Toward a Trust Model for Knowledge-Based Communities

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ABSTRACT

The ultimate goal of trust is to reach and make decisions based upon the available knowledge. We think that it is not enough to build trust on beliefs or on recommendation-based models. Our approach aims to implement it within a programming methodology inspired from the theorem proving domain. We propose a conceptual framework which transposes this to the context of virtual organizations. In this paper we describe our approach and partially illustrate it with a prototype system dedicated to information searching in the context of academic exchanges.

Categories and Subject Descriptors

I.2.4 [Artificial Intelligence] Knowledge Representation Formalisms and Methods

General Terms

Management, Security, Languages, Theory.

Keywords

Knowledge, Specification, Trust.

1. THE NEED OF A NEW PARADIGM FOR TRUST

The concept of trust plays an important part in the knowledge society. A knowledge society cannot exist without a high level (abstract) model of trust. It is not enough to build trust on beliefs or on recommendation-based models (such as those developed within social networks). Indeed, trust should be defined firmly and within well-defined boundaries. This is the attempt in this paper.

The ultimate goal of trust is to reach and make decisions based upon the available knowledge. Thus, the trust requirement must be fulfilled in the sharing and exchange of knowledge prior to decision making. However, contrarily to other approaches, we do not consider information sources acting in the sharing processes. This would lead to the design of reputation models. We consider the contents exchanged. An obvious further work will have to combine trust reputation models with content-based trust model.

We consider that trust based decision making can be defined in the area of cognitive world as theorem proving has been defined in the area of mathematics [3]. For this, we have to precisely define what computing means in the area of cognitive world, especially for addressing trust. Thus, we must extend existing specification along epistemological purposes.

Exchanges in-between computers rely on a syntactical basis. Contrarily, exchanges in-between people rely on an interdisciplinary complex basis composed of sociology, semantics, and language. Interplay between virtual and real worlds appear since computers are used to mediate exchanges in-between people and they even participate to such exchanges. Internet of things and social network applications are examples of implementations of such systems. From this, we consider that interdisciplinary modeling is required to further develop the information society, and more specifically, we make use of sociology approaches because we believe that sociology has a positive impact in the approaches, especially in the way knowledge is handled, defining thus a new epistemology.

The goal of this paper is to outline how trust can be defined, implemented and handled in the context of decision making and in the frame of virtual communities or virtual enterprises. The following section will present related work dealing with or illustrating this objective. The next section will be related to the building blocks of our proposal: the design perspective, the specifications of knowledge and the virtual knowledge community. The next section will present our model of trust for knowledge based communities. We finally give some concluding remarks.

2. RELATED WORKS

A domain where the impact of a trust-building knowledge engineering approach is high is the domain of knowledge-based organizations. We take two examples from the literature that had a significant impact and that show that the ways of working of these organizations are far from obvious.

The paper of Joshi et al. [12] analyses the global-local tensions that emerge within the context of knowledge communities in global organizations. Their research findings provide key insights into why global organizations find it challenging to address these tensions and suggest what may be done to overcome them. Also the paper of Zakaria et al. [20] outlines the emergence of a significant new form of working known as ‘global virtual teams’. They emphasize that global virtual teams require innovative communication and learning capabilities for different team

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members to effectively work together across cultural, organizational and geographical boundaries. We consider that trust should be introduced as a key ingredient to improve the cooperative work of these global innovative teams.

It has been pointed out (C. Cevenini [6] G. Sartor [17]), that software agents can be used in every stage of the life of a virtual enterprise. A society of software agents can be seen as a virtual enterprise when it is regulated with special contract clauses. Our work will rely on this assumption that a company can be modeled along agents as a virtual organization.

The representation of knowledge is a challenging task because of the multiple facets such representations may have. A very generic approach that is used by default when none is obvious is the Bayesian Epistemology. As pointed out in [10] the probability calculus is especially suited to represent degrees of belief and to deal with questions of belief change, confirmation, evidence, justification, and coherence. The authors also emphasize the so-called Principle of Lewis stating that "If an agent knows the objective probability of proposition *A* to be equal to *p* and there is no overruling information available, then the rational degree of belief in *A* must also be equal to *p*". This is a crucial step because it enables to identify a link to trust in knowledge engineering.

3. THE BUILDING BLOCKS

3.1 Design perspectives

Our approach aims at providing a model to the problem raised by Joshi and Zakaria: we want to smooth out the tensions within virtual teams by describing a framework to solve them through trust arising from knowledge engineering. A full comprehensive centralized knowledge base is not the right solution to address this issue because we cannot list all possible issues leading to tensions in a virtual company. We must then propose a different approach for this framework. Our design concepts consist of accepting incompleteness, enforcing a bottom-up approach, and enabling a progressive growth: knowledge will arise from multiple independent sources and will be processed for the evaluation of trust. Another design decision is to assume, although the methodology is based on non-trivial mathematics, that users are not expected to have any background in this domain or in computer science.

Our approach is based upon the fact that any company can be modeled along systems of software agents as a virtual organization [13]. We set then our approach within models of multi-agent systems. Such a methodology is adopted in most fields derived from distributed artificial intelligence including business [11]. This implies to deal with a society of agents and to analyze the characteristics of such a society. We have proposed in [1] to consider an agent society with the sociology of Weber, meaning that the action of the agents will determine the behavior of the society. This investigation leads to define and to design the concept of virtual knowledge communities (VKC, cf. 3.3).

3.2 Specification of knowledge

Our specification of knowledge relies on the concept "ABIT" (Abstraction Based Information Technology, [2]). It is inspired from the Open Mechanized Reasoning Systems (OMRS) from the area of automated reasoning [9]. It proposes an high-level abstraction for all domains of knowledge from culture to law or sciences. The concept ABIT consists of:

- a theory, which represents a description of a given domain, a set of concepts, rules and findings over this domain;
- a control mechanism, which is acting on the theory's elements and operates on any application in real life.
- an environment, which represents the external influences around the theory and the control mechanism.

Table 1 gives a single and naïve illustration of the ABIT approach applied to the university domain.

Table 1. ABIT naïve example in the university domain.

Theory	Ontology of courses, faculty, campus, sport facilities, student registration
Control mechanism	Decision making process for the validation of courses Decision making process for registering
Environment	University U has several campuses Course C is canceled for 2012-13 Course A and B are not compatible together

3.3 Knowledge and Virtual Knowledge Communities

As previously stated, our design perspective leads to multi-agent systems. Thus, knowledge is necessarily distributed among the agents. In a previous paper we have proposed the concept of Virtual Knowledge Community as a means for a group of agents to build their distributed knowledge base [14].

The overall pieces of information that a community of agents is able to share build a distributed knowledge base accessible to these agents. We call it Virtual Knowledge Community, VKC. The glue aggregating several agents in a VKC can take different forms. A VKC could be dedicated to a given subject (such as French literature), or it could aggregate agents with given characteristics (such as having the German nationality or a German IP address). Agents can use any protocol to exchange with each other. A VKC can have multiple variants, creating thus sub-VKCs.

The basic operations performed on VKCs are as follows (inspired from the ACL FIPA performatives):

- Initiate: an agent proposes a community (for instance a community topic);
- Join: an agent interested in the community joins it;
- Inform: an agent sends a piece of information;
- Request: an agent asks for some information;
- Leave, delete, terminate.

The concept VKC provides a distributed approach to the management of knowledge [8]. Crucial characteristics of VKC are that it is founded on a bottom-up approach, it is dynamic and incremental. The approach aptly treats the characteristic that knowledge does not have boundaries or limits and that a community may simply means a view on a given domain. Also, dealing with different communities opens the door to comparing

points of views, to evaluate their relative distance. This is the mechanism that we will use to propose a trust model.

4. TRUST FOR KNOWLEDGE BASED COMMUNITIES

4.1 Trust main approaches

Trust is a major topic in IT nowadays. It has always been, but the intrusion of the web has drastically changed the scope of the problem. It was always possible to introduce a trust layer in the architecture of a system to have a first approximation solution to enforce trust; however this was, more or less, complementing security requirements. There is an extensive literature on the topic of trust. We outline only a few of them. Recent works have designed algorithmic solutions for trust evaluation in public-key infrastructures [7]. Nowadays, Recommendation Systems [19] are gaining tremendous prominence in the digital society, and they are fast becoming the bastions of electronic commerce. Trust-enhanced recommender systems are designed to help us to form an opinion on matters that are not entirely known to us, or even not known at all. They generalize the concept of belief that has been a key approach to trust. Trust may be modeled and understood by computational models as shown in [5]. In [15] a method to support trust in virtual communities is presented. This paper is very often cited in this domain.

4.2 Our view of trust

Trust is possible if one's actions can be explained and proven by conceptual means. Our aim is to build a model that restricts the range of actions that must be investigated to assess trust.

Knowledge is at the heart of decision-making system. Our methodology consists of enabling to assess trust for well-defined pieces of knowledge defined as VKCs (see §3.3). Dealing with VKCs means being able to share and exchange well-defined pieces of knowledge. Let us assume that a VKC is the overall knowledge of a company. In the ABIT approach, this VKC constitutes the theory. Its related control mechanism is the decision-making system of the company. As we do when we prove theorems, assuming trust means that we must define exactly the conditions under which a decision in the company is valid. In our investigation this means that we must state precisely what concept of trust is under consideration and what the domain of investigation is.

Let us assume that a knowledge base K1 is described in an element of type VKC and that it is trustful for a company C1. Within the theory K1 trust is assumed because it is trustful in C1. Now, let us assume that decisions must be taken based on knowledge pieces (K2) which are not in the trusted knowledge base K1. Trust evaluation implies to evaluate knowledge base K2. A way for this is to move from the first knowledge base to the second one in a continuous way, or to identify the "border" of validity of trust for this very decision.

A simple example is again in the academic field. For instance, between French and Japanese procedure for applying to a Master's program (Table 2). To trust the quality of the information gathered depends on the ability to switch from one environment to the other since each information it is function of the cultural background: just to name a few, the availability for an interview should be carefully considered to obtain admission in Japan while this is not necessary in France, the required duration to get the Bachelor's degree is very important in France, the expression "pass an exam" may be bad translated by French students because of frequent wrong translation from French language. The differences can be so complex that there are topics that will always raise advanced questions and forbid a real trust in the information gathered.

Table 2. Example of the differences in the academic field expressed in the ABIT approach

Theory	French academic system French Culture
Decision	Selection of a Master's program
Environment	Bachelor obtained Duration required to obtain the degree Age

Theory	Japanese academic system Japanese Culture
Decision	Selection of a Master's program
Environment	Nationality Availability for interview Resources

Another example in a completely different domain is about legal knowledge. We may have concepts dealing with publication rights and property rights. It is known that both may lead to different analysis and opposite decisions, depending on the environment and the point of view. This is illustrated by the present discussions in some countries on how to tax social networks or web providers. Considering that publication on the Internet crosses the borders, the question raised is even more complex. A decision such as to publish or not publish data as public information requires some trust in the knowledge available in this field, for each point of view (even in a single national context). Table 3 illustrates this issue in a naïve form.

Table 3. The example of different view of the publication laws expressed in the ABIT approach

Theory	French laws dealing with publication rights and with property rights Organization of the Cinema industry
Decision	Publishing data
Environment	Wikileaks scandal Weigh of the cinema industry

Theory	French laws dealing with publication rights and with property rights Internet providers
Decision	Publishing data
Environment	Wikileaks scandal Coming elections

4.3 Our assessment of trust

Our goal to obtain well-defined boundaries of trust can be achieved through the theoretical framework we have described. It relies on the exchange and sharing of pieces of knowledge among knowledge bases. These knowledge bases must be implemented

as VKCs. The respective exchanges of knowledge must be implemented via the abstraction ABIT inspired from the theorem proving area. ABIT defines the combination of a theory (a VKC instance), control mechanism on this theory (decisions-making) and interactions with the environment (including others VKCs).

Trust in decision making will arise from the availability (quantification) of trusted knowledge required for this decision. This quantification will evaluate the knowledge trust-continuity in-between different VKCs. This quantification will be one of the operators of the VKC type. For a given decision, a trust threshold may be defined and an operator may identify a "border" of validity of trust. This is a challenge we know to solve in computer science, and we can state that our model is able to restrict the range of actions that must be investigated to assess trust.

5. Prototype

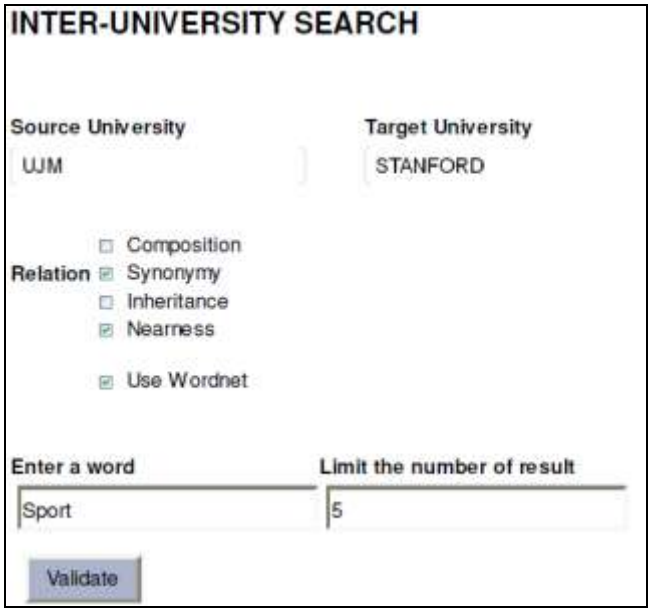
We can illustrate our approach with a real-world oriented prototype which is dedicated to students for the promotion of academic exchanges.

In the application, a knowledge base represents a university and its environment. It is described in terms of concepts, relations and contents. A student belongs to a university, which represent here its community. A student is supposed to trust (understand) the description of his/her university. Universities are described independently in several knowledge bases. Notice that the language differences are not considered in the prototype. The very final objective of the scenario is to help students to make trusted decision as for a place he/she could visit for a period of time. For this, concepts, relations and contents from different knowledge bases are linkable using relations (inheritance, aggregation, synonymy, and nearness). The mechanism of specialization of knowledge bases is implemented. In this case intrinsic relations between terms are automatically created.

The aim is that a student from a given university (source) will get information from a given academic partner (target) and specifically will get a trust value for this information. For this, a user interface and algorithms have been implemented on top of the knowledge bases. A user query is expressed by the student (Fig. 1). The system considers the related concepts, relations and contents in the source knowledge base and then searches for contents in the target knowledge base. The retrieval process is executed based on the successive concepts and intra-/inter-bases relations. The user can select types of relations to be used, as well as the activation of Wordnet functionalities (use synonyms of the typed word). Our algorithm builds paths starting from the source knowledge base to some contents belonging to the target knowledge base. The valuation of these paths (yet not done) will give a trust value related to the source base to each contents from the target base. A threshold on the number of answers or on the trust value can be introduced.

Our prototype illustrates our bottom-up approach since university environments can be described independently and their descriptions can be incomplete and not formally aligned with other descriptions. The prototype illustrates also the concepts of community (although not VKC in this case because knowledge bases of communities are not distributed among their participants). Communities have their respective knowledge base which represents their respective theory (ABIT vocabulary). Trust principles arise from the connections between terms of these knowledge bases and on the possibility to explain and valuate this path.

Fig. 1. User interface for Inter-University Search



The prototype has been designed by master students. They have used simple technologies like MySQL, Java programming, Javascrip, Wordnet.

6. CONCLUSION

Trust is a concept that may not be fully described with algorithms. Our approach aims to implement it within a programming methodology. To make things simple, we require to be able to share and exchange pieces of knowledge, and to quantify the distance between these pieces of knowledge.

We believe that this approach of trust can be applied to the context of virtual enterprises where decisions must be taken in a complex configuration and where actors may not know each other, or even on a fully mechanized manner. A point to be stressed is that if the assumption that any virtual enterprise can be model by virtual knowledge communities is not valid because it would require too much effort, then our approach is in any case suitable for systems relying on knowledge bases.

Another remark is that the so-called "data paradox" (e.g. as in [15]) expressing the fact that "the world is drowning in data, but lacks knowledge" can be addressed by our methodology. Our methodology contributes to the definition of proper enumerable abstract data structures as outlined in [4].

Several features of our model have strong links to epistemology. There are also links with strong artificial intelligence [18] and even with philosophy [16]. The link to philosophy is to Popper and his Three Worlds theory that expresses the concept of reality. World one is for objects and events (physical), world two is for mental objects (emotional/conceptual) while world three is devoted to objective knowledge (theoretical). Our model belongs to the third world since it aims at specifying knowledge as objective knowledge.

This can be linked to modern attempts to extend the scope of AI (see [18] for references) through bypassing or extending the Turing's test of intelligence. None of them is fully satisfactory but they are challenging. It is a modern way of saying that computer science is the domain of exact mathematics while AI is the domain of heuristics.

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