Ontology Negotiation in an Intelligent Agents Dynamic System for Military Resources and Capabilities Planning

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ABSTRACT

The division Concepts of the Assistant Chief of Staff Evaluation (ACOS Eval) of the Belgian Ministry of Defence is making a study on the subject of "management by costs" based on an approach of capabilities. The original idea was based on the generation of future capabilities (investments and planning) and later extended to the operational use of the existing capabilities. In this paper an intelligent agents framework is proposed to simulate the possible scenarios of capabilities. Central to this subject is the ontology issue, where the Ontology Negotiation Protocol, as explained by Bailin and Truszkowski [Bailin 2001], is one of the solutions that should be further developed to resolve the problems related to the ontologies.

Keywords: Intelligent agent, strategy, capabilities, resources planning, ontologies, ONP (Ontolgy Negotiation Protocol), Military

1. INTRODUCTION

The division Concepts of the Assistant Chief of Staff Evaluation (ACOS Eval) of the Belgian Ministry of Defence is making a study on the subject of "management by costs". The purpose of the study is not only to develop a system to manage the costs, but also to provide a decision support system (DSS) to the leaders and managers, based on information about costs.

The original idea was based on the generation of future capabilities (investments and planning) and later extended to the operational use of the existing capabilities. The challenge is that the political (and social) environment is changing fast, which has a considerable influence on the (political) way of using Defence in such a fast moving world.

Flexibility and quick adaptability to new situations are very important in the planning and acquisition of resources for military capabilities. Therefore a system to support the process of acquisition and operational use of capabilities should be dynamic and agile. Scenarios must be quickly and thoroughly evaluated without ignoring the impacts on existing programs and performances.

The study has three phases. The first one is to define an ideal system where different kind of techniques are used like operational research, commercial-of-the-shelf software, benchmarking and intelligent agents. The latter is the subject of this paper. The second phase is to distillate the necessary conditions of "the management by costs" and confront them in a third phase with the existing (dispersed but not integrated) systems to propose the change management, which implies the implementation of the new system.

This paper will treat a conceptual model of "management by costs" to plan the acquisition of future resources and to follow up the operational use of the actual resources, by using intelligent agents (pieces of software which can determine their own strategy to obtain their given objectives). In the following paragraph, the global context of capability approach is described. Paragraph three discusses the framework of intelligent agents for the configuration of future capabilities and the issues around ontologies. The operational use of capabilities is described in paragraph four. This paper ends with possible extensions of this framework, further research and conclusions.

2. CAPABILITY APPROACH

The political leaders would like to have some effects on the society (outcomes) by using the military power, which will then perform actions (output) to obtain these effects. The wanted effects will be described in a number of scenarios ([Bernard 1978], [Géré 2000]) . Therefore the Military Command will configure capabilities to perform actions for all scenarios. However due to budgetary and operational reasons, not all scenarios can be covered at the same moment. The political leaders have to express which will be the maximum deployment of forces (capabilities) at the same time. Military Command can propose different configurations, each with the costs. Or the political leaders can decide a maximum budget, for which the Military Command can optimise the configuration of capabilities. Rabaey et al. [Rabaey 2006b] describe a model of the capability approach based on semantic web technologies, however this model uses only web services and concerns more the business processes necessary in a framework of capability approach.

Modules deliver the necessary capabilities, where one module can serve multiple capabilities. These modules are composed of resources. In the process area of capabilities generation, modules and/or resources are acquired following investment and recruiting plans (acquisition function). So we have a schema of outcomes – outputs – capabilities – modules – resources [Rabaey 2006a].

3. DYNAMIC SYSTEM WITH INTELLIGENT AGENTS

3.1. General Description

As already mentioned, the environment of a country or allied countries is changing very fast. A 'stable' future cannot be foreseen and the enemies of the democratic countries and the operation theatres are all over the world and are quite unpredictable. Therefore a dynamic system to determine the most optimal configuration is necessary.

Rabaey et al. described the concept of Business Intelligent Agents (BIA) to construct dynamic processes [Rabaey 2003]. The BIA asks for services at web services or other BIA. The correct communications through the different ontologies are therefore very important. In this paper we present a framework that goes deeper into the processes and services, namely the resources which use the processes.

So, we are studying a model where intelligent agents (IA) represent the items of some levels. Intelligent Agents are software entities that carry out some set of operations on behalf of a user or another program with some degree of independence or autonomy, and in so doing, employ some knowledge or representation of the user's goals or desires.

They get their information out of a Knowledge Base (KnB) by appealing to the KnB's IA and its ontology. Citing Gruber, an ontology is "a specification of a conceptualization" [Gruber 1993]. It describes the terms with their attributes and relationships in a specific domain. When ontologies were introduced in computer science, they were designed for artificial intelligence purposes since they pertain to knowledge sharing and reuse [Gruber 1991]. More recently, they are also used in the fields of information retrieval and the like [Fensel 2004]. The introduction of ontologies in information retrieval improved the search results in a repository or knowledge base. Contrary to a traditional keywords search, only information relevant to the request or query is shown due to the shared understanding. Not

only a shared vocabulary is available, but also axioms for specifying the relationships between the different terms [Decker 1999]. Therefore, the information of the KnB is categorized on the basis of an ontology.

3.2. Dynamic and Complex System

The idea of IA's came from concepts of quantum medicine and quantum healing. Some forms of quantum medicine tell us amongst other things that the whole body keeps memories of events and emotions and that organs, molecules and so on have knowledge or intelligence of what has to be done in the body (through some sort of 'communication channels'). This implies that the brains control not everything, but that intelligence and communication capabilities are spread all over the body [Chopra 1989].

So the model of the armed forces is the quantum model of the body and the mind, and each part, represented by an IA, can communicate to bring and to keep the body and the mind (Defence-model) in balance and optimise its functioning. However, it is not the purpose to develop a "Quantum Defence" where everything is leaded and managed by software pieces. The purpose of the quantum medicine is to construct a model of the mind/body to better understand the complex set of mind and body of a human being. Our purpose is to give the military leaders a model/tool to help them better understand the complex organisation, which Defence is. Nothing can replace the military genius.

An intelligent agent (IA) or group of IA's represents each item of every level. Each IA is having its own domain ontology. In other words, an ontology is specific related to the agent's world ([Tamma 2006], [Rabaey 2006b]).

The IA's are however working under the guidance of a management cell (Mgmt), which defines the environment, given in a container, that the IA's have to use. This means that the environment or the domain the IA's have to use is described by the ontology of the container. Each IA will receive its ontology or environment by the management cell.

The first semantic problem which poses a problem is when the IA has to formulate a strategy by consulting the information available in the KnB. This implies that the IA needs to understand the ontology employed for categorizing the information in this KnB.

The communication with other IA's is a second ontology conflict which poses a threat. They have to communicate with other IA's of the same or other levels in order to reach its (acceptable) optimised configuration (taking into account the set of constraints and the expected output). At this point, all costs of the resources to acquire (humans, material, infrastructure, etc.) and the costs of existing resources and the maintenance of both can be calculated for a certain period. Of course, the Military Command and/or political leaders will decide themselves, which will be the final solution. The dynamic system is only a decision support system. Therefore, some kind of shared understanding for enabling communication between IA's is imperative [Fensel 2004]

Figure 1. The capabilities generation-framework

Since each IA is using its own private ontology, a mechanism for bridging this ontology heterogeneity is essential [Tamma 2006].

3.3. Ontology Negotiation

Li Ding et al distinguish in their work [Ding 2006] five different kinds of solutions for tackling this problem: one centralized global ontology, merging ontologies, mapping ontologies, ontology translation and runtime ontology resolution. By creating one centralized global ontology, ontology heterogeneity is excluded, but its creation and maintenance is very time-consuming and consequently very expensive. In case different ontologies are having domain similarities, it is interesting to merge them into one ontology. This has as drawback that the merging procedures have to be retaken each time something has changed to one of the initial ontologies. The process where relations between similar words are mapped is called mapping ontologies [Ding 2006]. This technique is very valuable for understanding each IA's view on the world or to visualize their boundary objects [Mika 2003]. A boundary object was first coined by [Star 1989] and can be defined as an object which is used as a kind of interface between boundaries of the domain knowledge of each IA Ontology translation is another solution for ontology heterogeneity. It translates two ontologies into a target ontology. The last kind of solution – runtime ontology resolution – takes place during the real time IA interaction [Ding 2006].

The ontology negotiation protocol (ONP) explained by Bailin and Truszkowski [Bailin 2001] belongs to this latter category. This protocol is focused on information retrieval tasks and is occurring automatically and without a human intervention [Bailin 2001]. The following paragraph summarizes the ONP of Bailin and Truszkowski since we deem that the implementation (with the necessary adaptation) of this protocol in our framework is quite valuable. This ONP distinguishes four parts: interpretation, clarification, relevance analysis and ontology evolution [Bailin 2001].

IA(a) sends a query message (which contains a sequence of keywords) to IA(b). IA(b) tries to interpret each word of the message by looking at its own terminology. In case the word is not retrieved in its terminology, it searches for synonyms at a semantic lexicon such as Wordnet (online available at http://wordnet.princeton. edu). Then, it compares the synonyms with the ones in its own lexicon and when there is a match, IA(b) sends a confirmation to IA(a). In case IA(b) does not find any of the synonyms in its repository, a clarification request is sent to IA(a). After a clarification and/or confirmation, the results of the query are analysed and compared with the query itself in order to determine how well the results (documents) are corresponding with the initial query. The relevance is computed by performing some tests. In the last phase of this negotiation, the possibility of expanding the ontology with new concepts is examined and depending on the results one of the ontologies is adjusted. [Bailin 2001].

3.4. The Working of the Dynamic System

In order to come to an optimised configuration, the ontology problems have to be resolved in order of appearance: interpretation of the KnB's ontology by each IA and the communication between the IA's of the different and equal levels. The paragraphs below describe how these conflicts can be resolved and they are mainly based on the ONP of Bailin and Truszkowski [Bailin 2001].

1. When the IA(a) receives its environment, it can start to collect relevant information in the KnB. It is important for the IA(a) receiving the most appropriate information for establishing its strategy. Based on its received ontology, the IA(a) can formulate and send a query to the IA(b) of the KnB. This query contains a set of keywords collected from the IA(a)'s ontology. Each keyword is being checked whether the IA(b) can understand the keyword. This check is performed by searching for it in its ontology. When the element is not retrieved, a semantic lexicon such as Wordnet should be consulted as is proposed in the ONP of Bailin and Truszkowski. It aims at locating synonyms in the IA(b). These synonyms can enable a semantic translation bridge between both IA's ontologies. In case the intervention of such a lexicon is not sufficient, a clarification should be asked at the IA(a). When a clarification and/or confirmation are obtained, the quality of the query results sent to IA(a) are examined. During the last phase, it should be determined whether the ontology of IA(a) or IA(b) has to be extended with a new concept.
    When this process is executed for every IA, all the IA's have to start formulating their own strategy. How this strategy is built will not be tackled in this paper.
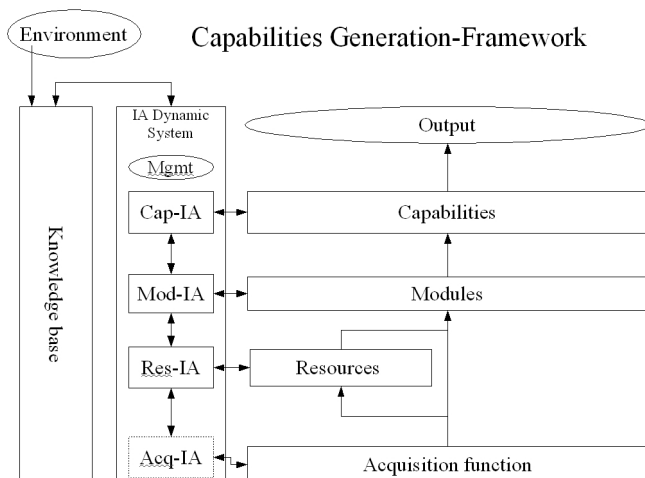
2. After the strategy creation, all the IA's have to communicate with each other in order to come to its optimised configuration. The desired effects and the strategy to obtain these are communicated from top to bottom. The horizontal negotiation or collaborative model is an approach which enables achieving these effects and strategy.

In this model the IA's are collaborating or negotiating horizontally to get a global optimum (at their level i). This global optimum is based on defining the optimum use of services of a lower level, level i+1. Therefore downwards negotiation for obtaining information on the lower existing services is necessary. The information will then be communicated upwards, to the level i. This means that ontology negotiation is respectively needed in two directions: horizontally and one level downwards. The horizontally ontology heterogeneity can be solved by merging the ontologies of all the IA's of the same level into one ontology X_i. In that way the IA's of the same level can collaborate and negotiate with each other. Consequently, an information query concerning the optimum use of services of the lower level (i+1) is sent to level i. The ontology X_i tries to interpret all the keywords of this query as described in the ONP of Bailin and Truszkowski. With this information the IA's of level i can create a global optimum at level i. This process is repeated until the highest level is reached.

4. OPERATIONAL USE

Derived from the first framework, we can also build a framework where the existing capabilities and its underlying components are trained and used. The main purpose in our study is to get an estimation of the operational costs (operations and training).

Combined with the objectives of the operations (or training), we can define the degrees of effectiveness, efficiency and transmittance. Transmittance is the ratio that determines the allocation of ALL resources of an organisation regarding ALL the objectives of the organisation.

However other aims than management by costs can be obtained. Heraclitus said once: "You could not step twice into the same river; for other waters are ever flowing on to you." If not only the generic characteristics of resources and modules are registered but also others, registered from earlier operations and training (p.e. Moral strength), then we can have the evolution of those items, so that we can differentiate modules and in this way gather the most ideal modules for one use of a specific capability.

Therefore a whole system of evaluation and/or lessons learned can be put in place to register and treat the performance of the different resources and modules. As a consequence, besides getting information about the operational and professional value of the elements of Defence, feedback for the KnB of the Capability Generation Framework will be obtained, so that more accurate information can be taken into account for a better DSS in that domain (See figure 2).

5. EXTENSIONS

Units of the Armed Forces can be in one of the different states (rest, action, and so on). After a period of rest, the resources could be put back for conditioning, forming, then reassigned into modules ready for training in capability scenarios. For a structure of Resources – Modules – Capabilities, this implies that for each level a different kind of management can be designed. If territorial capabilities are demanded, like helping the population during and after disasters, then the capability manager can train the military unites (modules) together with civilian units of the government. This can be done by extending the system to other parts of government departments.

If the military units are deployed with other units of allied nations, then a standardised system can be designed , or the interfaces with the respective systems can be standardised.

In both cases of collaboration with others, the security of the Knowledge Base and of the intelligence must be assured.

The next logical step is to make simulations. Therefore the environment should be modelled. Other systems may represent enemies, terrorist groups, population and so on.

6. FURTHER RESEARCH

Intelligent agents are communicating with each other in so called containers. In the beginning IA could only determine its strategy regarding the environment, if this environment was explicitly defined in its set of parameters. Now IA technology has evolved, IA can now react differently according the rules of the container in which the IA has to undertake actions. Flexibility and adaptability are some of the advantages of specific containers. In the Capability Generation framework, the same system of IA can be used in different countries, each with its own set of acquisition rules, represented by their respective country IA-container.

A second point is the formal way of representing the characteristics of the resources, modules and capabilities, so that they can be interpreted by the IA.

A third point is the refinement of the Ontology Negotiation Protocol of Bailin and Truszkowski [Bailin 2001]. Since a collaboration with other countries and agencies

Figure 2. Training and operational use

Training & Operational Use
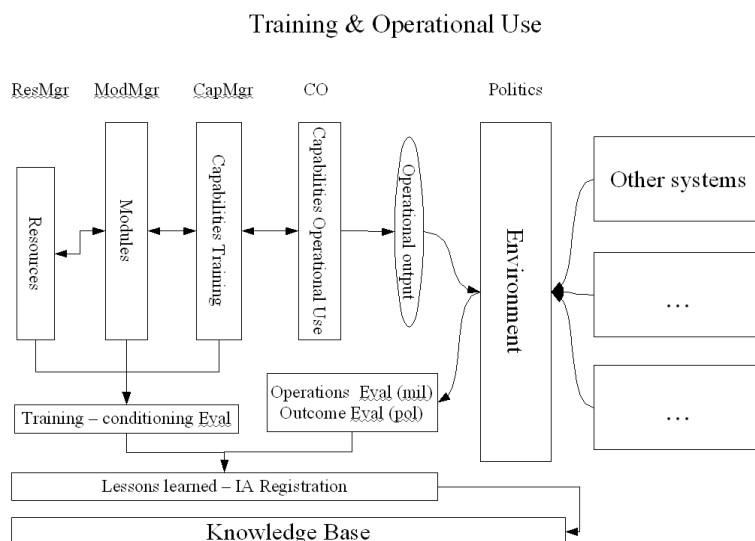
is necessary, we may have to consider the incorporation of boundary objects for solving the multi-linguistic ontologies and differences in culture and reasoning. This means that ontology mapping should be embedded in this ONP in order to come to ontology mapping negotiation protocol. This will be the challenge, if no global, universal semantic system will exist.

The system of capabilities and resources planning can also be used in a civilian context (business and/or government), so that synergies with civilian parties can be found.

7. CONCLUSIONS

The dynamic systems of resources and capabilities planning and of capabilities generation are still in a conceptual stage, where further research is still needed. It was originally conceived to calculate the costs of the capabilities generation. We have also seen that the derived operational use model can not only be used to calculate the operational use of existing capabilities, but also to build a global evaluation system, where lessons learned can be established, and that can give feedback to the capabilities generation framework. The possible integration of an "environmental" context could give the opportunity to simulate scenarios and to hold computer aided military exercises.

In this paper an intelligent agents framework is proposed to simulate the possible scenario's of capabilities. Central to this subject is the ontology issue, where the Ontology Negotiation Protocol, as explained by Bailin and Truszkowski [Bailin 2001], is one of the solutions that should be further developed to resolve the problems related to the ontologies.

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