Journal of Universal Computer Science, vol. 13, no. 2 (2007), 209-223
submitted: 31/7/06, accepted: 15/1/07, appeared: 28/2/07 © J.UCS

An OWL Ontology of Set of Experience Knowledge Structure

Cesar Sanin
(University of Newcastle, Australia
Cesar.Maldonadosanin@Newcastle.edu.au)

Edward Szczerbicki
(University of Newcastle, Australia
Edward.Szczerbicki@Newcastle.edu.au)

Carlos Toro
(VICOMTech Research Centre, Spain
ctoro@vicomtech.es)

Abstract: Collecting, distributing and sharing knowledge in a knowledge-explicit way is a significant task for any company. However, collecting decisional knowledge in the form of *formal decision events* as the fingerprints of a company is an utmost advance. Such decisional fingerprint is called decisional DNA. Set of experience knowledge structure can assist on accomplishing this purpose. In addition, Ontology-based technology applied to set of experience knowledge structure would facilitate distributing and sharing companies' decisional DNA. Such possibility would assist in the development of an *e-decisional community*, which will support decision-makers on their overwhelming job. The purpose of this paper is to explain the development of .an OWL decisional Ontology built upon set of experience, which would make decisional DNA, that is, explicit knowledge of formal decision events, a useful element in multiple systems and technologies, as well as in the construction of the e-decisional community.

Keywords: Knowledge Acquisition, Knowledge Representation Formalism and Method, Artificial Intelligence, Information Systems Applications, Semantic Networks
Categories: I.2.6, I.2.4, I.2, H.4, I.2

1 Introduction

Since the word knowledge took place into the business argot, managers have tried to make it part of their assets. Knowledge seems to be an invaluable asset of incalculable significance and it has been considered as the only true source of competitive advantage of a company [Drucker, 95]. Thus, the focus of managers has turned to knowledge administration and many companies have invested huge amounts of money to research technologies that facilitate control of all forms of knowledge. In consequence, the means and the ability of acquisition of knowledge, through efficient transformation of information, can make the difference between the success and failure of a company in the competitive environment of global economy [Sanin, 04] and knowledge society.

However, knowledge society arrived and brought with it all the difficulties that information faces. Characteristics such as unstructured, disintegrated, not shareable, incomplete, and uncertain information represent an enormous problem for information technologies (IT) [Ferruci, 04; Deveau, 02]. Under these circumstances, the process of transforming information into knowledge is critical and difficult, because unfortunately, knowledge depends upon information [Sanin, 04]. Moreover, Awad and Ghaziri [Awad, 04] gives acknowledge of another difficulty when affirms that up to 95 percent of information is preserved as tacit knowledge (for tacit and explicit knowledge see [Nonaka, 95]). Thus, one of the most complicated issues about knowledge is its representation, because it determines how knowledge is acquired and how knowledge is transformed from tacit knowledge to explicit knowledge. Knowledge must be obtained and represented in an understandable form for the agents that experienced it. Hence, it is evident that some kind of technology is necessary to transform information into, not just knowledge, but explicit knowledge.

One theory proposes that experienced decision-makers base most of their decisions on situation assessments [Noble, 98]. In other words, decision-makers principally use experience for their decisions, i.e. when a decision event emerges, managers select actions that have worked well in previous similar situations. Similar situations at thi stage operate at an abstract level. Nevertheless, when applying similarity in a realistic level, it depends upon the knowledge representation used. Then, managers, in a not yet well known brain process, extract the most significant characteristics from the current circumstances, and relate them to similar situations and actions that have worked well in the past. However, what it is clear here is that it is very important to keep a record of earlier decisions events. In consequence, tools for representing and storing formal decision events in a knowledge-explicit way are evidently necessary, understanding that a formal decision event is a decision occurrence that was made following procedures that make it structured and formal [Sanin, 05a].

Many technologies, such as Knowledge Management Systems (KMS), Data Mining (DM) and Knowledge-base Systems (KbS) among others, are currently working with different types of knowledge. Moreover, although these technologies work with decision-making in some approaches, they do not keep structured knowledge of the formal decision events they participate on. For us, any technology able to capture and store formal decision events as explicit knowledge will improve the decision-making process, reducing decision time, as well as avoiding repetition and duplication in the process. Unfortunately, computers are not as clever as to form internal representations of the world, and even simpler, representations of just formal decision events. Instead of gathering knowledge for themselves, computers must rely on people to place knowledge directly into their memories. This problem suggests deciding on ways to represent information and knowledge inside computers. Set of Experience Knowledge Structure is a combination of filtered information obtained from formal decision events performed by different technologies, i.e. it acquires knowledge from technologies that take structured decisions. Nevertheless, despite the fact that set of experience knowledge structure is already developed, the ways for acquiring its knowledge are supported on the confidence of every technology that performs formal decisions [Sanin, 06b].

Set of experience knowledge structure has been developed as part of a platform for transforming information into knowledge named Knowledge Supply Chain System (KSCS) [Sanin, 05a]. KSCS performs by manipulating sets of experience to keep formal decision events and to help managers in the daily operation of decision-making. In brief, the KSCS takes information from different technologies that make formal decision events, integrates them and transforms them into knowledge making use of sets of experience. Fully developed, KSCS certainly would improve the quality of decision-making, and could advance the notion of administering knowledge in the current decision making environment.

Once a structure such as set of experience allows constructing the decisional DNA of a company, it is necessary to increase the means for sharing this experience among different agents. Distributing decisional DNA, not just inside a company, but also among many companies, would help on the establishment of a knowledge sharing community, which, if it is developed through internet, it would be called the e-decisional community, that is, a decisional Community of Practice (CoP).

Different technologies can help in accomplishing such task, but no one like Ontology-based technology, which offers differentiable advantages. Ontology-based applications are probably the fields in which computer-based semantic tools and systems are more extended nowadays for several heterogeneous domains, mainly focused in querying and classification purposes in information sharing and knowledge management contexts. Ontologies are commonly used in artificial intelligence and knowledge representation. Computer programs can use Ontologies for a variety of purposes including inductive reasoning, classification, a variety of problem solving techniques, as well as to facilitate communication and sharing of information among different systems. In addition, emerging semantic web systems use Ontologies for a better interaction and understanding between different web-based systems using agents. In this last direction, a recent survey of Ontology-based applications, with focus on e-commerce, knowledge management, multimedia, information sharing and educational applications, can be found in Ramos and Gomez-Perez [Ramos, 04].

In conclusion, the purpose of this paper is to explore Ontologies under the view of set of experience knowledge structure, leading onto the creation of a new community of practice named *e-decisional community*, which would share companies' decisional DNA. In such way, set of experience Ontology-based knowledge structure would have the potential to improve the way knowledge is managed as an asset in current decision-making environments.

2 Background

Nature has developed potent tools to store and manage information and knowledge. Firstly, DNA has been judged by many researchers as the most excellent data structure. The survival of information in nature over successive generations has showed the success of the DNA structure, and its mechanisms. DNA stores information for survival of the species, and allows for improvement through evolution. Secondly, the brain has been considered as the most powerful processor and database. The brain stores knowledge in terms of keeping experience from past situations, as well as knowledge from preventive experience of others, i.a. a cultural

knowledge. This stored knowledge is used for the survival of the individual, and the improvement of its existence [Sanin, 05a].

Two potent natural structures created for the survival of the group and the individual showing that one of the most valuable intellectual assets are the experiences accumulated during processes.

2.1 Deoxyribonucleic Acid (DNA)

DNA is a nucleic acid found in cells that carries genetic information, and is the molecular basis of heredity. DNA is made from two strands that stick together with a slight twist; it looks like two strands forming a helical spiral winding around a helix axis. Each strand is a long combination of four basic elements called nucleotides. These nucleotides are Adenine (A), Thymine (T), Guanine (G) and Cytosine (C). Their combination allows for the different characteristics of each individual, and becomes as one of the highlighted uniqueness of this kind of structure. One part of the long strand comprises a gene. A gene is a portion of a DNA molecule, which guides the operation of one particular component of an organism. Genes give orders to a living organism about how to respond to different stimuli. Finally, a set of genes makes a chromosome, and multiple chromosomes make the whole genetic code of an individual [see Fig. 1]. For a deeper information please refer to [Miller, 02].

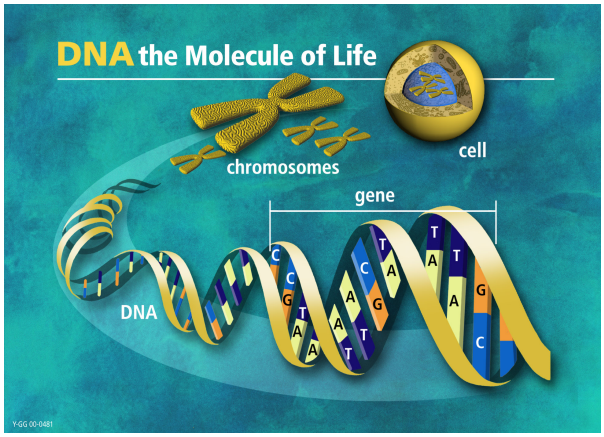

Figure 1: DNA the Molecule of Life (Image credit U.S. Department of Energy Human Genome Program (http://www.ornl.gov/hgmis)

DNA demonstrates unique aspects as a data structure [Ryu, 04]. Information about the living organism is kept to be passed on to future generations, as well as being the basis of new elements in the organism which are evaluated in terms of performance. DNA stores information for the survival of the species, and improvement in the evolutionary chain.

2.2 The Brain

The brain, as the organ of the central nervous system of vertebrates, controls thought and neural coordination. It receives stimuli from the sense organs, and combines and interprets them to formulate a response.

Psychologists have tried to explain how the brain acts and keeps experience, and most important, how it takes decisions. One of these psychologists, George Kelly, established a theory and introduced the idea of a *psychological space* as a term for an imaginary region in which we may place and classify elements of our experience. This space does not pre-exist, and in consequence, each individual goes through a process of construction. This space will provide a kind of topological system of personal experience [Shaw, 92]. Hence, the theory proposes that experience is kept in our brain in the way of multiple correlated variables describing a situation. Decisions events are part of these situations that can be kept in the psychological space. Experience is, possibly, stored in the brain in the way Kelly proposes, and once the psychological space is constructed, it can be used in the way that Noble [Noble, 98] proposes decision-makers operate.

Experienced decision events of the living organism are kept in the brain for future situations. The brain stores experience for the survival of the individual, and improvement of its own existence.

2.3 Current Trends in Knowledge and Data Structures

From a mechanistic point of view, reasoning in machines is a computational process. This computational process, to be feasible, definitely needs systemic techniques and data structures, and in consequence, several techniques have been developed trying to represent and acquire knowledge. Although, every representation must be implemented in the machine by some data structure, the representational property is in correspondence to something in the world, says a *decision event*, and in the constraints imposed by association [Sanin, 05a].

A Knowledge Representation (KR) is fundamentally a replacement, a substitute for the thing itself. It is used to allow determining consequences by thinking rather than acting, i.e. by reasoning about the world rather than taking action in it. Moreover, a KR is a medium of human expression, i.e. a language in which we say things about the world. It is an element of intelligent reasoning, a medium for organizing information to facilitate making inferences and recommendations, and a set of ontological commitments, i.e. an answer of how to interpret the world [Davis, 93].

KR looks to be equally useful for intangible objects as well as tangible objects. Davis, Shrobe, and Szolovits expressed that “representations function as surrogates for abstract notions such as actions, processes, beliefs, causality, and categories” [Davis, 93], and therefore, representations can be also used on formal *decision events*.

In past years, many knowledge representation structures have been developed. Logic, rules, and frames appear as the most generalized techniques, and symbolize the kinds of things that are important in the world; even though developed systems can used exclusively one of the techniques, their hybridization is a common element. Logic implicates understanding the world in terms of individual entities and associations between them. Rule-based systems view the world in terms of attribute-

object-value and the rules that connect them. Frames, on the other hand, comprise thinking about the world in terms of prototypical concepts. Hence, each of these representation techniques supplies its own view of what is important to focus on, and suggests that anything out of this focus may be ignored [Davis, 93].

Recent advances in the field of KR have converged on constructing a Semantic Web, an extension of the current World Wide Web, looking for publishing information in a form that is easily inferable to both humans and machines. Current progresses have led to the standardisation of the Web Ontology Language (OWL) by the World Wide Web Consortium (W3C). OWL provides the means for specifying and defining ontologies – collections of descriptions of concepts in a domain (classes), properties of classes, and limitations on properties. OWL can be seen as an extension from the frame based approach to knowledge representation, and a division of logic called Description Logics (DL) [Schatz, 04].

All these possible representations can be used for many purposes, and those points of view are useful, but they are not the only ones. Only finite representations of something are available, never something complete. Sokolowski observes, "the thing can always be presented in more ways than we already know; the thing will always hold more appearances in reserve" [Tsoukas, 04, p.4].

3 Set of Experience Knowledge Structure

Knowledge is a fluid mix of experiences expressed in terms of values, related information, and expert insight, which provides a framework for evaluating and incorporating new experiences and information [Coakes, 03].

As was said above, one of the most valuable intellectual assets is the experience accumulated during processes, and in our case, the experience acquired in making a decision. Based upon Kelly's theory of *psychological space,* we develop a knowledge structure to manage formal *decision events*, a structure that builds up this space with formal decision experiences.

Set of experience has been developed to store formal decision events in an explicit way. It is a model based upon existing and available knowledge, which must adjust to the decision event is built from. Four basic components surround decision-making events: *variables, functions, constraints,* and *rules.* They are stored in a combined dynamic structure that comprises set of experience [see Fig. 2]. In this text a concise idea of set of experience and its components is offered, for additional information Sanin and Szczerbicki [Sanin, 05a] should be examined.

Variables usually involve representing knowledge using an attribute-value language (that is, by a vector of variables and values) [Lloyd, 03]. This is a traditional approach from the origin of knowledge representation, and is the starting point for set of experience. Variables that intervene in the process of decision-making are the first component of the set of experience. These variables are the centre root of the structure, because they are the origin of the other components.

Based on the idea of Malhotra [Malhotra, 00] who maintains that "to grasp the meaning of a thing, an event, or a situation is to see it in its relations to other things", variables are related among them in the shape of functions. Functions, the second component, describe associations between a dependent variable and a set of input variables; moreover, functions can be applied for reasoning optimal states, because

they come out from the goals of the decision event. Therefore, set of experience uses functions, and establishes links among the variables constructing multiobjective goals.

According to Theory of Constraints (TOC), Goldratt [Goldratt, 86] affirms that any system has at least one constraint; otherwise, its performance would be infinite. Thus, constraints are another way of relationships among the variables; in fact, they are functions as well. A constraint, as the third component of set of experience, is a restriction of the feasible solutions in a decision problem, and a factor that limits the performance of a system with respect to its goals.

Finally, rules are suitable for associating actions with conditions under which the actions should be performed. Rules, the fourth component of set of experience, are another form of expressing relationships among variables. They are conditional relationships that operate in the universe of variables. Rules are relationships between a condition and a consequence connected by the statements IF-THEN-ELSE.

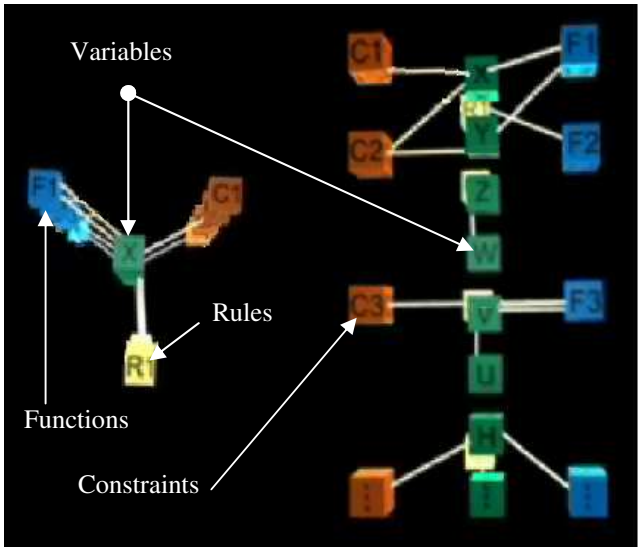

Figure 2: Structure of the Set of Experience

In conclusion, the set of experience consists of variables, functions, constraint and rules, which are uniquely combined to represent a formal decision event. Set of experience can be used in platforms to support decision-making, and new decisions can be made based on sets of experience.

Following the description of the four components of set of experience, its structure is organized taking into account some important features of DNA. Firstly, the combination of the four nucleotides gives uniqueness to DNA, just as the combination of the four components of the set of experience offer distinctiveness. Moreover, the elements of the structure are connected among themselves imitating part of a long strand of DNA, that is, a gene. Then, a gene can be assimilated to a set of experience, and, in the same way as a gene produces a phenotype, a set of experience produces a value of decision in terms of its objective functions. This value of decision is what is called the *efficiency* of the set of experience. The efficiency or

phenotype value is a combination of the objective functions and the effect values of the variables [Sanin, 05a].

Furthermore, it is possible to group sets of experience by category, that is, by their phenotype or efficiency. Each set of experience built after a formal decision event can be categorized, and acts as a gene in DNA. A gene guides hereditary responses in living organisms. As an analogy, a set of experience guides the responses of certain areas of the company about future decisions. For instance, a formal decision took effect in the production area about a production quantity; the set of experience formed after this decision becomes a gene for the area and could help to shape future decisions in the same field. The sets of experience give advice to the company's areas about how to respond.

Additionally, suppose two formal decision events have the same characteristics in terms of structure and category, i.e. same variables, functions, constraints, and rules [Sanin, 06c], but, are slightly changed in the efficiency value, then both sets of experience can originate a new improved and more precise set of experience. They are transformed achieving an improvement due to a mixing of the efficiency of the sets of experience. It acts as if two similar parent genes are mixed up to obtain a unique improved gene. This possibility opens doors for reformulating sets of experience.

According to Kelly [Shaw, 92], a unique personal construct (a set of experience) is appropriate only for the anticipation of a finite number of events, and the psychological space is never a complete system, then one set of experience cannot rule a whole system, even in a specific area or category. Therefore, more sets of experience should be acquired and constructed. The day-to-day operation provides many decisions, and the result of this is a collection of many different sets of experience. Hence, a group of sets of experience of the same category comprise a kind of chromosome, as DNA does with genes. These chromosomes or groups of sets of experience could make a "strategy" for a category, i.e. an area of the company. They are a group of ways to operate when making decisions. Each module of chromosomes forms an entire inference tool, and provides a schematic view for knowledge. Such complete group is what we called the *Decisional DNA* of the company.

In conclusion, set of experience knowledge structure acts as a representation for explicit knowledge according to the world it perceives from formal decision events. It is composed by four components, which are uniquely combined. Sets of experience can be collected, classified, and organized according to their efficiency, grouping them into chromosomes. Chromosomes are groups of sets of experience that can comprise a strategy for a specific area of the company. Moreover, improvements can be made upon some sets of experience by transformations and groups of chromosomes are the decisional DNA of the company.

4 Ontology-based Technology

Let us recall shortly what Ontologies are and how they are used. In philosophy, Ontology is the most fundamental branch of metaphysics. It studies being or existence, as well as the basic categories thereof, that is, tries to find out what entities and what types of entities exist. However, in the Computer Science domain there is a

different definition. The following is a Tom Gruber's widespread accepted definition of what Ontology is in this context: Ontology is the explicit specification of a conceptualization; a description of the concepts and relationships in a domain [Gruber, 95].

Nowadays, probably the fields in which computer-based semantic tools and systems are more extended are Ontology-based applications for several heterogeneous domains, for instance: medical (LinkBase), chemical (ChEBI BAO), legal (LODE), cultural (CIDOC-CRM), among others. They mainly focus in information sharing and knowledge management contexts for querying and classification purposes.

It is true, however, that many researchers in the AI society start their publications with their own definitions of Ontologies, but in short, the definition above is well accepted. Thus, in the context of AI, we can describe the Ontology of a program by defining a set of representational terms. In such Ontology, definitions associate names of entities in the universe of discourse (e.g. classes, relations, functions, or other objects) with human-readable text describing what the names mean, and formal axioms that constrain the interpretation and well-formed use of these terms.

Ontologies are commonly used in artificial intelligence and knowledge representation. Computer programs can use Ontologies for a variety of purposes including inductive reasoning, classification, and problem solving techniques, as well as communication and sharing of information among different systems. In addition, emerging semantic web systems use Ontologies for a better interaction and understanding between different agent web-based systems. In this last direction, a recent survey of Ontology-based applications, focused on e-commerce, knowledge management, multimedia, information sharing and educational applications, can be found in Ramos and Gomez-Perez [Ramos, 04].

Ontologies can be modelled using several languages, being the most widely used RFD and recently OWL (both expressed in eXtensible Markup Language-XML). OWL (Ontology Web Language), a W3C Recommendation since February 2004 [W3C, 04], has been designed to be used by applications that need to process content of information instead of just presenting information to humans. OWL facilitates machine interpretability of web content by providing additional vocabulary along with formal semantics, and it is considered better than XML, RDF, and RDF Schema (RDF-S). Moreover, OWL has three increasingly-expressive sublanguages: OWL Lite, OWL DL, and OWL Full.

One of the most widely reviewed problems arising when handling large amount of data is to query the repository in an efficient way. Such problem has been researched from the databases point of view; however, one big handicap is the fact that every query must be highly structured and well defined. Ontology modelling can deliver interesting benefits as it allows inferring semantically new derived queries. These queries relate concepts that were not taken into account initially. Modern inference engines and reasoners like Pellet and Racer [Sattler, 06] deliver a highly specialized, yet efficient way to perform such queries via a JAVA compliant API. In the literature, data handling by Ontology-based technology is reported by researchers in fields such as Large Model Visualization for industrial plants [Posada, 05], Geographic information Systems [Rewerse, 05], and the modelling of design stages and processes [Brandt, 06].

Furthermore, user modelling, task and experience are also possible scenarios for the exploitation of semantic data by Ontology-based technology as it was addressed for example in the IST-Project WIDE [Smithers, 04]. Moreover, by its own nature Ontologies provide a semantic point of view over an XML approach as the query process of the shareable knowledge structure is enhanced by the use of reasoners and semantic information embedded in the system.

In conclusion, set of experience Ontology-based containing knowledge about formal decision events can be a scenario for exploitation of semantic data, and in such way, it can be used as a shareable structure for helping in the decision-making process. Following, set of experience Ontology-based knowledge structure is exposed.

5 Set of Experience Ontology-based Knowledge Structure

In this section, we introduce our approach to the modelling of sets of experience knowledge structure from an Ontology perspective. In order to obtain such Ontology, we start from the XML set of experience model presented by Sanin and Szczerbicki [Sanin, 05b; Sanin, 06a], where they established an initial shareable model for set of experience. Afterwards, an Ontology model process was performed using the Protégé editor [Protégé, 05].

5.1 Class, Slots and Instances Organization

When developing Ontologies three actions must be taken into account:

1. Initially a set of classes must be modelled with the elements of the domain; these classes contain the abstract concepts and their roles as concrete or abstract depending on the level of conceptualization desired.
2. Every class has properties including name, cardinality (single or multiple) and the data type that describes the property. In RDF, properties are called slots; while in OWL, they are branded properties with the capability to be data typed or object typed, that is, they can refer to other properties and even classes or instances of the Ontology.
3. When the Ontology modelling process is done, it must be instanced. This process can be performed using an Ontology editor like Protégé or programmatically via an API. The instancing process populates every class and the relationships between them with real world values. At this stage of our work we have modelled the Ontology under an RDF approach.

5.2 Set of Experience Knowledge Structure modelling – implementation - visualization

For every first level tag of the XML set of experience knowledge structure a concrete class of the Ontology is created (role concrete), that is, variables, functions, constraints, and rules, among others. For second level tags, a slot with the proper cardinality and data type is created. A tag from the XML version of set of experience knowledge structure can be seen in [Fig. 3] (using a free visualization tool for XML).

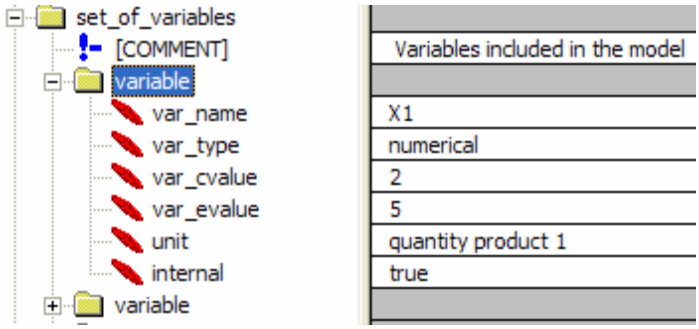

Figure 3: Tag Variable in the XML version of the Set of experience Knowledge Structure

Same tag is shown in its Ontology perspective in [Fig. 4], while the Ontology instancing process using the Protégé editor can be seen in [Fig. 5].

In [Fig. 3, 4 and 5], the different stages of the variable class can be observed. Same process was performed on the functions, constraints and rules classes.

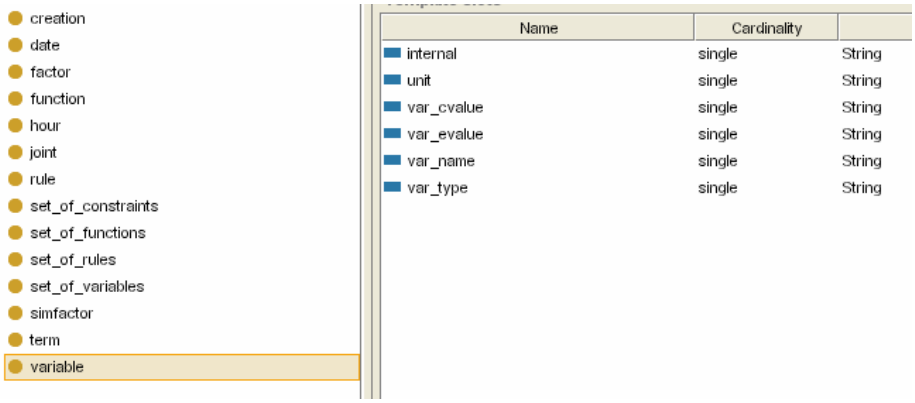

Figure 4: Tag Variable in the Ontology version of the Set of experience Knowledge Structure

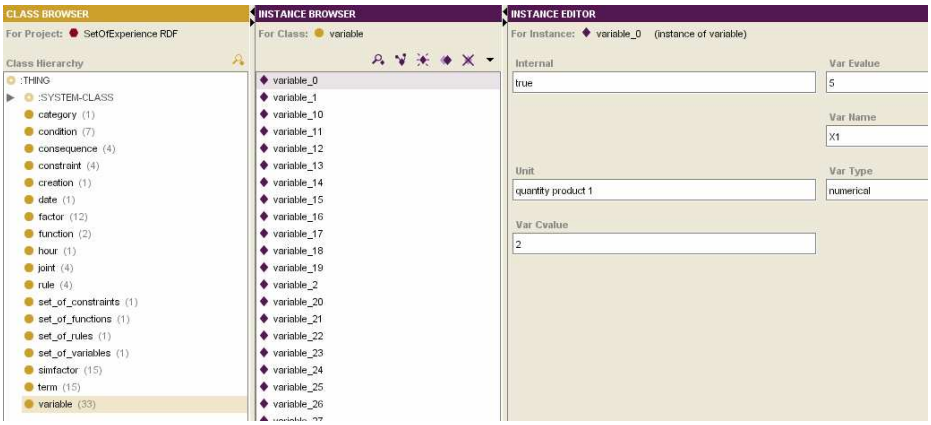

Figure 5: Tag Variable instanced in the Ontology version of the Set of experience Knowledge

In [Fig. 6], relationships among the different classes of the Ontology can be seen using a plug-in for visualization of the Ontology model.

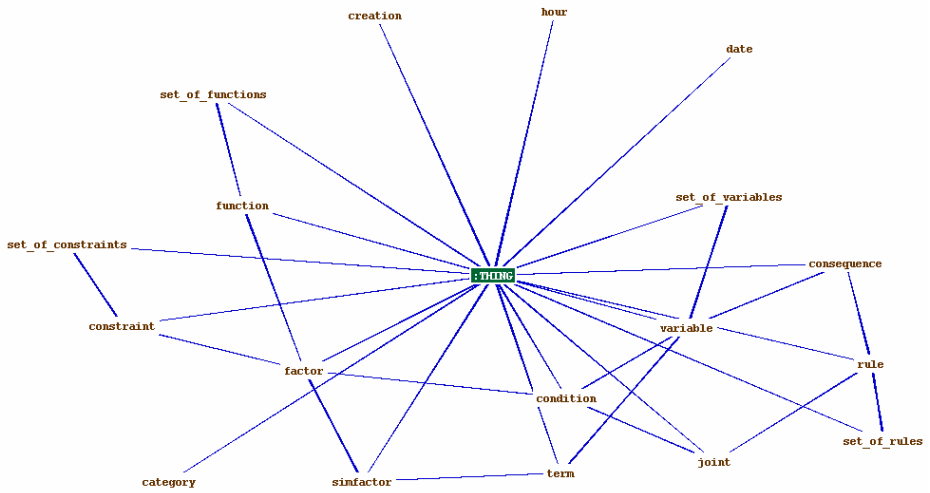

Figure 6: Ontology model relationships

Structural changes were not developed in the transformation of set of experience XML-structure to set of experience OWL-structure. Having finished first and second actions of the Ontology modelling process, the third action continues as it is explain in the next section [Section 5.3].

5.3 Instancing Set of Experience Ontology-based Knowledge Structure

Formal decision events can be evaluated via an Ontology API (Protégé provides one which is based in JENA). Using such API programmatically, the Ontology instantiation process can be performed, that is, filling in the knowledge model with real world values. Furthermore, the API provides several mechanisms to test semantics on the conceptual model and the instanced model as well.

The Ontology model by nature is a Web based application with a predefined namespace. This permits storage of several instanced models in a web server way, allowing the users to interact with the model using a simple web browser, or in our case, a JAVA application for the handling of the Ontology.

Once the Ontology is instanced, the model becomes a shareable explicit knowledge that can be considered a repository.

Moreover and very important, the standardization of RDF and OWL by the W3 consortium indirectly gives this process a sort of modelling standardization, thus the instances themselves will be shareable among users.

The model is now ready for instancing with companies' decisional DNA, that is, formal decision events. A repository for sets of experience according to the Knowledge Supply Chain System platform exposed by Sanin and Szczerbicki in [Sanin, 04] can be created. Once this is done, this repository can be accessed through different queries, which would be developed according to similarity parameters [Sanin, 06c] and users' requirements.

Having an Ontology-based repository ready to be feed with decisional DNA produced by the members of the e-decisional community is the beginning of a new way of sharing knowledge. The e-decisional community would share decisions among its members allowing decision-maker users to improve their day-to-day operation by consulting such repository, and along with this interaction, the e-decisional community would increase and improve the decisional DNA available for being shared.

Currently, a specific case of application is being implemented on industrial design where set of experience Ontology-based knowledge structure is used on the basis of creating decisional DNA for the elements that comprise a plant and the users that control its maintenance and revision. Besides, the KSCS is now approaching its final developments which will put it through a process of implementation by using set of experience Ontology-based knowledge structure.

6 Conclusion

Improving set of experience knowledge structure from a XML-based technology to an Ontology-based technology XML adheres heavier semantics and logic, as well as more expresivness. A shareable enhanced set of experience Ontology-based knowledge structure able to store formal decision events, i.e. decisional DNA, would advance the notion of administering knowledge in the current decision making environment. Decisional DNA enables us to distribute experience among different applications, and in that form, and through the e-decisional community, companies that are expanding the knowledge management concept externally, can explore new

ways to put explicit classifiable knowledge in the hands of employees, customers, suppliers, and partners.

References

[Awad, 04] Awad, E. and Ghaziri, H.: "Knowledge Management"; Pearson Education Inc., Prentice Hall / New Jersey (2004).

[Brandt, 06] Brandt, S.C., Morbach, J., Miatidis M., et al: "Ontology-based information management in design processes"; Proc. 16th European Symposium on Computer Aided Process Engineering (ESCAPE) and 9th International Symposium on Process Systems Engineering (PSE), Garmisch-Partenkirchen, (2006).

[Coakes, 03] Coakes, E.: "Knowledge Management: Current Issues and Challenges"; IRM Press / London (2003).

[Davis, 93] Davis, R., Shrobe, H. and Szolovitz, P.: "What is a Knowledge Representation?"; AI Magazine, 14, 1 (1993), 17-33.

[Deveau, 02] Deveau, D.: "No brain, no gain: Knowledge management"; Computing Canada, 28, (2002), 14-15.

[Drucker, 95] Drucker, P.: "The Post-Capitalist Executive: Managing in a Time of Great Change"; Penguin / New York (1995).

[Ferruci, 04] Ferruci, D. and Lally, A.: "Building an example application with the Unstructured Information Management Architecture"; IBM Systems Journal, 43, 2 (2004), 455-475.

[Goldratt, 86] Goldratt, E.M. and Cox, J.: "The Goal"; Grover / Aldershot, Hants (1986).

[Gruber, 95] Gruber, T.R.: "Toward principles for the design of Ontologies used for knowledge sharing"; International Journal of Human-Computer Studies, 43, 5-6 (1995), 907-928.

[Lloyd, 03] Lloyd, J.W.: "Logic for Learning: Learning Comprehensible Theories from Structure Data"; Springer / Berlin (2003).

[Malhotra, 00] Malhotra, Y.: "From Information Management to Knowledge Management: Beyond the 'Hi-Tech Hidebound' Systems"; Knowledge Management for the Information Professional, Information Today, Inc., 37-61.

[Miller, 02] Miller, Kenneth, R. and Levin, J.: "Biology"; Prentice Hall / Saddle River (2002).

[Noble, 98] Noble, D.: "Distributed Situation Assessment"; Proc. FUSION '98 International Conference (1998).

[Nonaka, 95] Nonaka, I. and Takeuchi, H.: "The Knowledge-Creating Company: How Japanese Companies Create The Dynamics Of Innovation"; Oxford University Press / New York (1995).

[Posada, 05] Posada, J., Toro, C.A., Wundrak, S., Stork, A.: "Ontology Supported Semantic Simplification of Large Data Sets of Industrial Plant CAD Models for Design Review Visualization"; Proc. Int. Conf. on Knowledge-base and Intelligent Information and Engineering Systems, KES, Part I LNCS 3681, Springer, Melbourne (2005).

[Protégé, 05] Protégé. Stanford Medical Informatics, http://protege.stanford.edu/index.html. (2005).

[Ramos, 04] Ramos, J. and Gomez-Perez, A.: "A survey on Ontology-based applications. e-commerce, knowledge management, multimedia, information sharing and educational applications"; Public deliverable of the EU-Project OntoWeb, January (2004).

[Rewerse, 05] Rewerse: "Ontology Driven Visualisation of Maps with SVG – Deliverable from the European Project REWERSE"; Project number: IST-2004-506779, Munich (2005).

[Ryu, 04] Ryu, W.: "DNA Computing: A Primer"; November, www.arstechnica.com/reviews/2q00/dna/dna-1.html. (2004)

[Sanin, 04] Sanin, C. and Szczerbicki, E.: "Knowledge Supply Chain System: A Conceptual Model"; Knowledge Management: Selected Issues, A. Szuwarzynski (Ed), Gdansk University Press / Gdansk, (2004) 79-97.

[Sanin, 05a] Sanin, C. and Szczerbicki, E.: "Set of Experience: A Knowledge Structure for Formal Decision Events"; Foundations of Control and Management Sciences, 3, (2005) 95-113.

[Sanin, 05b] Sanin, C. and Szczerbicki, E.: "Using XML for Implementing Set of Experience Knowledge Structure"; Proc. Int. Conf. on Knowledge-base and Intelligent Information and Engineering Systems, KES, Part I LNCS 3681, Springer, (2005), 946-952.

[Sanin, 06a] Sanin, C. and Szczerbicki, E.: "Extending Set of Experience Knowledge Structure into a Transportable Language XML (eXtensible Markup Language)"; Cybernetics and Systems: An International Journal, 37, 2-3 (2006), 97-117.

[Sanin, 06b] Sanin, C. and Szczerbicki, E.: "Using Set of Experience in the Process of Transforming Information into Knowledge"; International Journal of Enterprise Information Systems, 2, (2006) 45-62.

[Sanin, 06c] Sanin, C. and Szczerbicki, E.: "Similarity Metrics for Set of Experience Knowledge Structure"; Proc. Int. Conf. on Knowledge-base and Intelligent Information and Engineering Systems, KES, Part I LNAI 4251, Springer, (2006), 663-670.

[Sattler, 06] Sattler, U.: "Description Logic Reasoners"; April, http://www.cs.man.ac.uk/~sattler/reasoners.html, (2006).

[Schatz, 04] Schatz, B., Mohay, G. and Clark, A.: "Rich Event Representation for Computer Forensics"; Proc. APIEMS - Fifth Asia Pacific Industrial Engineering and Management Systems Conference, QUT, Gold Coast (2004).

[Shaw, 92] Shaw, M. and Gaines, B.: "Kelly's "Geometry of Psychological Space" and its Significance for Cognitive Modelling"; The New Psychologist, October, (1992) 23-31.

[Smithers, 04] Smithers, T., Posada, J., Stork, A., Pianciamore, M., et al.: "Information management and knowledge sharing in WIDE"; Proc. European Workshop on the Integration of Knowledge, Semantics and Digital, (2004).

[Tsoukas, 04] Tsoukas, H. and Mylonopoulos, N.: "Organizations as Knowledge Systems: Knowledge, Learning and Dynamic Capabilities"; Palgrave Macmillan / New York (2004).

[W3C, 04] W3C: "OWL Web Ontology Language Reference"; W3C Recommendation, 10 February 2004, http://www.w3.org/TR/2004/REC-owl-ref-20040210/. (2004).

[Watson, 53] Watson, J. and Crick, F.: "A Structure for Deoxyribose Nucleic Acid", Nature, April 171, (1953) 737-738.