A Methodology to Ascertain the Level of Failure in an E-Commerce Interaction

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Abstract

To ascertain the possible level of risk in an e-commerce interaction, the initiating agent needs to determine beforehand the probability of failure and the possible consequences of failure to its resources in interacting with an agent. The initiating agent can determine beforehand the probability of failure in interacting with an agent either by considering its past interaction history with it or by soliciting recommendations from other agents. In both cases, it is imperative for the agent who is either considering its past interaction history, or who is communicating a recommendation about another agent, to know the accurate level of failure in interacting with the other agent. To achieve this, in this paper we propose a methodology by which the initiating agent of the interaction ascertains the level of failure in the interaction, after interacting with an agent.

Keywords: Criterion, Evaluation, Failure scale, Level of Failure, Un-committed behaviour

1. Introduction

The development of the internet has given its users more flexibility for conducting e-commerce interactions. It has provided its users with various functionalities which will facilitate the way e-commerce interactions are carried out. With the provision of increased functionality for facilitating e-commerce transactions also comes the fear of loss or the fear of not achieving what is desired in an interaction. This fear of loss or not achieving what is desired is associated with 'Risk' in the interaction. In the literature, risk has often been seen as a synonym for trust. Mayer et al. (1995) highlight the confusion in the relationship between risk and trust by stating '*it is unclear whether risk is an antecedent to trust, is trust, or is an outcome of trust*'. But in real terms, trust and risk refer to two important concepts that complement each other and help the initiating agent of the interaction to analyse and then make an informed decision about its future course of interaction with the other agent. Both these concepts, although are complementary, express different meanings which in turn cannot be reciprocated. Hence, it is incorrect to compare and decide as to which one of them is more important for better decision making in an interaction.

The term 'Risk' has been defined in different ways in the literature according to the context in which it is being discussed in. The literature defines risk according to how it best fits and expresses its object of analysis in the context of discussion (Gefen et al. 2003; March et al. 1987; Luhmann 1988; Rousseau et al. 1998; Sztompka 1999) Subsequently, risk is assessed according to how it is defined in that particular context. The definition of risk and its assessment methods of a discipline cannot be applied to define and analyse risk in other disciplines, as the way risk is interpreted and assessed in those disciplines varies and would result in incorrect conclusions if applied. Therefore, in the context of e-commerce interactions, we define and interpret risk as a multidimensional construct which is a

combination of the probability of failure of an interaction and the subsequent possible consequences of failure.

Risk analysis in the context of e-commerce interactions requires that the initiating agent to determine beforehand the probability of failure and the subsequent possible consequences to its resources if it were to proceed with an interaction with an agent. This is different from trust analysis, where the initiating agent measures the belief that it has in a probable agent in attaining its desired outcomes. During trust analysis the initiating agent does not take into account the amount of resources that it is going to invest in the interaction and hence does not determine the possible consequences of failure in those. A lot of work has been done in the literature to determine and evaluate trust in an interaction (Koutrouli et al. 2006; Chein et al. 2006; Hussain et al. 2004; Cornelli et al. 2002; Carter et al. 2004). We will not discuss that work as, in this paper; our view is towards risk analysis. Hence, we term the two agents participating in an interaction as the 'risk assessing agent' and 'risk assessed agent'. The former refers to the one initiating the interaction while the latter refers to the one with whom it interacts with, to achieve its desired outcomes in the interaction. It is possible that the risk assessing agent before initiating an interaction might have to choose an agent to interact with, among a set of probable agents. In such a case, it can ease its decision making process by analyzing the possible risk present in interacting with each of them. The Australian and New Zealand Standard on Risk Management, AS/NZS 4360:2004 too states that Risk Identification is the heart of Risk Management (Cooper 2004). The significance of the risk assessing agent to analyse the possible risk before initiating an interaction with a probable risk assessed agent is substantial. The risk assessing agent, by analysing the possible risk beforehand, could gain an idea of whether it will achieve its desired outcomes from the interaction or not. Based on this, it can safeguard its resources. Risk plays a central role in deciding whether to proceed with a transaction or not. It can broadly be defined as an attribute of decision making that reflects the variance of its possible outcomes. Risk analysis is important in the study of behaviour in e-commerce transactions because 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 (Greenland 2004). Thus, it commands a central role in any discussion of e-commerce that is related to a transaction.

For risk analysis in e-commerce interactions, the risk assessing agent has to determine beforehand the two above-mentioned factors in interacting with a probable risk assessed agent. We have developed methodologies by which the risk assessing agent can determine beforehand the probability of failure and the possible consequences of failure in interacting with an agent (Hussain et al. 2007). In that methodology, we proposed that the risk assessing agent determines the probability of failure in interacting with a probable risk assessed agent either by considering its past interaction history or, if it does not have any, then by taking recommendations from other agents. In both the cases, it is important that the risk assessing agent or the agent giving the recommendation has previous knowledge about the level of failure of the risk assessed agent in the particular context. These agents can have the previous knowledge about the risk assessed agent only based on their past interaction history with it. So, in this paper, our aim is to propose a methodology by which an agent summarises the level of failure in the interaction, after interacting with an agent, so that it can utilise it in the future for further possible interactions with the same agent, or to act as a recommending agent itself. The proposed methodology is explained in the next sections.

2. Defining the Failure Scale

For the risk assessing agent to determine the probability of failure in interacting with a probable risk assessed agent before initiating an interaction with it, we proposed the terms 'FailureLevel' and the 'Failure scale'. FailureLevel quantifies and semantically expresses the possible level of failure in the interaction on the failure scale. The Failure scale as shown in Figure 1 represents the different levels of failure possible in an interaction. In the methodology, we proposed that the risk assessing agent determines the FailureLevel in interacting with a probable risk assessed agent by ascertaining its in-capability to complete the interaction according to the context and criteria of its future interaction with it. Context represents the high level nature of the risk assessing agent's interaction with the probable risk assessed agent (Hussain et al 2004). It can be decomposed into several detail aspects called criteria. 'Criteria' is defined as the 'demand' or the 'set of factors' which show specifically what the risk assessing agent wants in its interaction with the probable risk assessed agent in that particular context. The risk assessing agent communicates its desired criteria to the probable risk assessed agent in the form of expected or mutually agreed behaviour, before initiating an interaction with it (Hussain et al 2004). 'Expected behaviour' is defined as that behaviour which the risk assessing agent expects the probable risk assessed agent to commit to achieve its desired criteria or when both the agents negotiate to behave in the interaction in a certain way to achieve the desired criteria, then that is called as the 'Mutually agreed behaviour'. The risk assessing agent, by considering the context and particular criteria of its future interaction, will ascertain the in-capability of the probable risk assessed agent to complete the interaction according to its expected behaviour or the mutually agreed behaviour. Further in this paper we use the terms expected and mutually agreed synonymously.

Semantics of Failure Level	Probability of Failure	FailureLevels	Star Rating
Unknown	.	- 1	Not Displayed
Total Failure	91 - 100 % Probability of Failure	0	Not Displayed
Extremely High	71 – 90 % Probability of Failure	1	From ⭐ to ⭐
Largely High	51 – 70 % Probability of Failure	2	From ⭐⭐ to ⭐⭐
High	26 – 50 % Probability of Failure	3	From ⭐⭐⭐ to ⭐⭐⭐
Low	11- 25 % Probability of Failure	4	From ⭐⭐⭐⭐ to ⭐⭐⭐⭐
Extremely Low	0 – 10 % Probability of Failure	5	From ⭐⭐⭐⭐⭐ to ⭐⭐⭐⭐⭐

Figure 1: The Failure scale

We propose that the risk assessing agent after interacting with a risk assessed agent should summarize the level of failure in interacting with it according to its expected behaviour, on the same Failure scale which it had utilized prior to the interaction. The failure scale as shown in Figure 1 represents seven levels of failure that could be possible in an interaction. Each level represents the possible degree or magnitude of failure of an interaction. In the next section, we will define the semantics of each level on the failure scale.

2.1 Defining the Semantics of the Failure scale

- Unknown

The first level of the failure scale is termed 'Unknown Failure' and its corresponding FailureLevel is -1. This level suggests that the level of failure in interacting with the risk assessed agent is unknown.

Semantics: This level can only be assigned by the recommending agent to the risk assessed agent if it does not have any past interaction history with it, in the context, criteria and time in which it is communicating its recommendation. In such a case, we propose that the recommending agent, instead of recommending any random FailureLevel in the range of (0, 5) on the Failure scale, recommends the level -1 to the risk assessing agent soliciting for recommendations. An important point to note is that all new agents in a network begin with this value and a FailureLevel of -1 is assigned to the risk assessed agent when there are no precedents that can help to determine its FailureLevel.

- Total Failure

The second level of the failure scale is defined as 'Total Failure' and its corresponding FailureLevel value is 0. A FailureLevel value of 0 suggests that the level of failure present in interacting with the risk assessed agent was between 91-100 %.

Semantics: This level on the failure scale suggests that at a given point in time and with the given criteria the risk assessed agent was totally or completely unreliable in completing the desired outcomes. In other words, it did not complete the interaction according to the expected or mutually agreed behaviour at all and acted fraudulently in the interaction thus resulting in total failure for the risk assessing agent in achieving its desired outcomes. The FailureLevel of 0 expresses the highest level of failure possible in an interaction.

- Extremely High

'Extremely High' is the third level on the failure scale with the corresponding FailureLevel value of 1. This level denotes that there was 71-90 % level of failure in interacting with the risk assessed agent.

Semantics: This level on the failure scale depicts that at a given point in time and with the given criteria the risk assessed agent was unreliable most of the time with regards to achieving the desired outcomes. It deviated from the expected behaviour most of the time, hence, resulting in an extremely high level of failure in the interaction.

- Largely High

The fourth level of the failure scale is termed a 'Largely High' level of failure. The corresponding FailureLevel value of this level is 2. This level depicts that there was 51-70 % probability of failure in interacting with the probable risk assessed agent.

Semantics: A FailureLevel of 2 on the failure scale indicates that there was a significantly high level of failure in the interaction as the risk assessed agent, at the given point in time, did not commit to a greater extent of the expected behaviour.

- High

The fifth level on the failure scale is termed a 'High' level of failure and is shown by a FailureLevel value of 3. This level outlines that there was 26-50 % probability of failure in the interaction.

Semantics: A FailureLevel value of 3 on the failure scale assigned to a risk assessed agent suggests that at that particular point in time, the risk assessed agent was unable to complete

the interaction to a large extent according to the expected or mutually agreed behaviour, hence, resulting in high level of failure in the interaction.

- Low

The sixth level on the failure scale is defined as 'Low' level of failure with a corresponding FailureLevel value of 4. This level depicts that there was 11-25 % probability of failure in the interaction.

Semantics: This level on the failure scale suggests that at a given point in time the risk assessed agent completed most but not the entire criterion according to the expected or mutually agreed behaviour. A FailureLevel of 4 indicates that the risk assessed agent assigned with this value can be relied on to a greater extent in that time, to commit to the desired outcomes of the interaction thus resulting in low failure level in the interaction.

- Extremely Low

'Extremely Low' is the seventh and the last level on the failure scale represented by the FailureLevel value of 5. This level shows that there was 0-10 % probability of failure in the interaction.

Semantics: This level on the failure scale implies that at a given point in time, the risk assessed agent has completed the interaction according to the expected or mutually behaviour, subsequently minimising the probability of failure in an interaction. The probability of failure in interacting with this risk assessed agent, if any, will be minimal. A FailureLevel of 5 expresses the lowest level of failure possible in an interaction. A FailureLevel of 5 expresses the lowest level of failure possible in an interaction.

In the next section, we will propose a methodology by which the risk assessing agent can determine the possible level of failure in interacting with a risk assessed agent.

3. Metrics for Determining the Actual FailureLevel of the Interaction

Our method for the risk assessing agent to determine the actual level of failure of an interaction in the post-interaction phase is by assessing the level of un-committed or un-fulfilment in its actual behaviour as compared to the expected behaviour. This is achieved through the notion of 'expectations' and 'assessing un-commitment' in the interaction. By 'expectations' we mean the expected behaviour. This is the way in which the interaction is supposed to proceed according to the criteria of the interaction. By 'assessing un-commitment' we mean assessing the degree of un-fulfilment or un-commitment in the actual behaviour of the risk assessed agent with respect to the expected behaviour during an interaction. To achieve this, we propose that the risk assessing agent should first determine the level of commitment that the risk assessed agent showed in its behaviour in the interaction. This will depict how the risk assessed agent actually behaved in the interaction and how much he fulfilled according to the expected behaviour. If the level of commitment (i.e. the actual behaviour) is compared with the expected behaviour (i.e. the promised commitment) then the un-committed behaviour in the interaction can be determined. It other terms, the level of un-committed behaviour in the interaction is the difference between expected and actual behaviour. This un-committed behaviour is used to determine the level of failure in the interaction. The greater the un-committed behaviour the greater is the level of failure in an interaction.

As mentioned earlier, the expected behaviour of an interaction is composed of the criterion that the risk assessing agent wants to achieve in the interaction. Hence, when determining the level of failure, it is important for the risk assessing agent to consider each criterion of its interaction to determine the commitment and subsequently the failure level of the risk

assessed agent in each criterion. In the next section, we define metrics by which the risk assessing agent determines the level of commitment by the risk assessed agent in each criterion of its interaction.

4. Determining the Total Commitment in an Interaction

I. Assessment of Total Commitment in an Interaction (Assess $_{Interaction}$)

We quantify the level of commitment by the risk assessed agent in the interaction by the metric Assess $_{Interaction}$. As mentioned previously, each interaction consists of a number of criterions. The total commitment in an interaction (Assess $_{Interaction}$) by the risk assessed agent can be quantified by:

- evaluating the level of commitment by the risk assessed agent in each criterion of the interaction;
- adding up the evaluations of all the criteria to get the total commitment of the interaction (Asses $_{Interaction}$).

To explain this with an example, let us consider a scenario where agent 'A' wants to interact with a logistic company to transport its goods. The possible companies for agent 'A' to interact with are logistic companies 'B' and 'C'. Let us suppose that the criteria agent 'A' wants in its interaction and which forms its expected behaviour are:

➢ Packing the goods properly
➢ Pickup on time
➢ Delivery of goods on time
➢ Delivery of goods in the same condition as that of pickup

Before initiating an interaction, agent 'A' wants to analyse the possible risk in interacting with each of the logistic companies according to its criteria. In this scenario, agent 'A' is the risk assessing agent and the logistic companies 'B' and 'C' are the probable risk assessed agents. After analysing the possible risk in interacting with each of the probable agents, agent 'A' interacts with logistic company 'B' to transport its goods. After the interaction, agent 'A' wants to ascertain the level of failure that was present in interacting with the risk assessed agent 'B', so that it can utilise this information in the future it wants to interact with the same agent, or while giving recommendation to the other agents about the risk assessed agent 'B'. The risk assessing agent has to determine the level of failure that was present in interacting with the risk assessed agent 'B' by using the criteria of its interaction. To achieve this, agent 'A' will first have to assess the level of commitment by the risk assessed agent 'B' in each criteria of its interaction.

The total assessment of the level of commitment (Asses $_{Interaction}$) by the risk assessed agent in the interaction is found out by the evaluation of individual commitment in each criterion. Hence:

$$\text{Asses }_{Interaction} = \sum_{i=1}^{n} \text{Eval }_{Criterion\ i}$$

where, n represents the number of criteria in an interaction.

II. Evaluation of Each Criterion in an Interaction (Eval $_{Criterion}$)

Eval $_{Criterion}$ is defined as the metric evaluating the degree of fulfilment of a criterion in the actual behaviour of the risk assessed agent with respect to the expected behaviour of the risk assessing. In other words, the metric Eval $_{Criterion}$ shows whether the particular criterion has

been fulfilled in accordance with the expected behaviour or not. Considering the previous example, the fulfilment of each criterion in the interaction can be evaluated by:

➢ Determining whether agent 'B' packed the goods on time,
➢ Determining whether agent 'B' picked the goods up on time,
➢ Determining whether agent 'B' delivered the goods on time,
➢ Determining whether agent 'B' delivered the goods in the same condition as that of pickup.

In order to evaluate the degree of fulfilment of a criterion in the actual behaviour with respect to the expected behaviour, we define two levels for the metric Eval $_{Criterion}$. Each of those two levels corresponds to a different level or degree which shows the level of fulfilment of each criterion. A numerical value is assigned to each level and the value which corresponds to the level of how the criteria were fulfilled by the risk assessed agent is taken into consideration while evaluating that criterion. The levels are explained in Table 1.

Table 1: Levels for the metric Eval $_{Criterion}$

Eval $_{Criterion}$ Value	Semantics of the Value
0	The risk assessed agent did not fulfil the criterion according to the expected behaviour or as it was promised according to the mutually agreed behaviour.
1	The criterion was fulfilled exactly according to the expected behaviour. There was no deviation from the expected behaviour.

While evaluating the fulfilment of each criterion to determine the level of failure in interacting with a risk assessed agent, it is also important to consider some other factors. We will explain those factors in the next subsection and define metrics to measure them.

III. Accuracy of Criteria Communication in an Interaction (Accu $_{Criterion}$)

The criteria of the interaction can be considered by the risk assessing agent while ascertaining the level of failure, only if they have been communicated to the risk assessed agent in clear terms beforehand. So, it is important that the risk assessing agent communicates each of those factors clearly to the risk assessed agent beforehand, so that after the interaction it is assigned a level of failure that it actually deserves. Hence, the Accuracy of the Criterion Communication metric (Accu $_{Criterion}$) can be defined as the metric which is used to express whether or not the criterion has been communicated to the risk assessed agent beforehand in clear terms.

To explain this, let us consider the previous example of agent 'A' interacting with the logistics company 'B'. Let us suppose that while determining the level of failure in interacting with it, agent 'A' considers the track and trace facility which agent 'B' did not provide. Then agent 'B' might not get the actual level of failure that he should receive or that he deserves because of the additional criterion that was not communicated to him.

Each of the criteria by which the level of failure in the interaction is going to be determined should be clearly communicated before the interaction begins. In order to determine the accuracy by which the criteria were communicated to the risk assessed agent by the risk assessing agent, we define two levels for the metric Accu $_{Criterion}$. The numerical value which corresponds to the level of accuracy by which the criterion was defined will be taken into consideration, while determining evaluation of the criterion and, subsequently, the level of failure of the risk assessed agent. The levels are explained in Table 2.

Table 2: Levels for the metric Accu $_{Criterion}$

Accu $_{Criterion}$ Value	Semantics of the Value
0	The factors against which the criterion is going to be judged in order to determine whether it has been completed according to the promised commitment or the expected behaviour has NOT been communicated to the risk assessed agent in clear terms.
1	The factors against which the criterion is going to be judged in order to determine whether it has been completed according to the promised commitment or the expected behaviour HAS BEEN communicated to the risk assessed agent in clear terms.

IV. Significance of the Criterion (Sig $_{Criterion}$)

Another important factor to consider while assessing the commitment in an interaction is the significance of each criterion. We define the metric Sig $_{Criterion}$ which expresses the significance of the particular criterion and, hence, gives the risk assessed agent an idea of which criterion should be considered important for the interaction. All the criteria of an interaction will not be of equal importance or significance. Some criteria might be more important to the risk assessing agent and, subsequently, they will have a greater role to play in determining the level of failure in the interaction. 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 risk assessing agent.

For example, if we take the criteria relating to the interaction between agent 'A' and logistics company 'B', let us assume that the first two criteria are very important to agent 'A' in its interaction with agent 'B' and, hence, those specific criteria will have a significant affect while determining the level of failure in the interaction. Subsequently, it might focus more on the first two factors in assessing the level of fulfilment in the actual behaviour compared to the expected behaviour to determine the level of failure of the interaction.

The metric Significance of the Criterion (Sig $_{Criterion}$) depicts how important the risk assessing agent thinks the criterion is for the successful completion of the interaction. The risk assessing agent will assign a significance level that he thinks is appropriate to each criterion. The numerical value which corresponds to that level of significance will be taken into account when evaluating the criterion and subsequently its level of failure. Those levels are explained in Table 3.

Table 3: Levels for the metric Sig $_{Criterion}$

Sig $_{Criterion}$ Value	Semantics of the Value
1	The criterion of this value is important and will have some significance in determining the level of failure of the risk assessed agent. But there are other criteria, apart from this, which will have a major affect on determining the level of failure in interacting with an agent.
2	A criterion of this value has the highest level of significance in determining the level of failure of the risk assessed agent.

Assessing the total commitment in the interaction (Assess $_{Interaction}$)

Once a value from each metric defined in the previous section has been assigned to all the criteria, then the total assessment of commitment by the risk assessed agent in the interaction can be determined. As explained before, the total assessment of commitment in the interaction Assess $_{Interaction}$ will take into consideration the:

- criteria against which the assessment is going to be determined;
- evaluation of the level of fulfilment in each of the criterion Eval $_{Criterion}$;
- accuracy by which those criteria were communicated to Accu $_{Criterion}$; and
- the significance of each criterion Sig $_{Criterion}$.

Hence, the commitment in the whole interaction can be expressed as:

$$\textbf{Assess}_{\textbf{Interaction}} = \sum_{i=1}^{n} (\text{Eval}_{Criterion\ i} * \text{Accu}_{Criterion\ i} * \text{Sig}_{Criterion\ i}) \qquad \textbf{Equation ---1}$$

where, i represent a particular criterion and n represents the number of criteria in the interaction.

The above equation indicates that the assessment of fulfilment in an interaction Assess $_{Interaction}$ is:

- the sum of the evaluation of each criterion in an interaction; and
- each criterion is further evaluated based on its communicated accuracy and significance.

Considering our previous example, there are four criterion in agent 'A's interaction with agent 'B'. Hence, the total commitment in the interaction (Assess $_{Interaction}$) which shows the level of fulfilment in the actual behaviour of the risk assessed agent can be calculated as:

$Assess_{Interaction} =$

$(Eval_{Criterion\ 1} * Accu_{Criterion\ 1} * Sig_{Criterion\ 1}) + (Eval_{Criterion\ 2} * Accu_{Criterion\ 2} * Sig_{Criterion\ 2}) +$

$(Eval_{Criterion\ 3} * Accu_{Criterion\ 3} * Sig_{Criterion\ 3}) + (Eval_{Criterion\ 4} * Accu_{Criterion\ 4} * Sig_{Criterion\ 4})$

Assess $_{Interaction}$ depicts how the risk assessed agent behaved in the interaction; the actual behaviour. The value that the risk assessing agent 'A' gets for Assess $_{Interaction}$ is dependent on the behaviour of the risk assessed agent 'B'. The larger the deviation in the actual behaviour from the expected behaviour, the lower the value of Assess $_{Interaction}$ and vice versa.

5. Determining the Actual FailureLevel in an Interaction

To find out the actual level of failure in interacting with a risk assessed agent, the risk assessing agent after finding out the level of commitment in its actual behaviour will need to determine how much this commitment is far from the expected behaviour. The difference between those two behaviours gives the level of un-committed behaviour in the interaction by the risk assessed agent.

We define the expected behaviour in the interaction as the promised commitment, which the risk assessed agent is expected to commit to, or decides to commit, before initiating the interaction. We represent the expected behaviour or the promised commitment in the interaction by the metric ProCom $_{Interaction}$. In the previous section, we defined a methodology by which the risk assessing agent quantifies numerically the actual behaviour of the risk assessed agent in the interaction. To determine the level of failure in the interaction, the risk assessing agent should also quantify numerically its expected behaviour or ProCom $_{Interaction}$. This can be achieved by substituting a value of 1 for the metric Eval $_{Criterion}$ in equation 1.

This value suggests that the criteria in the interaction have been committed according to expected behaviour. So, the expected behaviour or the promised commitment in the interaction can be quantified as:

$$\textbf{ProCom}_{\text{Interaction}} = \sum_{i=1}^{n} (1 * \text{Accu}_{\text{Criterion } i} * \text{Sig}_{\text{Criterion } i}) \qquad \textbf{Equation ---2}$$

where, n represents the number of criteria in the interaction.

We define level of failure in the interaction by the metric Failure $_{\text{Interaction}}$. This metric expresses the actual level of failure that was present in the interaction. This is calculated by determining the level of un-commitment in the interaction versus promised commitment. The level of un-commitment in the interaction is found by the difference between the promised commitments (ProCom $_{\text{Interaction}}$), that is, the numerical value which quantifies the expected behaviour, and the actual commitment (Assess $_{\text{Interaction}}$); the numerical value which quantifies the actual behaviour. Hence, Failure $_{\text{Interaction}}$ is expressed as:

$$\textbf{Failure}_{\text{Interaction}} = \frac{ProCom_{\text{Interaction}} - Assess_{\text{Interaction}}}{ProCom_{\text{Interaction}}} * 100 \qquad \textbf{Equation ---3}$$

In other terms, the metric Failure $_{\text{Interaction}}$ shows the percent of un-commitment that was present in the actual behaviour as compared to the expected behaviour. This also shows the level of failure in the interaction.

In order to find the actual FailureLevel of the risk assessed agent on the failure scale, the risk assessing agent has to map the Failure $_{\text{Interaction}}$ to the Failure scale which ranges from (-1, 5) as shown in Figure 1. However, the level of -1 on the failure scale shows that the level of failure in the interaction is unknown. This level cannot be assigned by the risk assessing agent to the risk assessed agent after interacting with it. After the interaction, the risk assessing agent can assign a risk assessed agent with a FailureLevel value between (0, 5) on the failure scale. The FailureLevel which corresponds to the percent of failure in the interaction, when mapped against the failure scale is taken as the actual FailureLevel of the risk assessed agent. Hence, the actual FailureLevel of the risk assessed agent in the interaction is determined as:

$$\textbf{Actual FailureLevel} = \text{LEVEL (Failure}_{\text{Interaction}}) \qquad \textbf{Equation ---4}$$

This can also be written as:

$$\textbf{Actual FailureLevel} = \text{LEVEL } (\frac{ProCom_{\text{Interaction}} - Assess_{\text{Interaction}}}{ProCom_{\text{Interaction}}} * 100)$$

The proposed concept and its significance will be understood better in the next section when we explain it by use of an example.

6. Example of Determining the Actual FailureLevel in an Interaction

In this section we will explain the process of the risk assessing agent determining the actual level of failure in interacting with a risk assessed agent using the above metrics. To proceed further, we will assume the previously mentioned example of a risk assessing agent 'A'

wanting to interact with a logistics company in the context of transporting goods. The criteria which agent 'A' wants in its interaction are:

➢ Inspect the goods and provide a quote,
➢ Pack the goods properly,
➢ Pick up the goods on time,
➢ Providing a facility for track and trace,
➢ Delivery of the goods to the destination address on the promised day.

These criterion form the expected behaviour for the interaction. The possible agents for agent 'A' to interact with are logistics companies 'B' and 'C'. As mentioned before, agent 'A' analyses beforehand the possible risk in interacting with the probable risk assessed agents and decides to interact with agent 'B'. After its interaction, agent 'A' wants to quantify the actual level of failure that was present in interacting with the risk assessed agent 'B'. To achieve that, it has to first ascertain the actual behaviour that agent 'A' showed in the interaction.

Further, let us suppose that the risk assessing agent by its criterion *'delivery of the goods on the promised day'* meant that the goods should be delivered by 8:00 am on that day. However, as seen from the criteria listed it was not communicated accurately to the risk assessed agent.

Let us suppose the behaviour of the risk assessed agent 'B' in the interaction was as follows:

➢ Inspected the goods and provided a quote,
➢ Packed the goods properly as promised,
➢ Did not pick up the goods on time as promised,
➢ Did not provide a track and trace facility,
➢ Delivered the goods to the destination address on the promised day.

This behaviour is the 'actual behaviour' in the interaction by agent 'B'. In order to determine the level of failure in interacting with agent 'B', agent 'A' will first assess the level of fulfilment or commitment in the actual behaviour of the risk assessed 'B' with respect to the expected behaviour in each criterion. So the value of $Eval_{Criterion}$ can be determined according to its metric as follows:

- For the first criterion, the risk assessed agent 'B' inspected the goods and provided a quote to the risk assessing agent 'A' and, hence, fulfilled the criterion according to the expected behaviour. So the value of $Eval_{Quote}$ according to Table 1 is 1.
- For the second criterion, the risk assessed agent 'B' packed the goods properly. So it fulfilled the criterion according to the expected behaviour. The value of $Eval_{Packing}$ is 1.
- For the third criterion, the risk assessed agent 'B' did not pick up the goods on time. Hence, the value of $Eval_{PickUp}$ is 0.
- For the fourth criterion, agent 'B' did not provide agent 'A' with the track and trace facility. Therefore, the $Eval_{TracknTrace}$ in this case is 0.
- For the fifth criterion, agent 'B' delivered the goods on the promised day but did not do it before the time agent 'A' wanted. Hence, the value of the $Eval_{Delivery}$ is 0.

After determining the fulfilment of each criterion, agent 'A' should then determine the accuracy with which each criterion was communicated to the risk assessed agent 'B'. For this the metric $Accu_{Criterion}$ will be used:

- Criterion 1 was communicated clearly - the value of $Accu_{Quote}$ is 1.
- Criterion 2 was communicated clearly - the value of $Accu_{Packing}$ is 1.
- Criterion 3 was communicated clearly - the value of $Accu_{Pickup}$ is 1.
- Criterion 4 was communicated clearly - the value of $Accu_{TracknTrace}$ is 1.

- Criterion 5 was NOT communicated clearly. Agent 'A' did not specify that it wanted the goods to be delivered by 8:00 am on the promised day - the value of Accu $_{Delivery}$ is 0.

Let us suppose that the risk assessing agent 'A' assigns a significance value of 2 to each criterion.

After assigning the relative numerical values of each metric to all the criteria, the actual behaviour of the risk assessed agent 'B' in the interaction (Assess $_{Interaction}$) can be quantified by adding the individual assessment of all the criteria. Utilising equation 1 to determine Assess $_{Interaction}$ =
(Eval $_{Quote}$ * Accu $_{Quote}$ * Sig $_{Quote}$) + (Eval $_{Packing}$ * Accu $_{Packing}$ * Sig $_{Packing}$) + (Eval $_{PickUp}$ * Accu $_{PickUp}$ * Sig $_{PickUp}$) + (Eval $_{TracknTrace}$ * Accu $_{TracknTrace}$ * Sig $_{TracknTrace}$) + (Eval $_{Delivery}$ * Accu $_{Delivery}$ * Sig $_{Delivery}$)

Substituting the respective values for each metric in the above equation:
Assess $_{Interaction}$ = (1*1*2) + (1*1*2) + (0*1*2) + (0*1*2) + (0*0*2)
Assess $_{Interaction}$ = 4

As discussed earlier, to ascertain the level of failure that was present in interacting with a risk assessed agent, the risk assessing agent needs to find out how much the commitment of the risk assessed agent diverged from the promised commitment. For that, it needs to quantify numerically its expected behaviour in the interaction. Using equation 2 quantifying the promised commitment ProCom $_{Interaction}$ =
(ProCom $_{Quote}$ * Accu $_{Quote}$ * Sig $_{Quote}$) + (ProCom $_{Packing}$ * Accu $_{Packing}$ * Sig $_{Packing}$) + (ProCom $_{PickUp}$ * Accu $_{PickUp}$ * Sig $_{PickUp}$) + (ProCom $_{TracknTrace}$ * Accu $_{TracknTrace}$ * Sig $_{TracknTrace}$) + (ProCom $_{Delivery}$ * Accu $_{Delivery}$ * Sig $_{Delivery}$)

ProCom $_{Interaction}$ = (1*1*2) + (1*1*2) + (1*1*2) + (1*1*2) + (1*0*2)
ProCom $_{Interaction}$ = 8

Substituting the values of Assess $_{Interaction}$ and ProCom $_{Interaction}$ in equation 3 to determine the level of failure in the interaction:
Failure $_{Interaction}$ = $\frac{8-4}{8}$ * 100
Failure $_{Interaction}$ = 50 %

Using equation 4 to map the value of the metric Failure $_{Interaction}$ on the failure scale to determine the FailureLevel of the risk assessed agent:
Actual FailureLevel = LEVEL (50 %)
Actual FailureLevel = 3

So the actual FailureLevel of the risk assessed agent 'B', as determined by the risk assessing agent 'A' in the context and criteria of its interaction is 3 on the failure scale.

From the above example, it can be seen that criterion 5 was not communicated to the risk assessed agent 'B' accurately before the interaction and, subsequently, that criterion was not included while determining the level of failure (Failure $_{Interaction}$) by not taking it into consideration while ascertaining the ProCom $_{Interaction}$.

The significance and advantages of the risk assessing agent determining the actual FailureLevel in interacting with a risk assessed agent are:

1. From our example, the risk assessing 'A' can utilise the actual FailureLevel determined for the risk assessed agent 'B' to make a risk based decision on future interactions with it, provided that its future interaction is in the same time, context and within the same criteria as that of this interaction; and
2. The risk assessing agent 'A' can act as the recommending agent and communicate its recommendation for agent 'B' to any other agent soliciting for it, in the same context and criteria. The recommendation contains the accurate level of failure in interacting with agent 'B' according to those criteria.

7. Conclusion

In this paper, we proposed a methodology by which the risk assessing agent of an interaction ascertains the actual level of failure in interacting with a risk assessed agent following an interaction with it. The actual level of failure is determined by comparing the actual behaviour of the risk assessed agent with the expected behaviour. Further, the interaction is analysed by considering the significance of each criterion and the accuracy by which each criterion was communicated. We also explained the proposed methodology by considering a real world example. The risk assessing agent can utilise the determined level of failure in interacting with the risk assessed agent, if it wants to interact with that particular agent in the near future in the same context and criteria as that of its previous interaction, or if it wants to provide a recommendation about the risk assessed agent to any other agent in the same context and criteria as that of its previous interaction.

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