Arguing over Evidences for Establishing Contracts

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Abstract. In the last decades, interest in systems of argumentation within the artificial intelligence community has grown considerably. Such interest has been disseminated across several sub-areas of artificial intelligence. The multi-agent systems (MAS) community began to work with argumentation by developing a notion of rational interaction. An important system of argumentation was proposed by Dung, who developed an abstract framework for argumentation and its semantics. More recently, argumentation-based negotiation (ABN) emerged as an important interaction method for MAS. In this paper, we use ABN with the purpose of embedding argumentation in a negotiation protocol. We propose the development of a model that includes the capability to argue over past contractual evidences. By this means, agents can generate and exchange arguments and counter-arguments in order to better assess the risk they incur in a business relationship. Based on such assessment, agents can also discuss the contract terms that better fit their purposes.

Keywords: Argumentation-based negotiation, Abstract framework for argumentation, Negotiation protocol

1 Introduction

In the last decades, interest in systems of argumentation within the artificial intelligence community has grown considerably. Such interest has been disseminated across several sub-areas of artificial intelligence, as can be seen in [1,2,3,4]. The multi-agent systems community began to work with argumentation by developing a notion of rational interaction [5, 6].

An important system of argumentation was developed by Dung [7], where he presents a very abstract framework for argumentation and a series of semantics for this framework. This system was the basis for several other proposals [8,9,10,11,12]. According to [13], an argumentation system is a useful abstraction mechanism for understanding several forms of reasoning needed to be performed by agents in either other cooperative or competitive scenarios.

More recently, argumentation-based negotiation (ABN) emerged as an important interaction method for multi-agent systems. According to [14] ABN can be seen as a way to enhance classical negotiation dialogues between artificial agents and progress toward human computer negotiation. In [15], McBurney states that ABN is gaining increasing importance as a fundamental concept in multi-agent interaction, mainly

because it enables rational dialogues and because it enables richer forms of negotiation than have hitherto been possible in classical approaches like game-theoretic [16] or heuristic-based models [17,18].

According to [19], an ABN allows agents to exchange additional meta-information such as justifications, critics, and other forms of persuasive locutions within their interactions. The author also says that the negotiation within ABN also provides a means for the agents to achieve mutually acceptable agreements to the conflicts of interests that they may have in relation to their different influences.

In [20], Toni classifies the use of argumentation as follows:

(i)   to help agents in making decisions, either in isolation (by evaluating pros and cons of conflicting decisions) or in an open and dynamic environment (by assessing the validity of information they become aware of);

(ii) to support negotiation and conflict resolution amongst agents; and

(iii) to improve the assessment of the trustworthiness of agents in contract-regulated interactions.

In this paper, we use ABN with the purpose of embedding argumentation on an existing negotiation protocol, which introduces advanced features, such as multiple-attribute negotiation and learning in a multi-round approach.

We propose a model that includes the capability to argue over past contractual evidences. By this means, agents can generate and exchange arguments and counter-arguments in order to better assess the risk they incur in a business relationship. Based on such assessment, agents can also discuss the contract terms that better fit their purposes.

This paper presents a preliminary investigation aimed at understanding how we can extend a contract negotiation protocol with argumentation over past contractual evidences. To this end, we studied several concepts about argumentation processes, analyzing some frameworks and reasoning methods with the purpose of defining an argumentation model that is to be employed in both the selection of the best business partner and in the negotiation of contract clauses to be included in a business relationship.

In the following section we present the motivation of the proposed work. In Section 3 we provide an overview of the main approaches to abstract argumentation frameworks and the works that derived from them. Section 4 is dedicated to the presentation of the proposed work. Finally, section 5 concludes.

2 Motivation

Frameworks for automated negotiation [21] have been developed mainly using either game-theory or heuristic approaches. Most researchers define negotiation as a process to reach a mutually acceptable agreement on a search space. Generally, the negotiation frameworks are based on a bargaining process and they offer negotiation protocols for reaching agreements.

We have implemented an agent-based platform – an Electronic Institution (EI) – that provides a number of services for B2B contracting, covering research areas as

diverse as automated negotiation protocols and strategies [22], ontology mapping [23], normative environments [24], and computational trust [25, 26].

Recently, there are several research initiatives [10,12,14,19] concerned with mechanisms for argumentation-based negotiation that can be used to facilitate negotiation among computational agents. In this way, negotiating agents can argue about conflict resolution during the negotiation process. According to [27], through a process of argumentation an agent may justify its negotiation stance and/or influence another agent's negotiation stance.

In our work, argumentation will be useful when a client agent finds some past contractual evidence indicating that a potential business partner did not fulfill an agreement, and thus cannot be taken as trustworthy. Therefore, the client agent will prepare an argument, to be put forward to the potential business partner. In this way, these agents must know to generate, select and evaluate arguments.

To illustrate these points, we have two agents, a client agent (CA) and a business partner (BP), in which the latter was selected as the one providing the best proposal, among a possible set of deals, by the client agent. Now, in this moment, the argumentation process will take place. The two agents need to provide an argument or counter-argument. The first argument is provided by the client agent, with the purpose of raising questions about the competence of the business partner, i.e., whether it is capable of fulfilling an agreement or not.

A possible short dialogue among these agents is the following:

- CA: I am happy with the proposal, but probably you cannot comply with the agreement.
- BP: no, I can
- CA: So, why did you fail an agreement with characteristics similar to this one?
- BP: Because I had some problems with my own supplier.
- CA: Who assures me that you will not fail again?
- BP: Now, I already have all the parts I need to provide you this product you are asking.

At one hand the client agent may provide arguments from past contractual experiences. On the other side, the business partner will attempt to ensure that it will not fail.

To design and build a reasoning model that allows those agents to exchange arguments/counter-arguments, the following steps must be accomplished:

- Abstract argumentation framework, and
- A reasoning model for argumentation

Therefore, the main intention of this paper is to define an argumentation model that encompasses an abstract argumentation framework and a logic-based reasoning model (i.e., inference mechanism). The first defines binary attack relations and their semantics. The latter allows generating certain conclusion from information.

In the next section we present the main existing approaches on abstract argumentation frameworks and the works that emerged from them.

3 Related Work

In this section we will present existing main approaches to argumentation systems. Works related to argumentation have been proposed by McBurney and Parsons [15,28], Leila Amgoud [29], Rahwan [30], Dimopoulos and Nebel [31], Jenninngs et al. [32], Tohmé [33], Novais [34], Marreiros et al. [35, 36], Toni [20], and Parsons et al. [5], focusing in several aspects of argumentation, including argumentation systems and study of different logic models.

Most of the works aforementioned are based on an abstract argumentation framework proposed by Dung in [7]. The Dung's framework is one the most popular and influential model of argumentation in multi-agent systems [37].

Dung's abstract argumentation theory identifies general dialectical principles that underpin common sense reasoning [38]. In the next paragraphs, we summarize some of these principles.

Definition 1 [Dung Argumentation Framework]: A Dung Argumentation Framework is a pair (A, R), where A is a set of arguments and R is a binary attack relation over A, i.e., $R \subseteq (A \times A)$. All elements in A are called arguments and xRy means that x attacks y, where x is a counter-argument for y.
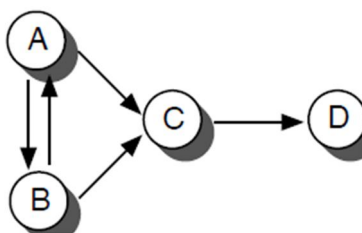
Figure 1 illustrates a Dung argumentation framework (AF).

Fig. 1. Dung's abstract argumentation framework.

In this figure the attack relation captures the situation where one argument undermines the credibility of another. Each node represents an argument and arcs represent "attack" relationship.

Definition 2 [Acceptability for Dung Framework]: Let (A, R) be an AF, and $S \subseteq A$. An argument $x \in A$ is acceptable with respect to S *iff* $\forall y \in A$ such that yRx, there exist a $z \in S$ such that zRy

In [38], Sanjay Modgil states that "the acceptability of arguments underpins evaluation of the status of arguments. If S is conflict free (no arguments in S attack each other), and all arguments in S are acceptable with respect to S, then S is said to be *admissible*. The status of arguments, under either a credulous or sceptical perspective, is then evaluated with respect to the extensions of a framework defined under different semantics".

Definition 3 [Extensions of a Dung Framework]: Let $\Delta = (A, R)$. Let $S \subseteq A$ such that $\forall x, y \in S$, it is not the case that xRy, in which case S is said to be conflict free. Then:

1. S is an admissible extension of Δ *iff* each argument in S is acceptable with respect to S.

2. S is a *complete* extension of Δ *iff* S is admissible, and every argument in A that is *acceptable* with respect to, is in S.

3. S is the *grounded* extension of Δ *iff* S is the minimal (with respect to set inclusion) complete extension

4. S is a *preferred* extension of Δ *iff* S is a maximal (with respect to set inclusion) complete extension.

5. S is a *stable* extension of Δ *iff* S is an admissible extension such that every argument not in S is attacked by an argument in S.

Definition 4 [Status of arguments in a Dung Framework] Let $\Delta = (A, R)$. For $s \in \{complete, preferred, stable, grounded\}$:

- If $x \in A$ is in at least one s extension of Δ then x is said to be credulously justified under the s semantics.
- If $x \in A$ is in all s extensions of Δ then x is said to be sceptically justified under the s semantics.
- If $x \in A$ is not in any s extension of Δ then x is said to be rejected under the s semantics.

According to [39] Dung's abstract framework provides the simplest way to formalize a set of arguments, consisting of naming arguments and representing the fact that an argument is challenged by another. This framework is abstract because both the nature of the arguments and the nature of the attack relation are ignored.

Therefore, the Dung's framework only captures attack relations and defines its semantics. However, it has not a reasoning model because each argument does not define a logical structure.

In this way, a number of argumentation frameworks were proposed based on Dung's framework that attempts to increase or generalise it.

The Assumption-Based Argumentation (ABA) [13,40], which is a slight modification of Dung's framework, enabling the construction of different argument systems, mainly based upon logic.

According to [40] ABA can be defined for any logic specified by means of (inference) rules, by identifying sentences in the underlying logic language that can be treated as assumptions.

From ABA a series of models were proposed. In [41], is defined a new semantic which uses preferences in a different way, namely to refine the result of an argumentation framework. In [42] ABA framework for a multi-agent system is mainly concerned with agents that have some common knowledge but may also have individual knowledge not necessarily shared by all agents. In [29] arguments are computed from a given set of rules and are supported by rules and assumptions. Also, an argument attacks another argument if the former supports a claim conflicting with some assumptions in the latter, where conflicts are given in terms of an underlying notion of contrary of assumptions. Rules, assumptions and contraries are defined in terms of an underlying logic language.

Other recent works related to systems of argumentation are being proposed in recent research projects as follows:

(i) Marreiros et al., [35] propose an agent-based model to simulate group decision making processes. The application area of this model is the multi-criteria decision problems, which aims to evaluate a set of alternatives relatively to a number of criteria which are conflicting in nature. Every agent

in this model is designed with emotional properties and reason with incomplete information, using persuasive argumentation for convincement and the best choice.

(ii) ArgEmotionAgents [43] is a project in the area of Ambient Intelligence that applies group argumentation and decision support considering emotional aspects. It models the participants in the Intelligent Reasoning module by means of a Multi-Agent approach. The idea of this system is to simulate the group of participants in order to feel the meeting trends, and generates as output a set of suggestions of arguments to exchange with other participants of the meeting.

(iii) VirtualECare [36] is a project that represents a new and cost-effective way for healthcare delivery and is in the intersection of Telemedicine, Virtual Healthcare and Electronic Medical Records. The VirtualECare is a group decision system supported by idea generation and argumentation. It is based on foundations of logical theory.

(iv) ArguGRID [44] is a project that developed a grid-based platform populated by rational decision-making agents associated with service requestors/providers and users. This platform also supports the argumentation-based negotiation between agents.

(v) ASPIC [45] is a project that aims to develop a theoretical consensus for four roles of argument (in inference, decision-making, dialogue and learning) and validate it within the context of a general software agent. It improves interaction between software agents and their human users in healthcare and other applications.

In the next section, we define an argumentation model to be used in a negotiation process that typically occurs in business relationships. Argumentation takes place among two agents on the final decision whether a deal among them will be reached or not. Furthermore, agents can also discuss contractual terms.

4   Proposed Work

This paper presents a preliminary investigation aimed at understanding how we can embed an argumentation process into a contract negotiation protocol. An existing EI platform [46] already provides a negotiation methodology that selects B2B partners, establishing and monitoring contracts between them. We would like to add to the existing negotiation protocol the capabilities of arguing over past contractual evidences and discussing the contract terms that better fit a particular business transaction. To this end, we study several concepts about argumentation process, analyzing some frameworks and reasoning methods with the purpose of defining an argumentation model that fits our purposes. In our case, an agent will use past contractual history to argue with a possible business partner.

Our EI platform contains a Computational Trust service that provides trustworthiness estimations based on contractual information about past business transactions that occurred. This information can be viewed as a set of evidences, each of which is described by a business context (including client, supplier and business

dimensions) and an enactment classification indicating, roughly, whether the contract was successful or not.

In [47], Urbano et al. define an evidence as an ordered tuple $Evd = AG \times AG \times CTX \times EO$, where AG represents the set of agents that can be involved in the interactions that are to be evaluated, CTX represents the set of all possible contexts that can describe the situation that lead to the evidence, and EO is the set of all evidence outcomes. Exemplifying, a business transaction is described in terms of the product that is being transacted with its quantity and delivery time. That is, to each transaction we get a possible instantiation of the context.

Negotiation is one of the most important tasks in electronic commerce. In our EI platform, the negotiation task may be assisted by a negotiation facilitator service. Through this service, agents representing different real-world entities and willing to engage in a collective contractual activity select partners according to different factors, including their capabilities, and current business needs.

During the negotiation process, a negotiation mediation agent (NegMed) may negotiate with several suppliers. This process is led using the QFNegotiation protocol [48]. In this protocol, negotiation proceeds in a number of rounds, with proposal submissions followed by an appropriate qualitative feedback of the NegMed agent. After a specified number of rounds, the proposal providing the best utility to the client is selected and a contract is established with the winning proposal's issuer. This process is illustrated in Figure 2.
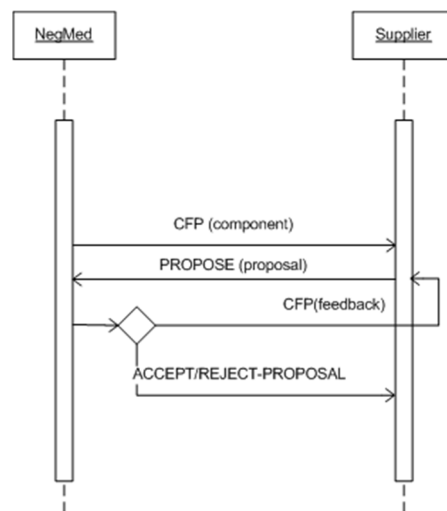
Fig. 2. QFNegotiation protocol.

Figure 2 depicts the QFNegotiation protocol, where NegMed and supplier agents engage themselves in a sequential negotiation process composed of multiple rounds of proposals and counterproposals that are actually qualitative comments to proposals (sent by NegMed to suppliers), until a winner proposal is selected. However, what happens if NegMed chooses a supplier that already failed a contract fulfillment with quite similar characteristics?

This question is very important and could have several answers depending on the approach. The main issue here is to try to find a way to improve the selection of business partners.

Trying to cope with this question, we could insert argumentation into the negotiation process, where NegMed may raise questions based on past business experiences. As soon as NegMed identifies the best proposal from a set of possible agreements, it could believe, based on past contractual evidences, that the selected supplier is not able to fulfill the agreement. On the other side, the selected supplier can be confident that it is able to fulfill this contract. This denotes an inconsistency among the agents. We will propose an approach to resolve this conflict through argumentation, in particular by extracting rationally justifiable positions using an abstract argumentation system [40].

According to [49] argumentation is a process through which arguments and counter-arguments are constructed and handled. Handling arguments may involve comparing arguments, evaluating them in some respects, and judging a constellation of arguments and counter-arguments to consider whether any of them are warranted according to some principled criterion. In [50], Toulmin states that argumentation is a process of making assertions or claims and providing support and justification for these claims using accumulated data, facts and evidence.

Figure 3 illustrates how an argumentation process could be coupled with the QFNegotiation protocol.
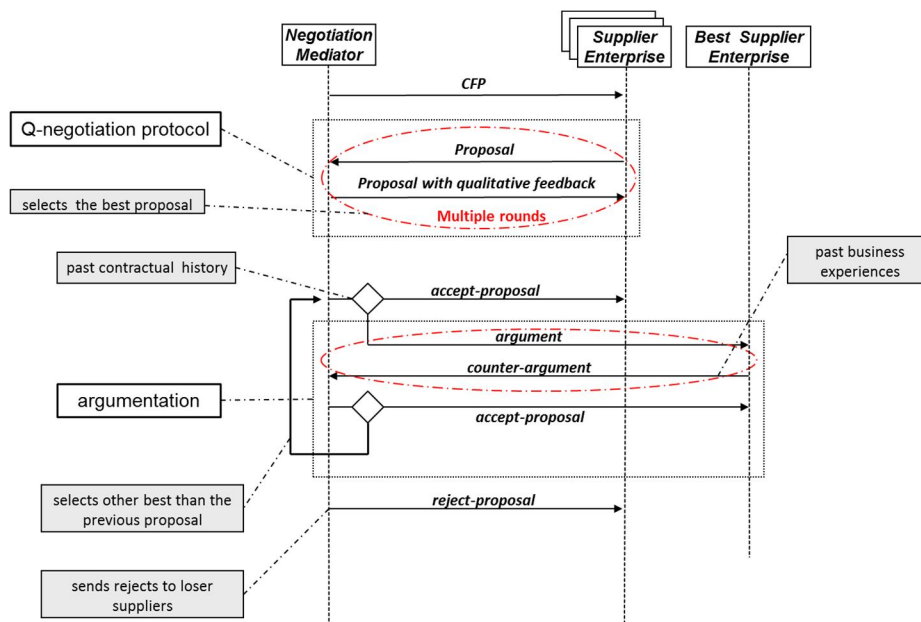

Fig. 3. Argumentation process within QFNegotiation protocol.

In the scenario depicted at Figure 3, NegMed tries to select the best deal from a set of deals. When the best proposal is chosen, it may put forward an argumentation

process with the supplier agent providing the best proposal in terms of utility. Thus, NegMed may argue about the future behavior of the supplier based on past contractual evidences. As soon as evidence is found, NegMed will generate an argument and the supplier agent will generate an argument/counter-argument.

As a result of evaluating an argument or counter-argument, NegMed will decide whether it either generates another argument, or comes to an agreement with this agent. But, if the supplier agent is not convincing about its capability to fulfill the to-be-formed contract, NegMed may initiate another argumentation process with the second best agent. This process may proceed until there are no more acceptable proposals or an agreement is reached.

Furthermore, in our argumentation model may be added to the QFNegotiation protocol the capability the agents discussing the contract clauses that better fit a particular business transaction.

4.1 Structure of partner selection process and Argumentation model

As mentioned before, the business partner selection is a phase where the NegMed agent has as main task to select a supplier agent based on negotiation utility. This decision task may result in a contract, which can be validated, registered and digitally signed. These contracts can to be handed by normative environment. The monitoring of the contracts can provide important information for trust building. A repository of trust information may then complete the circle by providing relevant inputs for future negotiations. Figure 4 shows the actual structure (1) and proposed new structure (2) of the services related with e-contract.
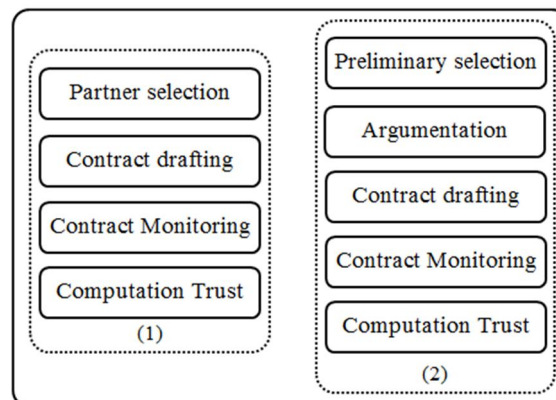

Fig. 4. E-contracting process: (1) without argumentation and (2) with argumentation

In this new structure (2), NegMed will use contractual evidences to compare its previous experiences (past context) with the actual situation (current context) in order to verify and choose the best partner. The argumentation process begins by detecting evidences that the partner has previously failed.

Taking previous experiences as a starting point, our argumentation model could take into consideration all available contractual evidences as input into a knowledge

base. Thus, from this base we could extract pertinent evidences for initiating an argumentation process. Therefore, the agent must generate arguments based on past contractual evidences.

The agent's knowledge base is composed of contractual evidences, taking from of a sequence of facts and rules. Further information may comprise the agent's beliefs, desires and intentions. In order to generate arguments, we will need some facts and some means of inferring conclusions from those facts. We will use as a starting point an inference mechanism, as can be view in the Figure 5.
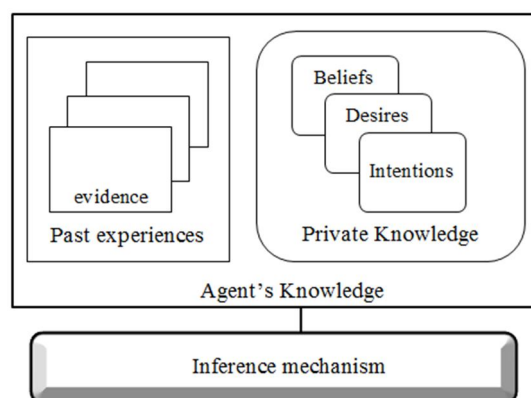
Fig. 5. Architecture of argumentation system

Taking into account that agents, NegMed and supplier, possess "in mind" some of the key arguments and counterarguments, the NegMed agent starts the argumentation process. This process is showed by means of an illustration in Figure 6.

NegMed: You have a tendency to fail in this context.
NegMed: So, it is very likely you come back to fail. **(a)**
supplier: yes, I know that. Because my quantity is high and delivery time
        is low. But my price is excellent. I think that worth risk. **(b)**
NegMed: The price is really very good, but I need for this short deadline. If
not, I need to be compensated. **(c)**
supplier: if I fail, you can apply me a penalty in the contract, so you will
        be compensated, but it is very unlikely. **(d)**
NegMed: ok, I accept your proposal

Fig. 6. Argumentation process among NegMed and supplier

In this illustration the NegMed raises a question using contractual evidences. That is, looking at past evidences, NegMed arrived in the following claim: it is likely that this supplier will fail in this context. Thus, an objection is raised in the form of a counter-argument made by the supplier, saying that although the quantity is high and delivery time is low, his price is excellent, and so on. In this dialogue, argument a

provides a justification, in which argument b challenges an a's justification part, which leads NegMed to propose a new justification with argument c.

To handle arguments systematically we need to formalize our constellation of arguments. The first step is to use abstract formalization using an attack relation. We follow the Dung abstract framework [7]. Figure 7 shows the attack relation among the arguments.

$$d \rightarrow c \rightarrow b \rightarrow a$$
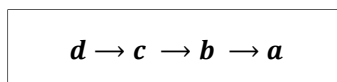
Fig. 7. Binary attack relation among arguments.

From Figure 7 we can draw that argument a was initial argument, which put forward a question; and other arguments are counter-arguments: the argument b contradicts a, and so son.

Through the formalization of figure 7, we will want from it to be able to construct argument and counterargument relevant to a particular situation of automatic way. To accomplish this task, however, we must of model reasoning, which we may use Dung abstract framework. Thus, we could compute the status of arguments (acceptability semantics).

In the present work, we consider agents having a knowledge base from past contractual evidences from which we will want from it to be able to construct different arguments for a determined claim. We might have the mechanism responsible for the generation, evaluation, and selection of arguments.

5   Conclusions

An argumentation-based negotiation approach is becoming more and more important in electronic business activities. This approach is mostly focused on how artificial entities can reach an agreement. In this way, nowadays, there are a number of approaches about abstract system and types of logics, aimed at richer argumentation process.

Our proposed work opens up the possibility of exploring different research issues about reasoning model and tools for generation, selection and evaluation of arguments. Specifically, our approach is to use contractual evidences-based reasoning in the business partner selection where the client agent may begin an argumentation process with a pre-selected partner. Each agent will maintain its own knowledge base.

First, how formalize the past contractual evidences in a knowledge base. What type of logic is more appropriate for our model? How handle with the conflicts and inconsistent information. Second, how pick up a possible argument between thousands. What existing techniques could to be used? Finally, how the agents could insert the contractual clauses within a dialogue.

We believe that our proposed model (or scenario), that establish contracts by arguing over evidences, may allow richer negotiations in e-business environments. However, the work is still preliminary.

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