Formal Models in Web Based Contracting

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Abstract

Legal principles have some difficulty to deal with software agents celebrating contracts and operating in e-commerce environments without direct human intervention. Autonomous intelligent agents have a control on their own actions and states, supporting or taking effective decisions. Therefore, some qualitative parameters such as trust, reputation and quality of information have to be taken under consideration to evaluate, certify and justify such decisions. Indeed, this paper shows how to construct a dynamic virtual world of complex and interacting entities or agents, organized in terms of Multi-Agent Systems (MAS), that compete against one another in order to solve a particular problem, according to a rigorous selection regime in which its fitness is judged by one criterion alone, a measure of the quality of information of the agent or agents, here understood as evolutionary logic theories. This virtual world could witness the emergence of our first learning, thinking machines, that may cater for some issues on the evolution of formal models of the world in general, and on what is concerned with the objectives set to this work, in contracting, and foray into a vast, untapped technological market.

1. Introduction

The use of intelligent software agents in Virtual Organizations (VO) brings along a lot of new issues in what contracting is concerned. Actually, to speak about contracts there must be two or more declarations of will, containing a consensual agreement, consisting of an offer and of an acceptance. But intelligent software agents operate in electronic commerce without any direct intervention of humans, and have a control on their own actions and on their own inner states. So, legal difficulties obviously arise in such situations of contracting through the only intervention and interaction of autonomous intelligent systems, capable of acting, learning, modifying instructions and taking decisions. In the terms of the general theory of Civil Law, the declaration of will is constituted by two different elements – the external element (the declaration itself) and the internal element (the will itself, the real and ultimate source of the declaration) and usually both are coincident. Traditional legal principles have some difficulty to deal with the fact of agents celebrating contracts on their own, but, declarations of will and agreements "will therefore no longer be generated through machines but by them, without any intervention or supervision of an individual [1]". This paper shows how to construct a dynamic virtual world of complex and interacting entities (i.e. agents and/or MAS) that compete against one another in a rigorous selection regime in which fitness is judged by one criterion alone: a measure of the quality of information of the agent and/or the MAS.

2. Defects of the Will in Electronic Contracting through Software Agents

Among the different types of error, the one that will most likely occur in situations of declaration issued by intelligent software agents is the so-called "error on the object of the negotius". This is supported by the developments in where the representation of incomplete information and the reasoning based on partial assumptions is studied, using the representation of null values to characterize abnormal or exceptional situations. The identification of null values emerges as a strategy for the enumeration of cases, for which one intends to distinguish between situations where the answers are known (true or false) or unknown [2]. It will be considered two types of null values: the former will allow the representation of unknown values, not necessarily taken from a given set of values, and the later will represent unknown values, taken from a given set of possible values. Consider the following as a case study to show some examples of how null values can be used to represent unknown situations. In what follows it will be considered the extensions of the predicates that denote some of the properties inherited by an agent, aiming at a measure of its awareness. This may be formally stated in terms of the predicate *error-on-the-object-of-negotiation* (*eon* for short), in the form:

eon: time-period x object-of-negotiation

where the arguments stand for themselves. In terms of the extension of predicate *eon* this may be stated as follows:

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/The closed word assumption is being
softened [2]/

¬eon( X,Y )  ←
    not eon( X,Y ) ∧
    not exception_eon(X,Y).
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exception_eon(january, silver).
exception_eon(january, gold).

/An invariant - it implements the XOR
operator, i.e. it states that that
the object-of-negotiation is either
silver`s or gold`s, but not an
amalgam of both/

¬((exception_eon(X1,Y1) ∨
   exception_eon(X2,Y2)) ∧
   ¬(exception_eon(X1,Y1) ∧
   exception_eon(X2,Y2))).
```

Program 1 – The extended logic program for *error-on-the-object of negotiation* (*eon* for short) with respect to January

i.e. with respect to the computational model it were considered extended logic programs with two kinds of negation, classical negation ¬ and default negation *not*. Intuitively, *not p* is true whenever there is no reason to believe *p*, whereas ¬*p* requires a proof of the negated literal. An extended logic program (program, for short) is a finite collection of rules r of the form

$$p \leftarrow p_1 \wedge \ldots \wedge p_n \;\wedge \text{not } q_1 \wedge \ldots \wedge \text{not } q_m \quad (n, m \geq 0)$$

where the p_i, q_j, and p are classical ground literals, i.e. either positive atoms or atoms preceded by the classical negation sign ¬ [3]. These extended logic programs or theories that will be also represented as evolutionary logic programs or theories, stand for the population of candidate solutions to model the universe of discourse. Indeed, in our approach, we will not get a solution to a particular problem, but rather model the universe of the discourse of the agent. Is there a reason for an annulation of the contract? If the contract had been celebrated and concluded between human people there could be a reason for annulation. What then in the case of a contract celebrated by software agents? The issue of incidental error must be considered.

Definition 1- Extended Logic Program

The knowledge in an agent's knowledge base is made of logic clauses of the form $r_k{:}p_{i+j+1} \leftarrow p_1 \wedge p_2 \wedge \ldots \wedge p_{i-1} \wedge not\ p_i \wedge \ldots \wedge not\ p_{i+j}$, *where i, j, k belong to the set of natural numbers,* $p_1, \ldots, p_{i+j}$ *are literals, i.e. a formula of the form p or ¬ p, where p is an atom, and where* r_k, *not*, p_{i+j+1}, *and* $p_1 \wedge p_2 \wedge \ldots \wedge p_{i-1} \wedge not\ p_i \wedge \ldots \wedge p_{i+j}$ *stand, respectively, for the clause's identifier, the negation-by-failure operator, the rule's consequent, and the rule's antecedent. If i=j=0 the clause is called a fact and is represented as* $r_k{:}p_1$. *An Extended Logic Program (ELP for short) is seen as a set of clauses, as given by the definition being referred to above.*

Definition 2 – Agent Knowledge Base

An Agent Knowledge Base (AKB) is taken from an ordered theory OT=(T,<,(S, ≺)), where T, >, S and ≺ stand, respectively, for an AKB in clausal form, a non-circular ordering relation over such clauses, a set of priority rules, and a non-circular ordering relation over such rules.

Definition 3 –Argument

An argument (i.e. a proof, or series of reasons in support or refutation of a proposition) or arguments have their genesis on mental-states seen as a consequence of the proof processes that go on unceasingly at the agent's own knowledge about its states of awareness, consciousness or erudition.

Definition 4 - Meta Theorem Problem Solver for an Universe of Discourse with Incomplete Information

A meta theorem problem solver in this context is given by the signature demo:T,V→{true,false}, which infers the valuation V of a theorem T in terms of the logical constants of ***false***, ***true*** *and* ***unknown***, *according to the following set of productions:*

demo(T, ***true****) ← T.*
demo(T, ***false****) ← ¬T.*
demo(T, ***unknown****) ← not T, not ¬ T.*

The concept of unknown/incomplete information is connected to that of null values. These elements are atoms that represent abstract concepts with no particular definition, i.e. elements which have a well-defined (or even non-defined) range of values have valid options.

Definition 5 - Negotiation Argument with an Implicit Meta Theorem Problem Solver

Taking ordered theory OT, a negotiation argument is a finite, non-empty sequence of rules of the form $\langle r_1,\ldots,demo(r_i, V_i),\ldots,r_n\rangle$ *such that, for each rule* r_j *with p as a part of the antecedent, there is a sequence rule* r_i *(i<j) on which the consequent is p.*

The conclusion of an argument relates to the consequent of the last rule used in that same argument. Formally, one may have:

Definition 6 - Argument Conclusion

The conclusion of an argument $A_1=\langle r_1,\ldots,r_n\rangle$, $conc(A_1)$, *is the consequent of the last rule* (r_n).

By composing an argument with rules or facts that spawn from local knowledge (e.g. previous experiences), the attack or counter-argument launched by other agent's during the meeting is conditioned (due to the fact that local knowledge is hard to deny). Taking into account the two forms of argument attack (*conclusion denial* and *premise denial*), a conflict amongst two agents (e.g.

against/favour a specific proposal) can be formally specified in the form:

Definition 7 - Conflict/Attack over Arguments

Let $A_1=\langle r_{1,1},...,r_{1,n}\rangle$ be the argument of agent 1 and $A_2=\langle r_{2,1},...,r_{2,m}\rangle$ be the argument of agent 2. Then,

1. *if $r_{1,i} \in A_1$ or $r_{2,j} \in A_2$ are local, the arguments are said to be in "probable conflict";*
2. *A_1 attacks A_2 iff A_1 executes a conclusion denial attack or a premise denial attack over A_2;*
3. *A_1 executes a conclusion denial attack over A_2 iff (if and only if) there is no local knowledge involved and conc(A_1) is contrary to conc(A_2);*
4. *A_1 executes a premise denial attack over A_2 iff there is no local knowledge involved and conc(A_1) is contrary to some $r_{2,j} \in A_2$.*

Having in mind the use of rational agents, a proper definition of coherency must be formulated:

Definition 8 - Argument Coherency

An argument $A_1=\langle r_1,...,r_n\rangle$ is said to be "coherent" iff $\neg\exists_{ai,aj}\ a_i,a_j \in subarguments(A) \wedge i{\neq}j : a_i$ attacks a_j.

Taking into account the definition of conflict/attack and the concept of evolution of the decision it is possible to logically define the victory/defeat pair.

Definition 9 - Victory/Defeat of Arguments

Let $A_1=\langle r_{1,1},...,r_{1,n}\rangle$ be the argument of agent 1 and $A_2=\langle r_{2,1},...,r_{2,m}\rangle$ be the argument of agent 2 and A_2 is presented after A_1. Then, A_1 is defeated by A_2 (or A_2 is victorious over A_1) iff

1. *A_2 is coherent and A_1 is incoherent;*
2. *A_2 is coherent, executes a conclusion denial attack over A_1 (coherent) and the conclusion rule of A_2 is prioritary (taking into account the OT theory) over A_1;*
3. *A_2 is coherent, executes a premise denial attack over A_1 (coherent) and the conclusion rule of A_2 is prioritary (taking into account the OT theory) over A_1.*

Definition 9 - Priority Clauses

Priority clauses, which are embedded in the KB of each agent, are rules of the form PRIO:r_k:priority(K_i,K_j) where K_i and K_j represent different knowledge classifications and r_k is the rule identification.

3. The Computational Model

Most evolutionary computation problems are well defined, and quantitative comparisons of performance among the competing entities are straightforward [3] [4] [5]. In our approach, the learning procedure is based on evolution and is built on a quantification process of the quality of information that stems from a logic program or theory. This may be stated as follows: let i ($i \in \{1,\dots,m\}$) denote the predicates whose extensions make an extended logic program or theory, and j ($j \in \{1,\dots,n\}$) the attributes for those predicates [2]. Let $x_j \in [min_j, max_j]$ be a value for attribute j. To each predicate it is also associated a scoring function V_{ij}:$[min_j, max_j] \rightarrow [0,1]$, that gives the score predicate i assigned to a value of attribute j in the range of its acceptable values, i.e. its domain (for the sake of simplicity, scores are kept in the interval [0,1]). The next element of the model to be considered, it is the relative importance that a predicate assigns to each of its attributes under observation, i.e w_{ij} stands for the relevance of attribute j for predicate i (it is also assumed that the weights of all predicates are normalized ($\sum_{1\le j\le n} w_{ij} = 1\ \forall i$). With this material in mind, it is now possible to define a predicate's scoring function, i.e a value $x=(x_1,\dots,x_n)$ in the multi-dimensional space defined by the attributes domains, may be given in the form $V_i(x) = \sum_{1\le j\le n} w_{ij} \times V_{ij}(x_j)$. It is therefore possible to measure the quality of the information that stems from a logic program or theory, by posting the $V_i(x)$ values into a multi-dimensional space, whose axes denote the logic program predicates, with a numbering ranging from 0 (at the center) to 1 (Figure 1), where the dashed area stands for the quality of information that springs from an extended logic program or theory P, built on the extension of five predicates, here named as $p_1 \dots p_5$. For example, let us now consider the case referred to above (that of contracting upon an erroneous conviction of the agent). For the sake of simplicity it will be considered only three predicates, namely those denoting the *object-of-the-negotiation* (*obn* for short), the *error-on-the-person-of-the-declare* (*eop* for short), and the *error-on-the-object-of-negotiation* (*eon* for short), whose extensions with respect to a well defined time period, namely that goes through January to April, are given as the set of axioms shown in Program 1. In terms of the predicate *eop* the assemblage is given by Program 2. It is now possible, using the learning procedure referred to above, to quantify the *quality of information* that stems from the agent knowledge base at a specific point in time, i.e. one may evolve the logic program or theory that models the universe of discourse of the agent, in which fitness is judged by one criterion alone, the *quality of information* (Figure 2).

The mental states of the agent, with respect to the months of February and March and April, are obtained in the same way, although are not explicitly represented, for a lack of space.

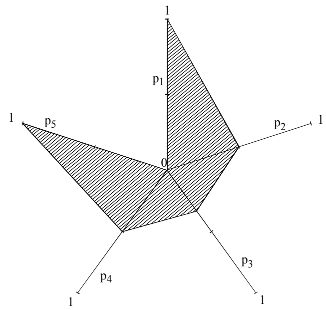

Figure 1 – A measure of the quality-of-information for logic program or theory P

```
eop(january,eop).
¬eop( X,Y ) ← not eop(X,Y) ∧
    not exception_eop (X,Y).
exception_eop (X,Y) ←eop( X,eop).
```

/The invariant below states that the person of the declare is unique/

$\neg((exception_{eop}(X_1,Y_1) \vee exception_{eop}(X_2,Y_2)) \wedge \neg(exception_{eop}(X_1,Y_1) \wedge exception_{eop}(X_2,Y_2)))$.

Program 2 – The extended logic program for *error-on-the-person-of-the-declare* (*eop* for short) with respect to January

Finally, and to predicate *obn*, one has:

```
obn(january, gold).
¬obn( X,Y ) ← not obn(X,Y) ∧
    not exception_obn (X,Y ).
```

/The invariant below states that the object of negotiation is made only on a specific metal/

$\neg((exception_{obn}(X_1,Y_1) \vee exception_{obn}(X_2,Y_2)) \wedge \neg(exception_{obn}(X_1,Y_1) \wedge exception_{obn}(X_2,Y_2)))$.

Program 3 – The extended logic program for *object-of-negotiation* (*obn* for short) with respect to January

4. Conclusion

This paper describes a formal approach to represent the reliability and trustworthiness of software agents, to transact business in the name of a real person, as in e-commerce or e-finance applications. The novelty in this work is given in terms of the approach to model and evolve the mental states of an agent, a step in the direction to overcome the shortcomings just referred to. The evolutionary process begins with an approximated representation of the agent's universe of discourse, and progresses based on a measure of the quality of information of the agent's mental state, until there is no improvement on it, based on a logic programming approach to program synthesis and analysis [2].

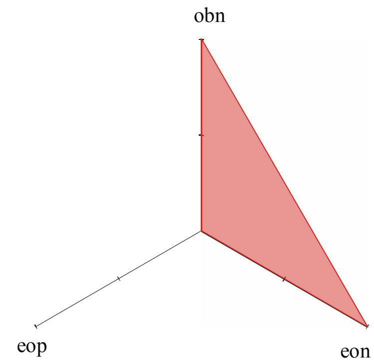

Figure 2 – A measure of the quality of information that drivens the contracting processes in January

Acknowledgement

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6. References

[1] Weitzenboeck, E. Electronic Agents and the formation of contracts[1] (visited 8/9/2003)

[2] Analide, C., Novais, P., Machado, J., and Neves, J. Quality of Knowledge in Virtual Entities, in Encyclopedia of Communities of Practice in Information and Knowledge Management, Idea Group Inc., 436-442, 2006.

[3] Angeline, P. J. Parse Trees, In: Evolutionary Computation 1: Basic Algorithms And Operators, T. Bäck, et. al. (Eds). Bristol: Institute of Physics Publishing, 2000.

[4] Rudolph, G. Convergence Analysis of Canonical Genetic Algorithms, in IEEE Transactions on Neural Networks, Special Issue on Evolutionary Computation, 5(1):96-101, 1994.

[5] Teller, A. Evolving programmers: The co-evolution of intelligent recombination operators. In K. Kinnear and P. Angeline, editors, Advances in Genetic Programming 2. MIT, 1996.

[1] http://www.eclip.org/documentsII/elecagents/contract_formation.pdf