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Markov Model for Modelling and Managing Dynamic Trust

Farookh Khadeer Hussain [1], Elizabeth Chang [1] and Tharam S. Dillon [2]

[1]School of Information Systems, Curtin University of Technology, W.A., Australia
Email :{Farookh.Hussain, Elizabeth.Chang }@cbs.curtin.edu.au
[2] Faculty of Information Technology, University of Technology, Sydney, NSW, Australia
Email: tharam@it.uts.edu.au

Abstract---**In this paper we propose a trust model for decision making that models both the context specific and the dynamic nature of trust. We propose to make use of the Markov Model for modelling the context specific and the dynamic nature of trust. Using the Markov Model, we will show how we can predict the trustworthiness value of an entity in the immediate future time slot. We make use of the trust levels and the trust scales that we had introduced in an earlier publication [3], in this paper.**

Index Terms— **Trust, Trustworthiness, Trustworthiness Prediction.**

I. INTRODUCTION

In previous publications we defined trust as the belief that the trusting agent has in the trusted agent in a given context and at a given point in time [2]. We outlined and explained in depth why the dimensions of *time* and *context* are essential while defining trust. As explained in previous publications, the belief in the trusted agent emancipates either due to the capability or the willingness of the trusted agent to act in a way as the trusting agent wants it to act in that context [2]. With the passage of time, the belief that the trusting agent has in the trusted agent may not necessarily be the same, due to the following factors:

1. The trusting agent can get a better idea of the capability and willingness of the trusted agent to act in a way as it wants the trusted agent to act, in a given context with further dealings with it.
2. The capability or willingness of the trusted agent to act in a given context as desired by the trusting agent may vary.
3. The trusting agent on getting recommendations from other entities can have a better idea about the capability and willingness of the trusted agent to act in a way that it wants it to act, in a given context.

As a result of the above mentioned three factors, if the trusting agent has interacted with the trusted agent, at a given point in time, say at time T_1 ,in the past and subsequently assigned it with a trustworthiness value(which reflects the willingness and capability of the trusted agent to act in a way as the trusting agent wants it to act at time T_1), this assigned trustworthiness may or may not be necessarily be the same at any point in time in the future when the trusting agent would interact with the trusted agent.

After the interaction let us assume that the trusting agent assigned a trustworthiness value of x, where x $\in[1,6]$ to the trusted agent in context C1. The trustworthiness of x assigned to the trusted agent depicts the willingness and the capability of the trusted agent to deliver up on the agreed services in context C2. However the same trustworthiness of value of x may or may not be able to depict the capability the trusted agent to deliver the upon the agreed services in another context C2.

Hence when the trusting agent is making a trust based decision of whether or not to interact with another agent, it needs to take into account:

1. The context in which the interaction decision is being made by the trusting agent. If it has interaction with the trusted agent was in a different context to that of the context in which the interaction decision has to be made, then the trustworthiness value of the trusted agent assigned to it by the trusting agent in a different context may not be necessarily be the same. ***(AND)***
2. The time at which the interaction decision has to be made. The trustworthiness value assigned to the trusted agent by the trusting agent reflects its willingness and capability to offer a given quality of service at the time at which the interaction took place, which may or may not be necessarily be the same when the trusting agent

wants to interact with the trusted agent in the future.

Through this paper we will make use of an example. The example is as follows;

Let us assume that East Field and West Field are two logistic companies and that East Field needs to the services being offered by West Field now or at some point in the future (say 10/12/2005). Furthermore, let us assume that East Field had interacted with West Field in the past, say 10/12/2004. East Field subsequently had assigned a trustworthiness value of '5' to West Field by making use of the CCCI metrics proposed in [3]. It is possible that the capability and willingness of East Field to offer very good services as it had done in the past to get a trustworthiness value of '5' may or may not be the same now. It is possible that the capability and willingness to offer good services may have increased over time or decreased over time or has remained the same over time. East Field cannot make use of the trustworthiness that it had assigned to West Field a year back as its current trustworthiness value, and then make a decision of whether or not to trust West Field based on the trustworthiness value assigned to it in the past.

In this paper we present a method, by which the trusting agent before making a trust based decision of whether or not to interact with a trusted agent,

1. Can model the change in the trustworthiness value of the trusted agent and based on the time dependent modelling of the trustworthiness value of the trusted agent, it can even predict what the future trustworthiness value of the trusted agent.
2. Takes into account the context of interaction with the trusted agent.

The contributions of this paper to the existing literature are as follows:

1. It presents a time dependent method of modelling trust.
2. It presents a context dependent method of modelling trust.

II. TERMINOLOGY USED IN MODELLING THE CONTEXT SPECIFIC NATURE OF TRUST

In this section we explain the terms that we will use to model the dynamic nature of trust. Additionally we will elucidate the proposed terms with examples.

We define the repute value as *a numeric value for an agent, denoting its reputation in a given context and at a given point in time as communicated by a witness agent.*

As mentioned before in the example, East Field had interacted with West Field on 10/12/2004 and subsequently assigned it with a trustworthiness value of 5. Let us assume that another agent say North Field asks East Field whether or not it should interact with West Field. Assuming that East Field communicates correct recommendation, it would communicate to North Field that it had interacted with West Field on 10/12/2004 in a given context and found its trustworthiness to be '5'. We term this communicated trustworthiness of West Field in a given context that is being communicated by East Field to North Field is called the repute value of West Field.

We define time space *as the past total duration of time over which the trustworthiness of the trusted agent will be analysed in order to make a trust based decision.*

For example, let us assume that East Field decides that the interaction that it is going to carry with West Field has an extremely high financial value and hence would like to find and analyse the trustworthiness of West Field in the same context over the past 10 years. In other words, it would like to find out the trustworthiness assigned to West Field by different entities in the same context, and then make a decision of whether or not to interact with West Field.

This past duration of 10 years over the trustworthiness of West Field would be analysed by East Field as the trusting agent is called at the time space. The time space, in the proposed method, can be as large as millions of centuries to as small as a second, and it depends on the trusting agent. However, it cannot be zero and has to be a finite non negative value.

We define time slot *as finite duration of time with in a time space over which the repute values of the reputation queried peer(or the trusted agent) are aggregated into a single value in order to analyse its dynamic behaviour.*

Once East Field as the trusting peer has decided the time space, it then divides the time space into a finite number of intervals. It will then determine the trustworthiness value of West Field for each interval in the time space. Assuming that for the time space of 10 years, East Field has decided to divide it into ten intervals and the duration of each interval is one year. Subsequently East Field would determine the trustworthiness value of West Field in each year following 10/12/2004. This would enable East Field to model the change in the trustworthiness value of West Field. In order to determine the trustworthiness value of West

Field in a interval of time, East Field would have to issue a reputation query for West Field in that interval of time and then aggregate all the replies back in to a single trustworthiness value. We discuss more about how the aggregation process works in the following sections.

WE define time spot *as the time at which an agent interacted with another agent and subsequently assigned a trustworthiness value to it.*

Each time spot has to fall within a single time slot. As mentioned before East Field had interacted with West Field on 10/12/2004. This time at which the interaction between them took place is called as the time spot.

We define **trustworthiness prediction** as *the process of determining the trustworthiness value of an agent in the immediate future time slot, given its trustworthiness values in the past time slots.*

Continuing with the above example, assuming that East Field has the trustworthiness value of West Field in each year following from 10/12/1994 till 10/12/2004 and wants has determine the trustworthiness value of West Field in the next time slot (starting from 11/12/2004 to 10/12/2005), since it has to interact with West Field on say 10/02/2005. This process of determining the trustworthiness value of West Field in the immediate future time slot, based on the past trustworthiness values of West Field is called trustworthiness prediction.

Continuing with the above example let us assume that East Field wants to make a trust based decision of whether or not to interact with West Field based at time 10/12/2005, i.e., at a point in time in the future. As we mentioned before, it wants to make this decision based on the trustworthiness value of West Field in the past 10 years. Assuming that the current time or the time at which the trust based decision is being made by East Field is 10/12/2004, the whole duration of time from 10/12/1994 to 10/12/2004, over which East Field as the trusting agent would analyse the behaviour of West Field as the trusted agent is termed as 'time space'.

Further let us assume that East Field has interacted with West Field in the same context in the past at the dates mentioned in Table 1 and assigned it with trustworthiness value as outlined in Table 1.

Each of the above points in time when an interaction between East Field and West Field took place is termed as time space.

Further more let us assume that in order to analyse the change in the trustworthiness value of West Field, East Field divides whole time space into 10 equal windows of time. The idea behind dividing the time space into a finite number of equal windows of time is to enable East Field to be able to track the changes in the trustworthiness value of West Field over the whole time space.

Table 1: East Field's Trust Table Containing the Time Spot of Interaction and the trust worthiness value

Time of the Interaction	Assigned trustworthiness value
11/05/1995	5
10/04/1996	4
10/04/1997	5
11/05/1997	6
08/05/1998	3
09/07/1999	4
09/09/1999	5
01/02/2000	6
02/03/2001	3
01/08/2001	2
03/04/2002	1
04/05/2003	5
05/06/2004	4

Similarly in order for East Field to be able to track and analyse the changes in the trustworthiness value of West Field each year, we need to combine the multiple trustworthiness values assigned to West Field in 1999 and 2001 into a single numeric value.

In this case since the time space is of 10 years, the each time division would be of a duration of (10/10) one year. WE term each window of time in the time space as a time slot.

Since East Field wants to analyse the behaviour of West Field starting from 10/12/1994, the first time slot would start from 10/12/1994 and would end at 09/12/1995 since the duration of each time slot is one year.

Table 2: The Start Time and End Time of Each Time Slot as decided by East Field

Time Slot No	Start and end of Time Slot
1	10/12/1994 to 09/12/1995
2	10/12/1995 to 09/12/1996
3	10/12/1996 to 09/12/1997
4	10/12/1997 to 09/12/1998
5	10/12/1998 to 09/12/1999
6	10/12/1999 to 09/12/2000
7	10/12/2000 to 09/12/2001
8	10/12/2001 to 09/12/2002
9	10/12/2002 to 09/12/2003
10	10/12/2003 to 09/12/2004

The second time slot would start from 10/12/1995 and would end on 09/12/1996. Table 2 above shows each of the ten time slots.

From the above example, let us assume that East Field wants to observe and track the changes in the trustworthiness value of West Field for each year following 10/12/2004. We can see from the table that East Field knows and has a single trustworthiness value for West Field in the 1995 and 1996 of '5' and '4' respectively. During the first time slot the trustworthiness value of West Field can was 5. Similarly during the second time slot the trustworthiness of West Field was 4. However it can be seen from table 1 that during the third time, East Field has interacted with East Field two times. During the first time spot (10/04/1997) with in the third time slot the trustworthiness value it was assigned a trustworthiness value of 5 and at the second time spot (11/05/1997) with in the third time slot the trustworthiness value it was assigned a trustworthiness value of 6.

In order to enable East Field to track and observe the changes in the trustworthiness value of West Field each year, we need to the combine the all trustworthiness values assigned to West Field in the third time slot into a single numeric value. The process of how this is done will be explained later in the paper.

We define the **dynamic nature of trust** as, *the change in the trustworthiness value of a given agent over a series consecutive time slots.*

Continuing from the above example, we can see that trustworthiness value of West Field during the first time slot was '5' and during the second time slot was '6'. As can be observed over a series of consecutive time slots West Field has received two different trustworthiness values. WE term this change in the trustworthiness value of an agent over a sequence of consecutive time slots as dynamic nature of trust.

Let us assume that East Field had determined the trustworthiness value of West Field in each year following from 10/12/1994 till 10/12/2004. For each intermediate time slot in the above mentioned time space, there would be a unique single trustworthiness value for West Field. The trustworthiness value for West Field may or may not be the same in the different time slots. This change in the trustworthiness value of West Field over the different time slots is due to the dynamic nature of trust.

WE define the witness trustworthiness value *as a numeric value that denotes the correctness of the recommendations communicated by the witness agent.*

Let us assume that East Field asks another peer agent, say North Field for example, about the trustworthiness of West Field in context C1 at the current time slot. Furthermore, Let us assume that North Field communicates a repute value of 6 to East Field. Based on this recommendation let us furthermore assume that East Field goes ahead and interacts with West Field and finds that the trustworthiness actual trustworthiness of West Field as determined by it is 4.

East Field would keep a record of the correctness of the recommendations communicated by each witness agent or recommending agent. This correctness value would show the extent to which the recommendations from the recommending agent (North Field in this case) can be regarded as being true.

Numerically the witness trustworthiness value of a witness agent is determined as the difference between:

- The value communicated by the witness agent about the reputation queried agent (and)
- The trustworthiness value that the reputation querying agent found on interaction with the reputation queried agent.

In the next section we describe the relationship between trust and reputation and the role of reputation in determining trust and the need to consider dynamic nature of trust.

III.TRUST AND REPUTATION

Reputation can be regarded as a means to substitute for trust between two entities. If the trusting agent has no previous interaction with the trusted agent (hence does not know about the trustworthiness of the trusted agent), then it uses the reputation of the trusted agent as the criteria for making a trust based decision. Reputation of an agent is obtained from other entities who have previously interacted with it (witness entities). The trusting agent issues a reputation query, gathers all the reputation replies and combines them to make a trust based decision. Two factors which relate to trust that need to be considered while soliciting reputation of the agent are as follows:

- The reputation being considered should be of the same context as the context in which a trust based decision is to be made
- The reputation values being communicated by witness entities about an agent correspond to the capability and willingness of that agent at the time at which the interaction between them took place. Due to factors that we mentioned in Section 1, these reputation values may not be necessarily

valid at the time when the trust decision is to be made. Hence relevant reputation values should be considered. In the next section we consider what reputation values are regarded as "valid" and consider three different cases of how to make a "valid" trust based decision.

With these problems in mind we propose a method that makes use of reputation to make a trustworthiness prediction about the trusted agent. This method takes into account the dynamic nature of trust and the context specific nature of trust. In the next section we describe the working of the **method in detail.**

IV. MARKOV METHOD FOR DETERMINING TRUSTWORTHINESS OF THE TRUSTED ENTITY IN THE IMMEDIATE FUTURE TIME SLOT

In the proposed method each agent in the service oriented environment maintains the following values about the other agents in the service oriented environment:

1. The witness trustworthiness values of all the witness entities from which it has solicited recommendations from. The witness trustworthiness value is additionally qualified by the time at which the recommendation was solicited.

The witness trustworthiness value of an agent, say South Field held by East Field, reflects the extent to which East Field regards the recommendations communicated by South Field as being correct. Table 3, shows an example of the witness trustworthiness values held by East Field is as follows:

As can be seen above East Field holds four entries in its Witness Trustworthiness Table. It has taken recommendations from South Field twice in the past. On the first occasion, i.e., on 10/10/2003 it had found that the witness trustworthiness value of South Field was '5'. However on the second occasion it has found that the witness trustworthiness value of South Field was -1. Since trust is dynamic the witness trustworthiness value of a given agent may or may not be the same always, i.e. in other words the witness trustworthiness value of an agent is dynamic as well. Hence in our proposed method we always qualify the witness trustworthiness value of an agent by the time at which the recommendation was solicited and the witness trustworthiness value was decided. This factor, as we will see later will help an agent (East Field in this case) in modelling the dynamic nature of the witness trustworthiness value.

The trustworthiness values of all the other entities, with whom it has previously interacted with. This trustworthiness value is additionally qualified with the context of interaction and the time spot.

Table 3: Witness trustworthiness values held by East Field about other entities

Agent Name	Witness Trustworthiness Value(WTV)	Time of Soliciting Recommendation
South Field	-1	10/10/2004
North Field	0	01/01/2002
East Logistics	-5	11/11/2002
South Field	5	10/10/2003
.....	.....	.....
.....	.....	.....
.....	.....	.....

The format of the trust table held by each agent is shown below in table 4. For elucidation purposes we take the example of East Field.

As can be seen below East Field has four entries in its Trust Table. It has three entries for West Field two of which are in the same context of C1. However as can be seen from the above trust table of East Field, the time at which the interactions took place is different.

On 10/12/2001 when the interaction took place for the first time East field had assigned it a trustworthiness value of 5. On the second occasion when the interaction between them took place in the same context, East Field had assigned it with a trustworthiness value of 4.

Table 4: Trustworthiness values held by East Field about other entities

Trust Agent's Id Agent	**Context of Interaction**	**Time of Interaction**	**Trustworthiness Value**
West Field	C1	10/12/2001	5
West Field	C1	10/02/2004	4
West Field	C3	10/12/2003	3
South Field	C3	10/12/2002	1
....	....	....	....
....	....	....	....

The purpose of the Markov Model is to provide a means to a trusting agent to determine the trustworthiness value of a given trusted agent, in a given context and at a given point in time. As mentioned before unlike the other models proposed in the literature [2,3,4,5,6,7] , the Markov model takes into account the *context specific* and the *dynamic* nature of trust while carrying out the task of determining the trustworthiness value of a given trusted agent. The trusting agent has to first decide on the following factors before it can make use if the Markov Model for determining the trustworthiness value of a given trusted agent, in a given context and a given time spot

1. The context in which the trusting agent wants to make a trust based decision of whether or not to interact with the trusted agent.
2. The time space over which the trusting agent wants to analyse the trustworthiness of the trusted agent.
3. The duration of the time slot over which the trusting agent wants to analyse the dynamic behaviour of the trusted agent. Based on the duration of each time slot and the time space, it can determine the number of time slots.
   For the rest of this paper we represent the paper we assume that there are N time slots, each with a duration of 't'. Hence the total time space is Nt.
4. The time spot at which at which the trusting agent wants to make a trust based decision of whether or not to interact with the trusted agent. In this paper we assume that the trusting agent wants to make a trust based decision of whether or not to interact with the trusted agent in a given context in the immediate next time slot i.e. (N+1).

If the time spot at which trusting agent wants to make a the trust based decision about the trusted agent falls in the immediate future time slot, then the trusting agent has to go through the a sequence of steps explained below in order to predict the possible trustworthiness value of an agent, based its previous trustworthiness values. The steps involved in sequential order are explained below

Step 1: Issue a reputation query and gathering replies.

When the trusting agent sends out a reputation query about the prospective trusted agent, it takes up the role of the reputation querying and the trusted agent takes up the role of the reputation queried agent.

When the reputation querying agent has to make a trust based decision of whether or not to interact with a given agent in future, it , issues a reputation querying agent would contain the fields.

- The identity of the agent of the reputation queried agent.
- The context in which the reputation querying agent has to make a trust based decision about the reputation querying agent.
- The start time and the end time of the time space.

All the witness entities, who have previously interacted with the reputation queried agent, in the same context and with in the duration specified by the reputation querying agent(the whole duration of the time space) in the reputation query, reply back to the reputation querying agent with the repute value for the reputation queried agent. This value is additionally qualified with the time spot at which the interaction between the witness agent and the reputation queried agent took place.

Step 2: Classifying the replies into the time slots.

Once the reputation querying agent gets back all the replies back from the other witness entities, it chucks them into their appropriate time slot. As mentioned before the reputation replies from the witness entities are always qualified by the time spot at which the interaction between the witness agent and the reputation queried agent had taken place. Based on the time spot in each reputation reply, the reputation querying agent determines which time slot it would fall it and chucks it appropriately in that time slot.

Step 3: Combining the repute values in each time slot.

Once the reputation querying agent has classified all the repute values obtained about the reputation querying agent into their appropriate time slots, it then classifies the repute values in each time slot into three different classes as follows:

- Recommendations from trustworthy entities.
- Recommendations from untrustworthy entities.
- Recommendations from unknown entities.

It then uses weeds out the recommendations obtained from untrustworthy entities. Finally it combines the recommendations obtained from trustworthy and unknown entities using the below formulae to determine the trustworthiness

of the reputation queried agent at each time slot in the whole time space.

Repute Value (m, A, T_A) =

$$\left(\sum_{i=1}^{N}(WTV[i]) \lozenge (\text{Repute Value}[m, i, A, t])\right)/N) + \beta*\left(\sum_{j=1}^{M} \text{Trustworthiness}[j]\right)/M)$$

Where N represents the total number recommendations obtained from trustworthy agent in the current time slot.

And M represents the total number recommendations obtained from unknown entities in the current time slot.

A denotes the context

T_A denotes the A th time slot on the time space

T denotes the time spot which the reputation querying peer finds that it is in time slot T_A

ReputeValue [m, i, A, t] is the reputation value communicated by witness agent we about reputation queried agent m at time spot t.

WTV[i] represents the witness trustworthiness value of witness WE .

◊ is an operator that adjusts the reputation value communicated by the witness agent with the witness trustworthiness value of the witness agent. As mentioned before, witness trustworthiness value is the average of the difference between the past recommendations of the witness agent to the trusting agent and what the trusting agent observed on interaction.

β gives weight to the recommendations communicated by the unknown entities.

The first term in the above formula combines the reputation values from the trusted agent and the second term in the above formula combines the reputation values from the unknown peer's.

Step 3 is repeated for each time slot N in the time space. This would give the reputation querying agent a chain of aggregated repute values of the reputation queried agent over a sequence of consecutive time slots. We define this chain of aggregated repute values corresponding to a sequence of consecutive time slots as the *Markov Chain.*

The Markov chain represents a sequence of repute values of the reputation queried agent, corresponding to a sequence of time slots starting from the first time slot in the time space to the last time slot in the time space (In other words the current time slot). Since the reputation querying agent has to determine the trustworthiness of the reputation queried agent, at a time spot which falls in the immediate future time slot, the trustworthiness value of the reputation queried agent at a time spot in the immediate future may or may not necessarily be the same as the trustworthiness value in the current time slot.

In order to determine the trustworthiness value of the reputation querying agent at a time spot which falls immediately in the future time slot, then the reputation querying agent has to construct the *Current State Vector* and the *Markov Matrix.*

Step 4: Constructing Current State Vector.

The current state vector shows the repute value of the reputation queried at time slot 'N'. It will be a 1*6 matrix, since we make use of 6 trustworthiness levels. The repute value of the reputation queried at time slot 'N' will be determined using the above formulae and will be denoted by a 1 in the column corresponding to the repute value at time slot 'N'. All other trustworthiness levels will be denoted by 0. Let us denote the current state as **C.**

Step 5: Constructing Markov matrix.

The Markov matrix of a given agent denotes the probability of that agent transiting from one trustworthiness level to another trustworthiness level based on its past behaviour is captured using the Markov Chain. Each element in the Markov matrix belonging to a given agent denotes the probability of that agent transiting from the trustworthiness state corresponding to the row in which the element falls in to the trustworthiness state corresponding which to the column in which the element falls in, based on its past behaviour is captured using the Markov Chain.

In order to determine the probability of a agent transiting from trustworthiness level A to trustworthiness level B, based on the Markov Chain, we find out the ratio of the number of times that agent has transited from trustworthiness level A to trustworthiness level B to that of the total number of time that the agent has transited from trustworthiness level A to any other trustworthiness level. This would give us the relative probability of an agent transiting from trustworthiness level A to trustworthiness level B to that of probability of it transiting from trustworthiness level A to any other trustworthiness level.

$$P(A \rightarrow B) = n(A \rightarrow B) / n(A \rightarrow)$$

Where, P (A→B) represents the Probability of an agent transiting from Trustworthiness Level A to Trustworthiness Level B;

n (A→B) represents the number of total number times that the agent has moved from State A to State B based on the Markov Chain.

n (A→) represents the number of total number times that the agent has moved from State A to any other state based on the Markov Chain.

In other words, P (A→B) denotes that probability of an agent being in trustworthiness state B in the immediate future time slot, given that it is state A in the current time slot. Let us denote Markov matrix of an agent as **M.** It would be a 6*6 matrix.

Step 6: Constructing the Future State Vector

Once the Markov matrix and current state vector has been derived from the Markov Chain, then the future state vector (denoted as **F**) of the agent is determined by multiplying the current state vector with the Markov matrix. The future state vector denotes the probability of the reputation queried agent being in a trustworthiness state. It would be a 1*6 matrix, with column 'I' corresponding to the probability that the reputation queried agent would be in trustworthiness state WE at time slot N+1.

Mathematically the process of deriving the future state vector can be represented as:

$$\mathbf{F = C*M}$$

From the future state vector we choose the future trustworthiness level of the reputation queried agent as the level which with has the highest probability of transiting to. A trusting agent decides to go ahead and interact with the trusted agent only if the trustworthiness level of the trusted agent is >=5, since 5 and 6 denote positive trust. This is same for all the three cases that we described above.

After interacting with the chosen agent, the trusting agent makes use of CCCWE metrics proposed in [3] to rate the behaviour of the trusted agent in the interaction. Based on the trustworthiness value assigned to the trusted agent after interacting, it modifies the witness trustworthiness values of all the witness entities, from which it had solicited recommendations, using the following formulae:

Witness Trustworthiness value (I)←

$$\Theta * \left(\sum_{i=1}^{Z} (X_{we} - U_{we}) / Z\right) + \beta * \left(\sum_{j=1}^{C} (Xj - Uj) / C\right)$$

where

Witness Trustworthiness value(i) is the trustworthiness of witness agent 'I' in the context of communicating recommendations.

X_{we} is the reputation value communicated by witness agent we about the reputation queried agent

U_{we} is the trust value that the trusting agent found when it interacted with the trusted agent

Θ and β are weights that distinguishes and pays more importance to recent experience that an agent has with a given witness agent in soliciting recommendations than to the old experiences. In general $\Theta >> \beta$ and $\Theta + \beta = 1$ .The weights Θ and β are to ensure that old reputation matches are given less importance or no importance ($\beta = 0$) it determining the repute value of a witness agent.

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