ECA RULE ONTOLOGY
Modelling Prescriptive Rules as Descriptive Ontology

Vandana Kabilan
Department of Computer and Systems Sciences, Royal Institute of Technology and Stockholm University
FORUM 100, SE- 16440, Kista, Sweden

Pernilla Svan
FOI, Swedish Defence Research Agency, Division of Systems Technology, Department of Systems Modelling
SE- 16490, Stockholm, Sweden

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Abstract: Ontology is said to be descriptive in contrast to the prescriptive nature of typical behaviour, process or rules. However, rules and behaviour models are in themselves a domain of re usable shared knowledge. Whether in the domain of enterprise systems or in military modelling and simulations, we find instances of such 'prescriptive' body of knowledge. While capturing such 'rules' as programmatic axioms using rule languages may be viable, it does not help us is establishing the reusable domain knowledge. In this paper, we combine software engineering technique based on the Event Condition Action logic to propose the ECA Rule Ontology as a mechanism for capturing such prescriptive rules as ontological conceptualisations. We exemplify our approach by applying it to the domain of military operations modelling and simulations.

1 INTRODUCTION

Ontology is a conceptualisation of domain knowledge. The fundamental objective behind the design of ontology is to conceptualize the domain of interest. The other main objectives for the use for ontology in information systems as proposed by (Noy and McGuiness, 2001) are:

- To make explicit implicit domain knowledge
- To promote easy understanding between human users, thereafter between humans and machines, followed by machine-to-machine understand ability and ultimately machine-to-human understand ability.
- To support reusability of conceptualised knowledge.

To achieve the above,we see at least two main hurdles as:

- We need guidelines,methods, tools to capture and represent domain knowledge consistently
- This knowledge capture and representation is to be carried out by non-ontology experts. That is the naive domain expert should be able to perform this domain knowledge analysis and representation.

The above mentioned issues are key to the success of all semantic web based applications. In this paper, we focus on these aspects. Our case study domain is that of military modelling and simulation, as shall be discussed in detail later. Thereafter, we focus specifically on modelling and represnting a body of presciptive, behaviour or rules in this domain, like Rules of Engagement and Standard Operating Procedures. Similar domain knowledge of rules in the enterprise system domain could be business rules and policies. Hence, our research is not restrictive in its domain of application. However, for this paper, we ellucidate and discuss it only in the context of military modelling and simulation. In this paper, we combine software engineering technique based on the Event Condition Action logic to propose the ECA Rule Ontology as a mechanism for capturing such prescriptive rules as ontological conceptualisations. The ECA Rule ontology has a two fold application; first, we use it as a conceptual schema for us to capture and model individual facts of the domain, i.e, it acts as our knowledge repository. Secondly, it acts as a lexicon and a guide for the nave information systems user, who is not necessarily an ontology expert. These information system users are our targeted audience, who will execute the task of conceptualising the

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domain knowledge from natural language to knowledge representation. We use conceptual models as the first visualisation of our knowledge representation followed by an instantiation in Web Ontology Language. We exemplify our approach by applying it to the domain of military operations modelling and simulations. We validate both our approach and the proposed ontology through a user feedback study of non-ontology experts, but military domain experts. The rest of this paper is structured as follows: in section 2 we give a short background description of the military simulation and modelling domain. Therafter, we introduce our proposed ECA Rule Ontology. In section 4, we give short illustrations from our case study followed by our evaluation study in section 5. Finally we conclude and summarise our work in section 6.

2 BACKGROUND

In this section we briefly review the theoretical background for our research as well as summarize the military modelling and simulation domain.

2.1 Related Research

we need to capture and analyze the knowledge and thereafter represent it in a cohesive, yet easy to understand knowledge representation. However, most of the domain knowledge is usually available as natural language descriptions. The goals of natural language understanding and semantic conceptualizations of domain knowledge representations, as investigated by (Sukkarieh, 2001) , are similar to those of ontology design goals and objectives in information systems as mentioned above. Yet, there exists a gap in design methodology how this extraction of explicit and implicit knowledge from natural language can be represented and modeled as conceptual models. Conceptual models as Knowledge Representation models are generally graphical and easy to understand. So for this research, we restrict ourselves to the context of natural language (English language) interpretation to knowledge representation as conceptual models. The transformability of UML conceptual models into formal Frame-based knowledge representation language like OWL (2004)(OWL, 2004) has been proposed by several researchers like (Baclawski et al., 2001), (Kabilan and Johannesson, 2004) and more recently the OMG recommendation for Ontology Definition Metamodel (2005)(ODM,), which proposes mapping rules for UML to OWL and vice versa. Thus, the reasoning and support features of formal knowledge representations can be attained. This brings us back to the issue of modelling knowledge representations from the highly expressive natural language. Ontology is said to be descriptive in contrast to the prescriptive nature of typical behaviour, process or rules. However, rules and behaviour models are in themselves a domain of re usable shared knowledge. Whether in the domain of enterprise systems or in military modelling and simulations, we find instances of such 'prescriptive' body of knowledge. While capturing such 'rules' as programmatic axioms using rule languages may be viable, it does not help us in establishing the reusable domain knowledge. We define based on definitions by (Gruber, 1993) and (Uschold and Gruninger, 1996): "An ontology is an explicit formal conceptualization of a shared under-standing of the domain of interest including the vocabulary of terms, semantics as well as their pragmatics." Hence, our approach is to capture not only the domain 'static' descriptive concepts but also the prescriptive details. We do not discuss our approach for conceptualisation of the military concepts in this paper, the interested reader is referred to (Kabilan, 2006) and (Mojtahed et al., 2005) .

2.2 Military Modelling and Simulation Background

Simulation is a technique where computers are used to imitate (simulate) real world processes. Because of the complexity of the real world we need a limited model of the specific system to be able to study it and understand better how it works. A simulation can also be described as an experiment with a model to follow and understand the behaviour and causal relationship in the model over time. Some examples of application areas where simulations is a useful tool are design and analyse of manufacturing systems, analysing financial and economic systems, reengineering of business processes and a numerous of areas in the military domain (Law and Kelton, 2000). The use of Modeling and Simulation within the military domain has increased since it reduces cost and increase the efficiency for implementing military operations. More specifically it is used to speed up and increase the quality of analysis and studies. Using Modelling and Simulation for training and education increases the efficiency and lower the costs substantially since simulators can be used. Simulators are also substantially for supporting Command and Control (C2) and planning functions (Holm, 2006) .

2.3 Case Study: Rule of Engagement

Military activities are regulated by different rules and guiding procedures. One of those are Rules of Engagement (ROE) which are directives designated to regulate situations and limitations for when force may be used. ROE reflect political and diplomatic constraints and should be set at high general level (Krigsman and Svensson, 1999). A ROE defines the constraints for a certain military activity, what is forbidden and what is allowed for the specific activity during certain circumstances. Examples of such activities are use of force, detention of civilians, use of land mines, use of warning shots, and prevention of crimes.

The aim of using ROE is threefold. The political aim is to guarantee that military operations are implemented to support the policy of the political management. The military aim is to guide commanders to solve conflicts. Finally the legal aim of ROE is to guarantee that military operations are implemented within the limits of national, international and human rights.

The ROEs used in this case study has been taken from a fictitious scenario used for experiments and exercise in the Swedish Defence Forces. The scenario contains a multinational operation with the end state goal to implement a signed Peace Agreement in an area with many years of ethnical and religious conflicts. A collection of ROEs taken from this scenario have been used for our analysis and case study.

The ROE was used as input information to the phase Knowledge Representation in the DCMF(Defence Conceptual Modelling Framework) process and analysed with the method Five Ws(Carey et al., 2001). In previous work (Mojtahed et al., 2005) we used the Five Ws to analyse a sequential scenario giving the result that it is feasible but much of the context was lost. This time we were interested in analysing rules with Five Ws but also to define more specifically how to keep the context after analysis. In the following section, we briefly summarise the Five Ws method.

2.3.1 5Ws Knowledge Analysis Method

The Five Ws is a concept used in journalism for structuring a story of something. The principle is that a complete report must answer the five interrogative words: Who, What, When, Why and Where. Sometimes an H is added representing How. All these questions should be answered with necessary facts in order to get a complete report and the full story of something that has happened. This structure is common in news style and news reports but has also been used for police investigations. The same Five Ws approach has been introduced and used for military operations analysis as seen in works of. ((Turnitsa et al., 2004).) and ((Carey et al., 2001))

The Five Ws has also been used in the miliatary domain for structuring information (Turnitsa et al., 2004) One example is the Battle Management Language (BML) effort aiming towards development of an unambigues language to be used by Command and Control (C2) forces providing the fundamentals for a common operational picture. BML consists of a number of components where one of them is a Data Information Exchange Model (JC3IEDM)(JC3IEDM, 2006) . In the JC3IEDM a set of tables has been identified to contain the structure of Five Ws where it functions as a format for capturing the required information for an operation order, report or an request.

3 INTRODUCING THE ECA RULEONTOLOGY

The use of ontologies as knowledge repositories for facilitating semantic web applications, is widely accepted. As with any other application, the need for supporting constraints, policies, rules is self evident. Event-Condition-Action rules are an intuitive choice for the same as has been proposed by Papamarkos et al (2003) (Papamarkos et al., 2003). Other alternatives like the proposed Semantic Web Rule Language (SWRL) were also considered, but in view of our second objective, that is to provide an easy to use guideline for the nave user, we chose to adopt the simple ECA rule approach. An ECA rule has a general syntax of

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On EVENT if CONDITION then DO Actions.
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We build our ECA Rule ontology on the same principle as seen in figure 1. The EVENT concept specifies the occurrence of any triggers, situations, orders , or incidents. The CONDITION concept specifies the other requirements like state of affairs, current situation contexts, preconditions, post conditions of other actions and so forth. The idea is that on the ocuurence of an EVENT, a pre determined CONDITION needs to be evaluated. And if the condition is evaluated to be true then the prescribed ACTION is allowed. Action in the ECA rule ontology indicates not only physical activities, but could also be used for delegation of authority, rights etc.

The above information is sufficient, from a data level software engineering perspective. However, from the domain knowledge perspective we need to capture further implicit knowledge like what caused

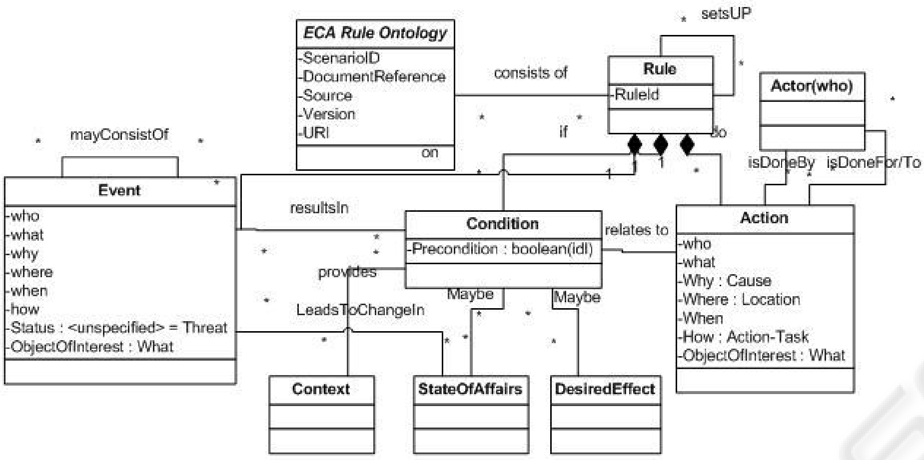

Figure 1: ECA Rule Ontology Basic- Concepts.

the event? Who was responsible for the event? Who is affected by the event? What are the consequences? And so on. This is necessary, as these form the context for the decision , whether the described rule is to be executed or not. Therefore, we now extend the concepts of EVENT with relationships to the Five Ws analysis approach: who, what, why, where , when . In the military domain, an event is usually an unplanned activity, and is perpetrated by enemy forces. Similarly, we extend the ACTION concept. For the CONDITION concept, we include aspects of preconditions, post conditions, dependencies etc. The Rule of Engagement is a prescription of expected and allowed military behaviour in the case of described events happening. To further aid for Military domain expert users in their analysis work, we mapped the ECA Rule Ontology to a military operations ontology, Defence Conceptual Modelling Framework Ontology (Kabilan, 2006). This domain ontology is based on the Joint Command Control and Communication Information Exchange Data Model (JC3IEDM)(JC3IEDM, 2006) specification from the Multilateral Interoperability Programme (MIP). For example figure 2 shows the mapping of 'who' concept to DCMFO (Defence Conceptual Modelling Framework Ontology) concepts. In our proof of concept demonstration, this is provided as a lexical help for the user making the analysis and subsequent knowledge representation.

4 CASE STUDY RESULTS

As mentioned earlier,the case study was based on a fictional document for military exercises and a short excerpt from that document is given below:

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   ROE 1:  The use of minimum force
to prevent any attempts by persons to
prevent the BFOR from dischargingits
duties is permitted.
ROE 2:  The use of minimum force to
defend friendly forces and persons with
designated special status against hostile
action is permitted.
ROE 5a:The use of minimum force to
prevent the taking possession of or
destruction of property with designated
special status is permitted.
ROE 5b:Individual service personnel are
to be informed when they are protecting
specific property on this basis.
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An analysis of the same through only the Five Ws gave result like that shown in Figure 3. The selected ROEs were analysed with Five Ws in order to study feasibility of analysing rules with this method and how to keep the context after analysis. The result showed that it is feasible to analyse ROE with Five Ws but it is not really satisfying since there is a loss in information and context which affects the reusability. If too much context is lost during the process it is difficult to reuse the analysed information. One way of dealing with this is to fill in the gaps with information and have a Subject Matter Expert verify the extended information.

Five Ws is useful on a conceptual level to get a

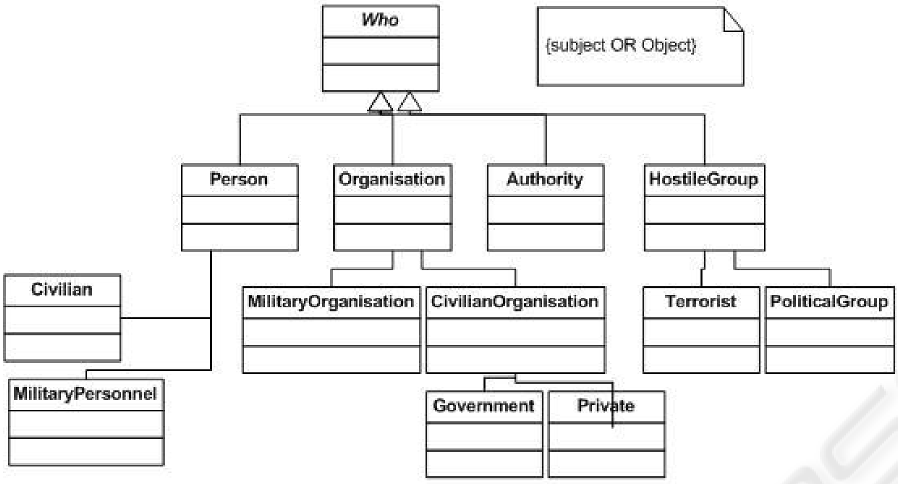

Figure 2: ECA mapped to Domain Ontology for Lexical help.

A The use of minimum force to prevent any attempts by persons to prevent the BFOR from discharging its duties is permitted.

No	WHO	WHAT	WHERE	WHEN	WHY
A1	BFOR Land Force	Is permitted to use minimum force	Joint Operations Area (JOA) in Bogaland	During implementation of UNSCR's 2377, 2427, 2450 and Bogaland Peace Agreement	To prevent any attempts by persons to prevent the BFOR from discharging its duties

Figure 3: Sample Rule analysed with only 5Ws.

quick categorisation and understanding of an event. Using the Five Ws as a support for categorising an event is feasible since it can contain the most important aspects of that event. The Five Ws is good start though but need to be complemented with rules.

Now,we apply the proposed ECA rule ontology along with its mapppings to the 5Ws and military concepts (DCMFO). The same rules were analysed as follows(figure 4): The ECArule ontology as well as the case study was implemented using Protege Ontology editor, a screenshot of which may be seen in figure 5. The targeted users can either create new knowledge instances of rules in the Protege ontology editor itself, as seen in figure 5 or can use our proof of concept demonstration application. The DCMF tool(figure 6) is wizard-like in its approach and aids the user to analyse and capture the knowledge in a stepwise process. The tool displays the military domain ontology which has been mapped to the ECA , and the user makes use of this information, while analysing the text at hand.

5 EVALUATING THE ECA RULE ONTOLOGY

To assess the ECA Rule Ontology, five persons were asked to compare the ECA Rule Ontology and Five Ws for analysing information. The test group had knowledge of the military domain and experience of categorising information. They were asked to categorise a couple ROE using the simple Five Ws ontology. After that they categorised the same ROE using the ECA rule ontology. Before beginning, they were introduced to the basic concepts of Five Ws and ECA rule ontology.

After accomplished the analysis and categorisation the test persons were asked the following questions:

1. Ease of analysing the ROE using Five Ws (on a scale 1-5)
2. Ease of analysing the ROE using ECA rule ontology (on a scale 1-5)
3. What information do you think can be analysed with Five Ws?
4. What information do you think could be analysed with ECA Rule Ontology?

ROE 1	Event	Condition	Action
	AttemptsToPrevent-discharge-of-duties	BFOR Prevented From Discharging normal duty	UseOfMinimumForce
Who	HostileForces (does it) BFOR (is affected)	-	BFOR (does it) HostileForces(against whom)
What	BFORisObstructed	-	UseForceToPreventOrDefend
When	WithinPeaceKeepingPeriod	-	WithinPeaceKeepingPeriod
Where	Bogaland	-	Bogaland
Why	TerrorismInBogaland	-	PeaceKeepingInBogaland

Figure 4: ECA Analysis for Rule of Engagement.

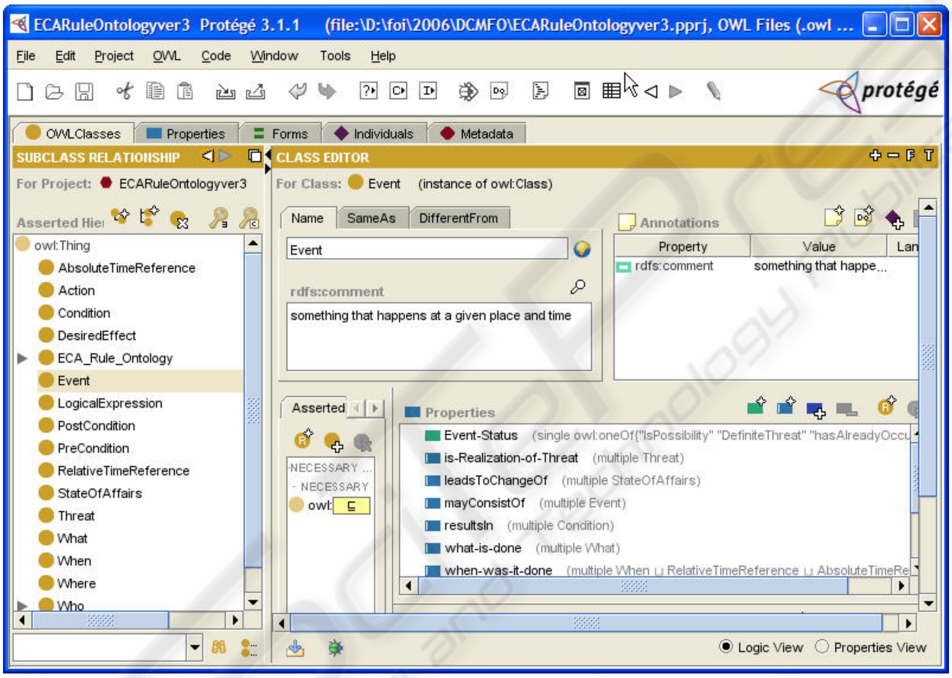

Figure 5: ECA Analysis for Rule of Engagement.

5. Have you used Protege before? If yes, how would you rate that the ECA Rule Ontology, for analysing ROE, has improved (on a scale 1-5) the following aspects:
   - usability
   - ease
   - utility

For the first question, ease of analysing with Five Ws, there was a mean answer of 3 (max= 4 and min=2). Analysing with ECA rule ontology was considered to be easier with an average of 3.6 (max= 5 and min = 2). The domain experts felt that analysing with only Five Ws was not satisfactory since contextual and implicit information was lost. Specifically in the case of Rules of Engagement, the rules do not explicitly predefine a 'when' or 'where' the rule may be applied. It depends on the situation and context. The assessment group answered that they would use the Five Ws to analyse information which described "sequences of events", "scenarios already occurred in a certain order and a certain place". On the question-when to use the ECA Rule Ontology- the test group had the view that the ECA rule ontology could be used in cases like description of rules which are not bound to time or location, instructions and general directives and so on. Hence, our basic intention to capture and model prescriptive behavior is fulfilled. The entire test group had seen or used the protege ontology editor prior to our interview.They rated an average of 4 on the questions regarding the actual ECA Rule Ontology implementation and interface built in protege.(on the account of usability (mean=3.8, max=5, min=3), utility (mean=4.0, max= 5, min=4) and ease

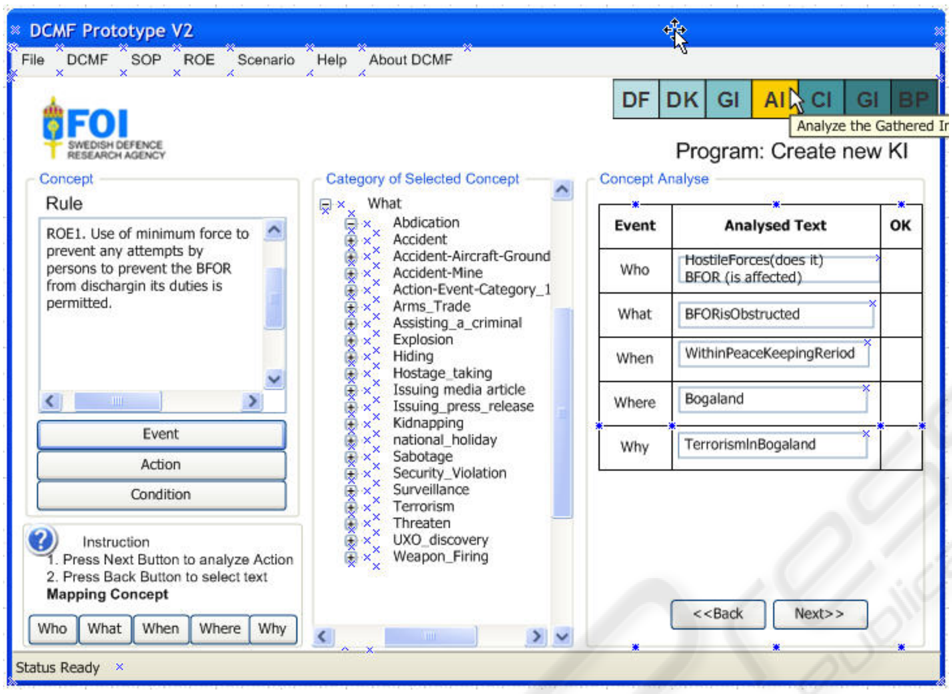

Figure 6: Screenshot of our Proof of concept DCMF Analysis tool.

(mean= 4.2, max= 5, min=3))

The Users felt that the main advantages with the ECA Rule Ontology are:-

- Their analysis from natural language to knowledge representation became easier, since they had a help from the ontology and previous 'instances' to look up.
- They could do the analysis from natural language to ontology consistently. That is , even though all the users in our target group were non-ontology experts, and they all independently carried out the exercises, they all came up with similar results. (the ECA analysis result)
- Since most of them were familiar with Five Ws analysis, the ECA which used 5Ws as well, was easy to comprehend and adopt.

However, the users also felt that the ECARule Ontology was not covering all the semantics of CONDITIONS and all its possible relationships to EVENT and ACTION. We consider this to be an useful input and hope to improve our model in the next iteration.

6 CONCLUSION

In this paper we focused on the issues of:

- **Making implicit knowledge explicit.** In every domain, the semantics reach far beyond the meaning of the natural language used. Contextual meaning, domain knowledge, purpose are some examples of implicit knowledge that needs to be made explicit. The purpose for this to have a common shared easy to understand model, that can be used for consensus, sharing knowledge among other uses.
- **Providing guidanace for knowledge analysis to knowledge representation for naive users (domain experts)** Most of the current state of the art ontology design methodologies and guidlines focus on building ontologies from scratch. While some like METHONTOLOGY(Fernandez et al., 1997) focus also on maintenance and evolution of ontology.The assumption is that these activities are carried out by the 'ontology designer' or experts in the art of conceptualisation. In reality, it is often so, that once a system is designed and setup in operation, it needs to be populated with information (instances) and maintained. It is expected that the targeted user groups(domain experts and not ontology experts) should be able to carry out

this ontology instantiation process by themselves. This needs that the designed ontology model is comprehensible for the naive user and is intuitive to use.

We have proposed ECA Rule Ontology for capturing and modelling prescriptive rules and behaviours while addressing the above mentioned key issues. Our proposed work has been validated on two fronts. First, we have tested the feasibility of capturing and analysing a large number of Rules from the case scenario, some standard operating procedures as well. Secondly, more importantly, our proposed ECA Rule Ontology has been assessed by the targeted users from the military domain. Our next aim is to apply the proposed ontology to other domains.

While we have illustrated the utility of the proposed ECA Rule Ontology for the military modelling and simulations domain, we contend that the same may be applied in different domains as well. For example, if we were to analyse a typical business case scenario from enterprise systems, like that of a Pizza fast food restaurent, that guarentees to deliver pizzas to its customers within 15 minutes or return the money. Such prescriptive behaviour may be modelled using ECA as the customer compliant being the 'EVENT' , the 'delivery of pizza after 15 minutes' being the 'CONDITION' , and the proposed 'ACTION' being 'return money to customer'. Thus our future work is focused on application of our proposed ontology in other domains. We belive that our research is aimed at resolving some of the practical issues which need to be addressed for the success of semantic web technology based applications.

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