Where do ‘ontologies’ come from? Seeking for the missing link

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Abstract – One of the possible matters for discussion between Web architects and philosophers relies in the use of the term ‘ontology’ by the former. Whether many computer scientists declare that their ‘ontologies’ have nothing to do with the philosophical concept, we must note the analogy between their positions and the positions of the Logical Positivism in the 1930s. However, drawing a guaranteed lineage is extremely difficult. Indeed, in computer science papers, bibliographical references to ontologies usually lead to 1991 only. Hence, this paper is an ‘inquiry’ in search of a chain of descent from the 1930s to 1991.

Keywords – Epistemology, Terminology, Artificial Intelligence, Semantic Web.

Ontologies : what for?

The link between the Web and philosophy is not straightforward. However, in 2001, a wide audience discovered in *Scientific American* that:

> A program that wants to compare or combine information across (...) two databases has to know that (...) two terms are being used to mean the same thing. Ideally, the program must have a way to discover such common meanings for whatever databases it encounters. A solution to this problem is provided by the third basic component of the Semantic Web, collections of information called ontologies.
>
> (Berners-Lee *et al.*, 2001)

Hence, faced to a mundane computing problem, Web architects summoned a concept – or at least a term – from one of the most ancient and arduous domains of western philosophy:

> In philosophy, an ontology is a theory about the nature of existence, of what types of things exist; ontology as a discipline studies such theories. Artificial intelligence and Web researchers have co-opted the term for their own jargon, and for them an ontology is a document or file that formally defines the relations among terms. The most typical kind of ontology for the Web has a taxonomy and a set of inference rules.
>
> (Berners-Lee *et al.*, 2001)

Critics

The mention of taxonomies briskly worried people who regularly use thesauri and classification systems in libraries. According to Clay Shirky, for example, ontologies have no reasons to age better than 'Marxism-Leninism' category in soviet libraries, or to be less ethnocentric than 'History' in the Library of Congress headings. Without denying the importance of such systems, he thinks that they should be confined to domains in which what is described is stable and restricted, in which categories are well formalised with clear edges (Shirky, 2005).

Years before, while some advocated for *reusable* (Gruber, 1991) or *portable* ontologies (Gruber, 1993) in knowledge bases, our French community of knowledge engineering expressed their reluctance to the alleged universality of ontologies:

> The task strongly influence the building of the ontology which, henceforth, cannot be portable nor universal. Moreover, this advocates in favor of a non-logical but rather constructivist vision of knowledge. (...). As any knowledge, ontologies are

interpreted by a human expert, depending on the idea he has about the task attributed to the system.

Translated from (Charlet, Bachimont *et al.*, 1996)

Models are not problematic by themselves but by the truth status ones give to them, and the last century precisely brought a drastic change in the definition of truth (Léonhardt, 2008). While truth had been defined since Aristotle as the *correspondence to the World*, its recent redefinition led to modern mathematics and modern sciences (see Figure 1).

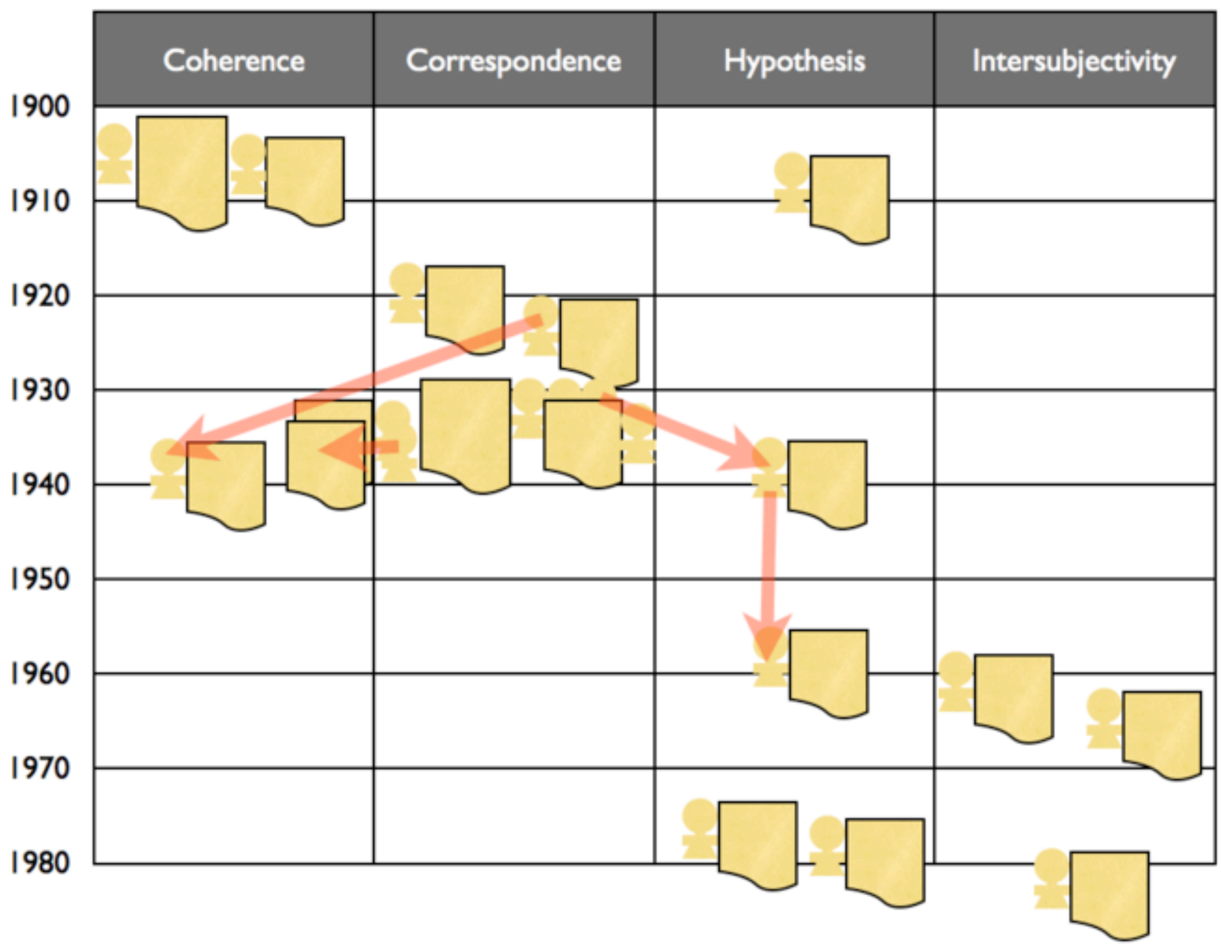

Figure 1. On the definitions of truth.

Hilbert's program (1900-1930), by refounding geometry with formal theorems built on conventional axioms, publicized the idea that truth in mathematics was a matter of *inner coherence*. This revolution was though greatly prepared by the advent of non-euclidian geometries, new imaginary ‘worlds’ that denied the idea that physics and mathematics shared the same object.

From Hilbert's and Poincaré's mathematics, Schlick (1917) inferred that in order to keep *truth as correspondence* in mathematized physics, axioms had to be replaced with experimental results. In Kant's terms: synthetic statements could only be *a posteriori.* Dedicated to Schlick, *The Scientific Conception of the World – The Vienna Circle* (1929) followed this trail through by founding “Logical Positivism” at the crossroad of empirism and logicism. Paradoxically, the critical impact of the Vienna Circle on modern epistemology was through the people on its margins.

Firstly, Popper (1934), by studying how experimental results and logic could be used together to build scientific knowledge, discovered that Schlick's method was indeed an induction, a logical fallacy condemned since Aristotle. Instead, he then proposed to build scientific method on *modus tollens* deduction: “if it is false for several, it cannot be true for all”. A particular experiment brings knowledge when it refutes a general theory. Therefore, while the falseness of a scientific theory can be certain, its truth is always *hypothetical.* Contrary to similar works (Duhem, 1906), Popper's ones had a major impact on modern science epistemology.

Secondly, Wittgenstein (1936), who was one of the early inspirers (1921) of the Vienna Circle, publicly denied his prior works. By introducing concepts like “Language games”, he clearly gave up the *correspondence* definition of truth for the *coherence* one.

Thirdly, Kuhn (1962), in the Vienna Circle series (*International Encyclopedia of Unified Science*), published a study about scientific revolutions in history. This study, by highlighting the social nature of scientific truth, reminded earlier Marxists works about the prominent role of communities in science, and opened a new field in the sociology of science.

This short historical incursion in the definitions of truth can help us analyse the status given by computer scientists to their ontologies. As an example, Nicola Guarino clearly advocates for “truth as coherence” when he claims:

> The general perspective I have in mind is that of Formal Ontology, which can be included as the theory of formal distinctions between the elements of a domain, independently of their actual reality.
>
> (Guarino, 1997)

In most of computer science works, the lack of reflection about creating, testing and revising ontologies seems to anachronically match the definition of truth advocated by Schlick (*truth as correspondence to the World*), with absolutely no place for knowledge construction and refutation.

On the contrary, some of us think that users of our systems should have the hypothetical and intersubjective value of truth in mind. Hence knowledge engineering should provide digital spaces for debate between contradictory user-generated viewpoints (Bénel *et al*., 2001; Cahier & Zacklad,2001).

A missing link

We supposed that orthodox ontologists' posture could be explained by a simple ‘residual’ positivism in the scientific community rather than by a true filiation to Logical Positivism. But then, how could we explain the use of the term `ontology’?

In the English community of knowledge modeling, one of the few authors who refer to philosophical readings is John F. Sowa (Sowa, 1992). However, when he used the word `ontology’ (Sowa, 2001), it was to criticize fiercely an artificial intelligence that would not take into account the failure of Logical Positivism.

Because it does not seem to be a direct filiation, we will study in the next sections two hypothetical trajectories of the idea and term of ‘ontology’.

In search of heirs

The trail of ontology is easy to follow from Greek philosophy to Logical Positivism, but it fades after the collapse of the Vienna Circle. Owing to Monique Slodzian's works, we know that, at this time in Vienna, a certain Eugen Wüster saw himself as the true heir of the Circle.

Contrary to the original members, Wüster was neither a physicist nor a mathematician, nor a logician, nor a philosopher. He was an entrepreneur who saw in the scientific program of the Circle the opportunity to solve the communication problem between engineers speaking different languages. To address this problem, he defined the “General Theory of Terminology”. From language he kept neither verbs nor syntax, but only ‘terms’. These terms are structured into what he called himself “an ontology” (Slodzian, 2006).

It is worth noting that Wüster's thesis was entitled “International Language Standardization in Technology” (1931) and that he was indeed at the origin of one of the ISO commissions. So, between Vienna Circle's program and Wüster's one, the goal had significantly changed: while the former did science, the latter did engineering, while the former aimed at describing Nature, the latter described artifacts. In the end, the Ontology became a nomenclature, and the term a purely conventional symbol (Slodzian, 2006).

In fact, Wüster's program was not very far from what François Rastier (Rastier, 2010) criticizes in “Web Science”, not far either of what Tim Berners-Lee himself states in his interview with Harry Halpin and Alexandre Monnin:

> When we design a protocol, we're actually creating... we get the chance to actually define the way a new world works. (...) When you create a protocol, you

get the right to play God, to define what words mean. (...) People (...) have to join in, (...) with agreeing.

Tim Berners-Lee in (Halpin & Monnin, 2010)

In search of ancestors

Another way to draw a lineage from Logical Positivism to the Semantic Web, could be to track down references in papers recursively. But here again, the trail fades. Bibliographical references to ontologies in computer science papers all leads to a short paper by Thomas Gruber (1991). This article itself contains only six references, the oldest ones being from the previous year.

Facing such a dead end, we are reduced to searching for quantitative clues in bibliographic databases (see Figure 2).

Decades	Papers counts	Most cited authors
1930-1939	$3,8*10^2$	Coomaraswamy, Ginzburg, Somerville
1940-1949	$6,0*10^2$	Cerf, Quine, Cellars
1950-1959	$1,5*10^3$	Quine, Cartwright, Wells
1960-1969	$3,1*10^3$	Sartre, Bazin, Sommers
1970-1979	$5,8*10^3$	Cavell, G'ivon, Hellman
1980-1989	$1,4*10^4$	Moens, Cracraft, Horgan
1990-1999	$6,6*10^4$	Gruber, Guarino, Ushold
2000-2009	$3,1*10^5$	Euzenat, Ashburner, McGuinness

Figure 2. Search in Google Scholar for papers containing the word 'ontology'.

The first straightforward observation is the geometric growth of the use of the term ‘ontology’. However this is probably biased by the lack of representativity of digitized contents depending on their age, and mostly by the explosion of scientific papers numbers in the 20th century. What is greatly more interesting is the evolution in the trends witnessed by the names of the most cited authors.

In the 1930s, at the time of the Vienna Circle, ‘ontology’ is still mainly used in religious studies and philosophy of science. The effects of the Vienna Circle show up in the 1940s and 1950s with the advent of Quine in the most cited authors. In the 1960s, analytical philosophy is overshadowed by phenomenology and reflections on art. It returns to the fore in the 1970s, along with a Viennese-inspired linguistics. This trend seems reinforced in the 1980s in the form of a ‘computational’ linguistics. Finally, we find Thomas Gruber's and Nicola Guarino's knowledge representations in the 1990s and the Semantic Web in the 2000s.

Of course the coarse-grained results of such a quantitative analysis are not quite satisfactory. However, we can note that, even if the lineages are still blurry, there is a real chronological continuity in the use of the term 'ontology' from Logical Positivism to computer science. Moreover, it is noteworthy that one of the key links in this continuity seems to be Quine.

Further researches on those who deal with ontologies and conjure up Quine lead us to John McCarthy in 1980, the same who introduced the concept of Artificial Intelligence at the famous Dartmouth Conference in 1956. According to him, builders of logic-based intelligent systems must first "list everything that exists, building an ontology of our world" (Smith & Welty, 2001).

By following the same trail, one discovers that the first to follow this advice was Patrick Hayes in 1985. His ontology was for a "naive physics". The word 'naive' was used here not in the sense of a simulation of human reasoning in everyday life, but in the sense of grasping the world pre-theoretically and reasoning about it formally (Smith & Casati, 1993). Nowadays, Patrick Hayes is involved in developing RDF-core, SPARQL and OWL, three core building blocks of the Semantic Web.

A loose link?

Thus emerges a direct filiation through Quine and Artificial Intelligence between logical positivism and the ontologies of the Semantic Web. However, we must admit that Quine's views are rather different from Schlick's. Moreover, matching all of the views of Quine with one definition of truth would be difficult as he denied the distinction between analytic and synthetic statements, and was even opposed to the idea of a normative epistemology.

To go further, we will focus on Quine's reflections *on what there is* (1948) and how they could have been of interest to McCarthy and his logic-based intelligent systems. In this very paper, he openly dismisses the idea that existence would be discovered or invented. According to him, reference is not a matter of *names* but of *pronouns*("bound variables" in formal logic).In other words, the referent is internal to language. As peculiar as this position can be for an 'ontology', it had tremendous advantages for the founder of Artificial Intelligence:

- explained in formal logic terms and with continuous references to Frege and Russell, it was "ready to use" in logic-based systems,
- by stating that mathematics was only an example of language, it let think that it could be used for all the fields covered by human language. McCarthy was also interested in linguists that shared this idea of internal reference (Grice, Searle, etc.).

It is noteworthy that such an ontology is, as stated by Quine, a 'myth' that we are committed to believe or not, that we can disagree with, that we can compare with another one, but whose truth (or falseness) has little to do with experiments. This may explain why, in 1982, when Newell proposed to add a "Knowledge level" to logic-based systems, Artificial Intelligence was still so far from real applications and tests (Rousseaux & Bouaziz, 2005). This could also explain why the introduction of 'knowledge' in Artificial Intelligence brought both interesting application fields and theoretical confusion on what is an ontology.

Epilogue

This article was an attempt to contribute to the debate about the philosophical status of what is called 'ontologies' in the Semantic Web. We adopted a 'genetic' approach and had to go further a bibliographical dead-end in computer science to see if 'ontologies' could be connected to philosophical works, and in particular with Logical Positivism. Our result is that the missing link could be, very likely, Quine, a dissident of Logical Positivism, and McCarthy, the founder of Artificial Intelligence.

This result reveals that the term 'ontology' has then a very non-classic meaning: it has nothing to do neither with essence nor with experience. Such an 'ontology' confers to Artificial Intelligence (and then to the Semantic Web) a very speculative status, hardly compatible with real-world applications, except at the cost of dangerous theoretical trade-offs.

The questions that remain are why this filiation is not clearly assumed by explicit bibliographical references, why the Semantic Web promoters did not reveal what they owed to techniques, philosophy and people of the Artificial Intelligence domain. One could wonder whether it was not to avoid the arguments that are opposed to this domain for forty years (Dreyfus, 1972) and present this kind of approach as a dead end.

References

Aurélien Bénel, Elöd Egyed-Zsigmond, Yannick Prié, Sylvie Calabretto, Alain Mille, Andrea Iacovella, Jean-Marie Pinon (2001). Truth in the Digital Library: From Ontological to Hermeneutical Systems. *Proceedings of the fifth European Conference on Research and Advanced Technology for Digital Libraries* [ECDL], LNCS no. 2163. Berlin : Springer-Verlag. p. 366-377.

Aurélien Bénel, Sylvie Calabretto (2004). Ontologies... déontologie : réflexion sur le statut des modèles informatiques, *Linguistica Computazionale, n°20-21*. p. 31-47.

Tim Berners-Lee, James Hendler, Ora Lassila (2001). The Semantic Web. *Scientific American, May 2001*.

Jean-Pierre Cahier, Manuel Zacklad (2001). Expérimentation d'une approche coopérative et multipoint de vue de la construction et de l'exploitation de catalogues commerciaux « actifs ». *Document numérique n°3-4, Volume 5.* Hermes. p.45-64.

Jean Charlet, Bruno Bachimont, Jacques Bouaud, Pierre Zweigenbaum (1996). Ontologie et réutilisabilité : expérience et discussion. In: N. Aussenac-Gilles, P. Laublet & C. Reynaud (Ed.) *Acquisition et ingénierie des connaissances. Cepaduès Editions*.

Hubert Dreyfus (1972). *What Computers Can't Do.* New York: MIT Press.

Thomas R. Gruber (1991). The Role of Common Ontology in Achieving Sharable, Reusable Knowledge Bases. In: J. A. Allen, R. Fikes, & E. Sandewall (Eds.), *Principles of Knowledge Representation and Reasoning: Proceedings of the Second International Conference*. Cambridge MA: Morgan Kaufmann. p. 601-602.

Thomas R. Gruber (1993). A translation approach to portable ontology specifications, In: *Knowledge Acquisition, Volume 5, Issue 2*. p. 199-220.

Nicola Guarino (1997). Some organizing principles for a unified top-level ontology, In: *Proceedings of AAAI 1997 Spring Symposium on Ontological Engineering*, AAAI Press.

Harry Halpin, Alexandre Monnin (2010). Tim Berners-Lee on PhiloWeb and Philosophical engineering, Interview. Available on Dailymotion.

Thomas S. Kuhn (1962). The structure of scientific revolutions, In: *International Encyclopedia of Unified Science, Volume 2, Issue 2.*

Jean-Louis Léonhardt (2008). *Le rationnalisme est-il rationnel ? L'Homme de science et sa raison.* Parangon.

Vladimir Lifschitz (1990). *Formalizing Common Sense: Papers by John Mc Carthy*. Norwood (New Jersey): Ablex Publishing.

Karl Popper (1934), *The Logic of Scientific Discovery (*translated from German in 1959). New York : Basic Books.

Willard Van Orman Quine (1948). On What There Is, *Review of Metaphysics.*

François Rastier (2010). Web Semantics vs the Semantic Web? The problem of keyness. In: M. Bondi, M. Scott (Eds.),*Keyness in Texts.* Amsterdam: John Benjamins Publishing. p. 93-110.

Francis Rousseaux, Thomas Bouaziz (2005). L'invention des Connaissances par les informaticiens. *Texto !, septembre 2005.*

Clay Shirky (2005). Ontology is Overrated: Categories, Links, and Tags. *O'Reilly Emerging Technology Conference [ETech'2005], San Diego, March 14-17, 2005*.

Monique Slodzian (2006). La terminologie : historique & orientations. Conférence invitée. *Semaine de la Connaissance, Nantes, 26-30 juin 2006.*

Barry Smith, Christopher Welty (2001). Ontology: Towards a new synthesis. *Proceedings of the International Conference on Formal Ontology in Information Systems*.

Barry Smith, Roberto Casati (1993). La physique naïve : un essai d'ontologie. *Intellectica*, 2, 17. p. 173-197.

John F. Sowa (1992). Semantic Networks. In: Stuart C. Shapiro (Ed.), *Encyclopedia of Articial Intelligence*, 2nd edition, vol. 2. New York: Wiley. p. 1493-1511.

John F. Sowa (2001). Signs, processes, and language games: Foundations for ontology. Invited talk. *Ninth International Conference on Conceptual Structures, "Broadening the Base", California, July 30-August 3, 2001.*