

Association for Information Systems AIS Electronic Library (AISeL)

PACIS 2007 Proceedings

Pacific Asia Conference on Information Systems
(PACIS)

2007

Using Semantic Web Technology to Design Agent-to-Agent Argumentation Mechanism in an E-Marketplace

Shiu-li Huang

Ming Chuan University, slhuang@mcu.edu.tw

Chia-yin Lin

Ming Chuan University, arielpiggy@gmail.com

Follow this and additional works at: <http://aisel.aisnet.org/pacis2007>

Recommended Citation

Huang, Shiu-li and Lin, Chia-yin, "Using Semantic Web Technology to Design Agent-to-Agent Argumentation Mechanism in an E-Marketplace" (2007). *PACIS 2007 Proceedings*. 33.

<http://aisel.aisnet.org/pacis2007/33>

This material is brought to you by the Pacific Asia Conference on Information Systems (PACIS) at AIS Electronic Library (AISeL). It has been accepted for inclusion in PACIS 2007 Proceedings by an authorized administrator of AIS Electronic Library (AISeL). For more information, please contact elibrary@aisnet.org.

43. Using Semantic Web Technology to Design Agent-to-Agent Argumentation Mechanism in an E-Marketplace

Shiu-li Huang
Department of Information Management
Ming Chuan University
Taoyuan County 333, Taiwan (R.O.C.)
slhuang@mcu.edu.tw

Chia-yin Lin
Department of Information Management
Ming Chuan University
Taoyuan County 333, Taiwan (R.O.C.)
arielpiggy@gmail.com

Abstract

In existing e-marketplaces, buyers can use search engines to find products that exactly match their demands, but some products those are potentially interesting to them cannot be found out. This research aims to design a multi-agent e-marketplace in which buyers and sellers can delegate their agents to argue over product attributes via an agent-to-agent argumentation mechanism. A seller agent is able to persuade a buyer agent to believe the seller's product is interesting to the buyer. To make this idea possible, this research adopts the Semantic Web technology to express agents' ontologies and uses an abstract argumentation framework with dialectical game approach to support defeasible reasoning. This research hopes the proposed architecture and approach can help buyers to find out potential interesting products and help sellers to increase revenue through their agents and help existing and initiative e-marketplaces to design their argumentation mechanisms.

Keywords: Multi-agent e-marketplace, Argumentation mechanism, Semantic Web, Abstract argumentation framework, Defeasible reasoning

Introduction

Persuasive presentation and negotiation are fundamental tasks in a selling process (Oberhaus, Ratliffe, and Stauble 1993; Anderson 1995). A sales presentation is a persuasive communication that is the heart of a selling process. The salesperson introduces potentially interesting products to the prospect and promotes these products. After that, the salesperson deals with prospect resistance and objections, and arranges the terms of an agreement with the prospect in the negotiation stage. For e-commerce, agent technologies have been applied to online recommendation, searching, and selling for reaching a certain level of autonomy to release human's cognition and manual loads. For online selling, many negotiation agents have been researched (Matwin, Szapiro, and Haigh 1991; Oliver 1997; Wasfy and Hosni 1998; Zeng and Sycara 1998; Lin and Chang 2001; Dumas et al. 2002; Huang and Lin 2005). However, how to use agent technologies to facilitate persuasion for online selling is not well addressed yet. Huang and Lin (2005) proposed a sales agent, called Isa, to handle online persuasion and negotiation dialogues with human buyers. Isa can stand for a seller to persuade a buyer into increasing his/her product evaluation but it only focuses on agent-to-human argumentation. How to design an agent-to-agent argumentation mechanism is needed to be researched for reducing both sellers and buyers' loads and facilitating online selling.

Two obstacles must be broken through for designing an agent-to-agent argumentation mechanism. The first is how to enable agents in an e-marketplace to understand other agents' arguments. Semantic Web technologies can help Web information to be machine-understandable (Berners-Lee, Hendler, and Lassila 2001). This research adopts these technologies to overcome this obstacle. The second is how to prove whose arguments are

acceptable or not. Therefore, we need a well-developed argumentation framework to describe relations among arguments and prove their status. Argumentation in a multi-agent context is a process by which one agent attempts to convince another agent of the truth (or falsity) of state of affairs. This process involves agents putting forward arguments for and against propositions, together with justifications for the acceptability of these arguments (Wooldridge 2002). In an argumentation process, a truth can be defeated when new information appears. Dung (1995) developed an abstract argumentation framework for defeasible reasoning. The advantage of this framework is that it pays no special attention on the internal structure of the arguments and therefore this framework can be applied to every domain.

In existing e-marketplaces, buyers can set conditions and find out products exactly matching these conditions using search engines. The products those are potentially interesting to the buyer but do not exactly match the conditions cannot be found out. Many chances to deal are missed. Some researches have introduced Semantic Web technologies to e-marketplaces. Tomaz, Labidi and Wanghon (2003) designed a matchmaker agent to compute the degree of similarity among customers' requests and suppliers' advertisements in a B2B system. Li and Horrocks (2004) proposed a software framework for Web service matchmaking. Noia et al. (2004) developed a system for matching demands and supplies in an e-marketplace using a description logics-based knowledge representation approach. Colucci et al. (2005) introduced concept abduction and contraction into an e-marketplace for semantic-based matching and negotiation. Those researches improve semantic matchmaking between demands and supplies but this research aims to design a multi-agent e-marketplace in which buyers and sellers can delegate their agents to argue over product attributes via an agent-to-agent argumentation mechanism. Here Semantic Web technologies and Dung's abstract argumentation framework are adopted to design this mechanism. This mechanism can help buyers to find out not only exactly but also potentially interesting products. Moreover, it gives sellers a chance to persuade the buyer agents as well as buyers into considering or even buying their products.

Related Works

This section briefly describes Semantic Web and argumentation theory those are foundations of our mechanism design.

Semantic Web

Semantic Web was proposed by Berners-Lee (2001), the idea inherits some concepts of World Wide Web and adds "meaning" to the Web that enables machines to comprehend semantic documents and data. Nowadays people use software agents to search information and deal with some time-consuming or complex tasks is more and more popular, however agents cannot understand all data on the Web like people do. To make agents understand what the Web document means, in February 2004, World Wide Web Consortium (W3C) released the Resource Description Framework (RDF) and the Web Ontology Language (OWL) as W3C Recommendations for the Semantic Web structure. RDF is used to express information and to exchange knowledge in the Web. OWL is used to publish and share ontologies, which support advanced Web search, software agents, and knowledge management.

RDF

To represent resource meaning on the Web pages and facilitate automatic processing, W3C defined the first RDF specification in 1997. RDF provides a triple-based description language encoded in set of triples, each triple is made of subject, predicate and object. Figure 1 is a conceptual graph to illustrate RDF model, which is composed of nodes and edges. Nodes are

represented for resources or objects and edges are for properties of these resources, both of them are labeled URIs that means everyone can link to it, or retrieve a representation of it thanked to URLs' global scope.

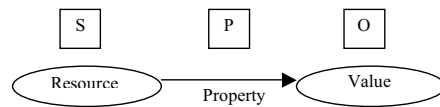


Figure 2: RDF Triple

In February 2004, RDF Schema (RDFS) became a recommendation. RDFS took the basic RDF model and XML syntax specification and extended it to support the expression of structured vocabularies. It has provided a minimal ontology representation language. Ontologies are used to capture knowledge about some domain of interest. An ontology describes the concepts in the domain and also the relationships between those concepts. Different ontology languages provide different capabilities. RDFS realizes ontology concept but still not represents meaning adequately, therefore, DAML+OIL and more recently OWL that are based on RDF appear.

OWL

The most recent development in standard ontology languages is OWL from W3C. OWL evolves from DAML+OIL that is a combination of OIL and DAML. The Ontology Inference Layer (OIL) is the first ontology language integrating feature from frame-based systems and description logics (DLs), and it is based on RDF and XML to express semantics. The DARPA Agent Markup Language (DAML) is used to develop a language and tools to facilitate the concept of the Semantic Web. For the same purpose, the joining of OIL and DAML bring a powerful language for defining and instantiating Web ontology. W3C slightly revised DAML+OIL to form OWL that builds on RDF and RDF Schema and adds more vocabularies for describing properties and classes (Herman and Hendler 2006). OWL is developed based on DL which makes it possible for concepts to be defined as well as described. Furthermore, OWL allows the use of a reasoner to check consistency (whether or not one class is possible to have any instances) and subsumption (whether or not one class is a subclass of another class).

There have been many scholars defining what an ontology is, in brief, ontologies are used to capture domain knowledge. An ontology describes the concepts (classes) in a domain and also the relationships (properties) between those concepts. Properties of each concept describe various characteristics and attributes (slots or roles) of the concept, and restrictions (facets or role restrictions) on slots. A knowledge base is composed of an ontology involving a set of individual instances of classes (Natalya & Deborah 2001). OWL can be categorized into three species according to its expressiveness: OWL-Lite, OWL-DL and OWL-Full. Readers can refer to the OWL Web Ontology Language Overview (Herman and Hendler 2006) for a more detailed synopsis of these species. This research will use OWL-DL to express agents' ontologies because it supports automatic reasoning based on DLs. DLs are a family of logic formalisms for knowledge representation (Baader, et al. 2002). The DL syntax and corresponding OWL elements are listed in Horrocks, Patel-Schneider, and van Harmelen (2003). Ontologies using the DLs can be easily described by OWL-DL for the Semantic Web. In addition to OWL, another language called SWRL is needed to specify rules in ontologies.

SWRL

SWRL (Semantic Web Rule Language) is a language to describe rules for the Semantic Web. The SWRL syntax is a combination of OWL and RuleML. RuleML is a XML-based rule language that adopts a kind of standardization and webizing form to present rules (Groszof 2004). SWRL also adopts OWL syntax because RuleML can make structure standardizing but cannot make content do, and rule usage cannot be stipulated either. OWL helps to define vocabulary and attributes used in the rules. We can use common [inference engine](#), such as Jess rule engine (<http://herzberg.ca.sandia.gov/jess/>), to reason a domain knowledge described by SWRL.

In common with many other rule languages, SWRL rules are written as antecedent-consequent pairs. In SWRL terminology, the antecedent corresponds to the rule body and the consequent corresponds to the rule head. The head and body consist of a conjunction of one or more atoms. SWRL rules reason about OWL individuals, primarily in terms of OWL classes and properties and also can refer explicitly to OWL individuals and support the common same-as and different-from concepts. Moreover, SWRL has an atom to determine if an individual, property, or variable is of a particular type. The type specified must be an XML Schema data type. Besides, SWRL supports a range of built-in predicates, which greatly expand its expressive power. SWRL built-ins are predicates that accept several arguments. They are described in detail in the SWRL Built-in Specification. The simplest built-ins are comparison operations. All built-ins in SWRL must be preceded by the namespace qualifier “swrlb:”. Finally, The SWRL Built-in Ontology describes the range of built-ins supported by SWRL. For mathematical built-ins, there are built-ins for strings, dates, and lists. Additions may be made to this namespace in the future so the range of built-ins supported by SWRL can grow.

Argumentation Theory

Toulmin Argument Structure

Toulmin Argument Structure gives a tool for both evaluating and making arguments. The main parts of Toulmin’s model are the data, claim, backing, warrant, rebuttal, and qualifier. A data is a fact that describes present situation. A claim is supported by data and by a warrant, which is a general rule or principle supporting the step from data to a claim. The backing is a justification for the warrant, and the rebuttal is a condition where a warrant does not hold. A qualifier expresses the applicability of the warrant (Toulmin 1958). Figure 2 illustrates an argument based on Toulmin’s model.

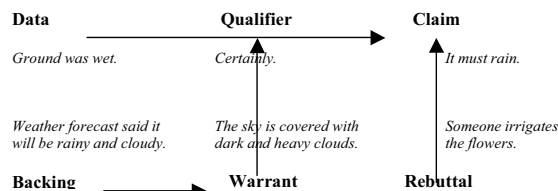


Figure 3: Toulmin Argument Structure

Toulmin Argument Structure is useful to organize arguments and knowledge but loosely specifies how arguments relate to each other and provides no guidance as to how to evaluate the arguments or prove their statuses.

Abstract Argumentation Framework

An abstract approach to non-monotonic logic developed in several articles by Bondarenko, Dung, Toni and Kowalski (below called the BDTK approach). The major innovation of the BDTK approach is that it provides a framework and vocabulary for investigating the general features of argumentation systems, and also for non-monotonic logics that are not argument-based. This section presents Dung's formulation (1995) because in Bondarenko et al. (1997) the basic notion is not for arguments but for a set of what they call "assumptions". They treat an argument as a set of assumptions.

Dung's abstract argumentation framework completely abstracts from both the internal structure of an argument and the origin of the set of arguments. The argumentation framework (AF) denoted as $AF = \langle AR, attacks \rangle$, where AR is a set of arguments, and an attack is a binary relation on AR . Here, an argument is an abstract entity whose role is solely determined by its relations to other arguments. The notation " \leftarrow " is an attack relation between two arguments. The relation $arg_1 \leftarrow arg_2$ denotes that arg_1 is attacked by arg_2 . Dung also defined various notions of so-called argument extensions, which are intended to capture various types of defeasible consequence. These notions are declarative, just declaring sets of arguments as having a certain status. The basic formal notions are as follows.

- An argument a is *attacked* by a set of arguments B if B contains an attacker of a (not all members of B need attack a).
 - An argument a is *acceptable* with respect to a set of arguments C , if every attacker of a is attacked by a member of C . For example, if $a \leftarrow b$ then $b \leftarrow c$ for some $c \in C$. In that case we say c defends a , and also that C defends a .
 - A set of arguments S is *conflict-free* if no argument in S attacks an argument in S .
 - A conflict-free set S of arguments is *admissible* if each argument in S is acceptable with respect to S .
 - A set of arguments is a *preferred extension* if it is a \subseteq -maximal admissible set.
 - A conflict-free set of arguments is a *stable extension* if it attacks every argument outside it.
- Dung showed that many existing nonmonotonic logics can be reformulated as instances of the abstract framework.

Defeasible Argumentation Systems

An argumentation framework also needs a proof theory to compute that a particular argument has a certain status. One approach is assigning priority ordering to arguments and an argument with lower priority cannot defeat a higher-priority argument. Another approach is using a dialectical game. Vreeswijk and Prakken (2000) proposed a dialectical form of an argumentation game between a proponent and an opponent as a natural form of a proof theory. The initial argument is acceptable if its proponent has a winning strategy; that is, if a proponent can make the opponent run out of moves against his/her any possible counter-arguments. Figure 3 illustrates two argumentation games, where a node means a move. A proponent's moves are denoted as black nodes and an opponent's moves are denoted as white nodes. The relation $P1 \leftarrow O1$ denotes that $P1$ is attacked by $O1$. Prakken (2001) defined the disputational status of a dispute move that a move M of a dispute D is *in* if and only if all moves in D that reply to it are *out*; otherwise M is *out*. The status of a move is *in* means that the argument of this move is acceptable. We can find that a leaf node in a dialogue tree must be *in* because it has no attackers. This approach is very easy to calculate the status of each argument. In game (a), for instance, $P1$ is acceptable and included in the admissible set $\{P1, P3, P4\}$. In game (b), however, $P1$ is unacceptable.

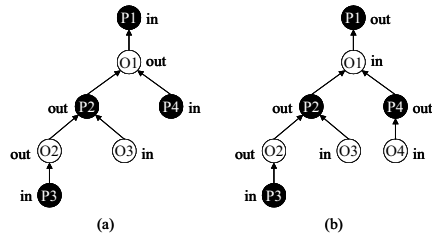


Figure 3: Argument Statuses in Dialectical Games

System Architecture

This research aims to design a multi-agent e-marketplace equipped with an agent-to-agent argumentation mechanism. In this e-marketplace, buyers can delegate their buyer agents to search products matching their needs and sellers can delegate their seller agents to persuade buyer agents to believe their products can match the buyers' needs. A buyer agent communicates with each seller agent and initiates an argumentation dialogue based on Dung's argumentation framework and Vreeswijk and Prakken's dialectical game approach.

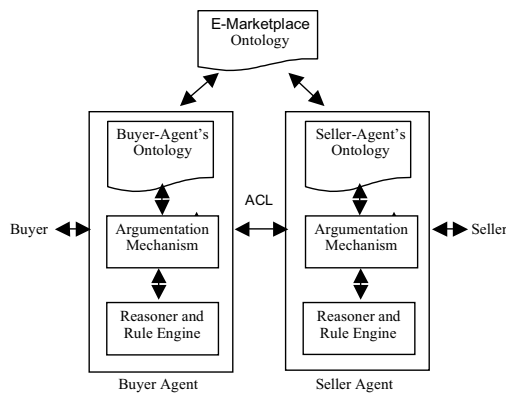


Figure 4: Architecture of Buyer and Seller Agents

Figure 4 illustrates the architecture of the buyer and seller agents. Each agent has its own ontology to represent its mental state and shares the e-marketplace ontology. An agent's mental state ontology describes concepts, relations, and rules about products defined by its master. The e-marketplace ontology defines the common vocabulary used in this e-marketplace and constitutes undefeatable rules that are supported by the most buyers and sellers. Once a dialectical game starts, an agent's argumentation mechanism is responsible for choosing arguments from its ontology to utter and these arguments are formed in Agent Communication Language or ACL based on speech acts (Searle 1969). The reasoner and rule engine help the agent to check the consistency between the opposite agent's arguments and its own mental state ontology. This research uses Java programming language to develop this system based on Jade multi-agent platform (<http://jade.tilab.com/>) that complies with the

FIPA (Foundation for Intelligent Physical Agents) specifications (<http://www.fipa.org>). Ontologies are described in OWL and SWRL formats.

Demonstration of Agent-to-Agent Dialogues

This research adopts a cell phone trading marketplace for demonstration. A buyer defines the conditions of a good or a bad cell phone and what conditions are non-negotiable according to his/her belief via a template (see Figure 5). These definitions will be transformed into rules in the buyer agent's ontology. A seller uses a similar template to define his/her own rules and inputs product information.

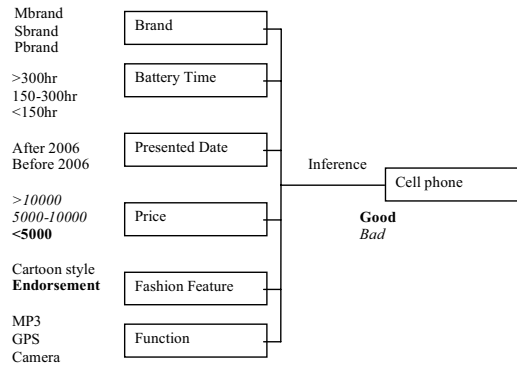


Figure 5: The Argumentation Template for a Buyer

Buyer and seller agents' arguments are issued according to the following steps:

- (1) Declaring demand and supply: The buyer agent proposes the initial argument about the buyer's ultimate need (stated in a rule head) and its conditions (stated in a rule body) and then the seller agent can agree or retort the buyer agent's argument. The seller agent seeks the rule in its ontology, which has the same rule head with the buyer agent's argument. Then, the seller agent checks if these two rules also have the same body. If they do, the seller agent will agree with the buyer agent, otherwise the seller agent will retort and declare its supply.
- (2) Checking the consistency of non-negotiable attributes: The buyer agent checks whether the non-negotiable attributes exist in the seller agent's argument. If they do not exist, the buyer agent will retort on the seller agent and the dialogue will be terminated. If they exist, the buyer agent will firstly check whether a conflict definition exists by asking the seller agent to inform the specific definitions. If the seller agent's definitions are consistent with the buyer agent's, then the buyer agent will agree with the seller, otherwise retort it and the dialogue is terminated.
- (3) Checking the consistency of negotiable attributes: The buyer agent asks the seller agent to inform the definitions of negotiable attributes. If the buyer agent's definitions are similar to the seller agent's then the buyer agent will agree with the seller agent. If the buyer agent's definitions are conflicting with the seller agent's then the buyer agent will retort it. If the buyer agent cannot find out a similar or a conflicting rule in its ontology with respect to the seller agent's definitions then the buyer agent will check the consistency between the e-marketplace ontology and the seller agent's definitions. The rules in the e-marketplace ontology have highest priority therefore if conflict occurs the buyer agent will retort on the seller agent, otherwise the buyer agent cannot disagree with the seller agent. The dialogue will be terminated when all attributes are checked.

(4) Updating the buyer agent's ontology: The seller agent's arguments that the buyer agent cannot refute will be added into the buyer agent's ontology. That means these arguments persuade the buyer agent to change its belief.

The following scenario with some cases of dialogue demonstrates how an argumentation proceeds using the argumentation mechanism.

Ariel wants to buy a cell phone and she thinks fashion and price are important criteria. She believes if a cell phone has the superstar Jay's endorsement, the cell phone is fashionable. Ariel's budget is smaller than NT\$ 5000, therefore Ariel does not consider the cell phones with prices higher than NT\$ 5000.

Ariel's demand can be represented by the following rules in her agent B's ontology:

B: $\text{GoodFashionCellphone}(x) \wedge \text{GoodPriceCellphone}(x) \rightarrow \text{GoodCellphone}(x)$
 $\text{hasEndorsement}(x, \text{Jay}) \rightarrow \text{GoodFashionCellphone}(x)$
 $\text{hasPrice}(x, \leq 5000) \rightarrow \text{GoodPriceCellphone}(x)$
 $\text{hasPrice}(x, > 5000) \rightarrow \text{BadPriceCellphone}(x)$
 $\text{BadPriceCellphone}(x) \rightarrow \text{BadCellphone}(x)$

Case 1: Seller agent S1 stands for its master to sell cell phone 1 described in Table 1. S1 believes that a good cell phone should have good function and good battery time. A cell phone has good function means it has the functions GPS and recorder. A cell phone has good battery time means its battery time exceed 200 hours. This belief can be represented as the following rules:

S1: $\text{GoodFunctionCellphone}(x) \wedge \text{GoodBatteryTimeCellphone}(x) \rightarrow \text{GoodCellphone}(x)$
 $\text{hasFunction}(x, \text{GPS}) \wedge \text{hasFunction}(x, \text{Recorder}) \rightarrow \text{GoodFunctionCellphone}(x)$
 $\text{hasBatteryTime}(x, \geq 200) \rightarrow \text{GoodBatteryTimeCellphone}(x)$

Table 1: The Specification of Cell Phone 1

| | |
|-----------------|---------------|
| Brand | Mbrand |
| Battery Time | 250 hrs |
| Presented Date | 2006/1/1 |
| Price | NT\$ 15998 |
| Fashion Feature | None |
| Function | GPS, recorder |

Dialogue between the agents B and S1 contains the following sequence of arguments:

B: $\text{GoodFashionCellphone}(x) \wedge \text{GoodPriceCellphone}(x) \rightarrow \text{GoodCellphone}(x)$
 \uparrow **retort**
S1: $\text{GoodFunctionCellphone}(x) \wedge \text{GoodBatteryTimeCellphone}(x) \rightarrow \text{GoodCellphone}(x)$
 \uparrow **retort**
B: $\text{BadPriceCellphone}(x) \rightarrow \text{BadCellphone}(x)$

In this case, S1 retorts B's initial argument because the two rules have same head but different bodies. Next, the buyer agent checks whether the non-negotiable attribute price can be satisfied by the seller agent's argument. In this case, B will retort S1 because the non-negotiable attribute price is not satisfied and the seller agent S1 cannot persuade the buyer agent B into believing Cell phone 1 satisfies Ariel's need. Thereafter, this dialogue is

terminated and the agent B does not add this cell phone into the buyer's option list. This is not a successful persuasion.

Case 2: Seller agent S2 sells Cell phone 2 (see Table 2) and believes that a good cell phone should have good function and good price. A cell phone has good function means it has the functions GPS and Email tool. A cell phone has good price means its price lower than NT\$ 10000. This belief can be represented as the following rules:

$$\begin{aligned} &S2: \text{GoodFunctionCellphone}(x) \wedge \text{GoodPriceCellphone}(x) \rightarrow \text{GoodCellphone}(x) \\ &\quad \text{hasFunction}(x, \text{GPS}) \wedge \text{hasFunction}(x, \text{EmailTool}) \rightarrow \text{GoodFunctionCellphone}(x) \\ &\quad \text{hasPrice}(x, \leq 10000) \rightarrow \text{GoodPriceCellphone}(x) \end{aligned}$$

Table 2: The Specification of Cell Phone 2

| | |
|-----------------|-----------------|
| Brand | Pbrand |
| Battery Time | 300 hrs |
| Presented Date | 2005/12/10 |
| Price | NT\$ 8999 |
| Fashion Feature | None |
| Function | GPS, Email tool |

Dialogue between the agents B and S2 includes the following sequence of arguments:

$$\begin{aligned} &B: \text{GoodFashionCellphone}(x) \wedge \text{GoodPriceCellphone}(x) \rightarrow \text{GoodCellphone}(x) \\ &\quad \uparrow \text{retort} \\ &S2: \text{GoodFunctionCellphone}(x) \wedge \text{GoodPriceCellphone}(x) \rightarrow \text{GoodCellphone}(x) \\ &\quad \uparrow \text{ask} \\ &B: \text{What is your definition of GoodPriceCellphone}(x)? \\ &\quad \uparrow \text{inform} \\ &S2: \text{hasPrice}(x, \leq 10000) \rightarrow \text{GoodPriceCellphone}(x) \\ &\quad \uparrow \text{retort} \\ &B: \text{hasPrice}(x, \leq 5000) \rightarrow \text{GoodPriceCellphone}(x) \end{aligned}$$

S2 firstly retorts B's initial argument. The dialogue can be continued because the buyer agent's non-negotiable attribute price is in the seller agent's argument. So, the buyer agent checks S2's definition of good price by asking it. The agent S2 believes a cell phone with price lower than NT\$ 10000 is a good-price cell phone but the agent B believes a cell phone with price lower than NT\$ 5000 is a good-price cell phone. The agent B retorts S2's argument because of this inconsistency. Thereafter, S2 cannot find any argument to retort back and this dialogue is terminated. Cell phone 2 does not be added into the option list. This is not a successful persuasion.

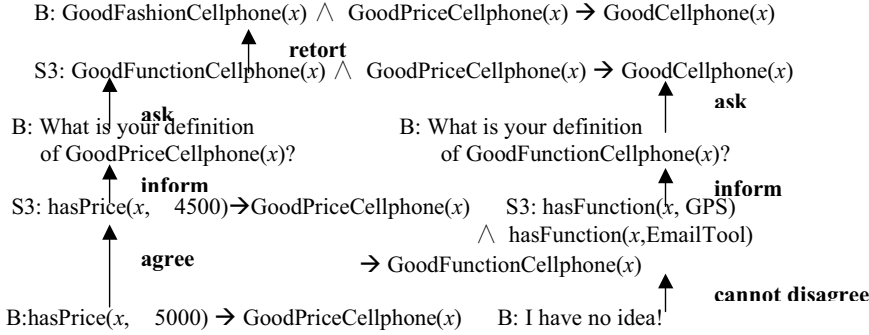
Case 3: Seller agent S3 sells Cell phone 3 (see Table 3) and believes that a good cell phone should have good function and good price. A cell phone has good function means it has the functions GPS and Email tool. A cell phone has good price means its price lower than NT\$ 4500. This belief can be represented as the following rules:

$$\begin{aligned} &S3: \text{GoodFunctionCellphone}(x) \wedge \text{GoodPriceCellphone}(x) \rightarrow \text{GoodCellphone}(x) \\ &\quad \text{hasFunction}(x, \text{GPS}) \wedge \text{hasFunction}(x, \text{EmailTool}) \rightarrow \text{GoodFunctionCellphone}(x) \\ &\quad \text{hasPrice}(x, \leq 4500) \rightarrow \text{GoodPriceCellphone}(x) \end{aligned}$$

Table 3: The Specification of Cell Phone 3

| | |
|-----------------|-----------------|
| Brand | Pbrand |
| Battery Time | 150 hrs |
| Presented Date | 2005/1/1 |
| Price | NT\$ 3999 |
| Fashion Feature | None |
| Function | GPS, Email tool |

Dialogue between the agents B and S3 contains the following sequence of arguments:



S3 informs B that a cell phone has a good price means its price is lower than NT\$ 4500, this definition is consist with B’s ontology. Therefore, agent B asks S3 what is its meaning about having a good function. S3 informs that a cell phone has good function means it has the functions GPS and email tool. After S3’s response, agent B cannot find any similar or conflicting rule in it and the e-marketplace ontology. Therefore, S3 persuades B into believing Cell phone 3 can potentially satisfy Ariel’s need. The buyer agent adds Cell phone 3 into option list even this cell phone does not exactly match the buyer’s need. The reasons: $\text{hasFunction}(\text{Cellphone}_3, \text{GPS}) \wedge \text{hasFunction}(\text{Cellphone}_3, \text{EmailTool}) \rightarrow \text{GoodFunctionCellphone}(\text{Cellphone}_3)$, and $\text{GoodFunctionCellphone}(\text{Cellphone}_3) \wedge \text{GoodPriceCellphone}(\text{Cellphone}_3) \rightarrow \text{GoodCellphone}(\text{Cellphone}_3)$ can used to explain to Ariel why the buyer agent add this cell phone into her option list. This is a successful persuasion.

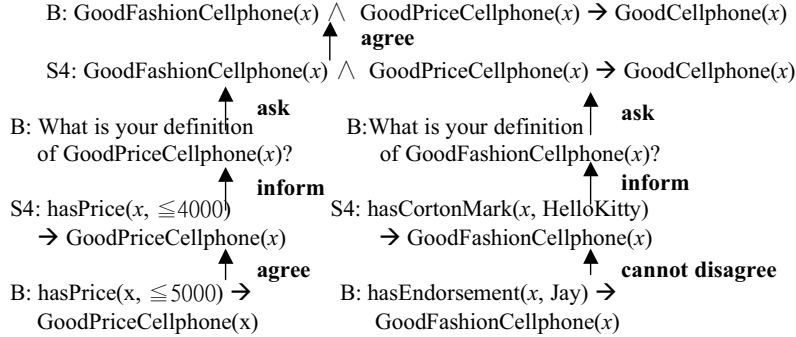
Case 4: Seller agent S4 sells Cell phone 4 (Table 4) and believes that a good cell phone should have good fashion feature and good price. A cell phone has good fashion feature means it has a Hello Kitty cartoon mark on it. A cell phone has good price means its price is lower than NT\$ 4000. This belief can be represented as the following rules:

- S4: $\text{GoodFashionCellphone}(x) \wedge \text{GoodPriceCellphone}(x) \rightarrow \text{GoodCellphone}(x)$
- $\text{hasCartoonMark}(x, \text{HelloKitty}) \rightarrow \text{GoodFashionCellphone}(x)$
- $\text{hasPrice}(x, \leq 4000) \rightarrow \text{GoodPriceCellphone}(x)$

Table 4: The Specification of Cell Phone 4

| | |
|-----------------|------------------------|
| Brand | Pbrand |
| Battery Time | 500 hrs |
| Presented Date | 2006/10/3 |
| Price | NT\$ 3455 |
| Fashion Feature | Hello Kitty style |
| Function | MP3 player, Email tool |

Dialogue between the agents B and S4 comprises the following sequence of arguments:



After the agent B checks whether they have the same definitions of having good price and having good fashion, the agent B concludes that the definitions of having good price are consistent. On the other hand, the agent B cannot disagree with S4's definition of having good fashion. The agent S4 believes a cell phone having a Hello Kitty cartoon mark is a fashionable cell phone. The agent B believes a cell phone having Jay's endorsement is a fashionable cell phone. These beliefs are not conflicting because the buyer did not say that a cell phone having a Hello Kitty cartoon mark is not fashionable, that is $\text{hasCortonMark}(x, \text{HelloKitty}) \rightarrow \text{BadFashionCellphone}(x)$. Therefore, the buyer cannot disagree with the S4's argument, and then Cell phone 4 will be shown in the buyer's option list. This is a successful persuasion.

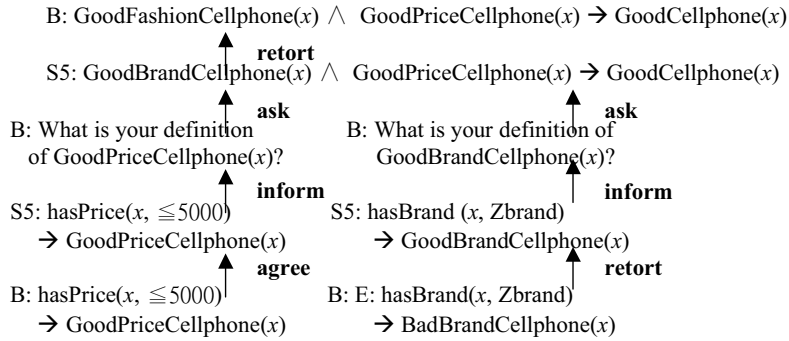
Case 5: Seller agent S5 sells Cell phone 5 (Table 5) and believes that a good cell phone should have good brand and good price. A cell phone has good brand means it is made by Zbrand Cooperation. A cell phone has good price means its price is lower than NT\$ 5000. This belief can be represented as the following rules:

S5: $\text{GoodBrandCellphone}(x) \wedge \text{GoodPriceCellphone}(x) \rightarrow \text{GoodCellphone}(x)$
 $\text{hasBrand}(x, \text{Zbrand}) \rightarrow \text{GoodBrandCellphone}(x)$
 $\text{hasPrice}(x, < 5000) \rightarrow \text{GoodPriceCellphone}(x)$

Table5: The Specification of Cell Phone 5

| | |
|-----------------|------------|
| Brand | Zbrand |
| Battery Time | 150 hrs |
| Presented Date | 2006/1/1 |
| Price | NT\$ 3999 |
| Fashion Feature | None |
| Function | MP3 player |

Dialogue between the agents B and S5 comprises the following sequence of arguments:



In this case, S5 believes a cell phone with the brand Zbrand is a good-brand cell phone. The buyer agent cannot find an inconsistent rule in its ontology but in the e-marketplace ontology. The e-marketplace ontology collects most members' opinions. Here most members believe that Zbrand is not a good cell phone brand. Therefore, the buyer agent retorts S5's argument using the rule backed by the e-marketplace. The agent S5 cannot retort back because the rule supported by the e-marketplace cannot be defeated. Cell phone 5 will not be added into the buyer's option list and this is not a successful persuasion.

In above cases, according to Vreeswijk and Prakken's approach (Vreeswijk and Prakken 2000; Prakken 2001), the system can judge argument statuses when a dialogue is terminated. If the buyer agent is finally able to retort the seller agent's argument, the seller agent cannot persuade the buyer agent to believe the product is interesting. If the buyer agent cannot retort the seller agent's arguments, the buyer agent will believe the seller agent's propositions.

Conclusion

This research designs an e-marketplace based on the proposed architecture and approaches. Using the agent-to-agent argumentation mechanism, buyers can find out potential interesting products through their agents. Moreover, sellers can delegate their agents to change buyer agents' beliefs and recommend their product to the buyers. To make agent-to-agent argumentation possible, this research adopts OWL and SWRL to clearly express agents' ontologies and uses an abstract argumentation framework with dialectical game approach to support defeasible reasoning. We hope the innovative architecture and approaches can help existing and initiative e-marketplaces to design their argumentation mechanisms and benefit both buyers and sellers. In the future, we will conduct a laboratory experiment to evaluate this argumentation mechanism by building many seller agents to sell cell phones and inviting subjects to act as buyers. After a buyer agent communicates with all seller agents an option list will be recommended to the buyer. The mechanism can be evaluated by measuring the subjects' satisfaction degrees with their option lists.

Acknowledgment

The authors would like to thank the National Science Council, Taiwan, for supporting this work (NSC 95-2416-H-130-020-).

References

- Anderson, R. *Essentials of Personal Selling: The New Professionalism*, Prentice-Hall, inc., New Jersey, 1995.
- Baader, F., Calvanese, D., Mc Guinness, D., Nardi, D. and Patel-Schneider, P. *The Description Logic Handbook*, Cambridge University Press, 2002.
- Berners-Lee, T. "Weaving the Web," *San Francisco: Harper*, 1999.
- Berners-Lee, T., Hendler, J., and Lassila, "The Semantic Web," *Scientific American*, 2001, pp. 34-44.
- Bondarenko, A., Dung, P. M., Kowalski, R. A., and Toni, F. "An Abstract, Argumentation-Theoretic Approach to Default Reasoning," *Artificial Intelligence* (93:1), 1997, pp. 63-101.
- Colucci, S., Noia, T. D., Di Sciascio, E., Donini, F and Mongiello, M. "Concept Abduction and Contraction for Semantic-based Discovery of Matches and Negotiation Spaces in an E-Marketplace," *Proceedings of the 6th International Conference on Electronic Commerce*, 2004, pp. 41-50.
- Colucci, S., Noia, T. D., Di Sciascio, E., Donini, F. and Pinto, A. "Knowledge Elicitation for Query Refinement in a Semantic-Enabled E-Marketplace," *Proceedings of the 7th International Conference on Electronic Commerce*, 2005, pp. 685-691.
- Dumas, M., Governatori, G., Hofstede, A.H.M., & Oaks, P. "A Formal Approach to Negotiating Agents Development," *Electronic Commerce Research and Applications* (1:2), 2002, pp. 193-207.
- Dung, P. M. "On the Acceptability of Arguments and its Fundamental Role in Nonmonotonic Reasoning, Logic Programming and N-Person Games," *Artificial Intelligence* (77:3), 1995, pp. 321-358.
- Grosz, B. N. "Representing E-Commerce Rules via Situated Courteous Logic Programs in RuleML," *Electronic Commerce Research and Applications* (3:1), 2004, pp. 2-20.
- Herman, I. and Hendler, J. "Web Ontology Language (OWL)," Retrieved from <http://www.w3.org/2004/OWL/>, 2006.
- Horrocks, I., Patel-Schneider P. F., and van Harmelen F. "SHIQ and RDF to OWL: The Making of a Web Ontology Language," *Journal of Web Semantics* (1:1), 2003, pp. 7-26.
- Horrocks, L., Patel-Schneider, P. F., Boley, H., Tabet, S., Grosz, B., and Dean, M. "SWRL: A Semantic Web Rule Language combining OWL and RuleML," Retrieved from <http://www.w3.org/Submission/SWRL/>, 2004.
- Huang, S. L., Lin, F. R. "Designing Intelligent Sales-agent for Online Selling," *Proceedings of the 7th International Conference on Electronic Commerce*, Xi'an, Chian, 2005, pp. 279-286.
- Li, L. and Horrocks, I. "A Software Framework for Matchmaking Based on Semantic Web Technology," *International Journal of Electronic Commerce* (8:4), 2004, pp. 39-60.
- Lin, F. R. and Chang, K. Y. "Enhancing the On-Line Automated Bargaining Process Using Bargaining Pattern and Dynamic Price Issuing Approaches," *IEEE Intelligent Systems* (16:4), 2001, pp. 41-47.
- Matwin, S., Szapiro, T., & Haigh, K. "Genetic Algorithm Approach to A Negotiation Support System," *IEEE Transactions on Systems, Man, and Cybernetics* (21:1), 1991, pp. 102-114.
- Natalya F. N. and Deborah L. M. *Ontology Development 101: A guide to Creating Your First Ontology*. Stanford University, Stanford, CA., 2001.
- Noia, T.D., Sciascio, E.D., Donini, F.M., and Mongiello, M. "A System for Principled Matchmaking in an Electronic Marketplace," *Proceedings of the International WWW Conference*, Budapest, Hungary, 2003, pp. 321-330.
- Oberhaus, M.A., Ratliffe, S. and Stauble, V. *Professional Selling: A Relationship Process*, Harcourt Brace Jovanovich College Publishers, Orlando, 1993.

- Oliver, J.R. "A Machine Learning Approach to Automated Negotiation and Prospects for Electronic Commerce," *Journal of Management Information Systems* (13:3), 1997, pp. 83-112.
- Prakken, H. "Relating Protocols for Dynamic Dispute with Logics for Defeasible Argumentation," *Synthese* (127:1-2), 2001, pp. 187-219.
- Searle, J. *Speech Acts, An Essay in the Philosophy of Language*, Cambridge, UK:Cambridge University Press, 1969.
- Shadbolt, N., Hall, W., and Berners-Lee, T. "The Semantic Web Revisited," *IEEE Intelligent Systems* (21:3), 2006, pp. 96-101.
- Tomaz, R.F., Labidi, S., and Wanghon, B. "A Semantic Matching Method for Clustering Traders in B2B Systems," *Proceedings of the IEEE/LA-Web First Latin American Web Congress*, Santiago, Chile, 2003.
- Toulmin, S. *The Uses of Argument*, Cambridge University Press, Cambridge, 1958.
- Vreeswijk, G. and Prakken, H. "Credulous and Sceptical Argument Games for Preferred Semantics," *Proceedings of the 7th European Workshop on Logic for Artificial Intelligence*, Berlin, Springer Verlag, 2000, pp. 239-253.
- Wasfy, A. M., and Hosni, Y. A. "Two-Party Negotiation Modeling: An Integrated Fuzzy Logic Approach," *Group Decision and Negotiation* (7:6), 1998, pp. 491-518.
- Wooldridge, M. *An Introduction to Multi-agent Systems*, John Wiley & Sons, 2002.
- Zeng, D., and Sycara, K. "Bayesian Learning in Negotiation," *International Journal of Human-Computer Studies* (48:1), 1998, pp. 125-141.