Ontological Architecture for Knowledge Management

Applied to Global Parts Logistics (IBM)

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Abstract. For many years the Global Service Parts Logistics branch of IBM has been struggling with the need for a world-wide integration of a rich variety of relevant local database and information systems, from the national level up to the intercontinental level. At the same time, managerial demands have been continually expressed, pressuring to be able to produce performance-measurement reports for management internationally on a regular, timely, globally standardized, and cost-effective basis. This paper shows that a global solution to this problem is provided by a foundational ontology-based architecture for industrial service parts logistics. It is outlined how the philosophy of the American pragmatist philosopher Charles Sanders Peirce provides the basics for a principled and solid foundational ontology for (IBM's) global service parts logistics. This ontology-based approach to global service parts logistics has been implemented in IBM's industrial practice. The underlying knowledge taxonomy is available, and has also been implemented in Protégé. More important in industrial practice, the ontology-based approach presented in this paper has been extensively applied in IBM performance management reporting projects, showing improved systems integration as well as much higher productivity in current management performance reporting. Specifically, the ontology-based work reported in this paper resulted in a saving of 200K$, plus doing twice as much as before, in half of the time.

Keywords: taxonomy, ontology, knowledge management architecture, industrial service logistics, IBM

Introduction. Ontology based data retrieval

Although I work for IBM, in this paper I speak on my own terms, not necessarily approved, nor disapproved by IBM. It is my personal initiative and endeavor in PhD research, with same title.

In 1988 IBM Netherlands proposed to consolidate service parts logistics for Europe, also including a measurement-team, to discover reality by means of queries and design measurements for management. The levels of management to be supported are strategic, tactical and operational. During ten years multiple improvements were implemented. One of the lessons learnt was that databases are optimized for database

management, but extracting the necessary data for management reports became cumbersome; taking too much time. All reports requested could not be created in one day. Special tables just for reports were created and later also for cubes, giving significant improvement from end user point of view. New continents are now becoming integrated, and we have to deliver more reports with fewer workforces (cost reduction). The dimensions of the cubes are the qualities/categories for the reports. The research question became: Can we come up with a set of possible categories (ontology) of the phenomena in reality (phenomenology), preventing interviewing all managers. Can we specify some general categories (the most universal categories or Ontology – with capital O), which can be used as a generic principle for the design of the structure of the categories?

The method of research is to investigate the works of philosopher/scientist Charles Sanders Peirce. Charles Sanders Peirce (1839-1914) developed one of the most promising systems of categories. Since Peirce's works offer a fundament for an evolutionary architecture (Sowa, 1995), he was selected to investigate further. Peirce reported that it took him twenty-five years to reach a provisional conclusion (Kent, 1987). Of particular interest are Peirce's natural (real) classification of the sciences, containing phenomenology (taxonomy), logical representation (ontology) [semiotics], and Ontology [part of metaphysics].

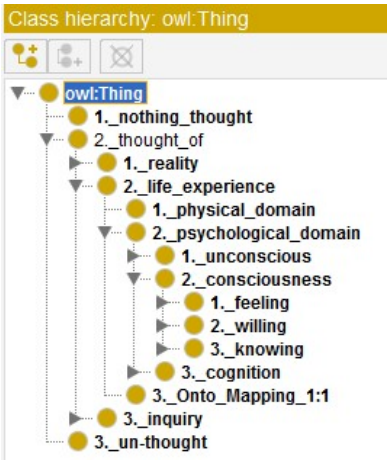
The expected outcome is one principled ontology, applied as design principle, and pervasive in all levels of (management) abstraction (strategic, tactical and operational management). The wider implication is that the needed data resources can be created as early as possible instead of ad-hoc on request, in other words – being prepared for future requirements of management. The resulting vocabulary, or better knowledge taxonomy functions as an ontology for data retrieval and resulted in a saving of 200K$, doing twice as much as before, in half of the time. The knowledge taxonomy is implemented in Protégé.

1 Main principle, Peirce: fundamental ontology

Fundamental ontology is an ontology based on basic principles, serving as an essential component. Peirce introduces his categories and their theory in "On a new list of Categories" (1867). Peirce's categories (technical name: the cenopythagorean categories) are firstness, typical characterized as Quality of feeling, secondness as Reaction, resistance, (dyadic) relation and thirdness as Representation, mediation. In the universe of experience firstness is about ideas, chance, possibility; secondness about brute facts, actuality and thirdness about habits, laws, necessity (the way). This principle division, of firstness, secondness and thirdness is applied to all the division in the ontology (https://en.wikipedia.org/wiki/Categories_(Peirce)).

2 Strategic planning : ontology of mind as class hierarchy in Protégé

Strategic thinking is an evolutionary continuous way of managing a business. Unless one can accurately measure current performance, it is virtually impossible to know where improvements are needed or even possible, says IBM executive, Pat McNabb (IBM; 1998; Business Strategy: Success Through Knowledge).

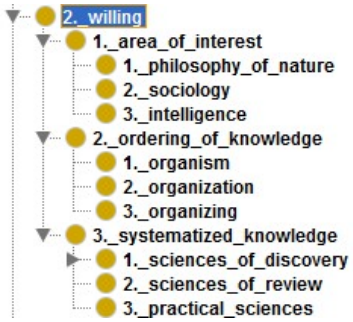


In 1988 IBM Netherlands started thinking on the consolidation of all worldwide service parts logistics locations. Software was developed: Common Parts Procedures and Systems, but how is it functioning in reality?

We have to inquire, by running queries (our measurements). Streams of events (life experiences) in reality become trains of thought. We know reality (physical domain) only by interpretation in our thoughts (psychological domain). The interpretation is a mapping between the physical domains onto the psychological domain. Most of our thoughts are unconscious; through cognition we become conscious of some thoughts. Consciousness can be divided into feeling, willing and knowing. Strategic planning is about the same. Awareness has an external scope, long range perspective, and focus on environment with targets for trends an direction having key questions as where are we doing business and how is it evolving. Management needs an understanding of the current situation versus the whished for targets and have insight into trends about the progress made; are we heading in the right direction? This knowing will guide what management is willing to do or change. Willing is having knowledge of the strategic position.

3 Strategic management: foundational ontology with continued example in Protégé

The strategic position map has three dimensions: What, who and how (Markides, 1997), which are striking similar to the definitions of knowledge: What: Area of interest (aboutness) or ontological knowledge; Who: ontological order of knowledge and How: ontology of knowledge.



The nature of dimensions of knowledge did not change much during many centuries, from Scholastics, a recent dictionary definition to contemporary knowledge management. Three dimensions of knowledge, as known by the Scholastics, are ontological knowledge, onto-

logical order of knowledge, and ontology of knowledge. First, ontological knowledge is knowledge of the being of things (aboutness), essences, of their social- and intelligible relations. Second, the ontological order is a) the hierarchy between beings and perfections; b) order, necessary and contingent, between beings or between their constitutive parts; c) real order. Third, the ontology of knowledge is the study of being and intentional nature of knowing rather than a study centering on the criticism of knowing, sometimes used as a synonym for the theory of knowledge (epistemology) (Wuelner, 1966).

Three dimensions of knowledge derived from the dictionary, looking up the definition for the word science (from Latin Scientia, meaning "knowledge") are first, referring to classical antiquity, science as a type of knowledge that was closely linked to philosophy. Second, science is a systematic enterprise that builds and organizes knowledge in the form of testable explanations and predictions about the universe. Third, referring to modern usage, science that most often refers to a way of pursuing knowledge, not only as knowledge itself, or epistemology (Webster, 2012).

Three types of knowledge in temporary knowledge management still use the same dimensions as used by the scholastics and dictionary. If the essential phenomenon of our domain is knowledge, then questions arise as "What is?" (aboutness), "How is knowledge ordered?" and "How do I know?", which forms the basis of epistemology, the science of knowing (Smiraglia, 2014).

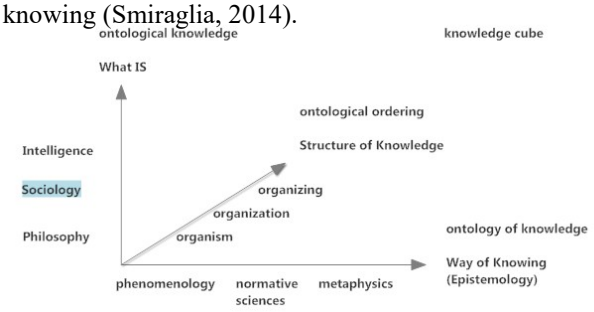


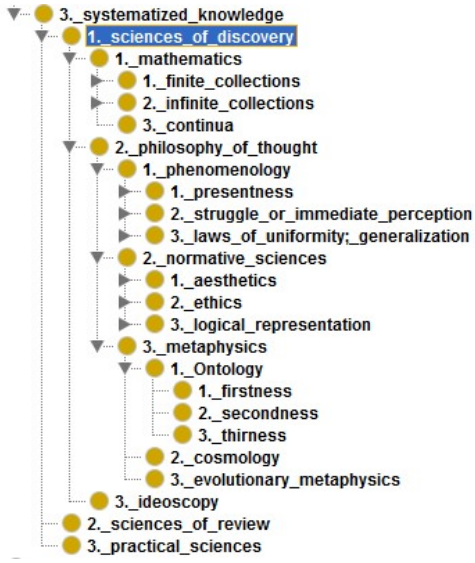
Fig. 1. Ontological commitment as universal knowledge architecture

Three-dimensional imagery is also found in Peirce's natural classification of the sciences: Comte's hierarchical ordering in terms of decreasing generality becomes, in Peirce's scheme, a series of steps; the sciences at the top provide principles for those below; not a single linear staircase, but a series of ladders related in a three-dimensional array so as to exhibit the more significant relations of a logical dependence among the sciences. The whole assemblage might be envisioned as a lattice – yet another diagrammatic thought advanced by Peirce (Ketner, 1987). In this paper, we focus on scientists working together (Wat-Is – Sociological) aiming to obtain results (how is knowledge ordered – organization) and structure (How do I know – way of knowing).

4 Tactical management: core ontology with continued example in Protégé

Science is understood in terms of activities of those who pursue it. At this broad level it can be related to other pursuits.

Peirce thought people might fit into one of three groups (dimensions). First: those who seek enjoyment; those are the most numerous. Second: those who lead lives of action and who aim at achieving results; included are the makers of civilization, the builders of industry, and the wielders of political power. Third: those whose lives are directed to developing ideas and truth, the scientist. A classification of the sciences is not concerned with the first two groups: the whole scientific enterprise falls within the third category. Science, regarded as the activity of those in search of truth, falls into the category of mind (Kent, 1987). The first group is about creative people (disrupting), the second group about order (organization), and the third group about the structure and classification of sciences.



5 Operational management: domain ontology

In the logistics domain the elements of the normative sciences can be renamed: 1. aesthetics becomes vision; 2. Ethics becomes mission; 3. Logical representation becomes documentation where the semiotics of Peirce is very useful.

We have to be careful with interpreting Peirce and not to confuse our current thoughts with the intentions of Peirce. It is argued by Liszka, 2017 that the best interpretation of Peirce´s aesthetics is a normative science of ideal ends. Peirce´s influences in this regard include Plato´s notion of kalos, Friedrich Schiller´s The Aesthetic Education of Man, and Kant´s notion of architectonic.

Ontological commitment to organization and knowledge management

An ontology defines the vocabulary that may be used to specify the queries and assertions for use by independently developed resources, processes, and applications. Ontological commitments are agreements to use a shared vocabulary in a coherent and consistent manner. Agreements can be specified as formal ontologies, or ontologies with additional rules, to enforce the policies stated in those agreements (Kendall,

2019). [Business-model]. Formalizing the ontological commitment means offering a way to specify the intended meaning of its vocabulary by constraining the set of models, giving explicit information about the intended nature of the modeling primitives, and a priory relationship (Guarino, 1994).

Organizing [2.3.x] = management	org. culture [2.3.1]	org. management structure [2.3.2]	knowledge management [2.3.3]
Organization [2.2.x]	org. identity [2.2.1]	org. action [2.2.2]	organizational knowledge [2.2.3]
Organ [2.1.x]	personal identity [2.1.1]	job roles [2.1.2]	communication [2.1.3]
Organizational thinking vs social ways of knowing	sociological phenomenology [2.x.1]	social behavior [2.x.2]	metaphysics of knowledge [2.x.3]

Fig. 2. Social layer - ontological commitment

What is important is what an ontology is for. Gruber and colleagues have been designing ontologies for the purpose of enabling knowledge sharing and reuse. In that context, an ontology is a specification used for making ontological commitments. We use ontologies to describe ontological commitments for a set of agents so that they can communicate about a domain of discourse without necessarily operating on a global shared theory. We say that an agent commits to ontology if its observable actions are consistent with the definitions in the ontology (Gruber, 1992).

6 Application and business value

Adding organizational dimension to the social level resulted in the ontological commitment, with at the center the commitment to deliver high performance (hence measure the performances of activities).

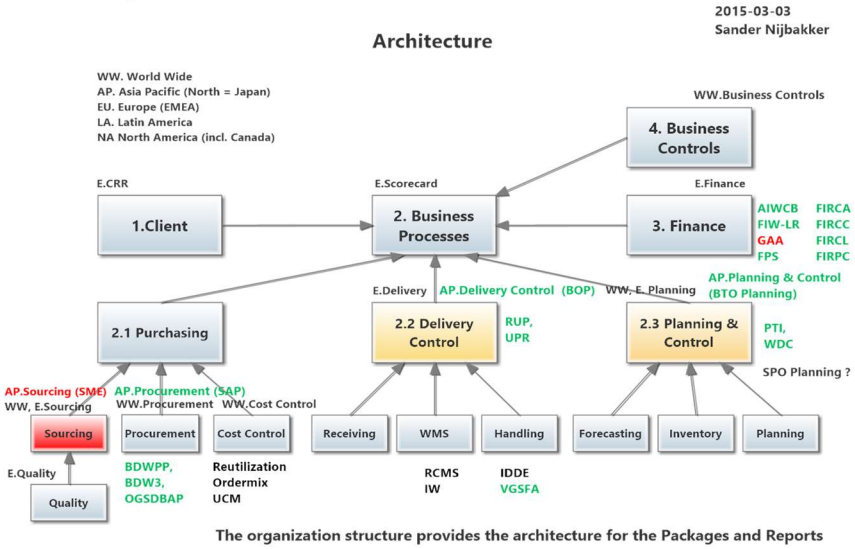


Fig. 3. Architecture for ontology-driven Information System

7 Business Value / cost avoidance

(Argument from Practice: Value: Cost Avoidance)

In our project (Asia Pacific Brio to Cognos migration), capital is retained due to cost avoidance to improved efficiency, common ground, common language, and improved productivity. In modern business practice, two categories distinguish capital into two categories of assets, intangible, and tangible. A striking example of intangible cost avoidance happened at the initiation of the project. During the first orientation call about the project, we explained the approach, organization, and structure derived from the previous project and how this project fits-in. During the meeting, access was provided to demonstrate the essence. The approach was approved during the first meeting! In contrast with earlier attempts years ago, for which it took two years to create a worked-out project plan, which, although approved, was sent to the waste-bin. Another example of intangible costs is the value of improved decision making to improve performance and the value of improved performance itself. The emphasis, for calculation, is on the tangible category. Two comparable project are used to demonstrate the business value (at a bare minimum).

	Project I (2010-2012)	Project II (2015)	Delta improvement
People developing	5	2.25	2.22x
Full-time?	1	0.5	2x
Duration (years)	2	1	2x
Total			8.9 x
			Improved efficiency

Table 1. resources used in two comparable projects

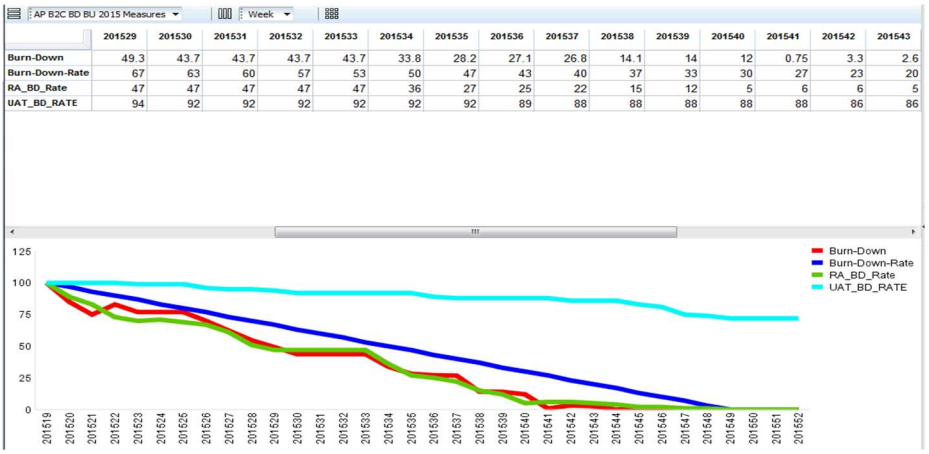


Fig. 4. burn-down chart of the project

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