INCREASING PRODUCTIVITY OF KNOWLEDGE WORKERS

BY ONTOLOGICAL TRAINING

Tatiana Gavrilova

Graduate School of Management, Saint-Petersburg State University,
tgavrilova@gsom.pu.ru

The session type selected for the paper presentation:

1) "Dialogue" Session ☐

2) "Author's Presentation" Session ■☐

INCREASING PRODUCTIVITY OF KNOWLEDGE WORKERS BY ONTOLOGICAL TRAINING

Tatiana Gavrilova

Graduate School of Management, Saint-Petersburg State University,
tgavrilova@gsom.pu.ru

Keywords: knowledge-driven organizations, productivity of knowledge workers, learning, thinking, analyst training.

1 INTRODUCTION

A central problem for supporting all phases of knowledge processing is still the productivity of the knowledge workers and usage of the special techniques and models for the integration of various knowledge patterns within and across enterprises. Knowledge work deals with structuring. New information age with huge information overload makes knowledge processing more and more sophisticated. Sophistication needs professionals.

How many professional knowledge engineers need the company targeted at busines sustainability? How to find them and to teach?

Knowledge Engineering traditionally emphasizes and developes a range of techniques and tools including knowledge acquisition, conceptual structuring and representation models [1], [2]. But for practitioners as enterprise analysts it is still a rather new, eclectic domain that draws upon areas like cognitive science. Accordingly, knowledge engineering has been, and still is, in danger from fragmentation, incoherence and superficiality. Still few universities deliver courses in practical knowledge engineering.

Many companies take decision to teach and train their IT-staff and developers. This paper describes recent experience in such training for some Russian subsidiaries of international companies (British-American Tobacco, Siemens Business Services, etc.). The total number of trainees that received certificates of knowledge analysts is more than 60.

Training for Knowledge Engineering (TKE) is based on university courses in intelligent-systems development, cognitive sciences, user modeling and human-computer interaction delivered by author in 1992-2005. TKE proposes information structuring multi-disciplinary methodology, including the principles, practices, issues, methods, techniques involved with the knowledge elicitation, structuring and formalizing. Emphasis is put not on technologies and tools, but in training of analytical skills. Ontological Engineering is further development of knowledge engineering towards ontology design and creating.

2 KNOWLEDGE ANALYSTS TRAINING OUTLINE

The future analysts gain an understanding the role of knowledge engineering and knowledge management in companies and organizations; in decision-making by members of an organization; in developing information framework. They study and are trained in practical methods mainly by doing.

Trainees are introduced to major issues in the field and to the role of the knowledge analyst in strategic information system development. Attention is given both to developing inter-personal information communication skills and analytical cognitive creative abilities. One group is not more than 8 persons.

The class features short lectures, discussions, tests, quizzes and exercises. Lectures are important but the emphasis is put on learning through discussions, simulation, special games, training and case studies. A good deal of the course focuses on auto-reflection and auto-formalizing of knowledge, training of analytical and communicative abilities, discovery, creativity, cognitive styles features, and gaining new insights.

TKE consists of 4 inter-connected modules:

- Getting Started in KE (12 hours),
- Practical KE in depth (12 hours),
- Ontological Engineering (12 hours),
- Business Processes Modelling (12 hours).

Different combination of sub-topics is possible.

Fig.1 illustrates the structure of one variant chosen by Business Engineering Group Company.

The main difference of TKE to existing methodologies is cognitive (not technological) bias. The topics of exercises cover categorization, observation, laddering, lateral thinking and other problem solving cognitive methods. IT-managers often under-value the significance of psychological background of categorization, laddering and lateral thinking. But during training some of them feel "insight" and become very enthusiastic.

But only knowledge structuring exercises show the importance of obtained analytical skills in practice. Even simple tests from their professional domains are rather difficult at the first workshops.

The training is aimed on semantics not syntax of knowledge engineering. We suppose that systems and languages may be self-studied while general scope and knowledge-stressed approach should be trained thoroughly. Practical specialists often under-estimate the role of cognitive styles, verbal skills and logics in information processing. It is supposed to be guided common sense while it needs to be taught.

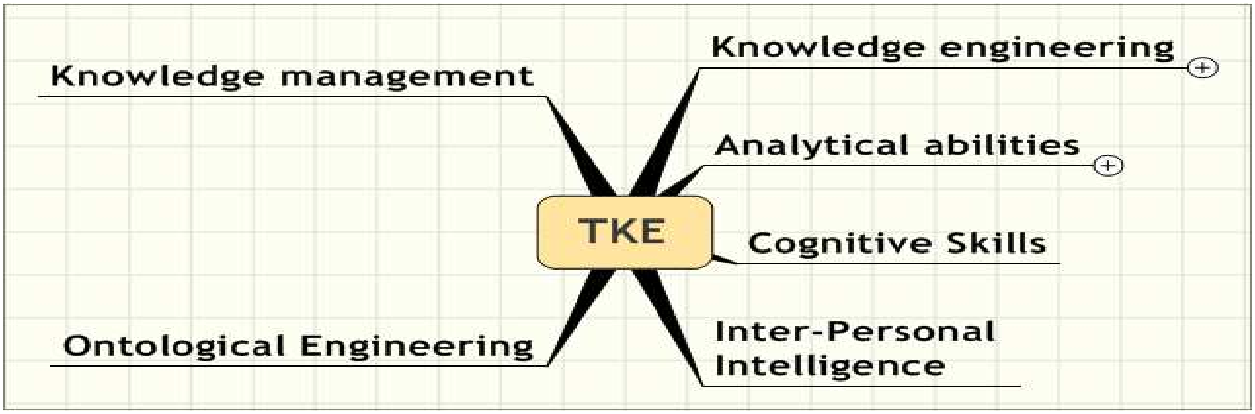

Fig.1. Outline of training of knowledge engineering

We try to implement the ontological approach into the teaching style and strategy. Philosophers of science define ontologism by postulating existence of the systemic hierarchial conceptual specification of any complex object.

3 TEACHING ONTOLOGICAL THINKING AND DESIGN

Ontologies can be used to descibe any business world. But our experience in training show that nobody can deal with ontologies without knowledge engineering practice. How to teach ontology design? The theory differs from practical needs…

There are numerous well-known definitions of this milestone term (Gruber , 1993; Guarino and Giaretta, 1998; Jasper and Uschold, 1999; Mizogushi and Bourdeau, 2000; Neches, 1991) but they may be generalized as "Ontology is a hierarchically structured set of terms for describing an arbitrary domain"[3]. In other words "ontologies are nothing but making knowledge explicit" [4].

Since 2000 a major interest of researchers focuses on building customized tools that aid in the process of knowledge capture and structuring. This new generation of tools – such as Protégé, OntoEdit, and OilEd - is concerned with visual knowledge mapping that facilitates knowledge sharing and reuse [5], [6], [7]. The problem of iconic representation has been partially solved by developing knowledge repositories and ontology servers where reusable static domain knowledge is stored. Ontolingua, and Ontobroker are examples of such projects [8], [9].

But practitioners from companies need simple and constructive algorithms for their activity.

Ontology creating also faces the knowledge acquisition bottleneck problem. The ontology developer encounters the additional problem of not having sufficiently tested practical methodologies, which would recommend what activities to perform. An example of this can be seen when each development team usually follows their own set of principles, design criteria, and steps in the ontology development process. The lack of structured guidelines hinders the development of shared and consensual ontologies within and between the teams. Moreover, it makes the extension of a given ontology by others, its reuse in other ontologies, and final applications difficult [10].

Several effective methodological approaches have been reported for building ontologies [11]; [12], [13]. What they have in common is that they start from the identification of the purpose of the ontology and the needs for the domain knowledge acquisition. However, having acquired a significant amount of knowledge, major researchers propose a formal language expressing the idea as a set of intermediate representations and then generating the ontology using translators. These representations bridge the gap between how people see a domain and the languages in which ontologies are formalized. The conceptual models are implicit in the implementation codes. A re-engineering process is usually required to make the conceptual models explicit.

Fig. 2 presents our vision of the mainstream state-of-the-art categorization in ontological engineering [4], [14], [15] and may help the knowledge analyst to figure out what type of ontology he/she really needs. We use Mindmanager™ and Cmap as they proved to be powerful visual tools.

We try to simplify a bunch of different approaches, terms and notations for practical use and dare to propose a 5-steps recipe for practical ontology design.

3.1 Ontology Design Recipe

The existing methodologies describing ontology life cycle [15], [13], [3] deal with general phases and sometimes don't discover the design process in details. Five simple practical steps were proposed.

Step 1. **Glossary development:** The first step should be devoted to gathering all the information relevant to the described domain. The main goal of this step is selecting and verbalizing all the essential objects and concepts in the domain.

Step 2. **Laddering:** Having all the essential objects and concepts of the domain in hand, the next step is to define the main levels of abstraction. It is also important to elucidate the type of ontology according to Fig. 1 classification, such as taxonomy, partonomy, and genealogy.

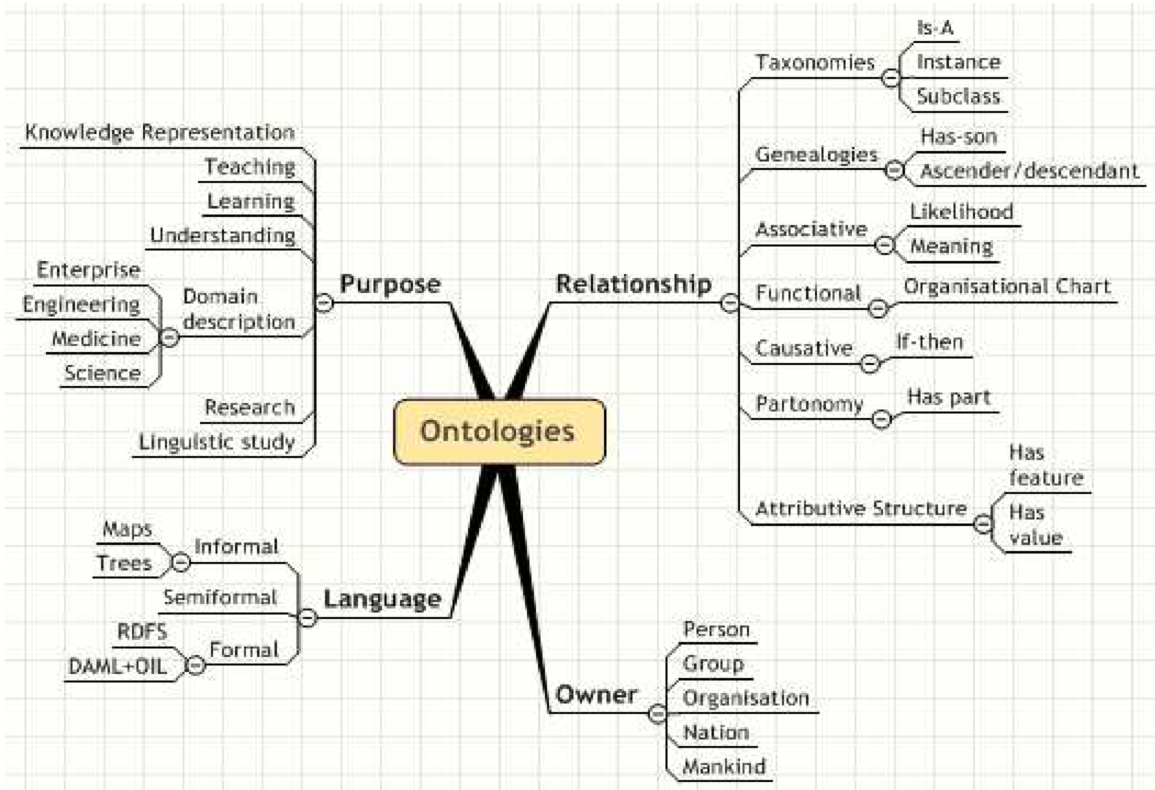

Fig.2. Ontology mind map

This is being done at this step since it affects the next stages of the design. Consequently, the high level hierarchies among the concepts should be revealed and the hierarchy should be represented visually on the defined levels.

Step3. **Disintegration:** the main goal of this step is breaking high level concepts, built in the previous step, into a set of detailed ones where it is needed. This could be done via a top-down strategy trying to break the high level concept from the root of previously built hierarchy.

Step4. **Categorization:** At this stage, detailed concepts are revealed in a structured hierarchy and the main goal at this stage is generalization via bottom-up structuring strategy. This could be done by associating similar concepts to create meta-concepts from leaves of the aforementioned hierarchy.

Step 5. **Refinement**: The final step is devoted to updating the visual structure by excluding the excessiveness, synonymy, and contradictions. As mentioned before, the main goal of the final step is try to create a beautiful ontology. We believe what makes ontology beautiful is harmony.

Using these tips the trainees develop several huge company ontologies.

3.2 “Beatification” of Business Ontology

The idea of the good shape in modeling is rather common in science. Let’s try to apply this approach to the ontology design. One of ontological engineering. Some essential Gestalt principles of this school [16]:

- Law of Pragnanz (M. Wertheimer) - organization of any structure in nature or cognition will be as good (regular, complete, balanced, or symmetrical) as the prevailing conditions allow (law of good shape).
- Law of Proximity – objects or stimuli that are viewed being close together will tend to be perceived as a unit.
- Law of Similarity – things that appear to have the same attributes are usually perceived as being a whole.
- Law of Inclusiveness (W.Kohler) - there is a tending to perceive only the larger figure and not the smaller when it is embedded in a larger.
- Law of Parsimony – the simplest example is the best or known as Ockham’s razor principle (14-th

substantial impulse to it was given by German psychological school of M. Wertheimer. His idea of good Gestalt (image or pattern) may be transferred into

century): ``entities should not be multiplied unnecessarily''.

We suggest to use these laws for pursuing conceptual balance and clarity of corporate knowledge ontology..

3.2.1 Conceptual balance

A well-balanced ontological hierarchy equals a strong and comprehensible representation of the domain knowledge. However, it is a challenge to formulate the idea of a well-balanced tree. Here we offer some tips to help formulate the “harmony”:

- Concepts of one level should be linked with the parent concept by one type of relationship such as is-a, or has part.
- The depth of the branches should be more or less equal (±2 nodes).
- The general outlay should be symmetrical.

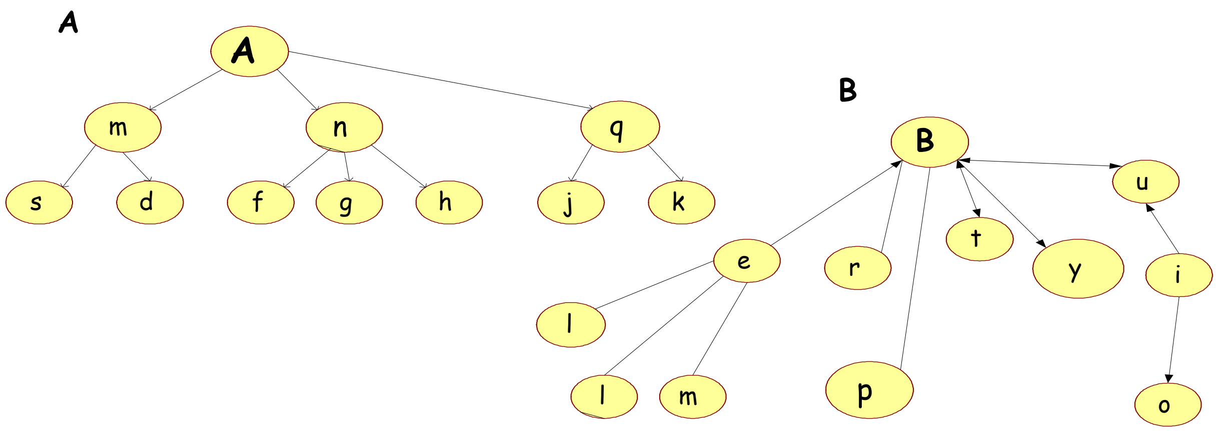

Fig.3. “Well-balanced” and “ill-balanced” ontologies

- Cross-links should be avoided as much as possible.

3.2.2 Clarity

Moreover, when building a comprehensible ontology it is important to pay attention to clarity. Clarity may be provided through number of concepts and type of the relationships among the concepts. Minimizing the number of concepts is the best tip according to Law of Parsimony .

Fig.3 illustrates the idea of well-balanced (A) and ill-balanced (B) ontology design.

The maximal number of branches and the number of levels should follow Miller’s magical number (7±2) [17]. Furthermore, the type of relationship should be clear and obvious if the name of the link is missed.

Some practical tips to refine and illuminate the ontology’s design layout stage can be proposed:

- Use different font sizes for different levels.
- Use different colours to distinguish particular subsets or branches.

- Use a vertical layout of the tree structure/diagram.
- If needed, use different shapes for different types of nodes.

At the first stages it is possible to use any of the available graphical editors to design an ontology, e.g. PaintBrush, Visio, Inspiration. A nice layout can be reached by using mindmapping tools as MindManager™ or Visual Mind ™.
The trainees really enjoy the process of "beatification" of their ontologies during test exercises.

4 DISCUSSION

Business modelling needs business analysts. Analysts are super-knowledge workers, but even they enter "the world of ontologies" with some doubt. But in the training their interest grows and rather soon they begin to use ontologies in their practical work. Our experience in training of knowledge analysts in the period of 1999-2007 confirm the unique role of knowledge structuring for developing ontologies quickly, efficiently and effectively. We follow David Jonassen's idea of мusing concept maps as a mind tool" [18]. The use of visual paradigm to represent and support the training process not only helps a professional trainer to concentrate on the problem rather than on details, but also enables students to process and understand greater volume of information.
The described approach is twice ontological as the development of educational knowledge structures in the form of ontologies provides training and learning support. Teaching ontologies used in the course scaffold and improve trainees' understanding of the courseware and later help to realize substantive and syntactic company knowledge. As such, they can play a part in the overall pattern of learning, facilitating for example analysis, comparison, generalization and transferability of understanding to analogous problems.
Business is based on knowledge processing in the new information age. So skillfull knowledge workers really increase the productivity and sustainability of modern business practice.

References

[1] Adeli, H. (1994) Knowledge Engineering. McGraw-Hill, New-York.
[2] Scott, A., Clayton, J.E. & Gibson E.L. (1994) A Practical Guide to Knowledge Acquisition, Addison-Wesley.
[3] Gómez-Pérez, A., Fernández-López, M., Corcho, O. (2004) Ontological Engineering with examples from the areas of Knowledge Management, e-Commerce and the Semantic Web, Springer.
[4] Guarino, N., Welty, C. (2000) A Formal Ontology of Properties. In R. Dieng and O. Corby (eds.), Knowledge Engineering and Knowledge Management: Methods, Models and Tools. 12th International Conference, EKAW2000. Springer Verlag, pp. 97-112.
[5] OilEd (2004) Bechhofer, S. and Ng G. http://oiled.man.ac.uk/
[6] OntoEdit (2004) AIFB, University Karlsruhe Accessed from http://www.ontoknowledge.org/tools/ at December 07.
[7] Protégé, Stanford Medical Informatics. Accessed from http://protege.stanford.edu/ at December 07, 2004.
[8] OntoBroker (2004), Accessed from http://ontobroker.aifb.uni-karlsruhe.de.
[9] Ontolingua, Stanford University. Accessed from http:// www.ksl.stanford.edu/ software/ontolingua/ at December 7, 2004.
[10] Guarino, N. & Giaretta, P. (1998) Ontologies and Knowledge Bases: Towards a Terminological Clarification. // Towards Very Large Knowledge Bases: Knowledge Building & Knowledge Sharing, IOS Press, pp.25- 32.
[11] Fensel, D. (2001) Ontologies: A Silver Bullet foe Knowledge Management and Electronic Commerce. Springer.
[12] Swartout, B., Patil, R., Knight, K. & Russ, T. (1997) Toward Distributed Use of Large-Scale Ontologies. In Ontological Engineering, AAAI- 97 Spring Symposium Series, pp.138- 148.
[13] Mizogushi, R. and Bourdeau J. (2000), Using Ontological Engineering to Overcome Common AI-ED Problems. International Journal of Artificial Intelligence in Education, v. 11, pp.1-12.
[14] Jasper, R. and Uschold, M (1999). A Framework for Understanding and Classifying Ontology Applications. In 12th Workshop on Knowledge Acquisition Modeling and Management KAW'99.
[15] Uschold, M., Gruninger M (1996). "Ontologies: Principles Methods and Applications", Knowledge Engineering Review,vol1, N1.
[16] Werthheimer, M. (1959) Productive Thinking, HarperCollins.
[17] Miller, G. (1956) The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information // The Psychological Review, v. 63, pp. 81-97.
[18] Jonassen, D.H. (1998) Designing constructivist learning environments. In Instructional design models and strategies (Reigeluth, C.M. (Ed), 2nd ed., Lawrence Eribaum, Mahwah, NJ.
[19] Boose, J.H. (1990) Knowledge Acquisition Tools, Methods and Mediating Representations. In Knowledge Acquisition for Knowledge-Based Systems (Motoda, H. et al., Eds), IOS Press, Ohinsha Ltd., Tokyo, pp.123-168.
[20] Eisenstadt, M., Domingue, J., Rajan, T. & Motta, E. (1990) Visual Knowledge Engineering. In IEEE Transactions on Software Engineering, Vol.16, No.10, pp.1164-1177.
[21] Gavrilova, T., Voinov, A. (1998) Work in Progress: Visual Specification of Knowledge Bases // Lecture Notes in Artificial Intelligence 1416 "Tasks and Methods in Applied Artificial Intelligence", A.P.del Pobil, J.Mira, M.Ali (Eds), Springer, pp. 717-726.

[22] Gavrilova, T.A., Voinov, A., Vasilyeva E. (1999) Visual Knowledge Engineering as a Cognitive Tool / Proc. of Int. Conf. on Artificial and Natural Networks IWANN'99, Spain, Benicassim. - pp.123-128.
[23] Gavrilova, T. (2003) Teaching via Using Ontological Engineering // Proceedings of XI Int. Conf. "Powerful ICT for Teaching and Learning" PEG-2003, St.Petersburg, p. 23-26.
[24] Gavrilova, T., Kurochkin M., Veremiev V. (2004) Teaching Strategies and Ontologies for E-learning // Int. J. "Information Theories and Applications", vol.11, N1, pp.35-42.
[25] Gruber, T. (1993) A translation approach to portable ontology specifications. Knowledge Acquisition , Vol. 5, pp.199- 220.
[26] Neches, et al (1991) Enabling Technology for Knowledge Sharing. AI Magazin, Winter, pp.36- 56.
[27] Sowa, J. F. (1984) Conceptual Structures: Information Processing in Mind and Machine. Addison-Wesley, Reading, Massachusetts.
[28] The CIO's Guide to Semantics (2004) Semantic Arts©, Inc. www.semantic-conference.com
[29] Tu, S., Eriksson, H., Gennari, J., Shahar, Y. & Musen M. (1995) Ontology-Based Configuration of Problem-Solving Methods and Generation of Knowledge-Acquisition Tools. In "Artificial Intelligence in Medicine", N7, pp.257-289.
[30] Wielinga, B., Schreiber, G. & Breuker J. (1992) A Modelling Approach to Knowledge Engineering. In Knowledge Acquisition, 4 (1), Special Issue, pp.23-39.