

# Modeling Trust in E-Commerce: An Approach Based on User Requirements

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## ABSTRACT

E-commerce is presently operating under its expected capacity, mainly because traders find it very difficult to trust one another online for trading decisions. It is therefore very important to develop an effective trust management system that assists e-commerce participants to make good trust decisions. This paper describes an approach based on users' requirements towards such a system. The benefits of this approach are threefold: First, it gives a better understanding of the components that can be used in a trust management system. Secondly, it illustrates that the components contributing to the trust making process can be different from one environment to another. Thirdly, it shows that the way one person trusts can be different from others. This approach, rather than using the same static attributes to calculate trust for everyone, uses specific attributes based on each trustor's goals. Moreover, by using GRL and UCM as notations for trust modeling, this approach provides a visual representation of trust, its components and the trusting process.

## Categories and Subject Descriptors

H.4.2 [Information Systems Applications]: Types of Systems – decision support.

## General Terms

Design, Reliability, Security, Human Factors

## Keywords

Trust, Trust modeling, E-Commerce, URN, GRL, UCM

## 1. INTRODUCTION

E-commerce will continue operating under its capacity unless there are effective trust management systems to assist traders with the problem of how to make good trust decisions online. In this

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section, we would like to look at the topic of trust in a broader perspective, and then bring in GRL and UCM as suitable tools for modeling trust.

### 1.1 A Broader Picture of Trust

Recent use of electronic environments and especially the Internet has increased significantly. Millions of computer users worldwide have begun to explore the Internet and engage in online commercial activities [10]. However, according to a survey by Information Systems Audit and Control Association (ISACA), security, risk management and trust are still some of the main key problems in the e-commerce world (Figure 1), all of which directly or indirectly have significant impact on trust [4]. Trust management systems therefore can help to reduce risk (e.g., ID theft), and make it easier for users and agents to interact with one another in a low risk environment. The importance of trust management has also been increasingly acknowledged due to the advent of virtual communities. Since participants in these communities do not know each other and do not have face-to-face contact, the ability to provide a system that allows communication to be done in a trusted environment is vitally desirable [10].

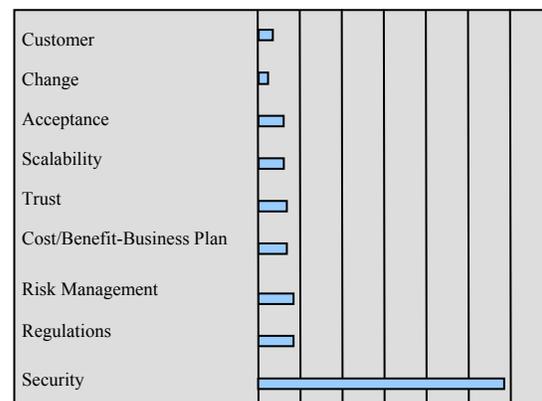


Figure 1: Key problems in e-Commerce [4]

Trust is considered as a critical fact for the success of e-commerce. Online trading has introduced new problems and challenges to online buyers: The uncertainty about the quality of products or services and the ability of sellers to stay anonymous have lead to a high level of risk in virtual market places, virtual communities and online auctions [2][10]. As the result, trust

management has been measured as one of the most important components in any electronic environment. This issue, however, is still under research and there is not yet a well defined system that provides all users requirements in this regard [2][9][15].

In recent years many researchers have worked on trust related issues [2][3][7][8][9][10][11][30][29], but only a few have tried to provide a broad and complete picture of trust [3]. It is important to note that without providing a unified framework for trust, it is very challenging to define suitable trust management models and to come up with good formalizations. A unified framework for trust provides a relevant picture of the subject matter by considering different points of view and perspectives of the parties engaged in the trust process. Having this wide picture in place, researchers would have a better understanding of the environment that they are going to concentrate on. In addition, undefined relationships between different components that are involved in trust make the trust process definition harder [8]. In fact, a number of researchers started to generate methods for computing trust without having a clear understanding of what the components that are used in the model should be, and how these components would interact with one another. This leads to incomplete and immature trust management systems. For example, in some trust management systems, although some well designed credibility formalization techniques have been used, there is no consideration in place to prevent noisy ratings of untruthful voters [25]. Other trust management systems have some other inadequacies. This paper, by considering a broader picture of trust and all implicated components, introduces an appropriate approach for modeling trust and developing effective trust management systems.

We have made use of URN, especially its two components GRL and UCM, for the modeling of trust. Let us briefly introduce these components and their suitability for trust modeling.

## 1.2 URN as Trust Modeling Tool

User Requirement Notation (URN) has been introduced by the International Telecommunication Union Standardization Sector (ITU-T) in 2003. The main intention of this visual modeling tool is to help with functional (behavioral) and non-functional (e.g., availability, scalability, and cost) requirements. Since the defined objectives for URN are broad and ambitious, the following two components are used for achieving the desired purposes.

The first component is Goal Requirement Language (GRL), which combines the Non-Functional Requirements Framework (NFR) [27] and i\* framework [28]. The advantages of modeling trust with i\* framework which is the ancestor of GRL has been elaborated and cited by many researchers previously [29]. GRL helps to define goals or objectives of a system. It provides the capability to compare different ways of reaching system goals and demonstrating the components that have contribution toward goal achievement. It can be used to show the impact of selecting one way of goal achievement against another, and therefore helps for better decision making in the process of system design [1][23]. GRL's soft goals (that are shown as cloud symbols) allow depicting objectives with ambiguity about their level of satisfaction in the system. In other words, they allow demonstrating relationship between concepts with fuzzy and semantic nature. This capability of GRL can be very useful for modeling trust related concepts, because in most cases they have

some level of uncertainty and fuzziness [2][15]. Soft goals can be decomposed and divided further into sub-goals to reach a quantifiable and operational solution. The operational part can be illustrated as tasks which in GRL are shown by hexagons symbol. This capability can help to find out the top level goals of a trust management system. Moreover, after enough decomposition of goals, we can reach an operational point that helps us to implement a trust management system by considering all top level requirements of such system. One of the advantages of GRL over other modeling languages is its higher level of abstraction that helps us find out the opportunities and vulnerabilities [29].

The second subset of URN is Use Case Map (UCM), which can be used for scenario definition. It is a useful notation to define behaviors of the system both in top level and operational level processes. In other words, it is general enough to be used for defining a business model or to define low level activities and responsibilities in one portion of an implemented system [23]. This capability of UCM can be used to define trust in a conceptual level, to show the responsibilities of different stakeholders in a trust management business, or to depict the components of a trust management system and their responsibilities. The entire trust process is therefore based on behaviors and actions of involved parties [3][8][9][12] and is defined in the boundaries of trustee and truster [10]. In addition, a trust process ends in two scenarios or paths - trust or distrust [12]. Consequently, UCM, which is a behavioral and scenario based notation with the ability of demonstrating different paths, parties and their activity boundaries [23], can be considered as a good notation for illustrating the notion of trust.

The tractability between UCM and GRL also allows us to find out the defined goals that are not covered by our operational system. In addition, this relationship between UCM and GRL helps to discover the subsets of our operational system that do not have anything to do with the identified goals in our GRL models.

Table 1 shows the entities and objects involved in a trust process. It also demonstrates the components and abilities of UCM and GRL. Comparing the trust column with the UCM and GRL columns confirms that we have enough components in URN to depict trust, including goals, processes, actors, and their behaviors. A summary of UCM and GRL notations is presented as Appendix A at the end of this paper for those readers that are not familiar with these notations.

**Table 1: URN Coverage of Trust Definition**

Trust	UCM	GRL
Behaviors	Behaviors	Tasks
Actors	Actors	Actors
Boundary	Boundary	Boundary
Paths	Paths	Paths Comparison
Actors' Goals		Goals

This paper attempts to use URN to both model the components that affect our main goal, namely the establishment of trust between a truster and a trustee, as well as to define trust and the trust making process. This visual representation provides a better understanding of trust and the components that contribute to the trust process. It also serves as a good starting point for designing a

trust management system with a more complete view of requirements.

The rest of paper is organized as follows: Section 2 provides literature review and related work. Section 3 proposes a model of trust using URN. Section 4 discusses the advantages of the proposed model and how an effective trust management system could be built based on this model. Finally, Section 5 concludes the paper.

## 2. LITERATURE REVIEW

Researchers in the area of trust have tried to define trust from different perspectives. Since trust is a multifactor and subjective concept [12], researchers have focused on this concept from their own points of view. It is not easy to reach an agreement on the characteristics of trust. For that reason, the formalization results based on different trust definitions differ from one another, and there is still not a single standard view of trust. Efforts of researchers in the areas of philosophy, psychology, sociology, transaction economics, organization theory, game theory, information theory, and technology have provided a disparate literature for trust [3].

Researchers like Deutsch have focused on the psychological aspects of the trust [12], and many people have agreed that psychology is one of the main factors that contribute to the trust making process [3]. Psychology, in most cases, looks at trust from two perspectives, namely the individual aspect and the social side of it. Moreover, psychology has focused on the mutual effects of risk and trust. It considers expectation and context as the two main parameters that help to increase or decrease the probability of performing an action based on trust. In other words, the factors that help reduce the risk lead to the enhancement of trust [10].

Other researchers like Barber have focused on the social aspects of the trust. These researchers, in most cases, study the influence of trust in group and group relationship in three phases: (i) when someone tries to join a group in the first step, (ii) the effect of trust in an intra-group relationship, and (iii) how trust helps to establish inter-group interactions [12]. Following this direction [17] that, "In human societies, previous experiences of the members of the group to which individual who is assessing a reputation belongs are also taken into account". Some other researchers such as Niklas Luhman have tried to relate trust with the concept of complexity reduction in society. Complexity reduction in this literature is widely discussed from two points of view: First, the notion of trust helps individuals reduce complexity of their work by using other people expertise, and second, it reduces the complexity of the interpersonal relationship [12].

The mentioned perspectives have been studied by researchers who have worked on the roots or "nature of trust" [3] in different bodies of knowledge other than computer science. However, several researchers have also studied trust from technological point of view. As an example, some researchers have tried to study the impact of the trust on e-commerce environment [2]. Other researchers have discussed the aspects of the trust from the security perspective [18]. Singh [19] suggests that trust covers more issues than just security, and that trust should be looked at from two standpoints: "hard trust", which deals more with security issues, and "soft trust" which deals with "control, comfort and caring".

A number of researchers have studied trust with focus on online reputation and agent communication perspective [13]. There are two main streams in this branch of research. While some researchers tried to develop a robust model for distributed, open and peer-to-peer online communication [11][25][30][31], others worked towards a centralized approach [8][22][eBay][onSale]. [22] defines these two different approaches in the following way: "By centralized trust, we refer to the situation where a globally trusted party calculates trust values for every node in the system. All users of the system ask this trusted party to give them information about other users. ...The decentralized version of the trust problem corresponds to each user being the "center of his own world." That is, users are responsible for calculating their own trust values for any target they want." The centralized model is more suitable for closed networks, especially for auction applications. The decentralized model could be used in open environments and mainly for agent-based interactions. [30] and [31] propose game theory and information theory based framework respectively to analyze trust in decentralized and peer-to-peer networks.

With the emergence of web services as one of the main components of software applications and business models, researchers also discuss trust related issues in this field [13]. They usually discuss how one can establish a business based on the services of other companies, and have enough trust on those companies to confidently guarantee the services that the business would provide for its consumers, through a combination of third party services.

## 3. THE PROPOSED MODEL OF TRUST

### 3.1 A Visual Definition of Trust

Although many researchers have been working on trust; yet, no single and clear definition of trust has been agreed upon in the field of computer science. Nevertheless, some definitions are more acceptable than others. One of the considerable definitions is Deutsch's (1962). Since this definition uses a structural approach, it can be useful for computer scientists and is one of the definitions used in this paper. Deutsch's implies the following in a trust process [12]:

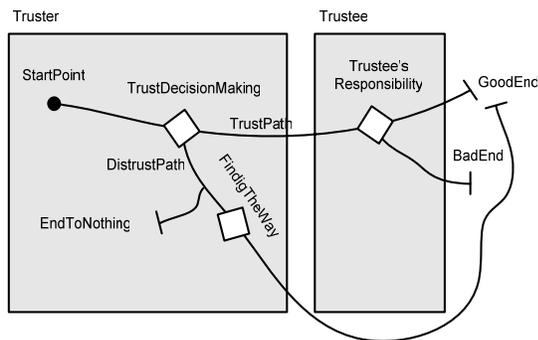
- The individual is confronted with an ambiguous path, a path that can lead to an event perceived to be beneficial ( $Va+$ ) or to an event perceived to be harmful ( $Va-$ ).
- The occurrence of  $Va+$  or  $Va-$  is contingent on the behavior of another person and the strength of  $Va-$  is greater than the strength of  $Va+$ .
- If the individual chooses to take the ambiguous path, he makes a trusting choice; if he chooses not to take the path, he makes a distrustful choice.

Some other definitions of trust can give us a better perception of other researchers' opinions:

- "Trust is a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behavior of another" [8].
- "Trust is an adoption, a generalization, or, as ... a means for the reduction of the complexity" [12].

- “Trust is an attitude, such as expectation or confidence that is directed toward a specific other” [3].
- Trust is “the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the truster, irrespective of the ability to monitor or control that other party” [9].
- “Trust is a personality characteristic of an individual that influences that person’s interactions with the world at large” [16].

Among all various definitions of trust, some common points can be observed and are used as our assumptions to generate Figure 2 below. First, as depicted in this figure, there are always two parties – truster and trustee – involved in the process of trust. The truster would like to rely on the trustee for a service or function that the trustee offers. As shown in the figure, the truster, in the process of trust decision making, decides whether he should select the trust path or distrust path. The trust decision making process is illustrated by a stub, a diamond symbol used to create hierarchical process maps in UCM models. This process can be detailed to show how exactly one decides to trust or distrust. Figure 3 (which will be detailed later) shows some of the criteria that one may use for decision making in this stage. Finally, the trust process can end in a positive outcome or a negative one, based on the behavior of the trustee. As demonstrated in Figure 2, the behavior of the trustee is beyond the truster’s boundary, and therefore is not controllable and predictable. In this case, the previous interactions and records that are available from the trustee can help to reduce the risk of trust and the complexity of trust decision making process.



**Figure 2: Trust Visual Definition (with UCM)**

Table 2 illustrates the concepts that have been introduced in Figure 2 in a specific scenario. In this table, the purchase of second hand books from online book stores has been considered as an adapted sample. In this case, an individual who wants to buy a second hand book will have to make a trust decision: She should first decide about buying online and then select one online store among others to fulfill her requirements. Otherwise, she should buy the book from physical stores or friends.

**Table 2: Book Buyers Scenario**

<b>Truster</b>	<b>Online second hand book buyer</b>
<b>Trustee</b>	<b>Online book stores with second hand items</b>
<b>Trust Decision making</b>	<b>Should I buy second hand books online? Which would be the best store to do that?</b>
<b>Trustee’s Responsibility</b>	<b>Offer the book and deliver it with the required qualitative values</b>
<b>Good End</b>	<b>Get the book with the required qualitative values</b>
<b>Bad End</b>	<b>Receive a wrong book, or receive the book without required qualitative values</b>
<b>Finding the way</b>	<b>Buy the book from friends, or buy the book from traditional book stores</b>

Figure 2 provides a better understanding of what trust means and which parties are engaged in the trust process. However, it doesn’t show the truster’s goals in the trust process or reasons of using another party to complete a specific task. Studying these reasons can help to define and formalize the trust decision making process and the criteria that are used in the process by the truster. To depict the mentioned goals, GRL is used in this paper as the notation of choice. Figure 3 shows the goals of a trust process which has been depicted in Figure 2. Using GRL, this figure shows the effects of trust and distrust (i.e., the two available paths for the truster in Figure 2) on the truster’s goals.

In Figure 3, the main goal of the process is considered as hard goal, while its relative qualitative values are defined as soft goals. The main goal of the truster is always to reach to the good end. In addition, the truster willingness to trust or distrust somebody is the result of the effects on the soft goals (e.g. time effectiveness, cost effectiveness etc.) Although the good end can be defined almost strictly, the qualitative values related to this result can’t be very clear and often have some degrees of uncertainty. Consequently, the mentioned qualitative values, as elaborated in Section 1.2, can be modeled as soft goals using GRL.

Trust can help to reduce the complexity of performing a task by using someone else’s experience. As the result, complexity reduction is considered as one of the soft goals in Figure 3. In the same way, trust helps to decrease the duration to accomplish the task (i.e., time effectiveness). Moreover, using someone else’s services may make the whole task more cost effective. Having someone trusted to do a specific work may also increase the confidence for success. However, it may increase the risk, especially when the truster doesn’t have enough knowledge or prior interaction with the trustee.

In our illustrating example, the main goal is to buy a second hand book. In this case, the qualitative aspects that could be affected by trust or distrust on an online book store could be books’ prices, search duration, variety of selections, and books conditions.

In addition to the discussed issues, Figure 3 shows a comparison between trust and distrust and their contributions to the truster’s soft goals. This model can help to select the right path in each individual case, based on soft goals evaluation. With the same

approach, this model can also be used for comparing and evaluating two or more third parties to see which one has better impact on the soft goals of the truster.

Continuing with the second hand book purchase scenario, either buying the book from the online store, that is, choosing the trust path, or finding the book in another way (e.g., through friends), that is, choosing the distrust path, could both reach to the good end, but each of them would have different consequences on the soft goals. Although one could select the distrust path to reach the main goal of buying second hand books, one may not be able to fulfill some of the soft goals as well as they are required. To illustrate, since an individual doesn't have so many resources, finding the required book would be a challenge and time consuming in the first step. Even if one is able to find the book from one's limited resources (e.g., friends, university bookstore etc.), the options to choose among them would be very limited. Consequently, one could sacrifice some of the qualitative values (e.g., good price) to acquire the required item. This could be otherwise if one trusts an online store which has the competitive advantage in providing second hand books. Nevertheless, selecting the online store might also increase the risk of purchasing the book in bad condition, because the buyer will not be able to see the book until the order fulfillment.

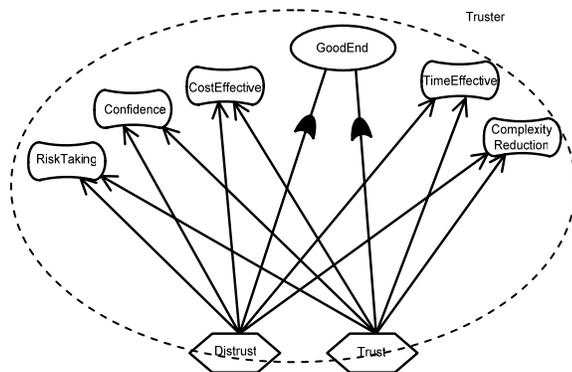


Figure 3: Truster's Goals in trust process

The introduced soft goals in Figure 3 and their associated values could be different from one person to another. In other words, people can have different goals in a trust process; or even in the case of having similar goals, their considered value for each of the goals could be different. These goals and their threshold values can have significant effect on the trust decision making process. As indicated in [12], the threshold values are the points where people decide between trust and distrust (Figure 4). The threshold values could be different from one person to another and even different for the same person in different situations. As the result, based on each individual's soft goals, one party can be trusted by an individual while it is not trusted by another.

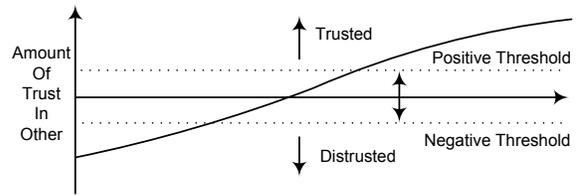


Figure 4: Trust Threshold [13 p42]

Following our example, the only draw back and negative impact on soft goals is the risk of receiving books in bad condition. This negative impact might have different values for different individuals. While a person might be interested in getting the book in a very good condition, the other one could be less concerned about this issue and just thinking about receiving the book as cheap as possible. On the other hand, another person could be in rush and have more concern about delivery time. Consequently, based on the provided qualitative values, one book store might be trusted only for one of the mentioned cases and not the others.

To analyze whether one should trust somebody, the impact of trust and distrust on one's soft goals should be evaluated. If distrust has better impact on the soft goals, there would be no point to trust a third party to perform a task on behalf of the truster. However, if trust fairly affects the soft goals, user can choose the trust path. In this case, different trustees can be compared against each other to see which one could have the best impact on the truster's soft goals.

### 3.2 Trust Components

After exploring the goals of trusters, it is now trustees' turns to be studied in more detail. The main goal of a reasonable trustee is to increase the trust associated to her. To do that, the trustee behaviors should be in accordance with Figure 5. This model is developed based on the framework introduced in [3]. It describes the components that have influence or contribution to the trust process.

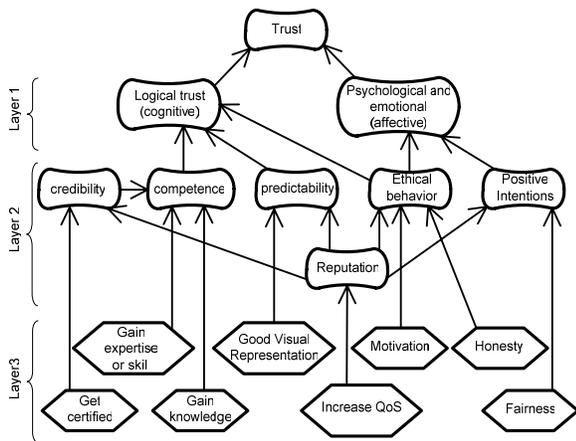
As depicted in Figure 5, most components that have influence on trust enforce their contribution through a cognitive or affective type of trust [3] (which are shown in the first layer after the main goal – Trust). This model is aligned with most researchers' belief that trust is directly or indirectly a combination of logical, emotional and psychological decision making [3].

The second layer of this model includes competency, predictability, ethical behavior and visibility of the trustee's positive intention. The mentioned components have contribution in trust value through one or both types of trust as described in the first layer.

As illustrated in Figure 5, although reputation can play a significant role to increase the credibility and predictability of the trustee in the view of a truster [9], it should not be the only factor to establish trust in a trust management system, as in the case of some existing works [25].

The last layer (shown in hexagons) illustrates some of the tasks or behaviors of the trustee that help to increase trust through the first and second layers. For example, the ability to show the

underlying motivation to the truster has a significant effect on convincing the truster that the trustee has positive intention [12]. Showing fairness and honesty can be considered as part of ethical behavior, which reduces the risk for the truster and helps her make trust decision more easily. In addition, increasing knowledge and becoming certified in the field (where the trustee provides services) increase the competence ability of the trustee and the confidence of the truster. Moreover, a good visual representation of the trustee and her services helps to increase the predictability of the trustee's behavior for the truster. Finally, the quality of provided services can affect reputation which has impact on other introduced values.

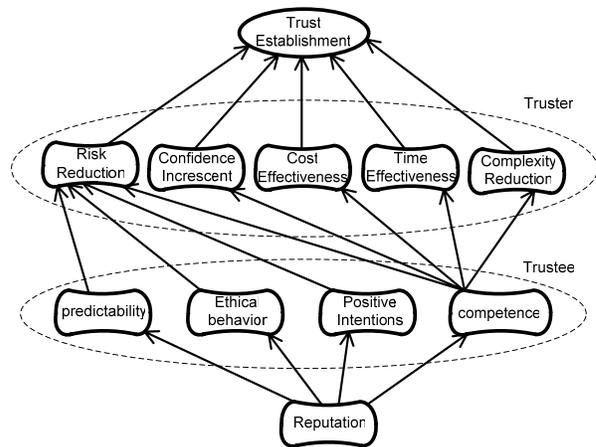


**Figure 5: Trust Components – Trustee Tasks to Build Trust**

These tasks can have different values in different scenarios and some scenarios may have their own individual specific tasks to be performed for increasing trust. For instance, in our example of the online book store, while getting certified and gaining knowledge might not be valid, good visual representation of website, showing honesty by providing the real picture of books, showing fairness by providing different prices for the book in different conditions, increasing the quality of service by providing variety of books and on time delivery, and providing books with promised and demonstrated conditions, could have significant effect on making the online book store more trustable.

### 3.3 A New Trust Management Model

A combination of the two models depicted in Figure 3 and Figure 5 is represented in Figure 6. This model shows the relationship between the trustee's behaviors and the truster's goals. It can be considered as a conceptual (high level) model for a trust management system, which evaluates different parties' trustworthiness to propose the best trustee to the truster based on the truster's goals, not on some predefined and limited attributes as in the case of some current trust management or reputation systems.



**Figure 6: Effects of Trustee's behavior on truster's goals**

In the above model (Figure 6), the main goal is to establish trust between truster and trustee. It illustrates how the trustee's attributes can contribute to the truster's soft goals. Having the truster's goals and the associated behaviors of trustee, one would be able to develop a trust management system that works based on what users look for. As mentioned before and elaborated in the context of Figure 3, trust is a subjective concept based on people's soft goals and is therefore different according to the points of view of different people.

It is also demonstrated in this model that most of the trustee's behaviors are toward reducing risks for the truster. In other word, the truster looks for less risk in an interaction with the trustee. Figure 6, by showing the importance of the risk factor in a trust making process, emphasizes on the fact that risk analysis should be considered as one of the most important components in a trust management system. By calculating risk factor, a trust management system helps the truster to demonstrate trust intention or trust behavior only when the level of trust exceeds the level of perceived risk.

In addition, as illustrated in Figure 6, competence can play a significant role. As the result, a trust management system should be able to calculate the competence factor of the trustee to compare it with the goals of the truster, and specify whether a good match has been found.

Furthermore, although the reputation module is an indispensable part of a trust management system, it is not the only module in the system, and therefore should be integrated with other modules in a more complete system. To clarify, after the values of all participating factors (e.g., competence, ethical behavior etc.) for trust calculation are received from the trustee or other sources, they should be validated and evaluated using the reputation module. As an example, the actual value for the competence factor of a trustee with higher reputation would be greater than that of a trustee with lower reputation, even though they both claim the same competence value.

In a more complicated example, different online stores with different goal models can be compared against one another and the best one that matches with users goals can be recommended to the end user by the trust management system.

## 4. Discussion

In this section we discuss the advantages of the proposed model and the possibility of designing an effective trust management system based on this model.

The advantages of the proposed approach can be evaluated from both the modeling and usage perspective. First, from the modeling perspective, since trust is an area with great level of uncertainty and fuzziness, GRL is indeed a good modeling notation for it. GRL's soft goals are very useful for showing the semantic concepts with some degree of uncertainty, which is usually a property of the components involved in trust. The other advantage of GRL is its ability of to compare different third parties and show the effect of each party on the end users' goals. In addition, since UCM is a behavioral and scenario based notation, it is a suitable modeling notation for trust, which usually consist of behaviors of concerned parties.

In terms of usage, this modeling method can be used both by a trustee to evaluate and improve herself based on users' goals, and by a truster in a trust management system for finding an appropriate trustee (i.e., matching trusters and trustees).

Using this proposed model, a trustee can establish a customized trust model based on their nature of activities and the trusters' requirements, and try to improve their services in a way that suites their clients. This model helps the trustee to not only look at trust from the user's perspective, but also to consider all involved aspects of trust and the mutual effect of the involved components.

Effective trust management systems can be designed based on the proposed model: We should be able to provide a recommender system that matches trustees and trusters, based on the information gathered from them. As discussed in the paper, the required information, which is defined based on user's goals, could vary from one environment to another, as well as from one cluster of users to another. As the result, based on each particular case, an appropriate trust model could be developed. Consequently, the developed trust management system would be flexible enough to accept and work according to different cases. It is also possible to specify a goal model in a higher level of abstract that is more generic but applicable to similar environments. The advantage of having such a reference model is to provide a guideline or framework which then can be customized and detailed for different environments and needs. Providing such a framework and conceptual model would be part of our future work in this arena. As an example, we can provide a framework for trust in online stores, which then can be customized to work for online book stores.

The proposed trust management system can gather information using methods proposed in the trust literature. As an example, to understand the end user's goals, the information can be gathered through direct dialog (or negotiation) with the end user (or agent), or it can be collected through the user's behaviors. The behavioral method could work in the same way that recommender systems work in the marketing area (e.g., collaborative filtering technique). For instance, the system can recommend the trustees whom previous trusters with the same attributes (goals) as the current truster have trusted in the past and were satisfied with the results.

Besides, the required facts and information from the trustee could be gathered by common methods and fed into the system. As an example, some of the information could be gathered from the trustee itself and validated using reputation method, or the information could be gathered through voting systems and social networks.

The trust management system therefore can include the information gathering components as well as the core trust computation module, or it can only have the core computation module in the form of a client that gathers the required information from the information providing web services.

In summary, the proposed approach of trust modeling provides a better realization of the necessary components in a complete trust management system, illustrates that the trust components vary depending on the environment and the type of transaction, and shows that different people trust in different ways based on their individual goals. In addition, the discussed trust modeling approach can be used in various contexts, from the design of a trust management system to the self evaluation of trustees.

For future work we would like to improve and complete our abstract model, provide customized models for different environments based on the design of a generic framework, and finally implement a flexible system that gets the required information and provides the best possible matches of trustees and trusters. In addition we are going to evaluate the performance and cost of our method and compare it with other existing frameworks. The new system will be tested in a more complicated case study with multiple parties playing the role of trustee and multiple parties playing the role of truster in order to demonstrate that the matches would be different based on trustee's and trusters goals. To achieve this goal we will expand the described example to multiple book buyers and multiple book sellers with different goals.

## 5. CONCLUSIONS

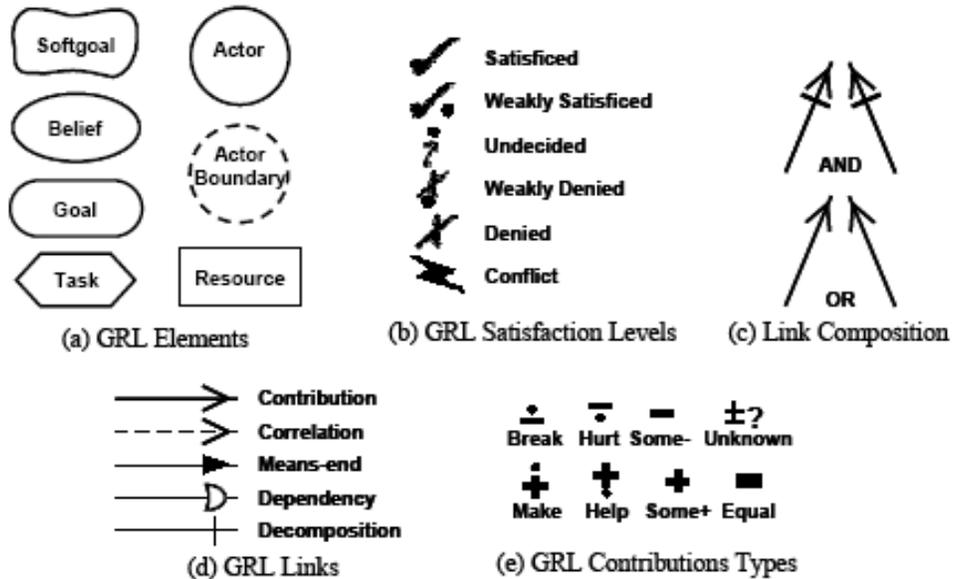
Structured methods for studying processes and environments as well as model driven software engineering have gained lots of popularity in the past few years. In this paper, a URN based approach in accordance with model driven software engineering was used to investigate trust related issues. The visual definition of trust that we introduced in Section 3.1 provides a better understanding for the concept of trust. Moreover, by defining truster's goals and trustee's attributes, and by combining them together (i.e., Figure 6), we suggest better formalization and computational solution for trust. Using this combination, we proposed a model for a new interactive trust management system. Such a system would calculate trust based on what the truster looks for, and therefore would recommend the best trustee according to the truster's requirements. We also showed that a trust management system with only one component (e.g., reputation) does not cover all the necessary functions and services.

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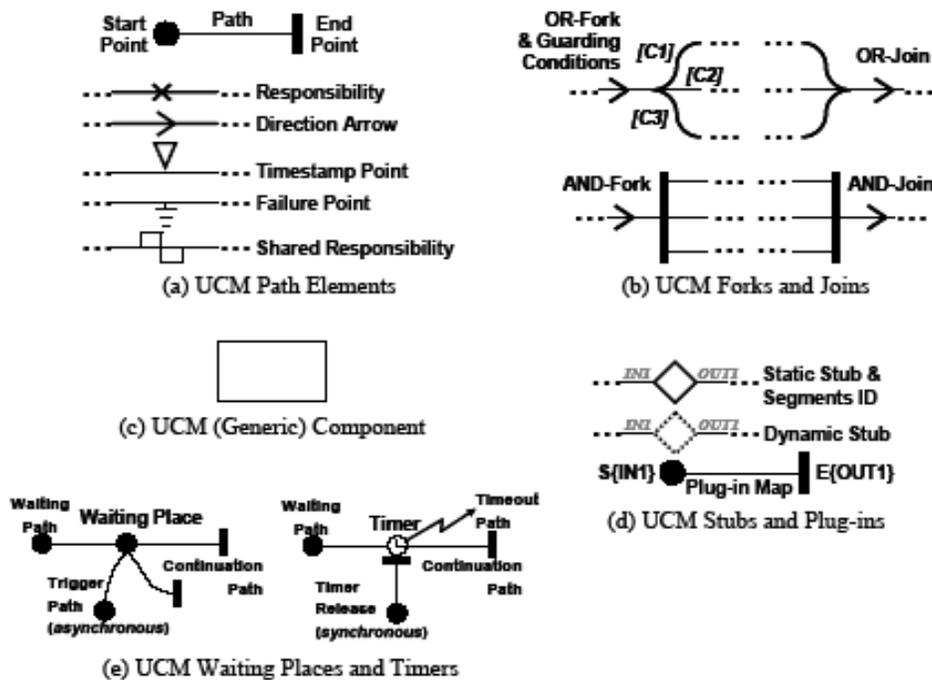
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## Appendix A: URN (UCM and GRL) Notation summary [23]



Summary of the GRL notation.



Summary of (a subset of) the UCM notation.