Semantic Web Based Formalization of Argumentation Mechanism in E-Commerce Negotiation

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ABSTRACT: *The argumentation-based negotiation is among the most recent negotiation approaches. It is studied in several research works which mainly propose general models. The modeling of argumentation-based negotiation mechanism for a specific domain such as e-commerce requires taking into account its specificity with regard to the nature of exchanged information, the various situations of the negotiation parts and advantages and disadvantages of possible decisions. The main issue in the use of the argumentation-based negotiation is the formalization of the negotiation mechanism. This study aims to propose a semantic web based formalization of argumentation mechanism in e-commerce negotiation; the proposed approach is inspired from the theoretical model developed by Toulmin, S. and the force field analysis technique of Lewin, K. We argue in this paper that our approach synthesizes and improves the general approaches of argumentation. The semantic web based formalization comprises the representation of the elements of arguments, the forces conducting the taken decisions, as well as the protocol of arguments exchange. Semantic web technologies are also employed in the representation of all knowledge which relates to marketplace and its elements (products, buyers and sellers). The electronic marketplace architecture presented in this work is a multi-agent system; the developed agents (Buyer agent and Seller agent) exploit a set of ontologies (MarketOntology, BuyerOntology, SellerOntology, LaptopOntology and ArgumentOntology) and Laptops are chosen as a case of study of sold products.*

Keywords: Multi-agent System, Argumentation-Based Negotiation, Semantic Web, Argument Formalization, Persuasion, Toulmin's Argument Model, Force Field Analysis, E-Commerce

Received: 1 September 2011, Revised 2 November 2011, Accepted 18 November 2012

1. Introduction

In Argumentation-based negotiation approaches like [27] [12] [17], each agent argues to convince other agents to change their beliefs and to adopt its own view, its own beliefs and its own intentions.

We noted that most researches concerned with the argumentation-based negotiation deal with problems in general, while there is a disparity between the various application domains of negotiation. The use of argumentation-based negotiation in electronic commerce needs to study human commercial negotiation strategies and tactics and to study extant theoretical frameworks on argumentation based negotiation, in order to propose a negotiation mechanism that able to succeed the negotiation dialogue between Seller agents and Buyer agents.

In this paper we propose a semantic web based formalization of the argumentation-based negotiation mechanism in electronic marketplace. The proposed approach aims to employ semantic web technologies [5] to represent the theoretical model of argument developed by the philosopher [32] that will be used as an interchanged argument between agents during the negotiation dialogue. In addition, this study aims to use the Force Field Analysis technique proposed by [13] as evaluation method of incoming arguments. Some elements of the negotiation mechanism are inspired from the works described in [27] [12] [17] [29-31]. The contribution of this work appears in the formalization of an argumentation based negotiation mechanism specific to e-commerce, the use of semantic web technologies in order to make interchanged arguments more meaningful and more understandable and the formalization of philosophical and psychological techniques to represent as possible the human behavior in negotiation process.

The reminder of the paper is organised as follows. In Section 2 related work; Toulmin's model of argument, persuasive argumentation based approaches and force field analysis technique are discussed. This section is concluded by the presentation of the limits of existing approaches. Section 3 describes the semantic web based formalization of elements and mechanisms in a specific domain. Section 4 describes the general architecture of the negotiation system. In Section 5 the semantic web techniques are employed to give formal representation of arguments. Next, in Section 6, the argumentation mechanism is also formalized. Finally, Section 7 presents authors conclusions and future work.

2. Related Work

2.1 Toulmin's model of argument

Stephen Toulmin is an English philosopher who developed a model for analyzing the kind of argument one use everyday in real life. He identified elements of a persuasive argument and gave useful categories by which an argument may be analyzed (Toulmin, 1958). He stated that good realistic arguments must be characterised by six parts described through the following items:

- **Data:** The facts or evidence used to prove the argument (for example statistics given for benefits of using my product).
- **Claim:** The statement or thesis being argued (for example people should buy my product to obtain a certain benefit).
- **Warrants:** The general, hypothetical (and often implicit) logical statements that serve as bridges between the claim and the data (what would justify the purchase of my product).
- **Qualifiers:** Statements that limit the strength of the argument or statements that propose the conditions under which the argument is true (for example, to acknowledge that there may be other causes for the lack of benefit sought).
- **Rebuttals:** Counter-arguments or statements indicating circumstances when the general argument does not hold true (i.e. against examples).
- **Backing:** Statements that serve to support the warrants (i.e., arguments that don't necessarily prove the main point being argued, but which prove the warrants are true).

Toulmin's diagram of arguments is illustrated through an example in Figure 1.

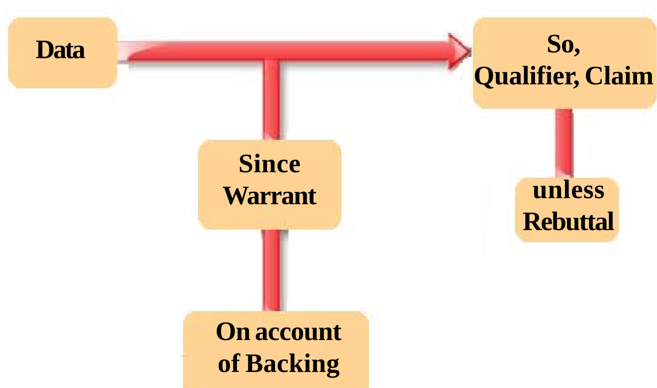

Figure 1. Toulmin Model of Argument

Toulmin's model stipulates that arguments are generally expressed with qualifiers and rebuttals and they are not given as absolutes.

2.2 Persuasive argumentation

The persuasive argumentation appeared in the work of [29-31], who developed a system called PERSUADER. The PERSUADER is an agent whose initial objective is to arrange labour negotiations between an agent representing a union (syndicate) and a company agent, using the persuasive argumentation. Meanwhile, this model has been applied in concurrent engineering field. Sycara presents persuasive argumentation, as a means of changing opposed perceptions, goals and constraints. A number of techniques are used such as case-based reasoning, analysis of preference and a number of heuristics which help in producing proposals and arguments during negotiation.

Among works which are based on the persuasive argumentation, there is the Framework of [27]; it consists in using the arguments to support the proposals exchanged between agents and to summarize the reasons for which the proposals should be accepted. The model of argumentation proposed in this Framework is employed in the Business Process Management, C. Sierra and all defined two sets of illocutions: I_{nego} ={offer, request, accept, reject, withdraw} corresponding to particles of negotiation used to offers and counter-offers, and I_{pers} ={threaten, reward, appeal} corresponding to persuasive particles used for the argumentation. A proposal is represented in the form of a sentence which is composed of variables representing the negotiated attributes, where each variable is associated a constant value, for example:

$$(\text{Price} = 10£) \wedge (\text{Quality} = \text{High}) \wedge (\text{Penalty} = ?)$$

Another work is presented in [24], it is a rhetoric approach for the persuasive negotiation of an autonomous agent. The role of such arguments or rhetorical means is to persuade the opponent to accept proposals more readily. Three illocutionary acts are defined: threaten(α, β, p, th) means that the agent α threats the agent β that it will pass to a state less favoured than the current state if it does not accept the proposal p, reward (α, β, p, rw) means that the agent α will pass the agent β to a state more favoured than the current state if it accepts the proposal p and finally appeal(α, β, p, m) which is used when the proposal p is less preferred than the current state for β.

There is also a study on the use of rewards in the negotiation [22-23], it consists in designing an algorithm which generates promises of rewards.

2.3 Force Field Analysis technique

The Force Field Analysis (FFA) is a technique developed by the German psychologist Kurt Lewin [13] in the Fifties; it is used in the analysis of the forces pushing and the forces retaining which influence a change or a decision suggested. The application of this technique goes through several stages: definition of the problem, definition of change objectives, identification of pushing and retaining forces of change and finally development of a complete strategy of change.

This technique has been applied in [18] on the planning of negotiation by using a visual representation of forces. It is a method used to weigh the advantages and disadvantages of preferred negotiating outcome on a given point. In this model the force is defined as a representation of different influences that surround the interaction between the negotiation parties.

Figure 2 represents the basic diagram of the force field analysis. The decision is based on the outcome scores of the forces driving and the forces restraining the change. Thus, the movement to the new position (point B) must hold equilibrium between all forces.

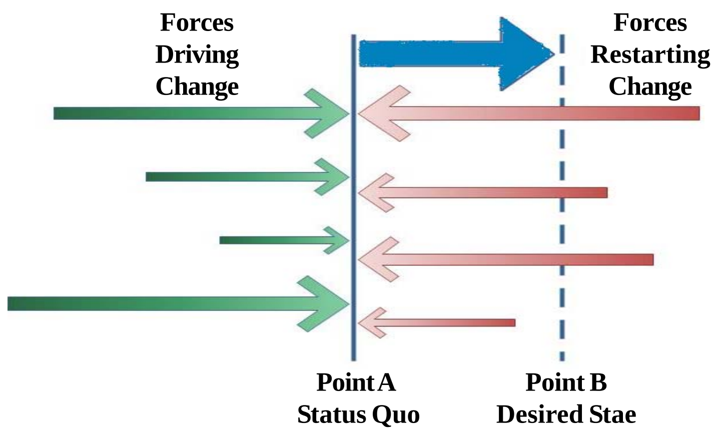

Figure 2. Basic diagram of the force fields analysis

2.4 Limits of the existing approaches

The study aims to apply an argumentation-based negotiation approach on the domain of e-commerce. Whereas, most of works that are based on persuasive argumentation [22-24] [2] [3] [4] are either general approaches or specific to domains different from the electronic commerce. Some generated arguments may be in the meaning of threatening the opponent agent to accept a proposal. The negotiation in electronic commerce is different because a negotiator is not obliged to accept a proposal as it is and neither party shall be considered only as a winner, a win/ win situation [14] [7] can therefore be created, so that both parties are satisfied. In addition, Toulmin's model of argument and force field analysis technique, are developed on general way. The force filed analysis technique is designed to develop a strategy of change; there are then two possible situations: either to change the position or to remain in the same position. In the commercial negotiation, this technique is limited because according to it, the agent which receives a proposal will have to accept or reject it, but in the commercial negotiation, it is possible to change the received proposal. So, in this paper we try to improve and to adapt the extant approaches (Toulmin's model of argument, Force Field Analysis technique and persuasive argumentation frameworks) and to use the semantic web languages as formalization tools to represent the elements of the agent based e-marketplace and the rules of the negotiation mechanism.

3. Semantic web languages as formalization tools

The semantic web [5], is an extension of current web and has as main objective to bring the semantics until then neglected to manipulated information aiming to facilitate communication between agents. Tim Bernes-Lee and colleagues [5] pointed up the fact that the current web is understandable by humans only. The purpose of Semantic Web technologies is to make the content of Web resources accessible and usable by programs and software agents through systems of formal metadata, using in particular the family of languages developed by W3C (World Wide Web Consortium: http://www.w3.org/).

The most recent Semantic Web languages are OWL (Ontology Web Language) [16] for defining Web ontologies and SWRL (Semantic Web Rule Language) [9] for defining rules into ontologies. SWRL is the combination of OWL language (as Web Ontology Language) and RuleML language [9] (as rule language), the rule extension is materialized by adding rule axioms to the set of OWL axioms. The proposal extends the OWL abstract syntax to include the syntax of these rules and the OWL model-theoretic semantics to provide a formal meaning for ontologies that include rules written in this syntax. The extension is strictly a syntactic and semantic extension, hence has a tight integration to OWL.

An SWRL rule atoms can be of the form:

• C(x), where C is an OWL Class (a simple named class or a class description) or a data range and x is either a variable, OWL individual or OWL data value.

• P(x, y), where P is an OWL Property (an object property or a datatype property), x is either a variable or an OWL individual and y is either a variable, an OWL individual or an OWL data value.

• sameAs (x, y), differentFrom (x,y), where x, y are variables or OWL individuals.

• builtIn (r, x, …), where r is a built-in relation and x,… are OWL data values.

An informal human-readable syntax for these rules is also specified for ease of readability and a typical rule in this syntax would look like: hasParent (?x,?y) $\wedge$ hasChild (?y,?z) $\rightarrow$ hasSibling (?x,?z).

In this work, OWL-DL [15] is adopted as OWL sub-language to define ontologies; it is so named for its correspondence with description logic.

4. General architecture of the negotiation system

The diagram of Figure 3 describes the general architecture of the negotiation system, for an electronic marketplace, based on agents. There are two kinds of agent, Buyer agent and Seller agent.

The arguments are exchanged through ACL messages, which comprise all the argument contents (Locution, Proposal, Asset, Backing, Qualifier…).

The system architecture counts five different ontologies:

- MarketOntology: Comprises knowledge that concerns the market elements (sellers, buyers, dialogues, extant Laptop models and compliance rules on the negotiations and purchases).

- BuyerOntology: Comprises knowledge that concerns the buyer (exchanged arguments, negotiation protocol, buyer's strategy, argumentation rules ...); it is employed by Buyer agent.

- SellerOntology: Comprises knowledge that concerns the seller (exposed Laptops models, exchanged arguments, negotiation protocol, seller's strategy, argumentation rules ...); it is employed by Seller agent.

- LaptopOntology: Comprises knowledge that concerns the laptop (features and models of laptop).

- ArgumentOntology: Represents the argument's content. The use of this ontology is to keep the structure and the content of the exchanged arguments through ACL messages, i.e. OWL is used as ACL content language; this idea is discussed in (Schiemann and Schreiber, 2006).

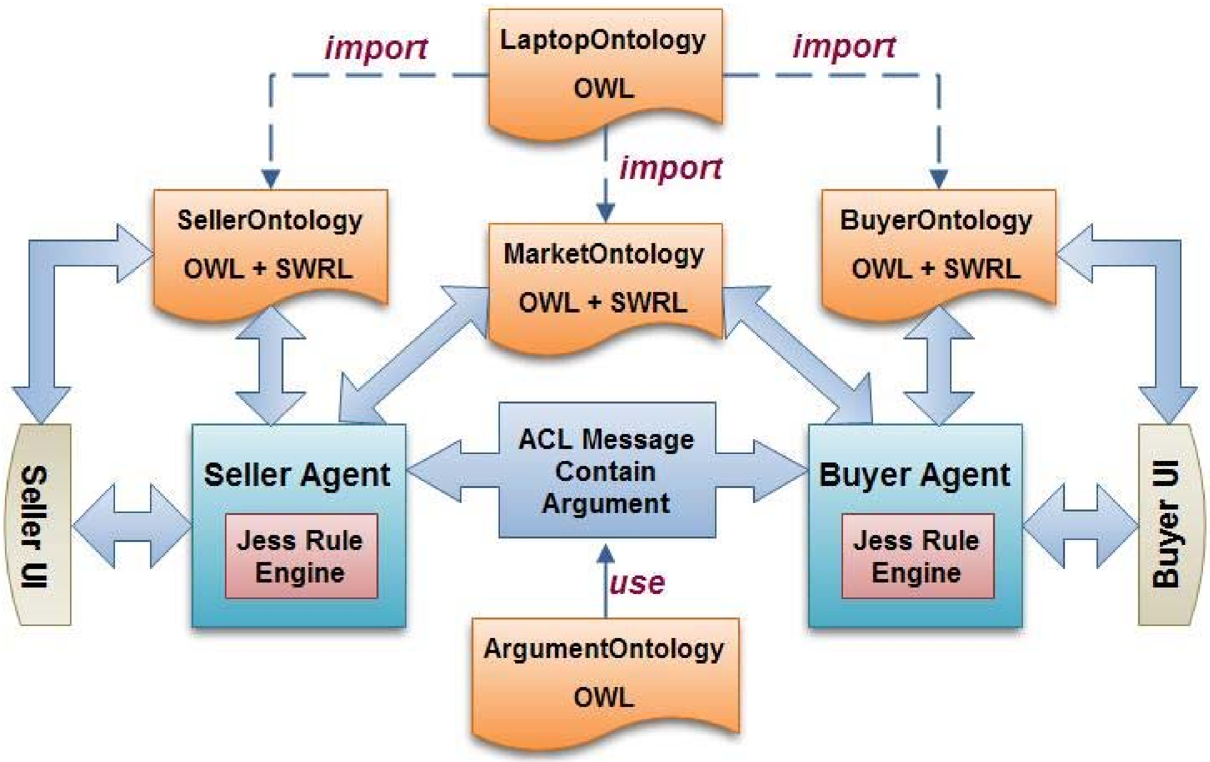

Figure 3. General architecture of negotiation system

The structure of LaptopOntology, ArgumentOntology and BuyerOntology is shown in Figure 4.

Whenever an agent (Buyer/ Seller) receives an argument, it executes SWRL argumentation rules using Jess rule engine to generate a new argument. The argumentation mechanism will be explained later.

5. Arguments formalisation

The semantic web based formalisation of arguments, proposed in this paper, is inspired, in some parts, from the theoretical model of Toulmin and the works studied previously. In addition, there exists a study of the potential of Semantic Web as a platform for arguments representation [20]. It is also an extension to Toulmin's model and it uses the Argument Interchange Format AIF [33]. But, our formalisation is specified to the domain of e-commerce. So, it comprises the concepts related to this domain and it has a direct relation with the argumentation mechanism that will be described in the next section.

In the presented system, the negotiation takes place separately between Buyer agent and a set of Seller agents in several stages. At each stage of negotiation, two agents $s \in S$ (Seller agents) and $b \in B$ (Buyer agents) exchange different kinds of arguments,

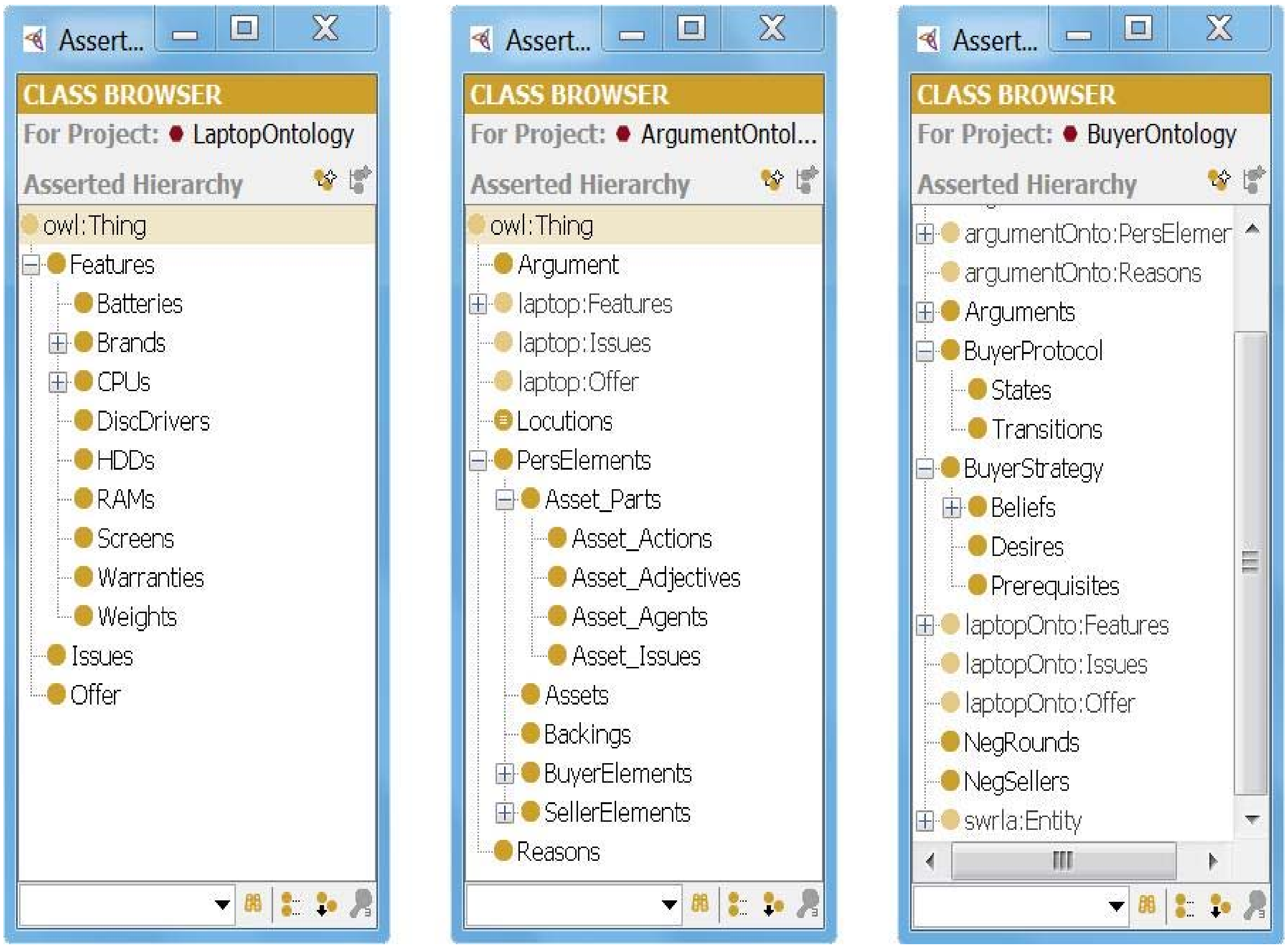

Figure 4. LaptopOntology, ArgumentOntology and BuyerOntology

each argument is distinguished by its locution loc∈ L (L: locutions set); it is a pronunciation that defines its nature. The set of locutions is divided into two subsets (Lp and Ln), where Lp is the set of persuasive locutions and Ln is the non persuasive locutions. An argument also comprises a proposal p∈ P. The proposal is considered as a draft contract, it is represented as a set of pairs, $P = \{(i_1, v_1)\dots(i_m, v_m)\}$, where (I is the set of Issues) and $v_j \in D_j$ (D_j is the domain of i_j) [22-23].

According to the locutions set decomposition, two types of arguments are distinguished:

• **Non persuasive arguments:** those are simple arguments, used to express a proposal or attitude to a proposal, they have the following form: loc(s, r, p, t), where loc∈ Ln = {Propose, Accept, Reject, Suspend}, s: sender agent, r: receiver agent, p∈ P: proposal and t: time. The use of Ln locutions is explained in Table 1.

Locution	Description
Propose	Submit proposal.
Accept	Accept received proposal.
Reject	Reject received proposal.
Suspend	Suspend dialogue.

Table 1. Locutions of not persuasive arguments

• **Persuasive arguments:** those are the arguments used by an agent to persuade the other agent of its own proposal, they have the following form: loc(s, r, p, δ, t), where loc ∈ Lp = {Encourage, Discourage, Promise, Appeal}, s: sender agent, r: receiver agent, p: proposal, δ : persuasive element and t: time. The various possible locutions of persuasive argument are described in Table 2.

Locution	Description
Encourage	Encourages an agent to accept proposal.
Discourage	Discourages an agent to retract a part of its proposal.
Promise	Gives a promise to offer one of opponent desires.
Appeal	Appeals to a past promise, to prevailing practice, to precedents or to personal interests

Table 2. Locutions of persuasive arguments

The persuasive argument components, presented in Table 3, are inspired from the original Toulmin's argument model and adapted to commercial negotiation problem.

Original components	Proposed components	Obtained (from/by)
Data	Data	Proposal evaluation, agent strategy and market status.
Warrant	Asset	Argument ontology (comprehensible by all agents).
Backing	Backing	Queries on MarketOntology.
Qualifier	Qualifier	Calculation of Backing (certainty degree).
Claim	Locution	Argument ontology.
Rebuttal	Collision	Opponent agent prerequisites or e-marketplace compliance rules.

Table 3. Persuasive argument components

The persuasive element δ is used to support the proposal of an argument, to this: $\delta \in$ Assets $\times$ Backings, where Assets is a set of assets used to influence the opponent agent to change its proposal and Backings contains a knowledge that support used assets. Some examples of Assets and Backings of Buyer agent and Seller agent are shown in Table 4 and Table 5. Because of the insufficiency in space, more examples are presented in (Said et al., 2011).

Buyer Locution	Assets	Backings
Encourage	Concedes in a part of the proposal (less important for the buyer).	It does not need to backing.
Discourage	The offer is not concurrent.	Comparison with offers of other sellers.
Promise	Promises of faithfulness.	History of number of past transactions.
Appeal	Appeals to a past promise of a discount.	History of seller promises.

Table 4. Some Assets used by the Buyer agent

Seller Locution	Assets	Backings
Encourage	The features in the proposal are among the most requested.	Statistics on the features most requested from the marketplace.
Discourage	Notification that the buyer has not made a good choice.	Statistics of products sold in the market with the features requested by the buyer.
Promise	Promises to make a discount at the next purchase.	It does not need to backing.
Appeal	Appeals to a promise of faithfulness.	History of buyer promises.

Table 5. Some Assets used by the Seller agent

The Asset concept is defined in ArgumentOntology as a class; an Asset is composed of four elements that are instances of Subjects, Issues, Adjectives and Actions classes. The used Asset is defined as Object property of the argument named:. The Table 6 represents the individuals of each class.

Element class	Individuals
Subjects	Me, You, My, Your.
Issues	Price, Quantity, Brand, CPU, RAM, HDD, Battery, DiscDriver, Display, Warranty.
Adjectives	Requested, Limited, Exceptional, Admissible, Concurrent, Faithful.
Actions	Concede, Discount, Compensate, Warn, BeFaithful.

Table 6. Elements of Assets

Taking example of the use of Asset, the seller says: "*Toshiba brand is among the most requested brands*", this clause can be represented as: hasAsset = ((hasSubject,My),(hasIssue,Brand), (hasAdjective, Requested), (hasAction, null)). The value of Brand "*Toshiba*" is defined from the proposal included in the argument.

The other argument components (Backing and Qualifier) are defined respectively as object property hasBacking and data type property hasQualifier. The property hasQualifier represents the degree of certainty of an Asset, so hasQualifier[0,1] and its value is specified according to the certainty of corresponding knowledge. Taking as example the first Asset of Seller agent: "*Toshiba brand is among the most requested brands*", so, the property hasBrande = "*Toshiba*" in the proposal of Seller, if Laptops, which brand is "*Toshiba*" had rank in number of sales equal to i among n various brands presented in the e-marketplace, then the property hasQualifier = (n-i)/(n-1), where:

$$\text{has Qualifer} = \begin{cases} 0, i = n \\ 1, i = 1 \end{cases}$$

The valuation of hasQualifier property expresses the non exactitude of the used adjectives, take the previous example, "*Toshiba brand is among the most requested brands*", it cannot affirm that "*Toshiba*" is the first, the second,… or the last requested brand in the market.

The following figure shows de general representation of ArgumentOntology:

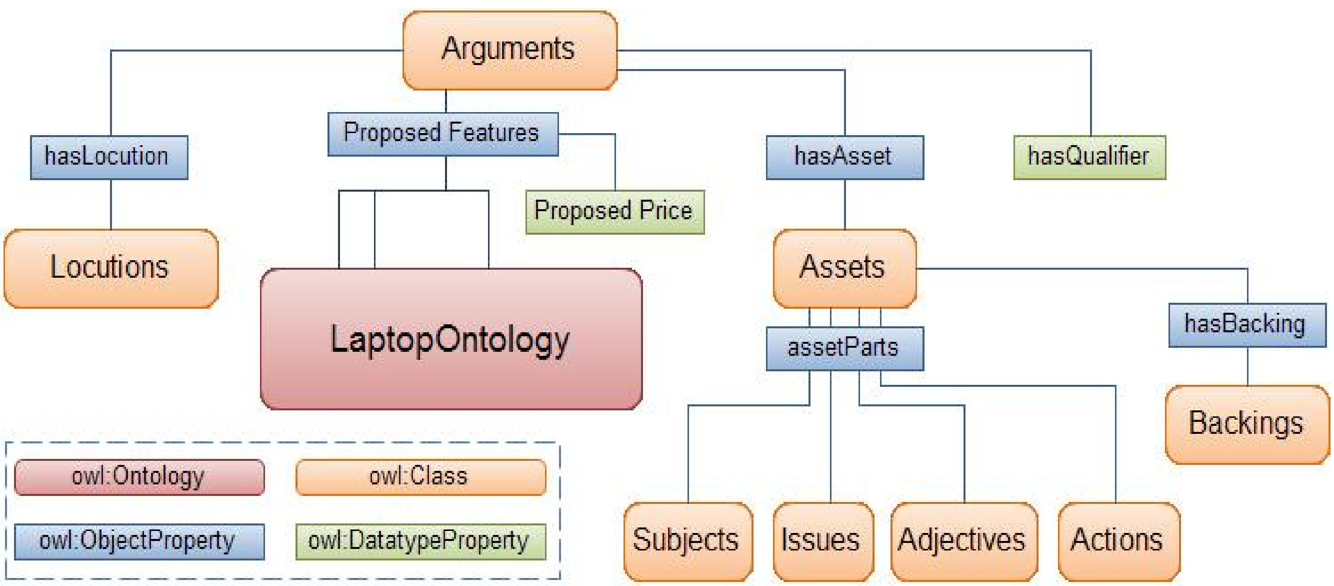

Figure 5. General representation of ArgumentOntology

6. Argumentation mechanism modeling and formalization

According to approaches proposed in [11] and in [21], the process of a negotiation comprises three basic operations: evaluation of received argument or proposal, generation of candidate arguments or proposals and finally selection of the strongest argument. In this work, the basic operations are defined as a set of rules that can be executed by the arguing agent. The rules are defined by SWRL language; it is able to express all basic operations of negotiation, due to a collection of libraries of

Built-Ins: swrlb for basic operations, swrlm for mathematical calculation, sqwrl for making queries on OWL ontologies and swrlx for handling individuals during the execution of the rules. Because of the height complexity observed in the SWRL rules, we paraphrase them in this section by a simple IF-THEN language.

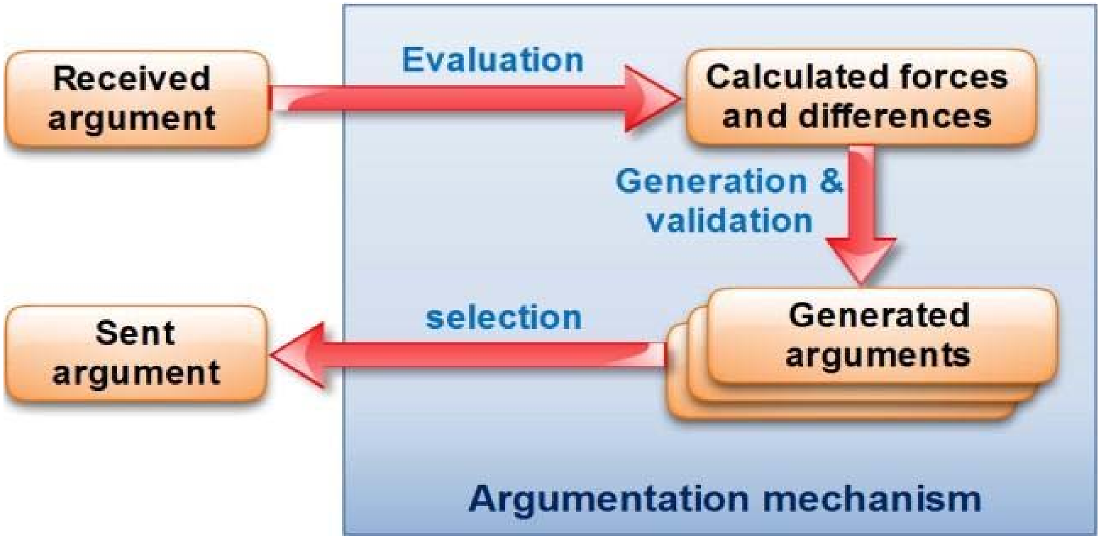

Figure 6. Argumentation mechanism scheme

This scheme describes the argumentation mechanism in a single stage. Practically the negotiation dialogue is governed by a process of purchase that is described in section 7.2, the negotiation dialogue comprises several rounds and each round can take many stages.

6.1 Argument evaluation

The evaluation rules allow to:

• specify if the received argument is persuasive or not persuasive;

• verify if it exists a collision between the received proposal and the prerequisites;

• calculate the difference for every attribute between the received proposal and the last sent proposal;

• calculate the degree of influence of the received argument according to (Locution, Asset and Qualifier);

• determine the forces, that contribute to the decision making, influenced by the received argument;

• update the ontology BuyerOntology/ SellerOntology.

The first stage of evaluation consists in determining if the argument is persuasive or not persuasive, by the verification of the boolean property is Persuasive of Locution.

Then to check that there is not any collision with the prerequisites, the values of the received proposal attributes are compared with the values defined by the user as extreme values. If there is a collision, the received argument will be rejected. Rule1 checks if there is a collision:

Rule1: **IF** Received (arg) **AND** hasProposal (arg, proposal) **WHERE** hasIssues (proposal, issues) **WHERE**
(is Allowed (issues [i], true)) **FOR** i:1..length (issues)
THEN hasRebuttal (arg, false)

Next, the difference between the proposal of the received argument and the proposal of the last sent argument will be calculated, as is described in Rule 2:

Rule 2: **IF** Received (arg) **AND** hasProposal (arg, proposal) **AND** LastProposal (lastproposal)
THEN CalculateDifference (proposal, lastproposal, difference) **AND** hasDifference (arg,difference)

Even, if it exists a non numerical attribute (eg. Brand) the rule follows the agent beliefs on which the individuals of Brand class are appreciated, by using brandApprec property and then it makes a subtraction between brandApprec properties of two individuals of Brand class. Let r = brandApprec (b1)- brandApprec (b2), then:

$$\begin{cases} r > 0, & \text{b1 betterthan b2} \\ r = 0, & \text{b1, b2 have thesame preference} \\ r < 0, & \text{b2 betterthan b1} \end{cases}$$

Another stage of evaluation consists in calculating the degree of influence, in case of persuasive argument, the content of the property hasAsset of the received argument can affect even the last sent proposal attributes. The calculation of influence degree of the argument depends on the values of its properties hasQualifier, hasLocution and the content of hasAsset property. There exist other parameters used in the calculation of influence degree; those are the weights of the proposal attributes, which represent the importance of attributes in user viewpoint. The user specifies firstly the weight of every attribute as Beliefs, where the property hasWeight ensure that the sum of all weights equals to 1:

$$\sum_{i=1}^{n} \text{has Weight} (\text{Issue}_i) = 1$$

Thus the influence of an argument is calculated in the following way:

has Influence (arg) = has Qualifer (arg) $\times \sum_{i \in U}$ has Weight (Issue$_i$), where U represents the numbers of attributes concerned with the property hasAsset.

Rule 3: **IF** Received (arg) **AND** hasQualifier (arg1, qualifier) **AND** hasAsset (arg, asset) **WHERE**
hasIssues (asset, issues) **WHERE** hasWeight(issues, weights)
THEN (Sum (weights [i], sw)) **FOR** i:1..length (issues) **AND** Multiply (sw, qualifier, influence)
AND hasInfluence (arg, influence)

After the calculation of influence degree, the forces which contribute to decision making, influenced by the received argument, are determined using the force field analysis (FFA) technique. In this work, the technique of FFA is improved to be adapted to the problem of commercial negotiation. So, a proposal is considered as a point; the coordinates of this point are the attributes of the proposal being negotiated. Figure 7 shows the various forces that keeps equilibrium in a negotiation state.

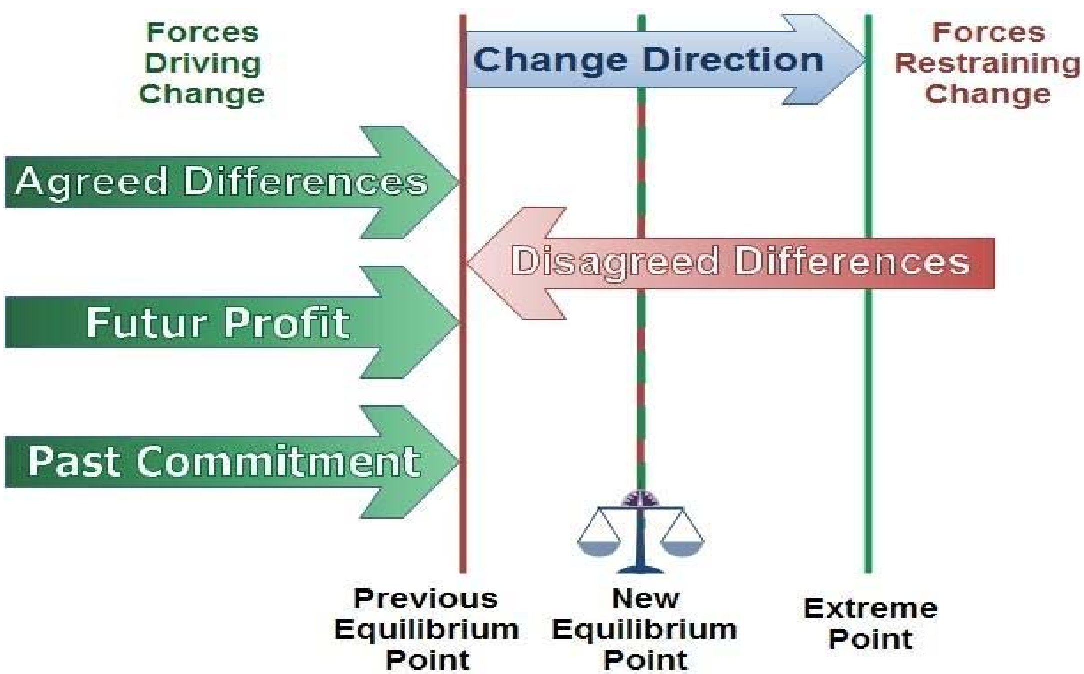

Figure 7. Forces driving and restraining position change

Each type of persuasive argument can influence a kind of force, as is explained in Table 7.

Persuasive Locution	Influenced force	influence manner
Encourage	Agreed Differences	Increase (+ +)
Discourage	Disagreed Differences	Decrease (- -)
Promise	Future Profit	Get positive value (> 0)
Appeal	Past Commitment	Get positive value (> 0)

Table 7. Forces influenced by the persuasive locutions

The forces are calculated initially in the following way: FuturProfit = 0, PastCommitment = 0 for all attributes. AgreedDifference(Issuei) = rate(Issuei) * Weight(Issue_i) for the attributes having a change in the desired direction, DisagreedDifference(Issuej) = rate(Issuej) * Weight(Issue_j) for the attributes having a change in the undesired direction, where the function rate is used to unify the calculation of the difference value because the attributes are not in the same type. Generally for the numerical attributes: rate (Issue_i) = (Difference (Issuei) /val(Issue_i)). Then, the forces influenced by the used Asset are determined according to the locution of received argument. Therefore, in the case of Encourage the AgreedDifferences force will be increased, while the Discourage locution decrease the DisagreedDifferences force, Promise increases the force FuturProfit and finally Appeal increases the PastCommitment force.

6.2 Arguments generation and validation

In this phase, the agent generates new arguments, according to the protocol of arguments exchange defined in its own ontology which specifies the potential generated locutions in each state of negotiation process. The negotiation protocol is described in Figure 8 using a state diagram.

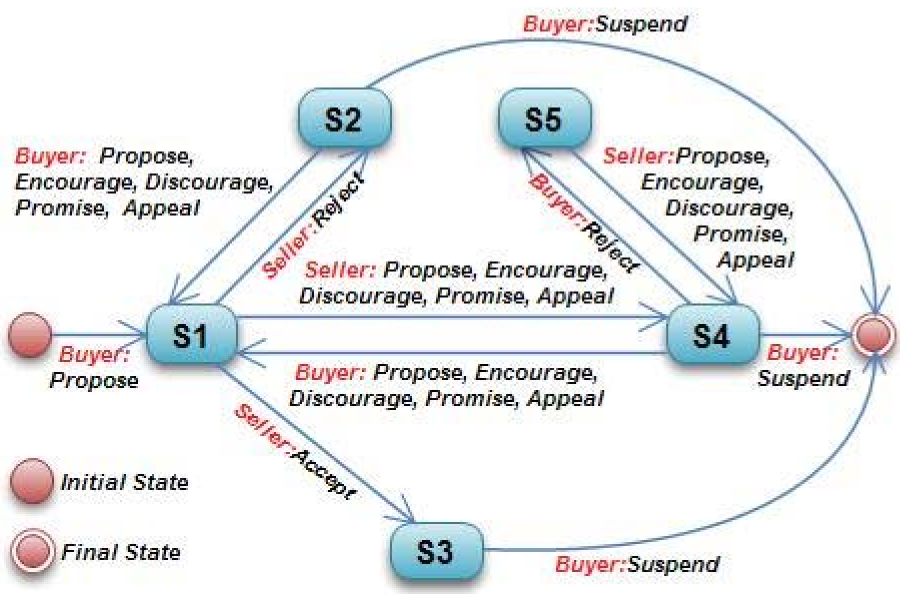

Figure 8. Protocol of arguments exchange

The following rule generates a new set of potential locutions according to the arguments exchange protocol.

> <u>**Rule 4:**</u> IF Received (arg) **AND** DialogRound (round) **WHERE** hasState(round, state) **AND** potentialLocutions(state, locutions)
> **THEN** (Create(args[i]) **AND** hasLocution(args[i], locutions[i])) **FOR** i:1..length(locutions)

Each type of Locution can be used with various kinds of Assets, i.e. the same Locution may be in some generated arguments which have different Assets. The preceding rule generates new candidate arguments. Then a new proposal will be determined by the calculation of a new equilibrium position in the diagram of force field, Figure 7. Differently of the original technique of force field analysis, in this approach the agent does not have two choices only (going to the extreme position or remaining at the preceding position of equilibrium), but it can determine a new position which keeps the equilibrium between the various forces and be considered as a new point of equilibrium.

Rule 5: (**IF** Received (arg) **AND** hasDifference (arg, difference) **WHERE** hasIssues (difference, issues) **AND** isDesired(issues[i], true) **AND** ForceField(force)
THEN hasAgreedDifference(force[i],1) **AND** hasDisagreedDifference (force[i],0)) FOR i:1..length (issues)

Rule 6: (**IF** Received (arg) **AND** hasDifference (arg, difference) WHERE hasIssues (difference, issues) **AND** isDesired (issues[i], false) **AND** ForceField(force)
THEN hasAgreedDifference(force[i],0) **AND** hasDisagreedDifference (force[i], 1)) **FOR** i:1..length (issues)

Rule 7: (**IF** Received (arg) **AND** hasLocution(arg, Encourage) **AND** hasInfluence(arg, influence) AND hasAsset(arg, asset)
WHERE hasIssues(asset, issues) **AND** ForceField(force) **AND** (hasAgreedDifference (force[i],difference[i])
THEN hasAgreedDifference (force[i], Min(difference[i]+influence,1))) **FOR** i:1..length(issues)
/* Locution= Encourage => Agreed Differences are increased */

Rule 8: (**IF** Received (arg) **AND** hasLocution (arg, Discourage) **AND** hasInfluence (arg, influence) **AND** hasAsset (arg, asset)
WHERE hasIssues(asset, issues) AND ForceField(force) **AND** (hasDisagreedDifference (force[i], difference[i])
THEN hasDisagreedDifference (force[i], Max(difference[i]- influence,0))) **FOR** i:1..length (issues)
/* Locution= Discourage => Disagreed Differences are decreased */

Rule 9: (**IF** Received (arg) **AND** hasLocution (arg, Promise) **AND** hasInfluence (arg, influence) **AND** hasAsset (arg, asset)
WHERE hasIssues (asset, issues) **AND** ForceField (force)
THEN hasFutureProfit (force[i], influence)) **FOR** i:1..length (issues)
/* Locution=Promise => Future Profit = Degree of Influence*/

Rule 10: (**IF** Received (arg) **AND** hasLocution (arg, Appeal) **AND** hasInfluence (arg, influence) **AND** hasAsset (arg, asset)
WHERE hasIssues (asset, issues) **AND** ForceField (force)
THEN hasPastCommitment (force[i], influence)) FOR i:1..length (issues)
/* Locution=Appeal => Past Commitment = Degree of Influence*/

After the definition of different forces, the new equilibrium point (new proposal) can be calculated by the application of these forces on concerned Issues. The new values of different Issues define the new proposal. It is important to consider that these new values, which determine laptop features, must be validated by searching extant laptops that have features similar to them because the majority of features cannot be changed in the same laptop. So, to get an effective proposal, it is necessary to make sqwrl queries on MarketOntology to find a laptop having the closest features values to the new proposal among laptops presented by Seller agent.

Rule 11: (**IF** Generated (args[i]) **AND** hasProposal (args[i], proposal) **AND** hasIssues (proposal, issues) **AND** hasSellerPart (arg,seller) **WHERE** exposedLaptops(seller, laptops) **WHERE** (hasFeatures (laptops[j], features) **AND** Sum (weights[k], sumweights) **WHERE** equalTo (features[k], issues[k])) **FOR** j:1..length (laptops) **AND** (Max (sumweights[j], max)) **FOR** j:1..length (laptops) **AND** equalTo(max, sumweights[p])
THEN closestFeatures (laptops[p], true) **AND** replaceBy (issues, features)) **FOR** i:1..length(args)
/* For each generated argument, this rule chooses the laptop having the closest features values to the negotiated issues by the calculation of the sum of features weights for each laptop when its feature value = negotiated issue */

Here, each feature of laptops is compared separately in SWRL rule with the feature in the generated argument, if they are equal then the validation factor of laptop feature get the value of feature weight. Finally, the global validation factor of each laptop is calculated from the sum of the validation factors of its features. So, the laptop with the maximum validation factor is considered as the model having the closest features to the features in generated argument.

The last part of arguments generation is the choice of the Assets. According to Rule 4 all Assets consistent with the potential locutions will be used in generated arguments. Some Assets may not be chosen in advance by the users (buyers/sellers), they will be so excluded from the arguments generation operation. The chosen Assets will be supported by the Backings that can be obtained from MarketOntology by the execution of SWRL rules containing sqwrl queries.

By the execution of these rules, the properties values of an individual Backing(j) corresponding to an individual Asset(i) are obtained from MarketOntology. For each type of Asset there exists a specific SWRL rule to get the corresponding Backing properties values.

Taking an example of encouragement Asset of Seller agent: "*The Brand(HP) is among the most requested brands in the market*", the Backing must present a statistics on Laptops with features (Brand=HP) sold in the market.

Rule 12: **IF** Generated (arg) **AND** hasProposal (arg, proposal) **AND** hasAsset (arg, asset) **WHERE** hasBacking (asset, backing) **AND** hasIssue (asset, Brand) **WHERE** hasSalesQuantity (proposal[Brand], quantity) **AND** saledQuantities (Brand, saledquantities)
THEN CalculateRank (quantity, saledquantities, rank) **AND** hasSalesRank (backing, rank)
/* The asset used in this rule contains always one issue */

In MarketOntology simple statistics were made (number of sales for each feature and for each laptop model, number of purchases of each buyer, given promises …). These statistics will be used in SWRL rules to obtain the backings of generated arguments. The Rule12 defines the rank of the proposed brand with regard to the number of sales, compared with the other brands, the definition of the rank of proposed brand requires making a set of brands having a number of sales > its number of sales and calculating the size of this set, so rank = size + 1. This rule calculates also the size of the full set of brands.

Rule 13: **IF** Generated (arg) **AND** hasAsset (arg, asset) **WHERE** hasIssue (asset, Brand) **AND** hasBacking (asset, backing) **WHERE** hasSalesRank (backing, rank) **AND** ExtantBrands (brands)
THEN calculate ((length (brands) - rank) / (length (brands) - 1), qualifier) **AND** hasQualifier (arg, qualifier)

Rule13 calculates the qualifier of generated argument by the application of the formula: hasQualifier = (fullNbSales-rank)/(fullNbSales-1), explained previously.

6.3 Argument selection

In this phase, the agent selects the strongest argument which is able to persuade the opponent agent, the factor which determines the strongest argument is the qualifier.

Rule 14: **IF** Generated (args) **AND** (hasQualifier (args[i], qualifiers[i])) **FOR** i:1..length (args) **AND** equalTo (qualifiers[k], Max (qualifiers))
THEN isSelected (args[k], true)

If there is more than one argument with a maximum qualification, the selected argument will be the argument having the more admired Locution, knowing that the Locutions are ordered from the beginning.

7. Experiment example

7.1 System presentation

To evaluate the proposed approach, we developed a multi-agent java based prototype. JADE platform 3.6.1 (http://jade.cselt.it) is used as agent development platform. Ontologies described in section 4 are created, with Protégé-OWL editor 3.4.4 of Stanford (http://protege.stanford.edu/overview/protege-owl.html), as OWL files, except MarketOntology which is created in the form of OWL MySQL database. MarketOntology contain information and knowledge about all laptops, buyers and sellers. JESS (http://herzberg.ca.sandia.gov/jess/) is integrated in Protégé-OWL editor, as rule engine, to execute SWRL rules defined into OWL ontologies.

The system comprises tow models of agent (Seller agent and Buyer agent). For each buyer and seller registered in the e-marketplace the system generates an instance of respectively Seller agent and Buyer agent. The instances of an agent model execute the same SWRL rules but they have different behaviours, because of the difference between users' profiles (beliefs, desires and prerequisites) described in the ontology instance associated to the agent instance.

7.2 Scenario description

In this experiment, sixty models of laptop are defined in MarketOntology. These models are taken from five electronic shops in France (Amazone; Darty; Pixmania; Cercouf; Fnac). Laptops are exposed by eight sellers, for each seller an instance of Seller agent is launched.

So, the process of purchase is described briefly as follow:

1. The buyer filled information concerning the wanted Laptop: beliefs, desires and prerequisites, and then *Buyer* agent will be launched by the system.
2. *Buyer* agent sends a CFP (Call For Proposal) message to each $Seller_i$ agent containing its desires.
3. Each $Seller_i$ agent answers Buyer agent with initial proposal $Proposal_i$.
4. *Buyer* agent evaluates all $Proposal_i$ proposals, and then it adds $Seller_i$ agents in a list sorted according to the preference order.
5. If the list is nonempty then Buyer agent open a negotiation dialogue (Figure 8) with each $Seller_i$ agent of the list, then it suspends the negotiation in a final state with the best offer proposed by $Seller_i$.
6. *Buyer* agent re-sorts the list of the sellers according to offers to which the negotiations are suspended. If there are changes in the list then go to 5, else go to 7.
7. If there are proposals in the list which check the buyer prerequisites, then *Buyer* agent accepts the best proposal from the list, else all proposals will be rejected.

The first step of this process is described in Table A.1. The supposed order of popularity about laptop features in the market is presented in Table A.2.

7.3 Results

Results obtained from the execution of the example according to the scenario described in Table A.1 are presented in Table A.3. This table shows the final proposals about laptop features given by the eight Seller agents. All proposals are evaluated and sorted by Buyer agent according to its beliefs about features preferences and weights presented in Table A.1. The result of final proposals evaluation is presented as a stacked histogram in Figure A.1.

7.4 Discussion

The final proposals given by all Seller agents (Table A.3) are the best proposals obtained from negotiation dialogue. During the negotiation dialogue, several locutions (persuasive and non persuasive) are exchanged between Buyer agent and Seller agents. For example:

- Encourage (Seller6, Buyer, Proposal, Asset, Qualifier), where Asset = (My, Price = 644, Exceptional, Backing = 699), Qualifier = 1.

- Encourage (Seller1, Buyer, Proposal, Asset, Qualifier), where Asset = (My, Brand, Requested, Backing = 2nd), Qualifier = 0.85.

After each negotiation round an agent (Seller or Buyer) may change its beliefs and desires about negotiated issues, if it is influenced by the opponent agent. But, if there is no influence Seller agent and Buyer agent try to find the laptop model that have features satisfying their desires. For example, if the price of a proposed laptop is expansive, Buyer agent ask Seller agent to reduce the price, if Seller agent can't make a discount it gives a proposal with another laptop model.

The list of final proposals is sorted after the termination of the negotiation dialogue. Buyer agent evaluates Seller agents' proposals according to its beliefs about laptop issues weights and preference order. The evaluation of final proposals is shown as a stacked histogram in Figure A.1. Each bar of the histogram represents a seller's proposal evaluation which is made by the calculation of the preference factors. A preference factor pf $\in [0, 10]$, is calculated for each negotiated issue.

So, the total preference factor for each seller is obtained as follow: pf (proposal) = $\sum_{i=1}^{n} \mathrm{pf}(\mathrm{Issue}_i) \times \mathrm{Weight}(\mathrm{Issue}_i)$

According to pf (proposal), the winner is Seller6 which has the greatest preference factor (9.05/10).

This experiment example shows that the use of argumentation in the negotiation mechanism allows an agent to influence opponent agents to change their beliefs and desires or allows an agent to be influenced by opponent agents. In the experiment example, we can view the modification of the initial desires in the final proposals, for each Seller agent, due to the exchange of arguments and proposals. For example, the buyer did not introduce Aser brand into the initial desires (Table A.1), but Seller1 agent persuaded Buyer agent that Aser is among the most popular brands in the market (Table A.2).

8. Conclusions and future works

In this paper, a new semantic web based approach for the argumentation mechanism formalization in multi-agent e-commerce negotiation environment is proposed. The impact of this work is that it uses semantic web technologies to represent different negotiation mechanism elements (arguments form, arguments exchange protocol, negotiation parts and negotiation rules).

The presented study is based on theoretical approaches (Toulmin's argument model and force field analysis of K. Lewin) and inspires many of ideas from general argumentation frameworks. The impact of the proposed approach is focalized on the increasing of negotiation agents influence power in virtue of the semantic web ability to express arguments content.

In this work, one deduces that in spite of the great amount of knowledge exploited by the negotiation agents and their capacities to manage agent-agent dialogues and to make crucial and very important decisions. So, it is not easy to model all human forces, reflexes and feelings during a commercial negotiation. Therefore, it is possible to study further computing or human sciences approaches and techniques to develop this approach, in order to substitute the human's negotiation.

The proposed approach studies semantic web based formalization of argumentation mechanism in e-commerce negotiation, this work deals with many concepts that have different degrees of certitude. To this end it is so suitable in future works to add a fuzzy logic based extension to the semantic web employed technologies in the proposed approach.

9. Appendix A. Scenario and results of the experiment example

	Brand	CPU	Memory	Hard Drive	Screen	Warranty	Price	Locution
Preference order beliefs	Apple, Sony, Asus, HP, Dell, Toshiba, Acer, Sumsung	Intel, AMD	Direct proportion	Direct proportion	15", 17", 14", 13", 12", 11", 10"	Direct proportion	Opposite proportion	Encourage Promise, Appeal, Discourage
Weight beliefs	0.2	0.2	0.12	0.1	0.08	0.08	0.22	/
Desires	HP, Asus, Dell, Sony	Intel Core i5 or more	4 Go or more	500 Go or more	15.6"	24 months	≤ 650 €	All
Prerequisites	Sony, HP, Asus, Dell, Toshiba, Aser	Intel Core i3 or more	2 Go or more	320 Go or more	15.6" or 17.3"	12 months or more	≤ 750 €	All

Table A.1. Buyer beliefs, desires and prerequisites about negotiation issues

	Brand	CPU	Screen
Supposed features popularity order in the market	HP, Aser, Dell, Sony, Asus, Apple, Toshiba, Sumsung	Intel Core i5, Intel Core i7, Intel Core i3, Intel Core 2 duo	15", 14", 17", 13", 12", 11", 10"

Table A.2. Supposed features popularity order in the market

Sorted sellers	Brand	CPU	Memory	Hard Drive	Screen	Warranty	Price
Seller1	Acer - Aspire	Intel Core i3	4 Go	500 Go	15.6"	12 months	509.00 €
Seller2	Toshiba Satellite	Intel Core i5	4 Go	500 Go	15.6"	12 months	682.00 €
Seller3	Sony - Vaio	Intel Core i5	6 Go	750 Go	15.6"	12 months	699.00 €
Seller4	Dell Inspiron 15R	Intel Core i5	6 Go	500 Go	15.6"	12 months	699.00 €
Seller5	HP - Pavillon	Intel Core i7	4 Go	750 Go	15.6"	24 months	~~799.00 €~~ 726.00 €
Seller6	HP - Pavillon	Intel Core i5	6 Go	640 Go	15.6"	24 months	~~699.00 €~~ 644.50 €
Seller7	Sony - Vaio	Intel Core i5	6 Go	750 Go	17.3"	12 months	749.00 €
Seller8	Asus	Intel Core i3	6 Go	750 Go	15.6"	12 months	~~599.00 €~~ 575.90 €

Table A.3. The final proposals about laptop features

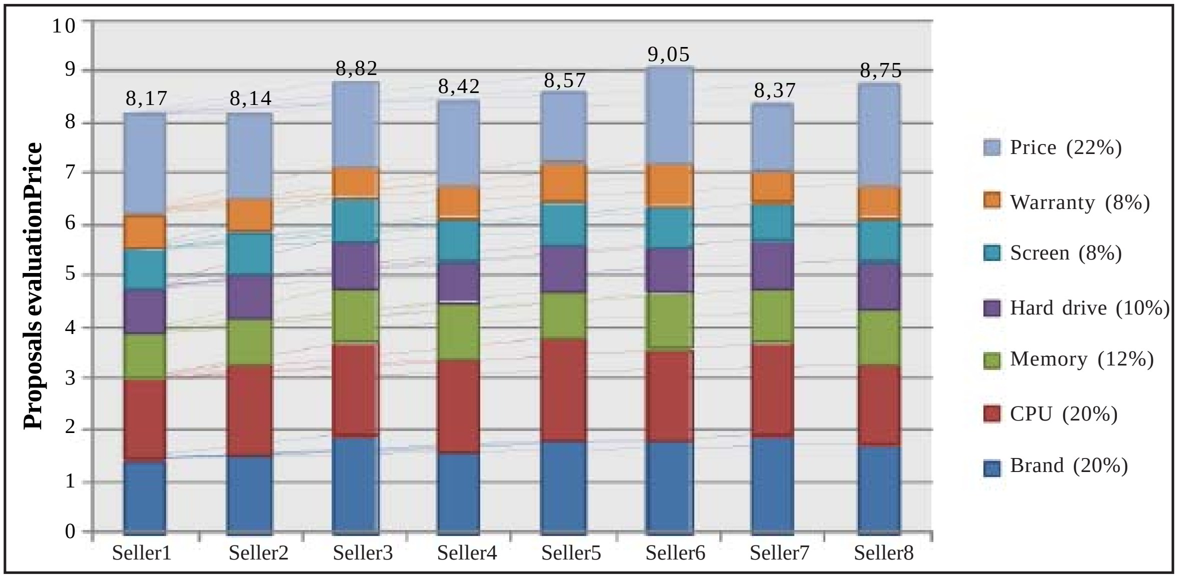

Figure A.1. Evaluation of final proposals

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