Towards Ascertaining Risk in Digital Business Ecosystem Interactions

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Abstract

In digital business ecosystem architecture, it is rational for the trusting agent to analyse the possible risk in interacting with a probable trusted agent beforehand. Doing so would assist the trusting agent in its decision process. The possible risk in an interaction is a combination of the probability of failure and the possible consequences of failure of an interaction. In this paper, we propose an approach by which the trusting agent determines the probability of failure in interacting with a probable trusted agent according to the demand of its future interaction with it.

1. Introduction

The significance of analysing risk in an interaction to achieve the desired outcomes from it is substantial. The trusting agent, by analysing the possible risk beforehand, could gain an idea or direction in which its interaction might head. The terms 'trusting agent' and 'trusted agent' define two agents participating in an interaction. The former refers to the instigator of the interaction while the latter refers to the agent accepting the request. In other words, this is the agent with whom the trusting agent interacts to achieve its desired outcomes. Risk is important in the study of behaviour in e-commerce 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 [1]. 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. Thus, it commands a central role in any discussion that is related to a transaction.

Digital Business Ecosystems are a new concept that is emerging worldwide as an innovative approach to support the adoption and development of information and communication technologies. A digital ecosystem is a self-organising digital infrastructure aimed at creating a digital environment for networked organisations that supports the cooperation, knowledge sharing, development of open and adaptive technologies and the evolutionary business models [2]. It can also be defined as a system which is loosely coupled, demand-driven, domain clustered, agent-based collaborative environment where each specie is proactive and responsive for its own benefit or profit. A business ecosystem is the network of buyers, suppliers and makers of related products or services plus the socio-economic environment. Hence, an aspect for the trusting agent to assist in deciding whether to interact or not with a probable trusted agent in a business ecosystem is to analyse the risk present in interacting with it. The possible risk in an interaction is a combination of:

- The probability of failure in achieving the outcome; and
- The possible consequences of failure.

The trusting agent has to determine these two aspects to analyse the possible risk in an interaction. As previously mentioned, a business ecosystem interaction is demand driven. Demand driven implies that the trusting agent wants to achieve certain desired outcomes and based on those desired outcomes it selects a trusted agent to interact with. Similarly, the trusting agent has to analyse the possible risk in interacting with a probable trusted agent according to the demand of its interaction. It is highly possible that there might be more than one probable trusted agent who can fulfil the demand of the trusting agent. The trusting agent can ease its decision making process of choosing a trusted agent to interact with by analysing the possible risk that could be present in interacting with each of them. To analyse the possible risk, the trusting agent has to determine the probability and consequences of failure of the interaction. In this paper, we propose a methodology by which the trusting agent can determine the probability of failure

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in interacting with a probable trusted agent according to the demand of its interaction. We will propose and explain the methodology in the next sections.

2. Analysing the Probability of Failure of an Interaction

To quantify and express semantically the probability of failure of an interaction, we propose and define the Failure scale as shown in figure 1. The Failure scale consists of seven different FailureLevels. 'FailureLevel' (FL) is defined as the numerical value that is assigned by the trusting agent to the trusted agent after interacting with it, which shows the level of failure of the interaction on the Failure scale. The level 0 represents the highest probable level of failure and the level 5 represents the lowest probable level of failure.

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
Significantly Low	11- 25 % Probability of Failure	4	From to
Extremely Low	0 – 10 % Probability of Failure	5	From to

Figure 1. Showing the Failure scale

Further in this paper, we represent the demand driven aspects that the trusting agent wants in interacting with a trusted agent as the 'criteria' in the interaction. The probability of failure in interacting with a probable trusted agent is the extent to which the trusting agent determines that it might not achieve its desired outcomes through this interaction. The trusting agent can determine the probability of failure beforehand in interacting with the probable trusted agent by analysing its in-capability to complete the interaction according to the expected behaviour of its future interaction with it. The trusting agent, by considering the expected behaviour of its future interaction, is determining accurately the probability of failure in this interaction according to the criteria.

The possible interaction of the trusting agent with the probable trusted agent is in the future state of time. Hence, the trusting agent has to determine the probability of failure in interacting with the probable trusted agent in that future state of time. In order to achieve this, we propose that the trusting agent should analyse the probability of failure in interacting with a probable trusted agent in two stages. They are:

1. Pre-Interaction start time phase
2. Post-Interaction start time phase

Pre-Interaction start time phase refers to the period before the trusting agent starts its interaction with the probable trusted agent, whereas Post-Interaction start time phase is the period after the trusting agent starts and interacts with the probable trusted agent. The trusting agent has to determine the probability of failure in interacting with a probable trusted agent in that future state of time, i.e. in the post-interaction start time phase. However, in order for the trusting agent to determine the probability of failure in interacting with a probable trusted agent in the post interaction start time phase, it should know its probability of failure according to the specific context and criteria as that of its future interaction, in the pre-interaction start time phase. Based on those values, the trusting agent can predict or determine the probability of failure in the post-interaction start time phase. In this paper, due to space constraints, we limit our discussion of determining the probability of failure of the interaction to the pre-interaction start time phase.

The trusting agent can determine the probability of failure in interacting with a probable trusted agent in the pre-interaction start time phase either by:

a) Considering its past interaction history with the probable trusted agent, if it is in the same context and criteria as that of its future interaction with it; or

b) Soliciting recommendations from other agents and determining the in-capability of the trusted agent to complete the interaction according to the criteria of its future interaction with it.

If the trusting agent has a previous interaction history with the probable trusted agent in the same context and criteria as that of its future interaction, then it can utilize the FailureLevel that it assigned to the probable trusted agent in those interactions to ascertain the probability of failure level in interacting with it in its future interaction. If the trusting agent does **not** have any previous interaction history with the probable trusted agent in any context or in the context and criteria as that of its future interaction with it, then it can determine the probability of failure level (FailureLevel) by soliciting for recommendations from other agents and assimilating them according to the context and criteria of its future interaction. As mentioned by Carter and Ghorbani, reputation can be relied on in the event of total ignorance [3]. But the reputation of a probable trusted agent shows its capability to complete the interaction. In order for the trusting agent to determine the probability of failure of an interaction it should determine the in-capability of the probable trusted agent to complete the interaction according to its expectations.

To achieve that, we propose the trusting agent should first determine the reputation of the probable trusted agent according to the criteria of its future interaction with it and then map it to the Failure scale. By doing so the trusting agent determines the capability of the probable trusted agent to complete the interaction according to the criteria of its future interaction on the Failure scale. It can then determine the probability of failure in interacting with that particular probable trusted agent on the Failure scale, by ascertaining the difference between what it expects in the interaction and how far the probable trusted agent can fulfil it according to its reputation. The value achieved gives the level of probability of failure of the interaction according to the criteria of its future interaction with it.

If the trusting agent does not have any previous interaction history with the trusted agent in the context and criteria of its future interaction then in order to determine the reputation of the probable trusted agent, the trusting agent should solicit for recommendations in the given context. The agents, who have had previous interaction history with the probable trusted agent in the particular context, reply back with their recommendations. We term the agents replying back with the recommendations as 'Recommending agents'. The recommending agents communicate their recommendations in the form of Risk set. The Risk set is an ordered way of communicating recommendations, so that it is easier for the trusting agent to interpret it. The format of the Risk set is discussed in Hussain et al. [4]. The trusting agent, upon receiving the recommendations, should assimilate them to determine the reputation and to ascertain the in-capability of the probable trusted agent on the Failure scale according to the criteria of its future interaction. Some factors to be considered by the trusting agent while assimilating the recommendations to determine the reputation of the probable trusted agent are:

1. The trustworthiness of the recommendations. It is possible that the recommending agent is communicating un-trustworthy recommendations or recommendations which the trusting agent finds to vary considerably. The trusting agent should omit such recommendations before it assimilates them. We propose that the agents whose RRP value is in the range of (-1, 1) is said to be communicating a trustworthy recommendation. Further we propose that the trusting agent should consider the recommendations from agents who are either trustworthy or unknown in giving them and omit the ones from agents which are un-trustworthy in giving them.
2. The trusting agent should also consider the time of the recommendation while assimilating it. This is the time at which the recommending agent interacted with the probable trusted agent in question. As mentioned in the literature, risk is dynamic. It is not possible for an agent to have the same impression for a trusted agent throughout that it had at a particular time.
3. The criteria of the recommending agent's interaction with the probable trusted agent. An important point to be understood is that even if the context of two interactions is the same, their criteria might differ considerably. The trusting agent, while assimilating the recommendations, should consider only those recommendations whose criterions are of interest to it in its future interaction.

3. Determining the Pre-Interaction start time FailureLevel of a Trusted Agent

Once the trusting agent receives recommendations and classifies them according to their trustworthiness, time and criteria, then it can assimilate them to determine the reputation and subsequently the FailureLevel of the probable trusted agent in the pre-interaction start time phase. To explain the process of assimilating the recommendations in order to ascertain the reputation and subsequently the FailureLevel of a probable trusted agent, let us consider the following example of a trusting agent 'E' wanting to interact with a logistic company in the context of transporting its goods. The criteria that the trusting agent wants in its interaction are C1 and C2. The possible agents to interact with are agents 'D' and 'Z' who are willing to fulfil the trusting agent's request. These agents are the set of probable trusted agents from which the trusting agent has to decide and choose one of them to interact with. The trusting agent 'E', in order to make an informed decision, decides to analyse the possible risk that could be present in interacting with each of them by ascertaining the probability of failure and the possible consequences of failure. xTo determine the probability of failure in dealing with each probable trusted agent, agent 'E' solicits for recommendations to determine the reputation and subsequently the FailureLevel of each probable trusted agent in the pre-interaction start time phase according to its set criteria. The agents who had interacted with the probable trusted agents previously in the same context reply back with their recommendations in the form of Risk set.

After determining which recommendations to consider, the trusting agent 'E' should assimilate them according to their trustworthiness, time and its criteria of future interaction in order to determine the reputation of the probable trusted agent in each criterion of its future interaction. Based on the

reputation achieved for each probable trusted agent in each criterion, agent 'E' can determine their level of in-capability to complete the criterion according to its expectations and subsequently the FailureLevel for that criterion in the pre-interaction start time phase. The FailureLevel achieved in a criterion for a probable trusted agent shows the level of probability of failure in interacting with the particular agent in that criterion during the pre-interaction start time phase.

The reputation of a particular trusted agent 'P' in criterion 'C' (Rep_{PC}) can be determined by assimilating the trustworthy and unknown recommendations by using the following formulae:

$$(\alpha * ((\gamma * \frac{1}{N} (\sum_{i=1}^{N} RRP_i \oplus \text{Commitment Level}_c)) +$$

$$(\delta * \frac{1}{K} (\sum_{l=1}^{K} RRP_l \oplus \text{Commitment Level}_c)))) \quad +$$

$$(\beta * ((\gamma * \frac{1}{J} (\sum_{o=1}^{J} \text{Commitment Level}_c)) +$$

$$(\delta * \frac{1}{M} (\sum_{q=1}^{M} \text{Commitment Level}_c))))$$

Equation-----1

where

RRP_i is the riskiness value of the trustworthy recommending agent 'i' whose recommendation is in the recent time slot of the trusting agent's interaction,

RRP_l is the riskiness value of the trustworthy recommending agent 'l' whose recommendation is in the far recent time slot of the trusting agent's interaction,

$Commitment\ level_c$ is the level of commitment by the trusted agent in the particular criterion 'c' as recommended by the recommending agent in its recommendations,

N and K are the number of trustworthy recommendations classified according to the recent and far recent time slots respectively,

J and M are the number of unknown recommendations classified according to the recent and far recent time slots respectively,

γ and δ are the variables attached to the parts of the equation which give more weight to recommendations which are in the recent time slot as compared to the far recent ones. In general, $\gamma > \delta$ and $\gamma + \delta = 1$,

α and β are the variables attached to the parts of the equation which will give more weight to the recommendation from the trustworthy recommending peers as compared to that from the unknown recommending peers. In general, $\alpha > \beta$ and $\alpha + \beta = 1$.

The reputation of the probable trusted agent 'P' in a criterion 'C' is determined in two parts as shown in equation 1. The first part of the equation calculates the reputation value of the probable trusted peer 'P' in the criterion 'C' by taking the recommendations of the trustworthy recommending agents. The second part calculates the reputation value of the same probable trusted agent 'P' in the same criterion by taking the recommendations of the unknown recommending agents. The recommendations from the un-trustworthy recommending agents are excluded. In order to give more weight to the recommendations from the trustworthy recommending agents as compared to ones from the unknown recommending agents, variables are attached to the two parts of the equation. These variables are represented by α and β respectively. It depends upon the trusting agent as to how much weight it wants to assign to each type of recommendation. Further, the reputation value determination of the probable trusted agent 'P' in a criterion 'C' by taking the trustworthy and unknown recommendations too is done in two parts according to the time slot of the recommendations. We propose that the trusting agent gives more weight to the recommendations which are in the recent time slot of its interaction as compared to the far recent time slot ones. Those weights are represented by the variables γ and δ respectively.

The RRP of the trustworthy recommending agent is also considered while assimilating its recommendation. As shown in equation 1, the RRP of the trustworthy recommendation is adjusted with the adjustment operator ' $\oplus$ ' to its recommendation. This would take into consideration the accurate recommendation from the trustworthy recommending agent according to its trustworthiness. The rules for the adjustment operator ' $\oplus$ ' are:

$$a \oplus b = \begin{cases} a + b, & \text{if } 0 \le (a + b) \le 1 \\ 1, & \text{if } (a + b) > 1 \\ 0, & \text{if } (a + b) < 0 \end{cases}$$

The reputation of the probable trusted agent 'P' in a criterion 'C' (Rep_{PC}) should be multiplied by 5 in order to map it to the Failure scale. Hence, the reputation value of the trusted agent 'P' in a criterion 'C', mapped to the Failure scale (Rep_{PCFS}) is:

$$Rep_{PCFS} = \text{ROUND}\ (Rep_{PC} * 5) \qquad \textbf{Equation-----2}$$

Once the reputation of a probable trusted agent has been determined by the trusting agent in a criterion of its future interaction with it on the Failure scale, then the probability of failure of that particular criterion in interacting with that particular probable trusted agent can be determined by ascertaining the difference between what the trusting agent expects from it in the

criterion and how far the probable trusted agent can fulfil it according to its reputation.

The trusting agent expects the probable trusted agent to complete the criterion according to the expected behaviour. This expectation of the trusting agent can be quantified with a value of 5 on the Failure scale. This value represents the lowest probability of failure of the criterion and expresses the maximum possible commitment in the criterion by the probable trusted agent. Hence, the probability of failure of a criterion 'C' in interacting with the probable trusted agent 'P' can then be determined as:

$$\text{Probability of Failure}_{CP} = \left(\frac{5 - \text{Rep}_{PCFS}}{5}\right) * 100$$

Equation-----3

The achieved probability of failure of criterion 'C' in interacting with probable trusted agent 'P' will be on a scale of 0-100%. Determining the FailureLevel (FL) for the probable trusted agent 'P' in criterion 'C' on the Failure scale (FL_{PCFS}) according to the level of possible failure of the criterion 'C':

$$FL_{PCFS} = \text{LEVEL}(\text{Probability of Failure}_{CP})$$

Equation-----4

When the 'FailureLevel' (FL) for a probable trusted agent in each criterion of the trusting agent's future interaction with it has been determined on the Failure scale, then its 'FailureLevel' in the whole interaction according to those criteria can be determined by weighing the individual 'FailureLevel' of each criterion according to its significance. All criteria of an interaction will not be of equal importance or significance. The significance of each criterion might depend on the degree to which it influences the successful outcome of the interaction according to the trusting agent. The levels of significance for each criterion (Sc) are shown in table 1 below.

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

Table 1 showing the significance level of each criterion

The pre-interaction start time phase FailureLevel of the probable trusted agent 'P' (FL_P) by ascertaining its in-capability to complete the interaction according to the criteria, further weighted by the significance of each criterion can be calculated as:

$$FL_P = \text{ROUND}\left(\frac{1}{\sum_{n=1}^{z} S_{Cn}} \left(\sum_{n=1}^{z} S_{Cn} * FL_{PCnFS}\right)\right)$$

Equation-----6

where
S_{Cn} is the significance of the criterion 'Cn',
FL_{PCnFS} represents the FailureLevel of the trusted agent 'P' in criterion 'C_n' on the Failure scale,
z is the number of criterions in the interaction.

Extending the previous example, when the trusting agent 'E' determines the FailureLevel (FL) of the probable trusted agents 'D' and 'Z' in the pre-interaction start time phase according to the criterions of its future interaction with them, then it can utilize the respective values of each agent to ascertain the probability of failure in interacting with them in the post-interaction start time phase. The probability of failure determined in the post-interaction start time phase is strictly according to the criteria of the trusting agent's future interaction.

4. Conclusion

In this paper, we discussed the need to ascertain the possible risk before initiating an interaction in a digital business ecosystem. The possible risk in an interaction can be ascertained by determining the probability of failure and the possible consequences of failure. Due to space constraints we limited our discussion in this paper to determining the FailureLevel of a probable trusted agent in the pre-interaction start time phase according to the criteria of the trusting agent's future interaction with it.

5. References

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