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ONTOLOGICAL FRAMEWORK FOR TRUST & REPUTATION FOR DBE

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Abstract— *Today's e-Businesses rely heavily on trust and reputation systems. These systems are key indicators for businesses performance. Businesses that interact with each other for their business needs form a Digital Business Ecosystem (DBE). Members of DBE need to know the trust and reputation value of each other before the start of business interactions. The feedback mechanism is needed so that members of DBE form a unanimous opinion about trustworthiness of any specific member of the community and based their business interactions on this opinion. We present an ontological framework that will combine the feedback from all different trust and reputation information publicly available for a specific member of a domain and gives the knowledge representation on the bases of combined feedback. We call this ontological framework 'feedback ontology'.*

Index Terms—Trust, Reputation, Ontology, Digital Business Ecosystems.

I. INTRODUCTION

Today's e-Businesses rely heavily on trust and reputation systems. These systems are key indicators for businesses performance. Trust and reputation tools indicate that what the users want from a business, how to increase the productivity, how to improve a product and services, how to attract more customers. The ultimate objective of trust and reputation systems is to increase profit and revenue. It is a valuable tool for those businesses that continuously look for consumer's feedback and try to improve their services/product. Organizations that always look for consumer's trend enjoy a good reputation and increase in their profit. These organizations acts dynamically on the feedback of consumers and review their business strategies and operations. If they earn a bad reputation it is very difficult for them to persuade consumers to do dealing with them. Hence their existence is in danger. Especially those businesses that do not have physical outlets and that only exist online cannot afford bad reputation. With the increasing trends of e-Businesses the importance of trust and reputation technologies becomes many folds.

One of the important issues that need to be addressed with respect to trust and reputation is sharing of trust or reputation value. Sharing of trust or reputation value is sometimes desirable in virtual community and it is beneficial for members of community. Currently, commercial systems in virtual world have their own trust or reputation mechanisms, which work well for those systems. The prob-

lem is that if a member of a community wants to know the trustworthiness of another member across the domain, it is not possible to get information about queried member from all trust or reputation information of which it has membership. In other words, there is no way to know the reputation of a member of virtual community across the whole domain. Moreover, even if it is possible to collect the information from all commercial systems for a specific member, it is not possible to share information due to semantic difference. In this paper, we address the issues of sharing of trust and reputation information and semantics unification using ontology model.

E-Businesses linked together through web. This network of linked e-Businesses is called Digital Business Ecosystem (DBE) where each business entity is like a species that collaborate and cooperate with other species for its own benefit. To work in collaboration the members (species) of community must have understanding of their environment. For example, for members of trust-based commercial systems, the semantics for trust and reputation must be clearly defined in order to start business transactions.

Ontology is therefore, used as mediator between all domain users to unite on the semantics of that domain. For this reason our purposed framework is based on ontology. We call this ontology, 'feedback ontology'. Rest of this paper is arranged as follows. Section II is gives the literature review of trust and reputation methodologies and ontology framework. Section III is proposes the ontological framework for trust and reputation in digital business ecosystems. Section IV gives the conclusion and future work.

II. BACKGROUND

Our proposed framework is based on 'trust and reputation' methodologies and current ontology study. In this section we discuss the work done in these two important streams. A very good and comprehensive work on 'trust and reputation' has been done by Hussain [1]. The author has done a comprehensive literature review on 'trust and reputation'. This study includes the review of trust and reputation with respect to page rank based approach, deterministic approach, Bayesian network based approach, soft computing based approach and belief theory based approach. The author concluded that no work has taken into account the context dependent nature and dynamic nature of trust in service oriented environment. The trust or repu-

tation value may change over the time. This is dynamic nature of trust or reputation. Similarly the trust or reputation value is defined for a specific context. This is context dependent nature of trust or reputation. Some researchers defined trust as context aware but they failed to address the dynamic nature of trust [2, 3].

Recent work on trust and reputation with respect to Digital Business Ecosystems has been done by [4], [5], [6] where the researchers discussed different aspects of trust and reputation in Digital Business Ecosystems.

Trust and reputation for Service Oriented environments has been defined and discussed in detail by [7]. Authors devoted the whole book to different aspects of trust and reputation. The concept of trust has been defined as "a belief that the trusting agent has in the trusted entities' willingness and capability to deliver mutually agreed behaviour in a given context, at a given time slot." In this definition trusting agent may be a service requester and trusted agent may be a service provider. The belief in trusted agent's willingness and capability is based on interaction with trusted agent in past. This willingness and capability may change with the same. Hence the belief that trusting agent has in trusted agent may change. On the bases of this belief trusting agent assigns a trust value. Trust value is stored in a database called trust database.

The concept of reputation is more complex since it involves third party recommendation agent. [7] defined reputation of an entity as "an aggregation of the recommendations from all third party recommendation agents in response to the reputation querying agent's reputation query about the trustworthiness value of the reputation queried entity in a given context and in a given time slot." In this definition third party recommendation agent is an entity that has direct interaction with trusted agent. Trusting agent in this case may not have direct interaction with trusted agent. It therefore, places a query about the reputation of trusted agent to recommendation agent. Trusting agent decides about interaction with trusted agent on the basis of recommendation it receives from recommendation agent. Different recommendation agents may have different trust value for a trusted agent in the same context and in the same time slot. Reputation value is aggregation of all these trust values. Reputation values are stored in a database called reputation database.

We have discussed in detail about what is trust and reputation, what are trust and reputation values and what are trust and reputation information. For our work [1], [7] provides more focused approach. However, they have not covered the sharing of trust or reputation value across the domain. We proposed the ontological framework to overcome this problem[8]. Therefore, we review some literature on ontology, especially the literature on ontology in services oriented environment.

Although research on ontology has been initiated by the researchers in Artificial Intelligence in Computer Science, lot of efforts has been put in Semantic Web. Semantic Web

is a science used to convert web information into meaningful information that can be interpreted by automated tools. Hence using Semantic Web, information can be searched, shared and integrated by machines [8]. Power to Semantic Web can be provided using Ontology. Important work has been done in Ontology for semantic web by [9], [10], [11].

The most cited definition of ontology is given by Thomas R. Gruber [12]. Simply this definition can be put as 'a shared conceptualization'. Conceptualization is an abstraction of concepts and relationships between concepts in a specific domain. Ontology represents shared knowledge of a domain. Hence ontology is representation of concepts and relationships between concepts for knowledge representation in a specific domain where these concepts and their relationships are agreed upon and shared by all members of domain.

According to [7] ontology can be classified into three levels of generality, namely generic ontologies, domain ontologies and application ontologies. Users of the domain need to agree at least on generic ontology otherwise, it is not an ontology. We propose a generic feedback ontology on the basis of which application level ontologies can be build for different commercial systems.

III. OUR PROPOSED FRAMEWORK

In section I we defined that the problem with existing commercial businesses in virtual world is that they cannot share the trust or reputation value of a user/consumer to other members of domain due to semantic difference and lack of tool/methodology that collects trust or reputation value from all trust or reputation information. We suggested that best solution to this problem is to share the knowledge in a domain and best way to share knowledge is to agree upon the semantics used in this domain. We also studied in section II that good solution to this problem is ontology. In this section we present a framework for feedback ontology.

Feedback ontology acts as a mediator between different trust and reputation information. The framework is depicted in figure 1 below. An entity makes request to know the reputation of another entity which is not known directly to requesting entity. The entity that is initiating request is called trusting agent and the entity for which reputation request is being made is called trusted agent. We call the reputation request as reputation query. We call the all commercial systems from where the information about a trusted agent is collected, as sites. If n sites are participating in one reputation query then we can represent these sites as a set $S = \{S_1, S_2, \dots, S_n\}$. Each site interacts with a feedback hub. A feedback hub is a repository that has pattern or semantic from each site. This repository is used by feedback agent to look for pattern that each site provides for a trusted agent. Feedback agent then translates the pattern of each web site into its own semantic using feedback ontology. The result of reputation query is then returned to trusting agent.

The process starts with the reputation query submitted by the trusting agent to feedback agent. The feedback agent performs two important tasks. It retrieves reputation value of trusted agent from each site on which trusted agent is registered. It looks for pattern/semantic from feedback hub. After that feedback agent uses feedback ontology. As we discussed earlier that feedback ontology defines semantic that is acceptable by all members of the domain. Feedback agent uses this semantic and match it with the patterns from feedback hub. Based on this matching all reputation values from sites are converged into one reputation value that can be than represented in a form that is acceptable by all members of the domain. We can see the ontological engine that actually processes the convergence of reputation values on the basis of semantics defined in feedback ontology.

The benefit of using feedback hub instead of directly enquiring site for the pattern is that feedback mechanisms are less likely to change and it is cost effective to acquire them in a repository instead of retrieving them for each reputation request.

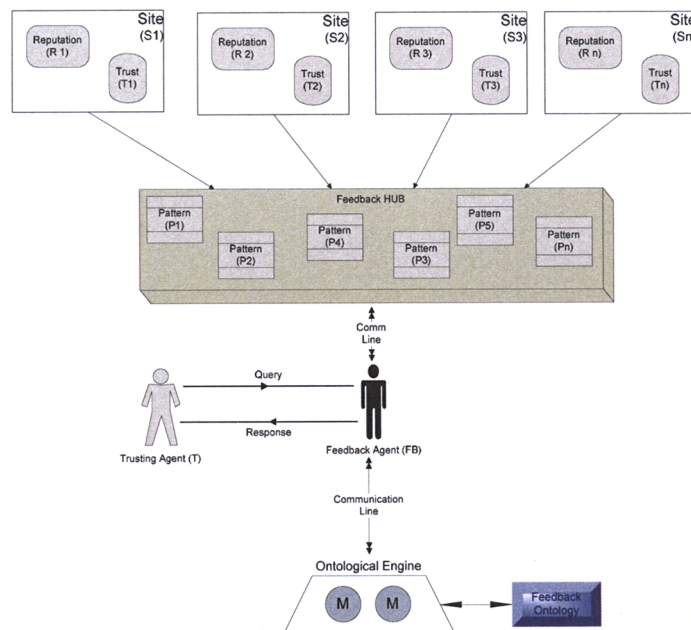


Figure 1: Proposed Ontological Framework

- Business process environment
- Database and resources

In Figure 2 we are going to further refine our framework by adopting layered approach where we separate similar environment entities and restrict them in a single environment layer. For example, in web services layer we grouped web services protocols. The complete process for feedback ontological transactions is shown in this figure. The whole process is divided into four basic layers.

- Web services
- Agent environment

As mentioned earlier the web services are confined with one single environment layer. All agents are defined in agent environment. The business process environment is the main layer where all the processes are defined and feedback ontology transactions processes are happening. All these process information as well as resources and Ontology info are stored in database layer.

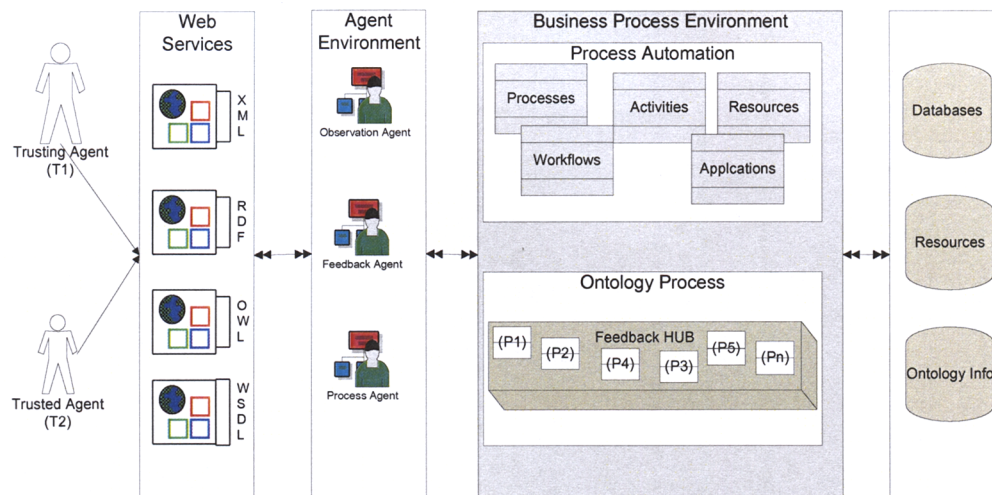


Figure 2: Layered process for feedback ontological transactions

Each layer of our framework communicates with other layers and performs their actions. The trusting agent (T1) sends a request for particular feedback. This request uses web services technologies and feedback agent uses business process environment to retrieve particular feedback from database. The business process environment also uses ontology process where feedback ontology is matched with different patterns. The requested feedback of trusted agent (T2) sends back to trusting agent. The process agent will communicate with feedback agent and responds to all incoming request. The observation agent will keep observing the changes and react with new changes.

IV. CONCLUSION AND FUTURE WORK

With the expansion of businesses over internet, the need to know reputation of business partners is increasing. In digital business ecosystems environment entities interacts with each other in a collaborative and cooperative manner. However, this collaboration and cooperation is not possible unless there is a business trust between each other. We are lack of model that makes it possible to share trust and reputation information between interacting business entities.

The solution we proposed is the ontological framework which enables the e-Businesses to share trust and reputation values. We have done this by use of ontology which acts as a mediator between members of domain so that feedback can be shared. In our framework feedback agent is introduced that interacts with other agents to integrate information and converge it to a single value. Feedback hub has also been introduced which is the repository of patterns/semantics for each business partner.

This is initial effort towards the building feedback ontology which has many other benefits for members of DBE. In this paper we have presented the framework for this ontology. Actual development of feedback ontology and its implementation is our future work.

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