Quantifying Risk in Financial Terms in an e-Transaction

Omar Khadeer Hussain, Elizabeth Chang and Farookh Khadeer Hussain
School of Information Systems
Curtin University of Technology
Perth, AUSTRALIA

II. RELATED WORK

In order to analyze the level of Risk that could be present in an interaction we defined the term Riskiness in Hussain et al [9]. Riskiness is defined as the numerical value that is assigned to the trusted agent on the Riskiness scale by the trusted agent after its interaction. This numerical value shows the level of Risk that was present in their interaction. The Riskiness scale, as shown in figure 1, depicts different levels of Risk that could be possible in an interaction. The Riskiness value is assigned to the trusted agent by the trusted agent after assessing the level of un-commitment in its actual behaviour with respect to the expected behaviour. Expected behaviour is the commitment that the trusted agent was supposed to show in the interaction. The actual behaviour is the actual commitment by the trusted agent in its interaction with the trusted agent. The methodology by which the trusted agent determines the un-committed behaviour by the trusted agent in the interaction and assigns it with a Riskiness value that it deserves is defined in Hussain et al [9].
If the future trusting agent has any previous interaction history with a probable trusted agent in the same time space and in the same context as its future interaction, then it can make a decision whether to interact or not with that particular trusted agent based on its previous interaction history with it, by analyzing the Riskiness value that it assigned to the trusted agent in the past interactions. If, on the other hand, the future trusting agent does not have any previous interaction history with a probable trusted agent, then it can decide whether to interact or not with that particular trusted agent by determining its Riskiness value by soliciting recommendations from other agents in the context of its future interaction. The agents replying back with the recommendations are called *Recommending Agents*. As mentioned in Hussain et al. [10] the recommending agents communicate their recommendations in the form of a Risk Set. The Risk set is an ordered way of communicating recommendations so that it is easier for the trusting agent to interpret and analyze them. The format of the Risk set is defined in Hussain et al. [10]. Once the future trusting agent receives the recommendations, then it can assimilate them and determine the Riskiness value of the probable trusted agent in question. Based on the Riskiness value achieved, the trusting agent can decide whether to interact or not with it.

However, as mentioned earlier the Riskiness value to a trusted agent is assigned by the trusting agent after assessing the level of un-commitment in its actual behaviour with respect to the expected behaviour. Expected behaviour is defined by the trusting agent according to the criteria of its interaction. The future Riskiness value of the trusted agent predicted from its previous interaction history with the trusting agent, if any, or on the reputation of the trusted agent determined by RDSS might be the same for one or more trusted agents. Then the basis for the future trusting agent to decide with which agent to interact with, shifts to another characteristic of Risk namely the possible loss that could be incurred. As mentioned before in a peer-to-peer financial interaction, the possible loss to the trusting agent is the financial loss in its resources in interacting with the trusted agent. The trusting agent can analyze the Risk and decide on with which agent to interact with by determining the possible loss to its resources in interacting with each probable trusted agent.

The financial loss to a trusting agent in an interaction is dependent on:
1. Its previous interaction history with the trusted agent, if any, or on the reputation of the trusted agent determined by the trusting agent by soliciting recommendations from other agents according to the criteria of its interaction;
2. The future Riskiness value of the trusted agent predicted by the trusting agent in the time space of its future interaction with it;
3. Willingness of the trusting agent in interacting with the trusted agent;
4. Familiarity of the trusting agent with the medium of interaction;
5. Familiarity of the trusting agent with the trusted agent; and

All these factors have to be considered when determining the possible financial loss in the trusting agent’s resources in interacting with the trusted agent. In the next section, we will explain each of these factors in detail and define the metrics which are used to quantify each of these factors and express them numerically.

### III. FACTORS FOR DETERMINING FINANCIAL LOSS IN AN INTERACTION

#### A. Previous interactions or considering reputation from other agents

The outcome of previous interactions, if any, between the future trusting agent and the probable trusted agent will help...
in analyzing the level of Risk that could be present in future interactions between them. Depending on the outcome of the previous interaction, the trusting agent might be able to make a decision to trust the trusted agent or not. If the outcome of the previous interaction was positive and it concluded according to expected behaviour, then the trusting agent might have some belief in the trusted agent and may proceed with any future interactions. Consequently, the Risk associated with this interaction might not be high, as there is some belief present among them. On the contrary, if the outcome of the previous interaction was negative then the trusting agent may have some doubts about proceeding with any future interaction with the trusted agent and fears the Risk involved in the interaction may be too high.

If there is no previous interaction history between the trusting and the probable trusted agents, then the trusting agent can analyze the Risk that could be present in its interaction with each agent by enquiring about its reputation in the particular context of its future interaction. As discussed earlier, reputation of a trusted agent can be determined by soliciting for recommendations from other agents and later assimilating the information. The methodology by which the trusting agent assimilates the recommendations according to its criteria is defined in Hussain et al [11].

We represent the Riskiness value of the probable trusted agent before starting an interaction, that is achieved either by the previous interaction history of the trusting agent with the trusted agent or by the trusting agent soliciting for its recommendations from other agents by the metric Pre \textit{Agent}. The value of the metric Pre \textit{Agent} is between (0, 5) on the Riskiness scale.

**B. Predicting the future Riskiness value of the trusted agent**

Risk varies according to time. It is not possible for a trusting agent to have the same impression of the trusted agent that it had at a particular time throughout all interactions. The trusting agent, in order to determine the possible financial loss in an interaction accurately should take into consideration the future Riskiness value of the probable trusted agent till the time space of their interaction. The future Riskiness value for the probable trusted agent is predicted based on either the recommendations acquired from the recommending agents according to the criteria of the trusting agent’s future interaction or the previous interaction of the trusting agent with the probable trusted agent in the same context and time space as its future interaction. The process of classifying the time of the trusting agent’s interaction with the probable trusted agent into different timeslots and predicting the future Riskiness value of the trusted agent in each timeslot has been defined in Hussain et al. [12].

We represent the future Riskiness value of the probable trusted agent within the given space of time of the trusting agent’s interaction by the metric Fut \textit{Agent}. The predicted future Riskiness value of the probable trusted agent Fut \textit{Agent} will be in the range of (0, 5) on the Riskiness scale.

**C. Willingness of the trusting agent to interact with the trusted agent**

The financial loss in an interaction also depends on the commitment / willingness of the trusting agent in dealing with the probable trusted agent. While choosing an agent to interact with from a set of probable trusted agents, it is possible that the trusting agent might have a favourable past interaction history with a particular trusted agent, in the context of its future interaction and as a result of that, it might prefer to choose and deal with that particular trusted agent in its future interaction among the other probable agents. Hence the trusting agent while determining the financial loss in its resources in interacting with a probable trusted agent should consider its willingness in interacting with that probable trusted agent.

We define the willingness of the trusting agent to interact with the probable trusted agent by the metric Will \textit{Agent}. In order to measure the willingness of the trusting agent in interacting with the trusted agent we define 3 levels of the metric Will \textit{Agent}. Those levels are defined in Table 1.

**D. Familiarity of the trusting agent with the medium of interaction**

The possible degree of financial loss in the trusting agent’s resources also varies according to the familiarity of the trusting agent towards the medium of interaction with the probable trusted agent. If the trusting agent is familiar with the medium in which it is going to interact then it will ease the Risk that could be present.

We represent the familiarity of the trusting agent with the medium of interaction by the metric Fam \textit{Agent}. In order to measure the familiarity of the trusting agent with the medium of interaction we define two levels for the metric Fam \textit{Agent}. Those levels are defined in Table 2.

**E. Familiarity of the trusting agent with the trusted agent**

In order to determine the potential financial loss in the trusting agent’s resources in an interaction it is important to consider the familiarity of the trusting agent with the particular trusted agent. The familiarity of the trusting agent with the trusted agent is represented by the metric Fam \textit{Agent}.
In order to measure the familiarity of the trusting agent with the trusted agent we define two levels of the metric Fam Trusted Agent as shown in Table 3.

TABLE 3
SHOWING THE LEVELS FOR THE METRIC FAM TRUSTED AGENT

<table>
<thead>
<tr>
<th>Metric Fam Trusted Agent Levels</th>
<th>Semantics of the Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>The trusting agent has not interacted with the trusted agent before and is not at all familiar with it.</td>
</tr>
<tr>
<td>1</td>
<td>The trusting agent has previous interaction history with the trusted agent and is familiar with it.</td>
</tr>
</tbody>
</table>

F. Nature of the trusting agent

One of the factors which vary Risk in an interaction is the nature and thinking attitude of the trusting agent, which decides how it will act and react in certain situations. The nature of the trusting agent plays an important role in deciding whether to proceed with the interaction or not, thus helping in determining the financial loss that could be involved in an interaction.

If the trusting agent has an impatient nature or acts in haste, then there is a possibility that he might proceed with the interaction without looking at the previous history of the probable trusted agent or soliciting for recommendations, hoping to achieve the desired outcome as soon as possible. The Risk associated in these interactions might be high.

The trusting agent might care for personal values and start an interaction. For example let us suppose that the trusting agent and the trusted agent might have dealt successfully before in a different context and in a different interaction. Now, they are dealing again in a context and in an interaction in which the trusted agent does not have any experience. Yet the trusting agent might care for personal values and might be ready to take the extra Risk involved and proceed with the interaction.

On the contrary, the trusting agent might have a cautious nature of proceeding according to the results and feedback of the previous interactions of the trusted agent. In this case, it might not be willing to trust the trusted agent in any other context in which it does not have any experience. He might feel the Risk involved in such an interaction could be high and might not proceed in interacting with him. Hence, the Risk too decreases according to the trusting agent’s decision. If the trusting agent decides to go ahead in an interaction according to the correct way, i.e. in a logical fashion not caring about the personal values then it will be making the decision to proceed with the interaction only if the expected advantages outweigh the negative factors. The Risk involved in such interactions might be less when compared to the other ones.

The trusting agent might decide to proceed in the interaction or not, depending on its nature and it is important to take that into consideration while determining the financial loss in an interaction. The nature of the trusting agent is represented by the metric Nat Trusting Agent. We define 3 levels of the metric Nat Trusting Agent in order to determine the nature of the trusting agent. Those levels are defined in Table 4.

IV. DETERMINING THE POSSIBLE FINANCIAL LOSS IN AN INTERACTION

To determine the possible financial loss in an interaction, the trusting agent by making use of the above mentioned metrics should derive a numerical value which quantifies its possible interaction with a particular trusted agent. The numerical value that is derived by using the above metrics will take into consideration factors namely

- the previous interaction of the trusting agent with the trusted agent if any,
- the reputation of the trusted agent determined by assimilating the recommendations,
- the predicted future Riskiness value of the trusted agent within the time slot of its interaction with the trusting agent,
- the willingness of the trusting agent in dealing with the trusted agent,
- familiarity of the trusting agent with the medium of interaction,
- familiarity of the trusting agent with the trusted agent,
- nature of the trusting agent which is a critical factor in deciding whether to interact or not with the trusted agent.

Hence the numerical value quantifying the possible interaction of the trusting agent with a probable trusted agent can be determined by adding the individual value that is assigned for each metric. We represent the numerical value quantifying the possible interaction of the trusting agent with the trusted agent as Poss Interaction.

Hence Poss Interaction =
Pre Trusted Agent + Fut Trusted Agent + Will Trusting Agent + Fam Medium + Fam Trusted Agent + Nat Trusting Agent

----------Equation 1

Once the numerical value quantifying the possible interaction between the trusting agent and the trusted agent has been determined, it should be compared with the numerical value which quantifies an interaction between the same agents with no financial loss at all to the trusting agent’s resources. This value is achieved by the above defined metrics by substituting the values for each metric in equation 1 that would represent a totally non-risky interaction. We represent the numerical value which quantifies an interaction with no financial loss at all to the trusting agent’s resources as Noloss Interaction.
Hence \( \text{Noloss}_{\text{Interaction}} = \) 
\[
\text{Pre} \text{Trusted Agent} + \text{Fut} \text{Trusted Agent} + \text{Will} \text{Trusted Agent} + \text{Fam} \text{Medium} + \text{Fam} \text{Trusted Agent} + \text{Nat} \text{Trusted Agent}
\]

\[ \text{Equation 2} \]

We define \( \text{Loss}_{\text{Interaction}} \) as the metric which expresses in numerical value the possible level of loss that could be possible in an interaction. This is achieved by comparing the difference of the numerical values representing a totally non-risky interaction and the possible way in which the interaction might proceed with respect to the numerical value that expresses an interaction with no financial loss at all. The metric \( \text{Loss}_{\text{Interaction}} \) depicts the level of financial loss that could be possible in an interaction to the trusting agent with the trusted agent.

\[
\text{Hence} \text{Loss}_{\text{Interaction}} \text{ is determined by:}
\]
\[
\begin{align*}
\text{Loss}_{\text{Interaction}} &= \frac{\text{Noloss}_{\text{Interaction}} - \text{PossInteraction}}{\text{Noloss}_{\text{Interaction}}} \\
\text{Equation 3}
\end{align*}
\]

Consequently, Financial Loss in an interaction =
\[
\text{(Cost of the Interaction} \times \text{Loss}_{\text{Interaction}}) \text{ Equation 4}
\]

The possible percent of loss in an interaction =
\[
\text{Possible Percent of Loss}_{\text{Interaction}} = (\text{Loss}_{\text{Interaction}} \times 100) \text{ Equation 5}
\]

V. EXAMPLE OF DETERMINING THE POSSIBLE FINANCIAL LOSS IN AN INTERACTION

In order to get a better understanding of the proposed model let us consider an example of determining the possible financial loss in an interaction to the trusting agent in interacting with a logistic company which would be the trusted agent by using the defined metrics.

Let us consider that a trusting agent ‘A’ has to interact with a logistic company in the context of transporting its goods. The trusting agent has to decide among a set of logistic companies (possible trusted agents) with which particular agent to interact with. The set of possible trusted agents are Agent ‘B’ and Agent ‘C’. Let us further assume that
\begin{itemize}
  \item The criteria in the trusting agent’s future interaction are C1, C2 and C3,
  \item The goods are of worth $15,000,
  \item The trusting agent wants to interact with the trusted agent in the period of 01/02/2006 to 05/02/2006, and
  \item The trusting agent ‘A’ had interacted favourably with the trusted agent ‘B’ previously in the same context but at a different time slot.
\end{itemize}

In order for the trusting agent to decide with which agent to interact with, it will divide the time space into different time slots and determine the Riskiness value or the reputation of each possible trusted agent in the time slots according to its criteria by utilizing the Risk based Decision Support System (RDSS) till the time spot of its interaction. The process of the trusting agent dividing the time into different time slots and determining the Riskiness values or the reputation of the possible trusted agents according to the criteria of its future interaction by either considering its previous interactions with the trusting agent or by assimilating recommendations from the recommending agents is mentioned in Hussain et al [11]. That Riskiness value is represented by the metric \( \text{PreTrusted Agent} \).

For explanation sake let us consider that:
\begin{itemize}
  \item The value of the metric \( \text{PreTrusted Agent} \) determined by the trusting agent for the possible trusted agents ‘B’ and ‘C’ is 4 and 4 respectively.
\end{itemize}

Based on the Riskiness values determined for the possible trusted agents in each previous time slots by RDSS, the trusting agent can then predict the future Riskiness value or the reputation of those agents within the time space of its interaction by utilizing the methodology mentioned in Hussain et al [12]. The future Riskiness value is represented by \( \text{FutTrusted Agent} \).

Again for explanation sake let us consider that:
\begin{itemize}
  \item The future Riskiness values predicted by the trusting agent from the previous time slots Riskiness values for the trusted agents ‘B’ and ‘C’ is 4 and 4 respectively.
\end{itemize}

Hence as the past and the future Riskiness values of both the possible trusted agents in the time space of the trusting agent’s future interaction is the same, it will be difficult for the trusting agent to decide with which particular agent to interact with. It can ease its decision making process through analysing the possible Risk present by considering the degree of possible financial loss to it in interacting with each of them.

G. Determining the Financial loss to the trusting agent in interacting with possible trusted agent ‘B’

Utilizing the above defined metrics to determine the financial loss to the trusting agent ‘A’ in interacting with the trusted agent ‘B’:
\[
\begin{align*}
\text{PreTrusted Agent} &= 4 \\
\text{FutTrusted Agent} &= 4
\end{align*}
\]

Since the trusting agent ‘A’ has a favourable interaction history with trusted agent ‘B’ it assigns a value of 2 to the metric \( \text{WillTrusted Agent} \).

As the trusting agent ‘A’ has previous interaction history with the trusted agent ‘B’ it is familiar with the medium of interaction. Hence the value of \( \text{FamMedium} \) is 1
\[
\text{The value of} \text{FamMedium} \text{ is 1}
\]

The trusting agent is determined in nature and the value for the metric \( \text{NatTrustedAgent} \) is 2.

Quantifying the possible interaction of the trusting agent ‘A’ with the trusted agent ‘B’ according to equation 1 we get:
\[
\text{PossInteraction} = 14
\]

Quantifying the value of the metric \( \text{Noloss}_{\text{Interaction}} \) that would represent a non-Risky interaction hence no loss in financial terms to the trusting agent by using equation 2 we get:
Determining the numerical value expressing the possible degree of loss that could be possible in an interaction by utilizing equation 3 we get:

\[
\text{Loss Interaction } B = \frac{16 - 14}{16} = 0.125
\]

Consequently determining the Financial Loss in an interaction according to equation 4

\[
\text{Financial Loss in interacting with agent } 'B' = (15000 \times 0.125) = $1875
\]

Possible Percent of Loss Interaction 'B' = (Loss Interaction 'B' * 100) / 100

Possible Percent of Loss Interaction 'B' = 12.5%

H. Determining the Financial loss to the trusting agent in interacting with possible trusted agent 'C'

Similarly determining the possible financial loss to the trusting agent 'A' by utilizing the metrics in interacting with the trusted agent 'C' we get:

\[
\text{Pre Trusted Agent } C = 4
\]

\[
\text{Fut Trusted Agent } C = 5
\]

\[
\text{Will Trusted Agent } C = 15
\]

\[
\text{Fam Medium } = 1
\]

\[
\text{Nat Trusting Agent } = 2
\]

Hence NoLoss Interaction 'C' = 16

\[
\text{Poss Interaction } C = 12
\]

\[
\text{Pre Trusted Agent } C = 5
\]

\[
\text{Fut Trusted Agent } C = 5
\]

\[
\text{Will Trusted Agent } C = 2
\]

\[
\text{Fam Medium } = 1
\]

\[
\text{Nat Trusting Agent } = 2
\]

Hence NoLoss Interaction 'C' = 16

\[
\text{Poss Interaction } C = 12
\]

\[
\text{Pre Trusted Agent } C = 4
\]

\[
\text{Fut Trusted Agent } C = 4
\]

\[
\text{Will Trusted Agent } C = 4
\]

\[
\text{Fam Medium } = 1
\]

\[
\text{Nat Trusting Agent } = 2
\]

Hence NoLoss Interaction 'C' = 16

\[
\text{Poss Interaction } C = 12
\]

\[
\text{Pre Trusted Agent } C = 4
\]

\[
\text{Fut Trusted Agent } C = 4
\]

\[
\text{Will Trusted Agent } C = 4
\]

\[
\text{Fam Medium } = 1
\]

\[
\text{Nat Trusting Agent } = 2
\]

Hence NoLoss Interaction 'C' = 16

\[
\text{Poss Interaction } C = 12
\]

Utilizing equation 3 to determine in numerical terms the degree of possible loss that could be possible in the interaction we get:

\[
\text{Financial Loss in interacting with agent 'C'} = (15000 \times 0.25) = $3750
\]

Possible Percent of Loss Interaction 'C' = (Loss Interaction 'C' * 100) / 100

Possible Percent of Loss Interaction 'C' = 25%

Hence the possible loss to the trusting agent 'A' in interacting with the trusted agents 'B' and 'C' is 1875 $ and 3750 $ respectively. Based on the values achieved the trusting agent can easily conclude on a decision with which agent to interact with.

VI. CONCLUSION

In this paper we highlighted an important characteristic of Risk in any interaction, its impact in financial terms on the trusting agent’s resources. Once the trusting agent gets an idea of the possible financial loss in its resources in the interaction then it can firm its decision of interacting with the trusted agent or not. In this paper we identified the factors by which the loss in the trusting agent’s resources involved in the interaction can be determined. Further we defined the metrics by which those factors can be quantified to determine the financial loss in an interaction. We then defined a methodology by which the trusting agent can determine the possible financial loss in interacting with the trusted agent and finally concluded the paper by explaining the methodology with an example.

VII. REFERENCES