w_{W1} + 1] \quad (8)$$

$$w_{Wm} = \frac{((m-1)\alpha - m)w_{W1} + 1}{(m-1)\alpha + 1 - mw_{W1}} \quad (9)$$

$$\alpha = \frac{1}{m-1}\sum_{j=1}^{m}(m-j)w_{Wj} \quad (10)$$

$x'(i)$ is the $(i-th)$ history evaluation data which meet the threshold conditions, m is the number of the time window in set $K_a = \{K_{W1}, K_{W2}, ..., K_{Wm}\}$, j represents the $(j-th)$ time window of $x'(i)$, n is the number of the history evaluation data in the $(j-th)$ time window, α is a fuzzy integrated operator, represents "and" operation Measure of Iowa operation.

EXPERIMENTAL COMPARATIVE ANALYSIS

Simulation method based on history aging model is as follows [14, 15]:

Determine the current evaluation time-scale T_N and confidence decision threshold T_y .Design time window and determine the time window number m. According to the emphasis degree of the actual history evaluation trust, we can determine the size of α operator in the history aging model. Calculating the trust degree of the current trust evaluation time according to (7), (8), (9) and (10).

In this paper, we used the random survey method to make several trust evaluation about a certain group-buying business at different times, and we collected eight kinds object history credit evaluation data by provider class service, and the total credit evaluation number of each object is no less than 100. In order to simplify the history evaluation data obtained by the simulation method, we can classify the obtained evaluation data to determine the degree of trust evaluation of different objects in the same time the same buy businesses by average, which range from 0-10, such as shown in Table 1.

Table 1. A history of trust evaluation data table

	x(1)	*x(2)*	*x(3)*	*x(4)*	*x(5)*	*x(6)*	*x(7)*	*x(8)*
Trust Evaluation	8.7	7.2	9.0	8.0	8.5	7.8	7.7	7.9
Time of occurrence	1	7	12	16	18	21	24	30

Now we need to provide group-buying business whose credibility is no less than 8 to conduct online transactions, confirming whether the business trust meets the need. If we use the traditional fixed weighted average calculation to calculate the evaluation on trust degree:

$$H_c = \sum_{i=1}^{n} x(i) * w_i = \frac{\sum_{i=1}^{n} x(i)}{n} \qquad (11)$$

Take history evaluation data into Equation 11, we can obtain the value of the trust $H_c = 81.00$. In the traditional way, the business can meet the requirements of the transaction.

According to the history aging model simulation method, set the current time $T_N = 35$, make trust assessment for a service node in the network, we need to determine the time threshold T_y to filter effective history evaluation data firstly. Assuming $T_y = 30$, according to the history aging model calculation rules, we have $x(1) \in K_{una}$, $x(i) \in K_a$, in which $i = 2,3,...,8$.

Set $K_a = \{K_{W1}, K_{W2}, K_{W3}, K_{W4}, K_{W5}\}$, i.e. $m = 5$, at this time $x(2) \in K_{W1}$, $x(3) \in K_{W2}$, $x(4), x(5) \in K_{W3}$, $x(6), x(7) \in K_{W4}$, $x(8) \in K_{W5}$, if we don't value too much about the timeless of the history trust evaluation, we can set $\alpha = 0.6$,take that into the model ,we can have the history aging model amplitude of $\{K_{W1}, K_{W2}, K_{W3}, K_{W4}, K_{W5}\}$:

$$W_{\alpha=0.6} = \{w_1, w_2, w_3, w_4, w_5\} = \{0.1278, 0.1566, 0.1920, 0.2353, 0.2884\}$$

According to the principle of equal aging amplitude within the same time window, we can take W into the model equation and get H :

$$x(2) * w_1 + x(3) * w_2 + \frac{x(4) + x(5)}{2} * w_3 + \frac{x(6) + x(7)}{2} * w_4 + x(8) * w_5 = 80.15$$

The result shows that the business can still meet the basic credibility of the transaction. If the trust evaluation requirements change, the distance of the current moment in recent history evaluation data will be more important, then you can change the value of α appropriately. Set $\alpha = 0.8$, the number of the time window doesn't change, then take the data into the model, we can get

$$W_{\alpha=0.8} = \{w_1, w_2, w_3, w_4, w_5\} = \{0.0002, 0.0411, 0.1808, 0.3244, 0.4536\}$$

$$x(2)*w_1 + x(3)*w_2 + \frac{x(4)+x(5)}{2}*w_3 + \frac{x(6)+x(7)}{2}*w_4 + x(8)*w_5 = 79.61$$

The result shows that the business cannot meet the basic needs of the transaction, so we end this transaction.

To analyze the three groups of calculating results comprehensively, the result of history aging model calculation is less than the fixed weighted average algorithm results, it is because the calculation of the weights in the history aging model rearrange by importance of the moment, reflecting the aging characteristics of the history evaluation data. Whereas the difference between the calculated results of $\alpha = 0.6$ and $\alpha = 0.8$ shows the different degree of importance of history data evaluation requirements caused by the different requirements. As we can see from the calculation above, the three calculation results made by two calculation methods are of little difference. In comparison, the history aging model for the importance of history license premium data given by moment occurred according to the evaluation, the operator α draw different computing history aging amplitude $W_{\alpha=0.6}$ and $W_{\alpha=0.8}$, more accurate response history evaluation and time dynamic relationship, which is better than the traditional trust calculation method.

At the same time, the history aging model has two problems: On one hand, although the history aging model can describe the relationship between time and history evaluation data dynamically, but it has high computational complexity, and the computing expenses grow exponentially with the growth of time window m. How to reduce the computing expenses is the focus of future research. On the other hand, the size of the time window of the history aging model lacks theoretical derivation, but the size of the time window determines the number of the valid history evaluation data contained within the time window, affect the classify of effective historical evaluation data, but also indirectly affect the computational complexity of the history aging model and the final results. We can only define the size of time window according to evaluation need or experience, so what we need to consider while deciding the size of time window in the model is also one problem we need to study in the area of aging model.

CONCLUSION

In recent years, due to the needs of Internet security applications, the trust model, the trust management system from a centralized trust relationship to distributed trust relationship, trust model from static to dynamic. Credibility for trust model is often based on weighted average, which cannot reflect the relationship between trust evaluation and time accurately. The inaccuracy of credibility can easily threat the application of open network security. It can be said that among the trust model and trust management, the aging of credibility requires more researches. In this paper, the history aging model can also be applied to the related fields, and the model has a good reference value.

Acknowledgments
The project was supported by the Scientific Research Program of Educational Commission of Hubei Province of China (Grant No. 20142905), and the Doctoral Scientific Fund Project of Huanggang Normal University (Grant No. 2013031103)

REFERENCES

[1] BETH T, BOREHERDING M, KLEIN B. Valuation of Trust in open networks[A]. *Proceedings of the European Symposium on Research in Computer Security(ESORICS)[C]*. New York：Springer-Verlag, pp1-18. **1994**
[2] JOSANG A, KNAPSKOG S J. A metric for trusted systems [A]. *Proceedings of the 21st National Security Conference*. pp541-549. **1998**
[3] JOSANG A, ISMAIL R. The beta reputation system [A]. *Proceedings of the 15th Bled Electronic Commerce Conference*.pp324-337. **2002**
[4] WANG Shou-Xin, Zhang Li, *Journal of Parallel and Distributed Computing*. Vol.21(06),pp1341-1352, **2010**.
[5] Li X Y, Feng Z, Xu D Y. *Journal of Parallel and Distributed Computing*. Vol.71,pp837–847, **2011**
[6] Yager R R. *IEEE Transactions on Systems, Man, and Cybernetics*, Vol.18(1):183-190, **1988**
[7] R.Fulle´r P.Majlender. *Fuzzy Sets and Systems* [J]. Vol.124,pp53–57. **2001**
[8] R.Fulle´r, P.Majlender. *Fuzzy Sets and Systems*. Vol.136,pp 203–215. **2003**.
[9] GU X, XU Z Q, LIU X J, *Journal on Communications*. Vol.132(7),pp176-181,**2011**.
[10] Jiang Wenbao,Guo Shaoxu; Chen Wenliang, A trust evaluation model and algorithm based on network behavior detection, 2010 *3rd IEEE International Conference on Broadband Network and Multimedia Technology, IC-BNMT2010*, pp706-710, **2010**
[11] Liang Hong-Quan,Wu Wei, *Tongxin Xuebao/Journal on Communications(Language: Chinese)*, Vol.34(9), pp68-76, September **2013**,

[12] Wang Xi, Maghami, Mahsa Sukthankar, Leveraging network properties for trust evaluation in multi-agent systems, *Proceedings of the 2011 IEEE/WIC/ACM International Conference on Intelligent Agent Technology*, Vol.2,pp288-295, **2011**

[13] Xiaoqian Liu, Shoubao Yang; Leitao Guo; Kai Shen, Profit sharing based routing trust evaluation algorithm in p2p network ,*Proceedings of the 3rd China Grid Annual Conference, China Grid 2008*, pp352-369, **2008**

[14] Dogan Gulustan; Brown Theodore; Govindan Kannan, Evaluation of network trust using provenance based on distributed local intelligence, *Proceedings - IEEE Military Communications Conference MILCOM*, pp1493-1498, **2011**

[15] Yu Li; Liu Zuhao; Gao Yuan; Samba Dudu, *Tinghua Science and Technology*, Vol.17, n 2, pp179-185, **2012**