A Methodology for Determining the Creditability of Recommending Agents

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Abstract. The trusting agent in order to analyze the Risk that could be present in its future interaction with a trusted agent might solicit for its recommendations from other agents. Based on the recommendations achieved the trusting agent can decide whether to interact or not with the trusted agent. If the trusting agent decides to proceed, then after its interaction it should adjust the creditability of the recommending agents, whose recommendation it considered. Doing this would help the future trusting agents to classify the recommending agents according to their trustworthiness and ignore those which are un-trustworthy. In this paper we propose such an approach by which the trusting agent adjusts the credibility of the recommending agent after its interaction depending on the recommendation that it gave.

1 Introduction

The Australian and New Zealand Standard on Risk Management, AS/NZS 4360:2004, states that Risk Identification is at the heart of risk management [1]. Hence, risk should be identified according to the context of the transaction in order to analyze and manage it better. Risk analysis is the science of evaluating risks resulting from past, current, anticipated or future activities. The amount of risk inherent in a transaction must be understood or analyzed before a transaction begins. This also applies to the transactions in the field of e-commerce and peer-to-peer business. Risk is a combination of: a) the uncertainty of an outcome; and b) the cost of the outcomes when it occurs, usually the loss incurred.

Analyzing risk is important in e-commerce transactions and there is a whole body of literature based in rational economics that argues that the decision to buy is based on the risk-adjusted cost-benefit analysis [2]. Thus, it commands a central role in any discussion of e-commerce that is related to a transaction. Risk plays a central role in deciding whether to proceed with a transaction or not. It can broadly be classified as an attribute of decision making that reflects the variance of its possible outcomes.

We have developed an approach by which the trusting agent can determine the risk beforehand that may be present in interactions with a trusted agent by assimilating the recommendations communicated by the recommending agents. In this paper, we propose a novel approach where the trusting agent, after its interaction with the trusted agent, adjusts the creditability of the recommending agents depending on the

recommendations communicated by them. This paper is organized into five sections. In section 2 we discuss previous related work and formalize the problem; in section 3 we propose a methodology for the creditability adjustment of the recommending agents; in section 4 we explain the methodology through example and in section 5 we conclude the paper.

2 Related Work

From the above discussion it can be concluded that risk analysis is necessary when a business interaction is carried out using the peer-to-peer interaction style. In order to analyze the risk in an interaction, we defined the term *Riskiness* in Hussain, Chang, Hussain & Dillon [3]. Riskiness is defined as *the numerical value that is assigned by the trusting agent to the trusted agent after the interaction, which shows its level of Risk on the Riskiness scale.* The Riskiness scale, as shown in Figure 1, has seven levels ranging from -1 to 5. The Riskiness scale has six levels to represent each type of risk and one level to represent *Unknown Risk.*

Riskiness Levels	Magnitude of Risk	Riskiness Value	Star Rating
Unknown Risk	-	- 1	Not Displayed
Totally Risky	91 - 100 % of Risk	0	Not Displayed
Extremely Risky	71 – 90 % of Risk	1	From ⯪ to ★
Largely Risky	51 – 70 % of Risk	2	From ★⯪ to ★★
Risky	26 – 50 % of Risk	3	From ★★⯪ to ★★★
Largely UnRisky	11 – 25 % of Risk	4	From ★★★⯪ to ★★★★
UnRisky	0 – 10 % of Risk	5	From ★★★★⯪ to ★★★★★

Fig. 1. The Riskiness scale

The Riskiness value assigned by the trusting agent to the trusted agent depends on the level of un-commitment versus promised. The promised commitment is the expected behaviour that is defined by the trusting agent according to its criteria before initiating interaction with the trusted agent. This is the behavior by which the trusted agent is expected to behave in the interaction. Criteria are defined as the set of factors or bases that the trusting agent wants in its interaction with the trusted agent and later against which it will determine the un-commitment behavior of the trusted agent. The greater the degree of un-commitment behavior the higher the Risk present in it and vice versa. The process by which the trusting agent assigns a Riskiness value to the trusted agent depending on the level of its un-committed behaviour is defined in Hussain et al. [3] and we will not be discussing it here due to space limitation.

But the Riskiness value that is assigned by the trusting agent to the trusted agent is after their interaction. As mentioned in section 1, the decision to proceed in the transaction is based on the risk adjusted cost benefit analysis. It would be much easier for the trusting agent to decide whether to proceed or not in an interaction with a trusted agent if it knows beforehand the level of risk that could be present in its interaction. In order for the trusting agent to analyze the risk beforehand that could be present, two scenarios arise. They are:

Scenario 1: If the trusting agent has interacted with the trusted agent previously in the same context using the same criteria, then it can determine the risk that could be

present in their interaction by analyzing the Riskiness value that it assigned to the trusted agent in its previous interactions.

Scenario 2: If the trusting agent has not interacted with the trusted agent previously OR in the same context with the same criteria as that of its future interaction then it can determine the risk that could be present in their future interaction by analyzing the reputation of the trusted agent. Reputation of the trusted agent can be used as an alternative when the Riskiness value of the trusted peer in not known. Reputation can be determined by soliciting for recommendations from other agents in the context of its future interaction with the trusted agent. The agents who have interacted with the particular trusted agent in a context similar to that for which the recommendations are being solicited reply back with their recommendation. The agents replying back with the recommendations are called *Recommending Agents*. Once the trusting agent receives the recommendations, it can assimilate them and determine the reputation or the Riskiness value of the trusted agent. Based on the reputation determined, the trusting agent can analyze the risk that could be present in its interaction with the trusted agent and can decide whether to interact with it or not.

We have developed a methodology in Hussain, Chang, Hussain, Dillon and Soh [4] where a trusting agent can determine the Riskiness value or the reputation of a trusted agent in each criterion of its future interaction by assimilating the recommendations. We proposed that while assimilating the recommendations the trusting agent considers only Trustworthy and Unknown recommendations and omits the un-trustworthy recommendations in order to reduce the Risk. We will not be discussing the methodology in this paper due to space limitation.

After determining the riskiness or reputation of the trusted agent if the trusting agent decides to proceed in an interaction then, based on the outcome of its interaction, it should adjust the creditability of all the recommending agents whose recommendation assisted in the decision. Adjusting the creditability of the recommending agents would help any future trusting agent soliciting recommendations to determine whether the recommending agent is giving a viable recommendation or not. As mentioned in Hussain et al [4], the creditability of the recommending agents is the RRP value that is associated with each recommending agent. This value determines whether the recommendation communicated by that agent is trustworthy or not. We will discuss the process of adjusting the creditability or the RRP of the recommending agents in the next section.

3. Adjusting Creditability of the Recommending Agents

In order to get a thorough understanding of the problem, let us consider this example:

A trusting agent '**A**' wants to interact with a trusted agent '**B**' over context '**C**' on 20/04/2006. The criteria in its interaction are C1, C2 and C3. The trusting agent 'A' has not had any previous interactions with the trusted agent 'B' in the context of its future interaction 'C'. To analyze the risk before proceeding in a business interaction with it, the A solicits recommendations from other agents in the range of the past month. Hence, the *time space* [5] is of one month. 'A' divides the time space into 2 *time slots* [5] each of 15 days i.e. one slot from 21/03/2006 to 04/04/2006 and the second time slot from 05/04/2006 to 19/04/2006. Of the recommendations received

in the time space of 21/03/2006 to 19/04/2006 the trusting agent should apply greater importance to recommendations in the time slot of 05/04/2006 to 19/04/2006 as it is near the *time slot* of its future interaction with the trusted agent.

Let us suppose that replies are received from agents 'D', 'E', 'F' and 'G' in the form of Risk set [6]. All these agents have interacted with the trusted agent 'B' previously over context 'C'. Let us suppose:

Recommendation from agent 'D':
{Agent 'D', Agent 'B', C, 4, 4, ((C1, 1) (C5, 0)), 3, $1000, 13/04/2006, 15/04/2006, -1}
Recommendation from agent 'E':
{Agent 'E', Agent 'B', C, 3, 4, ((C5, 1) (C6, 1)), 4, $500, 10/04/2006, 11/04/2006, 1}
Recommendation from agent 'F':
{Agent 'F', Agent 'B', C, 3, 2, ((C1, 1)(C6, 1)),2,$200, 22/03/2006, 25/03/2006, UNKNOWN}
Recommendation from agent 'G':
{Agent 'G', Agent 'B', C, 4, 5, ((C1, 1) (C3, 1)), 5, $1200, 15/4/2006, 16/4/2006, 2}

From the recommendations it can be seen that:
1. Recommendation from agent 'D' is a trustworthy recommendation as its RRP is in the range of (-1, 1) and the criteria in which it interacted with the 'B' is C1 and C5.
2. The recommendation from 'E' is trustworthy but the criteria in its interaction are C5 and C6. It is baseless for 'A' to consider this recommendation as the criteria do not match, even though the context is same
3. The RRP of 'F' is unknown and the criteria of its recommendation are C1 and C6.
4. The criteria of the recommendation from 'G' are C1 and C3 but the recommendation is un-trustworthy as its RRP is not in the range of (-1, 1).

Once the trusting agent decides which recommendations to consider it can then utilize the methodology mentioned in Hussain et al. [4] and determine the Riskiness value of the trusted agent in each criteria of its interaction i.e. C1, C2 and C3.

For example, let us assume that the trusting agent 'A' after analyzing the risk proceeds in the interaction with 'B'. Then after completing its interaction, 'A' should adjust the credibility or the RRP of the agents from which it took recommendations namely, agents 'D' and 'F' depending on its outcome and the what those agents recommended.

We think that the the creditability of a recommending agent should be adjusted by considering only the criterion in which it offered recommendations and not by considering the criterion of the whole interaction. For example, 'F' is communicating its recommendation in criteria C1 and C6. 'A' wants recommendations in criterion C1, C2 and C3. Hence, it will take recommendation from 'F' only in criterion C1. After its interaction with the trusted agent 'B', the trusting agent 'A' should adjust the creditability of 'F' only according to according to the outcome of criterion C1 and not according to the whole criterions i.e. C1, C2 and C3

Adjusting the creditability or the RRP of a recommending agent 'R' after an interaction, can be done by determining the deviation in the criterion commitment that the trusting agent found out after interacting with the trusted agent and what 'R' recommended to the trusting agent in that particular criteria before its interaction.

The deviation in the recommendation, when weighed with the significance of the criterion and the trustworthiness of 'R' gives the accurate measure of adjustment that is to be done to the RRP of the recommending agent.

Determining the adjustment to be made to 'R's' credibility according to the recommendation that it gave to the trusting agent 'TA' in criterion 'C' can be done by:

$$A_C^R = (\alpha * ((\frac{1}{N} * \gamma * (\sum_{i=1}^{N} Com\,^C_{TA} - Com\,^C_R)) + (\frac{1}{K} * \delta * (\sum_{l=1}^{K} Com\,^C_{TA} - Com\,^C_R)))) \;+$$

$$(\beta * ((\frac{1}{J} * \gamma * (\sum_{o=1}^{J} Com\,^C_{TA} - Com\,^C_R)) + (\frac{1}{M} * \delta * (\sum_{q=1}^{M} Com\,^C_{TA} - Com\,^C_R))))$$

Equation ------ 1

Where:

$Com\,^C_{TA}$ represents the commitment level of the trusted agent determined by the trusting agent 'TA' in criterion 'C' after the interaction,

$Com\,^C_R$ represents the commitment level recommended by the recommending agent 'R' to the trusting agent 'TA' for the trusted agent in criterion 'C' before the interaction,

N and K are the number of recommendations given by *trustworthy* recommending agents classified according to the time slot of the recommendations,

J and M are the number of recommendations given by *unknown* recommending agents classified according to the time slot of the recommendations,

γ and δ are the weights attached to the parts of the equation which gives more weight to the creditability adjustment if it was in the recent time slot of the trusting agent's future interaction with the trusted agent as compared to the far recent ones respectively. In general $\gamma > \delta$ and $\gamma + \delta = 1$,

α and β are the weights attached to the parts of the equation which will gives more weight to the credibility adjustment if it was from a trustworthy recommending agent as compared to from an unknown recommending agent respectively. In general $\alpha > \beta$, and $\alpha + \beta = 1$.

The first part of the above equation calculates the adjustment to be made in the creditability of the recommending agent 'R' if it was a *Trustworthy* recommending agent while giving this recommendation. The second part of the same equation calculates the adjustment to be made in the creditability of the same recommending agent 'R' if it was an *Unknown* recommending agent while giving this recommendation. The trusting agent in Hussain et al. [4] considers only these two types of recommendations to determine the reputation of the trusted agent and, hence, adjusts the creditability of only those after its interaction.

If there is a discrepancy between the commitment level that the trusting agent found out after its interaction and the commitment level communicated by a recommending agent prior to interaction, then we believe that the degree of adjustment in the creditability of the recommending agent should be more if it was a trustworthy recommending agent as compared to if it was an unknown recommending agent. This is done by the weights α and β attached to equation 1. It is because in the methodology discussed in Hussain et al. [4] that the trusting agent, while determining the reputation of the trusted agent by assimilating the recommendations of the

recommending agents, gives more weight to recommendations from agents who are trustworthy in giving them. Hence, if there is any deviation in the recommendation then after its interaction the creditability adjustment too should be done accordingly.

Once the creditability adjustment to be done for a recommending agent 'R' in criterion 'C' has been determined, then it should be weighed with the significance of that criterion according to the trusting agent. All the criteria of an interaction will not be of equal importance or significance. The significance of each criterion in an interaction might depend on the degree to which it influences the successful outcome of the interaction according to the trusting agent. So the credibility adjustment of the recommending agent in a criterion too should be done according to its significance. The possible levels of significance for a criterion are shown in Table 1.

Table 1: Showing the significance level of each criterion

Significance level of the Criterion (Sc)	Significance Rating and Semantics of the level
1	Minor Significant
2	Moderate Significant
3	Large Significant
4	Major Significant
5	High or Extreme Significant

Determining the adjustment A^R to be made to the recommending agent's 'R' creditability in a criterion according to its significance:

$$A^R = \frac{1}{TS} \left(\sum_{i=1}^{n} S_{Ci} * A^R_{Ci} \right) \qquad \textbf{Equation ------ 2}$$

Where A^R denotes the final adjustment to be made to the creditability of the recommending agent 'R',

TS represent the total significance of the criterions in the interaction according to the trusting agent,

S_{Ci} represents the significance of the criterion 'Ci' in which the recommending agent gave its recommendation,

A^R_{Ci} represents the adjustment to be made to the recommending agent's 'R' credibility according to the recommendation that it gave to the trusting agent 'TA' in criterion 'Ci'.

Finally, adjusting the creditability of the recommending agent:

$$RRP_{NEW\,R} = RRP_{OLD\,R} \oplus A^R \qquad \textbf{Equation ------ 3}$$

Where $\oplus$ is the adjustment operator.

$RRP_{NEW\,R}$ will become the Riskiness value of 'R' when it is communicating recommendation any time in the future. The proposed concept will become clear when we explain it by using an example in the next section.

4. Illustrating with a Real World Example

Continuing our discussion from the previous section, the trusting agent 'A' in order to determine the reputation of the trusted agent 'B' solicits for recommendations from other agents in the time space of 1 month. The trusting agent 'A' divided the time space into 2 time slots each of 15 days. It gets recommendations from agents 'D', 'E',

'F' and 'G'. The trusting agent will consider recommendations from Agent 'D' and Agent 'F' as they both are communicating recommendations in the criterions of its interest. The rest of them are either un-trustworthy recommendations or deal with other criterions. Let us assume that the trusting agent 'A' after determining the reputation of the trusted agent 'B' decides to proceed ahead in the interaction with it. Further let us assume that the commitment level found out for the trusted agent 'B' by the trusting agent 'A' in the criterions C1, C2 and C3 of its interaction are 0, 1 and 1 respectively. Further, the significance of the criterions C1, C2 and C3 according to the trusting agent 'A' is 4, 3 and 5 respectively.

In order to adjust the creditability of the recommending agents 'D' and 'F' according to the recommendation that they gave, the trusting peer has to first determine the deviation in the criterion commitment level that it found out and what the recommending agents recommended for that criterion.

4.1 Adjusting Creditability of Agent 'D'

Determining and representing in table 2 the deviation in the commitment level for criterion C1 between what the trusting agent 'A' found after its interaction and what the recommending agent 'D' recommended:

Table 2: Determining deviation in recommendation of Agent 'D'

Criterion C1	Commitment Level
Commitment level determined by the trusting agent	0
Commitment level recommended by the recommending agent	1

As can be seen from the risk set, agent 'D' is a trustworthy recommending agent and its recommendation is in the recent time slot of the trusting agent's future interaction with the trusted agent. Let us assume that the trusting agent 'A' gives a weight of 0.8 and 0.2 to recommendations from trustworthy and unknown recommending agents and a weight of 0.6 and 0.4 to the recommendations in the recent time slot and in the far recent ones respectively.

Utilizing equation 1 to determine the adjustment to be made to the creditability of the recommending agent 'D' according to the recommendation it gave in criterion C1:

$$A_{C1}^{D} = (0.9 * (0.6 *(0-1))) + 0 + 0 + 0 \quad = - 0.54$$

Using equation 2 to determine the adjustment to be made to the recommending agent's 'D' creditability according to the significance of the criterion:

$$A^{D} = \frac{1}{12} (4 * -0.54) = -0.18$$

Finally, adjusting the creditability of the recommending agent by utilizing equation 3:

$$RRP_{NEW\ D} = -1 \oplus (-0.18) = -1.18$$

4.2 Adjusting Creditability of Agent 'F'

Determining and representing in table 3 the deviation in the commitment level in criterion C1 between what the trusting agent 'A' found after its interaction and what the recommending agent 'F' recommended:

Table 3: Determining deviation in recommendation of Agent 'F'

Criterion C1	Commitment Level
Commitment level determined by the trusting agent	0
Commitment level recommended by the recommending agent	1

From the risk set it can be seen that agent F's RRP is unknown and its recommendation is in the far recent time slot of the trusting agent's future interaction with the trusted agent.

Utilizing equation 1 to determine the adjustment to be made to the creditability of the recommending agent 'F' according to the recommendation it gave in criterion C1:

$$A_{C1}^{F} = 0 + 0 + 0 + (0.1*(0.4 * (0-1))) = -0.04$$

Using equation 2 to weigh A_{C1}^{F} with the significance of the criterion:

$$A^{F} = \frac{1}{12} (4 * -0.04) = -0.01$$

Finally, adjusting the creditability of the recommending agent by utilizing equation 3:

$$RRP_{NEW\ F} = -0.01$$

From the above examples it can be seen that:

1. The RRP of agent 'D' has become -1.18 due to the incorrect recommendation that it gave to the trusting agent in criterion C1.
2. The RRP of agent 'F' has changed from Unknown to -0.01 after the interaction.

5. Conclusion

In this paper, we proposed a novel approach by which the trusting agent can adjust the creditability of the recommending agents after its interaction. This would considerably help the future trusting agents, soliciting for recommendations to classify them according to its trustworthiness and discard those which are untrustworthy. In our approach the creditability of the recommending agents is adjusted by considering only those criteria in which they communicated their recommendation and not by considering the total criterion of the interaction. By doing this, the recommending agent is adjusted with the accurate creditability that it deserves according to the recommendation it gave.

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