Market-Driven Product Ontologies: a Conceptual Framework for Customer Information Integration in Product Innovation Processes

Davor Meersman
Digital Ecosystems and Business Intelligence Institute - Curtin University of Technology
davor.meersman@postgrad.curtin.edu.au

Abstract
In this paper we introduce a market-driven product ontology for creating market orientation and customer focus in innovation and product development/marketing processes in the extended enterprise. We describe and evaluate the main building blocks and uses of the market-driven product ontology. We describe how the ontology can interact with innovation process system components such as case-based reasoners and TRIZ in order to decrease the knowledge acquisition bottleneck and leverage market learning capabilities. Finally, we discuss the suitability of the proposed solution for the issues at hand.

Introduction
As the life cycles of products and service shrink, companies need to constantly improve existing and develop new products and/or services in order to grow revenue (Hartley 2000, Barton 1995). The pace of innovation in companies is constantly accelerating, and product development teams need to keep up with this pace. In order to develop relevant, useful products, organisations are becoming more and more market-oriented and try to integrate marketing and market knowledge into their business processes and more specifically, into their innovation processes (Day 1994). The relation between the degree of market-orientation and an organisation's innovativeness has been amply established (Li and Cantalone 1998, Han, Kim and Srivastaya 1998). As the concept of the extended enterprise is fast becoming a reality, relevant market information also needs to be delivered to a considerable number of value life cycle partners, which adds to the complexity of the tasks ahead.

Organisational Market Learning Capabilities
One of the major challenges ahead is to augment what is referred to as the market learning capabilities (or competencies) of organisations (Cillo 2003), i.e. the competencies of organisations to process, learn and innovate based on market information, in a traceable and manageable way. Today this ambition is hindered by the fact that market information is poorly and non-systemically processed, resulting in information loss or even mutilation and overall inefficiency. By leveraging the way this is done, technology supported operationalisation of customer information in innovation processes in multiple contexts of the extended enterprise would augment the innovation and market learning competencies of the employees and of the distributed workforce in the network of value life cycle partners.

Competencies are seen as a major source of competitive advantage because they are gained through learning processes and for this reason they are imperfectly imitable, transferable or moveable (Wernerfelt 1984, Barney 1991). However, the flip side of this coin is that gaining such competencies also presents a major cost for enterprises. Even when we expand the concept of competencies from a merely people-centered view to a broader, organisational view (see e.g. Prahalad and Hamel 1999) that includes systems and processes, the knowledge acquisition process is a relatively slow and costly one (Main 2004). The key to overcoming the knowledge acquisition bottleneck is by making tacit knowledge explicit. This involves the process of formalising individual knowledge to a level where it can be shared within the enterprise (Nonaka 2001, Scharmer 2001, Chesbrough and Kusunoki 2001, Takeuchi 2001). By making knowledge explicit and formal, it becomes easier for people in an organisation to learn and use that knowledge, as well as for systems to use that knowledge.

Customer Knowledge in the Enterprise
Today, approximately *80 percent* of all new products or services fails within six months or falls significantly short of forecast profits once brought to the market (Morwitz, Steckel, and Gupta 1997). A considerable part of this

percentage is due to factors involving poor market information processing and poor decision making based on incomplete and/or erroneous information. In a perfect situation, product technology, properties, functionality, design, pricing, marketing etc. would be based on perfect market information and thus succeed, but in reality this knowledge is imperfectly shared over time and across people, organisations and industries (Hagardon, and Sutton 1997).

Broadly spoken, the kind of information that can be obtained about the market can be divided into three categories: consumer knowledge, competitor knowledge and technological knowledge. Consumer knowledge refers to the current and potential wants and needs of consumers. Competitor knowledge refers to knowledge about the products, processes and knowledge of competitors. Technological knowledge is knowledge that enables R&D departments to make technological advances and to interface with the marketing department in order to develop useful marketable products. In our research, we currently focus mainly on consumer knowledge.

Customer knowledge is obtained through consumer research via various quantitative and qualitative methodologies such as empathic design, observation, customer visits, ethnography, alien interviewing, ZMET (Zaltman Metaphor Elicitation Technique), archetype discovery, codiscovery conferences, storyboarding, usability testing, proxy technologies, etc. (Meersman 2007). The output of these methodologies varies from simple age/location segmentations (for example when signing up for a new software product) to advanced conceptual constructs of human minds (as obtained by ZMET, for example).

Customer knowledge is characterised by different levels of complexity and codification. Its intrinsic variety should be considered because it requires an organisation to use different approaches in order to process it (Cillo 2003).

In market-oriented organisations, customer knowledge is relevant to everybody in the organisation (and by extension to every external body in the product development cycle), albeit only partially, in certain forms, under certain conditions and to a certain extent. This calls for a shared semantic framework between market researchers, marketers, managers, engineers, suppliers and every other relevant stakeholder, which can be linked to already existing traditional products and services ontologies (e.g. eclassOWL, unspscOWL, GoodRelations) and various innovation support systems in the extended enterprise. This shared semantic framework will help to transparently leverage organisations' market-orientation and market learning competencies.

In this paper we introduce a Market-Driven Product Ontology, which allows the annotation of different sources of market research output data for optimised conversion and distribution of consumer knowledge to all partners of the product development/marketing cycle, in combination with a market learning competency framework, which allows identifying, fostering and managing market learning competencies throughout an organisation.

Market-Driven Product Ontologies

In this section we discuss Market-Driven Product Ontologies (MDPOs). An MDPO consists of three mutually exclusive, collectively exhaustive building blocks: properties, functions and context.

- **Product properties** are variables; attributes of a product, mainly expressed in adjectives. Examples: hollow, smooth, transparent, the aggressive front shape of a car,... In the ontology, a distinction is made between *perceivable* and *non-perceivable* properties. The reason behind this is that perceivable properties do not need to be communicated when the product is marketed, whilst non-perceivable properties do. For example, when talking about a shampoo, it does not need to be stated that it is liquid, whilst one might want to communicate that it is bio-degradable. Evidently, this distinction is mainly of interest to the marketing and communications actors in the product development/marketing cycle.
- **Product functions** are the purpose of a product, its useful action, mainly expressed in verbs. Examples: joining, cleaning, wearing, shining,... The functions of a product greatly vary in terms of complexity. We see this when comparing household to software products, for example.
- **Product context** refers to the identity of a product in a market. The product context building block is context-sensitive (which is paramount for cultural and geographical differentiation in a global market) and consists of brand perception, usability data, symbolic interaction patterns, quality of experience data etc.

The MDPO is used in the annotation, conversion and dissemination of various market knowledge output formats based on semantic roles within the companies. Semantic roles are system roles based on the semantics of the product ontology, i.e. the aspects of a product somebody is involved with in real life, ranging from packaging to certain engineering aspects, instead of the relatively ad-hoc and hierarchical organisational HR, knowledge management or learning management system roles in place today.

Integration of Customer Knowledge in Product Innovation Processes

Merely presenting the customer knowledge to relevant stakeholders is not enough: the vast amount of customer knowledge and the limited resources available within a firm make that additional techniques for effectively operationalising the knowledge should be developed. We are currently integrating of the MDPO with case-based reasoning systems, which store their cases in a format that can be linked the model of the MDPO. This is particularly interesting because it allows the market to specify (implicitly or explicitly) certain needs and designers to understand these needs in terms of requirements, constraints and resources within the context of company-specific innovation processes.

Case-based reasoning (CBR) systems are knowledge-intensive systems that store, retrieve and apply similar cases from the past to new problems. The underlying idea is that similar problems have similar soluitons. As a result, solutions from the past can solve problems in the future. This is in fact analogous to how humans solve problems. They are increasingly being used also for design tasks and problems (Main 2004, d'Acquin 2006). The case-based reaasoning process consists of four steps:

1. Retrieval: given a problem, a case is retrieved from the case base. The case describes a similar problem and how it was solved in the past. Often notes on the way in which the solution was reached is also included. The case base is the database where all cases are stored.
2. Reusage: the solution of the previous case is mapped to the new problem. This may require adaptation.
3. Revision: the new solution is tested in a real-world setting and a revision is made if necessary.
4. Retention: the new solution is stored in the case base and can be used to solve problems in the future.

We are currently examining how different case representations (the format in which cases are stored) can be (semantically) mapped to the MDPO, linking (the metadata of) customer information to cases in the case base. The underlying idea is to treat customer wishes and market preferences as problems that can be solved using existing company resources (i.e. resources that have been used in the past to solve similar problems), thus offering solutions that are close to the company's core competencies and are asked for by the market. The expectation is that this could decrease the average product failure rate of 80 percent.

Besides case-based reasoning systems, other innovation support systems are in place in enterprises today. One of these systems, or methodologies, depending on the type of implementation, is called TRIZ. TRIZ systems are very similar to case-based reasoners as they also apply a form of analogical reasoning, but they operate on a higher lever of abstraction and are not restricted to a certain domain like case-based reasoners typically are (Altschuller 1999, Chai 2005). The idea is that a solution for a problem in a certain domain can also be used in another domain. What is interesting is that the abstract representations of these problems can be expressed in properties (or attributes) and functions, which are already present in the MDPO.

Figure 1 depicts how the framework integrates the various technologies into an innovation process. Building on the empirically validated work of the Innovanet project (M. Paukert, C. Niederée, C. Muscogiuri, P. Bouquet and M. Hemmje 2004), the innovation process can be split up into six generic phases:

1. Problem identification phase: this is the start of the innovation process. Based on the market information input, an organisation can identify problems that need to be solved in its domain. The market information is semantically annotated and is delivered to the right person according to his or her semantic role (i.e. his or her expertise domain). Market information can be obtained through the above described market research methods, by web mining, or by analysing sales and CRM data.
2. Ideation phase: this phase is considered to be the core of the innovation process. The central innovation idea is developed using a combination of a case-based reasoner and TRIZ. Some recent efforts have been made to integrate case-based reasoning and TRIZ (Cortes Robles, Negny and Le Lann 2009, Cortes Robles, Hernandez, Lasserre and Gomez 2009), although we find that the current approach is lacking real integration. This system basically looks whether a case is present for a certain problem. If there is a case, it uses the case-based reasoner. If not, it resorts to TRIZ. We think there is much room for improvement in leveraging the strengths of both CBR and TRIZ, as the current approach does not take into account the actual content of the cases and problems in the system design (beyond determining whether there is a case or not).
3. Approach development phase: based on the central innovation idea, a conceptual framework for implementation is developed and the idea is validated in terms of novelty, appropriateness and feasibility. This phase still relies heavily on the cases and solutions presented by the CBR/TRIZ system.

4. Operationalisation phase: this phase is the most resource-intensive of the innovation process and considers the operational development of the innovation. The actual nature of this phase is highly domain-dependent (for example, consider the difference between innovation in a software company vs. a milkshake manufacturer).
5. Evaluation phase: the innovation is evaluated in terms of the goals that were set out for it to solve. This means assessing the innovation in terms of novelty, appropriateness and cost/benefits, as well as involving the market once more: this is the stage in which one conducts additional user studies. If the evaluation is positive, the innovation can be moved to the exploitation phase.
6. Exploitation phase: depending on the type of innovation, this phase means the commercialisation of the innovation, the adaptation of processes based on the innovation (e.g. to achieve cost reductions) or simply the publication of the results when it concerns an academic innovation. Successful innovations, i.e. successful solutions to problems are stored in the case base for future reference.

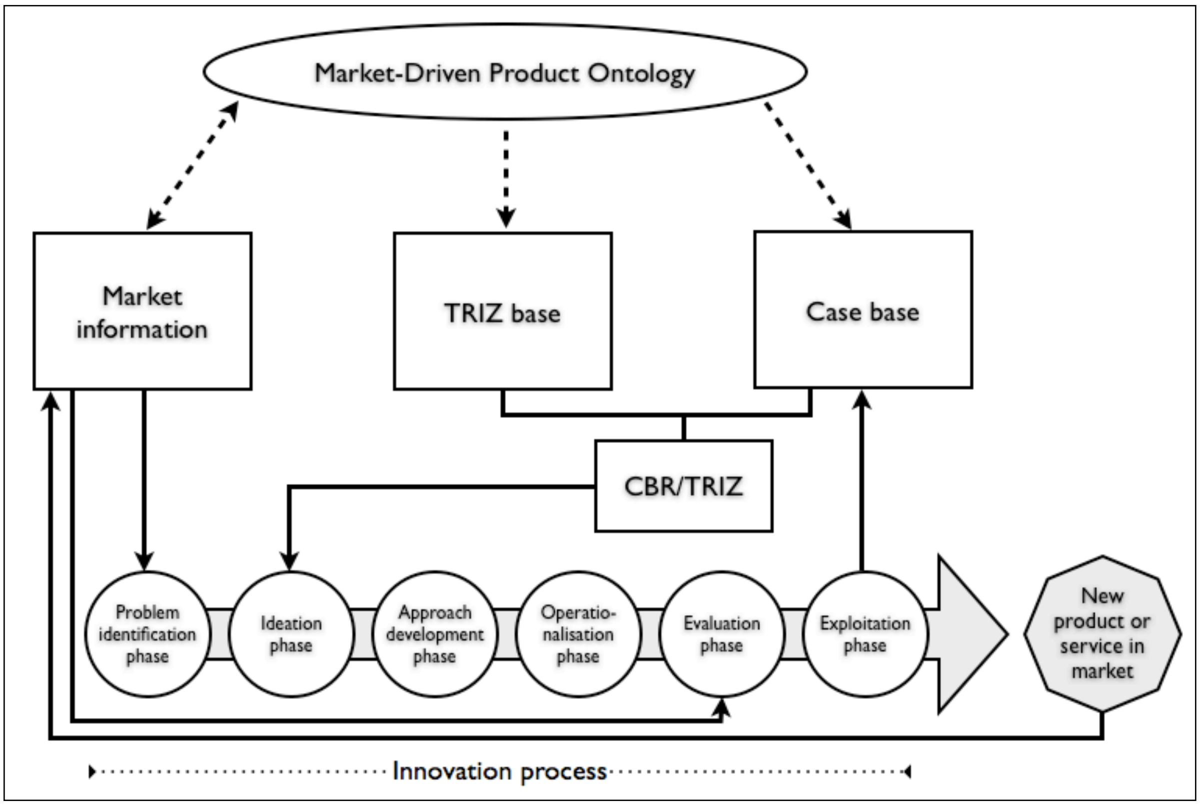

Figure 1: Schematic representation of the customer information integration framework

The Market-Driven Product Ontology serves as a metamodel for the product representation in the framework. The market information is annotated and both the TRIZ problems/solutions and CBR cases are represented using the concepts of the ontology. The ontology is market-driven in the sense that insights from market research drive the concept evolution of the product ontology. Whilst the properties of a product are per definition stable and known, the context in which it is used or even how it will be used are extremely difficult to predict. The notion that Tomas Edison thought of the phonograph as a device that would be used to “record the wishes of old men on their death beds” (S. McDonald, D. Lamberton, and T. Mandeville 1983) is only one of many examples that the market puts solutions to use for initially unexpected needs. Producers think in terms of properties, whilst consumers think in terms of functions, or the ‘job they want to get done’ by using the product or service (C.M. Christensen, S.D. Anthony, G. Berstell and D. Nitterhouse 2007). If an organisation wants to keep in touch with all the ways its products are used (and use that information to drive innovation), the information will have to come from the market. This process is represented by the arrow from the final product to the market information in Figure 1.

Findings

Market-Driven Product Ontologies and their application in case-based reasoning and TRIZ environments form a useful concept to making organisational efforts in market orientation more systemic, transparent and manageable.

MDPOs deliver a useful concept for annotating, converting and distributing market research data, as they structure the data around the greatest common devisor in a company: the product. In regard to the use of ontologies in the enterprise, they could offer a considerable advancement in bridging the ontology engineering lag in the conceptual dynamics bottleneck. The conceptual dynamics bottleneck is essentially about the (lack of) coverage of concepts by an ontology in a reality that is continually changing. When the conceptual dynamics in a domain change, there is a 'maintenance lag' in the ontology engineering process (Hepp 2007). If we look at the causes of conceptual dynamics in corporate environments, these will often be changing market conditions. Market-driven product ontologies are just about that, and could offer a shorter lag, since the market information is already semantically structured, although this should be the case for technology and competitor concepts also.

In order to operationalise the market information in existing innovation support systems, we have looked at a combination of a case-based reasoning system and TRIZ. We are currently looking at (re)defining the cases in the case base and the TRIZ conceptual solutions in the terms of the ontology, although this part of the research is a work in progress.

The use of semantic technology allows for the expression of the 'problem' (the market needs and wants) and the possible 'solutions' (the CBR cases and TRIZ solutions) in the same, shared concepts. This helps to translate the needs of the market to requirements at the design table.

Discussion

Market orientation alone is not enough for an organisation to succeed in a competitive market. Besides market knowledge, concepts such as experiential knowledge, conceptual knowledge, systemic knowledge, and routine knowledge exist (Nonaka, Toyama and Nagata 2000) which (technically) can and also should be elicited if the system wants to be truly useful in a corporate setting. Contributions from organisational sciences could advance this topic considerably.

The Market Driven Product Ontology needs to be tested in a more service-oriented environment in order see how well it works and whether it can simply include services. Research also needs to be done on how an MDPO could be linked to more common product ontologies like eclassOWL, which can fairly easily be generated from already shared classification schemes between value cycle partners. The concept of 'Product Context' in the MDPO, although important, will probably be reconsidered and broken up based on additional empirical research, as we feel its scope is just too wide at the moment. Contributions from the market research sciences will help solve this upcoming issue.

Regarding case-based reasoning and TRIZ, we further need to study is how we can advance the state of the art in the integration of TRIZ and case-based reasoning, i.e. find a way to merge both approaches. We also need to take into account the important notion of context from the ontology, as this represents the possible diversification in product design according to certain market segmentations, if any. Another problem that needs to be accounted for is the storage of the successful innovations in the case base. Because these are market-driven innovations, they serve the whims of the market and are often temporary solutions to temporary needs. Market needs and wants evolve continuously, and what was a good solution in the past may not be one in the future. The systems needs to be able to cope with this, and it doesn't today.

Finally, we need to look at the representation possibilities of the innovation processes, so that other stakeholders that use the MDPO (marketing department, advertising agencies, other suppliers, market researchers, etc.) can fathom the thought process and the role of the market information within that process. This knowledge can provide valuable insight in how and why a product came into being. Different stakeholders can then use this knowledge to perform more meaningful product-centric actions such as marketing campaigns, market research and collaborative innovation in the extended enterprise.

Conclusions

In this paper we have introduced the combination of Market-Driven Product Ontologies, CBR systems and TRIZ methodologies as a relatively promising concept for helping organisations become more market-oriented.

The MDPO consists of three fundamental building blocks: properties (perceivable and non-perceivable), functions and context. The MDPO is used in the annotation, conversion and dissemination of various market knowledge output formats based on semantic roles within the organisations of the product development/marketing life cycle.

Both case-based reasoning and TRIZ are valuable innovation support systems that can be used in conjunction for operationalising the market information delivered through the MDPO. Exactly how this is to be done and to what extent, is the subject of future research.

References

G. Altschuller, *The Innovation Algorithm: TRIZ, Systematic Innovation and Technical Creativity*. Technical Innovation Center, Inc., Worcester, MA, 2000.

J.B. Barney, 1991, "Firm resources and sustained competitive advantage" *Journal of Management*, Sage, Thousand Oaks, CA, 1991:17, pp. 99-120.

D.L. Barton, *Wellsprings of Knowledge: Building and Sustaining the Sources of Innovation*, Harvard Business School Press, Boston, 1995.

H.W. Chesbrough and K. Kusinoki, "The Modularity Trap: Innovation, Technology Phase Shifts and the Resulting Limits of Virtual Organizations" *Managing Industrial Knowledge: Creation, transfer and Utilization*, Sage, London, 2001.

C.M. Christensen, S.D. Anthony, G. Berstell and D. Nitterhouse, "Finding the Right Job For Your Product", *MIT Sloan Management Review*, MIT, Cambridge, MA, 2007:3, pp. 38-47.

P. Cillo, "Market learning capability and innovation. An explorative empirical study in the fashion industry." *3rd International Congress Marketing Trends*, Venice, 2003.

G. Cortes Robles, S. Negny and J.M. Le Lann, "Case Based Reasoning and TRIZ : a coupling for Innovative conception in Chemical Engineering" *Chemical Engineering and Processing*, Elsevier2009:48, pp. 239-249.

G. Cortes Robles, G.A. Hernandez, A.A. Lasserre and R.P. Gomez, "Accelerating the Knowledge Innovation Process", Lecture Notes in Computer Science, Springer, Berlin, 2009:5619, pp. 184-192.

G.S. Day, "The Capabilities of Market-Driven Organizations", *Journal of Marketing,* American Marketing Association, Birmingham, AL, Oct. 1994, pp. 37-52.

A. Hagardon, and R. Sutton, "Technology Brokering and Innovation in a Product-Development Firm". *Administrative Science Quarterly*, The Johnson School at Cornell University, Ithaca, NY, 1997:42, pp. 716-749.

R.F. Hartley, *Marketing Mistakes and Successes*, John Wiley, New York, 2000.

J.K. Han, N. Kim, and Rajendra K. Srivastava, "Market Orientation and Organizational Performance: Is Innovation a Missing Link?", *Journal of Marketing,* American Marketing Association, Birmingham, AL, Oct. 1998, pp. 30-45.

M. Hepp, "Possible Ontologies: How Reality Constrains the Development of Relevant Ontologies." *IEEE Internet Computing*, Los Alamitos, CA, 2007:1, pp. 90-96.

T. Li, and R.G. Cantalone, “The Impact of Market Knowledge Competence on New Product Advantage: Conceptualization and Empirical Examination”, *Journal of Marketing,* American Marketing Association, Birmingham, AL, Oct. 1998, pp. 13-29.

S. McDonald, D. Lamberton, and T. Mandeville (Eds), *The Trouble with Technology. Explorations in the Process of Technological Change*, Frances Printer Publishers Limited, London, 1983.

J. Main, *A Neural Network Approach to Case-Based Reasoning*, La Trobe Unversity, Bundoora, 2004.

D. Meersman, “Market Driven Product Ontologies”, *On the Move to Meaningful Internet Systems 2007: OTM 2007 Workshops*, Springer LNCS, Berlin, 2007, pp. 275-283.

V.G. Morwitz, J.H. Steckel, and A. Gupta, “When Do Purchase Intentions Predict Sales?” *Working Paper*, Marketing Science Institute, Cambridge, MA, 1997.

I. Nonaka, R. Toyama, and N. Kunno, “SECI, Ba and Leadership: a Unified Model of Dynamic Knowledge Creation” *Managing Industrial Knowledge: Creation, transfer and Utilization*, Sage, London, 2001.

I. Nonaka, R. Toyama, and A. Nagata, “A Firm as a knowledge-creating Entity: A New Perspective on the Theory of the Firm”. *Industrial and Corporate Change*, Oxford University Press, Oxford, 2000:1 pp. 1-20.

M. Paukert, C. Niederée, C. Muscogiuri, P. Bouquet and M. Hemmje, *Knowledge in the Innovation Process: An Empirical Study for Validating the Innovation Knowledge Life Cycle*, http://downloads.brainguide.com/publications/PDF/pub29442.pdf, 2004.

C.K. Prahalad and G. Hamel, *Competing for the Future*, Harvard Business School Press, Boston, 1994

C.O. Scharmer, “Self-transcending Knowledge: Organizing Around Emerging Realities” *Managing Industrial Knowledge: Creation, transfer and Utilization*, Sage, London, 2001.

H. Takeuchi, “Towards a Universal Management of the Concept of Knowledge” *Managing Industrial Knowledge: Creation, transfer and Utilization*, Sage, London, 2001.

B. Wernerfelt, “A resource-based view of the firm”, *Strategic Management Journal*, Wiley, Hoboken, NJ, 1984:5, pp.171-180.