Kim H. Veltman

"The Semantic Web and Multi-level Links", Amritsar, September 2008 (In Press).

Abstract

Work on semantic networks predates the introduction of the Internet in 1968. The idea of making a semantic web the basis of the World Wide Web was broached by Tim Berners Lee at WWW7 (Brisbane, 1998) and further described in a roadmap (September 1998). Since then it has become a mainstream vision with progress on many fronts. A key element of the semantic web vision that makes assertions on the Web machine-readable is a Resource Description Framework (RDF). This has transformed the Internet into a Web for sharing knowledge and prepares the way for a transaction web, fundamental for business dimensions of the web by providing validation of nodes and links in the system.

In all this, the term "semantic" is used in a very specific way: to make the meaning of (programming) instructions understandable to computers without human intervention. This marks an enormous contribution. Even so, the focus on "semantic" instructions for machines, does not yet address the needs of those in the Social Sciences, the Humanities, and indeed all Sciences, which have temporal-spatial dimensions. The present approach ignores the traditional meaning of semantics, whereby it was linked with etymology: the history of meanings given to words by humans, which change with time and space. It also uses a very limited form of hypertext that links one hyperlinked word in one document with another hyperlinked word in another document.

This paper reviews briefly the history of these efforts and outlines the potentials of a semantic web with multiple levels of hyperlinks. It suggests that current efforts focus on a Web that privileges born digital materials. As the ITU has suggested, a next generation needs to include an Internet of things. We need much more. Scholars in earlier cultures distinguished between different worlds ranging from metaphysical and mental to physical, man-made, social, and creative. These ideas need to be integrated into our plans for a semantic web such that we can search for knowledge and information at different levels.

---

1. Introduction
2. Dreams of Automatic Systems
3. Verification and Truth
4. Assertions and Scholarship
5. Powers and Limits of Born Digital
6. Current Limits of RDF
7. Multiple Level Links
8. Worlds Wide Webs
9. Physical World as Knowledge Interface
10. Conclusions

1. Introduction

Semantics as the science of meaning of words is a relatively recent term that goes back to the latter 19th century. One of the first English language books on semantics appeared in 1900.[1] Semantic networks became a significant topic in the computer science community in the late 1960s, just prior to the advent of the Internet.[2] A seminal article by William A. Woods (1975) foresaw how "Semantic networks, in which nodes are connected to other nodes by relationships called links, are widely used to represent knowledge and to support various algorithms that operate on that knowledge."[3] The following year (1976), Peter Chen established the idea of Entity Relationship diagrams.[4] The following decades saw the rise of "is a" and "has a"[5] as paradigms in object oriented programming and in the World Wide Web. While seemingly novel, these were simply the *divisio* (taxonomy) and *partitio* (partonomy) of classical logic in a new guise.

The idea of using HyperText Markup Language (HTML) and HyperText Transfer Protocol (HTTP) at CERN (1989-1990) transformed the Internet into a World Wide Web (WWW). A first WWW conference took place in May, 1994 (CERN, Geneva).[6] At WWW7 in April 1998 (Brisbane), Tim Berners Lee described the need for evolvability[7] and explored retrospective documentation of equivalence. This led to a Semantic Web roadmap in September 1998.[8] At WWW8 in May 1999 (Toronto) he outlined his vision of a Semantic Web,[9] beginning with a quest for "human communication through shared knowledge" and a principal principle that "anything can refer to anything." A first conference followed in 2001.[10] Since then the semantic web has become a mainstream effort with projects all over the world.

The Resource Description Framework (RDF), that makes materials on the web machine readable, has opened immense new amounts of human communication and prepares the way for a transaction web, which is fundamental for business dimensions of the web. These remarkable efforts entail the greatest technological success story of all time. It took a century to reach 100 million telephone users. While the Internet took twenty years (1969-1989) to reach 1 million users, the WWW has in the past 18 years grown by a further 1.462 billion fixed-line users, with predictions of a doubling of those figures in the next years as mobile Internet becomes the norm.[11] With a billion new mobile phones annually, it is technologically possible to foresee a world where everyone could one day be connected such that all knowledge could theoretically be shared online.

2. Dreams of Automatic Systems

Underlying the Resource Description Framework (RDF) is a quest for automatic verification of the nodes in web hyperlinks. The mechanical version of this quest has its roots in Antiquity with traditions of building automata.[12] Leibniz (1646-1716)[13] took this vision a decisive step forward with his "wonderful idea of…a special language built with an alphabet of concepts, plus the algebra of logic to determine the truth-value (true or false) of sentences in this language."[14] This led him to a *calculus ratiocinator*[15] and efforts to determine *characteristica universalis*.[16] Leibniz explored what has since been called the Symbol Grounding Problem[17]; explored automated reasoning and "dreamt of building a system where the truth of any assertion could be determined by calculation."[18] These were early premonitions of one version of a semantic Web.[19]

During the 1920s and 1930s, scientists in Germany, Britain, Russia and the United States prepared the way for programmable computers. In Britain, Alan Turing worked on an Automatic Computing Engine.[20] In the United States, this led to the work of Vannevar Bush[21] and his student Claude Shannon.[22] During the 1940s, these efforts took a curious turn. The quest for a programmable computer became a quest to produce machine-to-machine (M2M) communications. John von Neumann[23] became a champion of this vision that machine-to-machine communication might one day replace entirely any role for humans in the decision process.

Norbert Wiener[24] saw the dangers of such an approach and argued for an alternative vision, which kept humans an integral part of the automation process. When his efforts were ignored, he developed the field of cybernetics (1948)[25] and subsequently inspired the first cybernetics institute in Naples (1968).[26] The dangers of machine-to-machine communication were further explored by Joseph Weizenbaum (1976)[27] and Grant Fjermedal (1986)[28] and at a popular level in films such as *War Games* (1983)[29], where a supercomputer named WOPR (War Operations Programmed Response)[30] almost destroyed the world because it made no distinction between simulated game and reality.

Such dangers are far removed from the ideals of the W3 Consortium. History should remind us, however, that the intentions of inventors are often far removed from those who apply those inventions. Parallel with the military, moreover, is a civilian dimension of M2M as a new kind of pervasive internet, where the market for M2M devices is expected to reach $300 billion by 2010.[31] Such interests could lead in very different directions.

As long as the Web remains a place where everyone is free to express their thoughts openly, within the limits of decency and basic legal frameworks, these dangers would appear to be minimal. But what if standard search engines, or extremely large consortia developed Private Virtual Networks (PVNS) and Intranets with different standards and possibly agendas contrary to the public good? Or even, as has occurred in the past, totalitarian regimes gain supremacy? What if they took control of sections of the web, perhaps even of whole countries? This could lead to forms of censorship where we have no simple way of determining a) what is being omitted or b) whether that which is being presented is true or false. For such eventualities, we need more than the present approach to verification and truth.

3. Verification and Truth

The semantic web in its present form has proof validation but not proof generation.[32] It strives to let everyone express their notions of truth, but is very skeptical of deciding about truth.[33] It is useful to quote at length what the Web strives to achieve:

> The Web works th[r]ough anyone being (technically) allowed to say anything about anything. This means that a relationship between two objects may be stored apart from any other information about the two objects. This is different from object-oriented systems often used to implement ER models, which generally assume that information

about an object is stored in an object: the definition of the class of an object defines the storage implied for its properties.
For example, one person may define a vehicle as having a number of wheels and a weight and a length, but not foresee a color. This will not stop another person making the assertion that a given car is red, using the color vocabulary from elsewhere.
Apart from this simple but significant change, many concepts involved in the ER modelling take across directly onto the Semantic Web model.[34]

The principle that everyone is free to make any assertions they like is fundamental to a democratic way of life. Even so, some things are true, while others are not. If there is a yellow car in my parking lot, no amount of assertions that the car is red, blue or some other colour will change the yellow colour of the car in my parking lot in the way that a paint job could. Hence, the Semantic Web may a) make assertions machine readable; b) tell us whether a passage is in proper XML format, i.e. whether the instructions are in correct form; c) validate that the nodes of the triples connecting to URIs are correct, but this still tells us nothing about the meaning and ultimately the truthfulness of what is being asserted. It only confirms that the system transporting those assertions is correct.

In the case of assertions about whether a car is yellow or red, this may not seem very important. But if we want to buy a car and have an aversion to yellow, then the actual colour of the car becomes immediately significant. Or if the claim is about the mechanical condition of the car we are wanting to buy through an online site, accurate assertions about its state are vital in order to make a wise investment. At the moment, the framework focuses more on the truth of the links and connections between documents rather than the veracity of the contents of documents.[35]

4. Assertions and Scholarship

The W3's "principal principle" that "anything can refer to anything" is very appealing as a manifesto of freedom of thought. It corresponds to our notions of what an author of fiction should be able to do. However, this is very far removed from the traditional goals of scholarship. When a scholar makes an assertion he/she is expected to provide a reference to the source. If we doubt the claims made by an author we can return to the original source to check the author's accuracy, interpretation, and possibly arrive at a different conclusion. Very simply a scholar can refer to anything and claim anything as long as there is a link back to the objects or sources about which the assertion or claim is being made.

In past centuries, these references have typically taken the form of footnotes or endnotes: i.e. they remained within the confines of an author's article or book. A limitation of this approach was that in the case of rare sources, tracking down the original in some location beyond the author's publication was often a difficult task. In an electronic environment, such references in a publication can potentially be linked directly with objects outside an author's text. To take a simple example. Assertions that the *Mona Lisa* by Leonardo da Vinci is in the Louvre Museum concern an object outside the Web. To test its veracity requires checking whether the Louvre has such a painting and certifying that it is indeed still at that location. One solution would be to insert an RFID sensor into every painting including the *Mona Lisa* and to determine whether the painting is in the place as asserted. Alternatively, a video camera could confirm that the painting is still in the section, Denon, 1st Floor, Salle des Etats.[36] In this case, a hyperlink would not only show us the original *in situ* but also give us an indication of its present state.[37] Proving that the video link is exact and that it has not been spoofed remains elusive however. There is no simple technological fix to the quest for truth but that ode snot diminish the importance of the quest.

5. Powers and Limits of Born Digital

The near trivial examples cited above of a yellow car in a parking lot and a painting in the Louvre point to a fundamental limitation of the Semantic Web as it exists today. It is about hyperlinks within a World Wide Web (WWW) as a self-enclosed system operating through an Internet of cables, wires and wireless connections. This is partly because the quest for a Semantic Web is focussed on the verification of URI nodes, RDF triples and XML syntax as if the Web in isolation were enough. The power of this approach is that the system can determine whether the statements within the Web are logically correct. This has also contributed to a rise in attention to so-called Born Digital information.

In its present form, the Resource Description Framework focusses on the correctness of descriptions of resources, i.e. on the logical correctness of annotations and commentaries about sources, rather than providing a method for linking claims with original sources, or for checking the veracity of statements about objects that are not digitally born. Paintings in the Louvre are but one example. The objects discussed and about which assertions are made on the WWW are increasingly in multiple "worlds" beyond the WWW. Modern astronomy is providing us with vast quantities of information from space. Projects such as Google Earth and Microsoft Live Local are creating a one to one model of the earth. Similar projects are underway for the oceans. To make scholarly assertions about these materials of the heavens, earth or the oceans requires linking back to the original "images" and objects on which our claims are based. In the case of a distant galaxy, a born digital document may be all that it is feasible to have. In many cases, however, we need to be able to link back to the original objects, materials or sources.

To do so effectively, it is important to introduce traditional distinctions into the digital environment. Some of the sources are physical (trees, plants, animals). Some are man-made (houses, buildings, churches, synagogues, mosques, temples). Some are social. Some are mental (literature). Some are metaphysical (metaphysics, religion, mythology). We need tools that distinguish between these. A future version of a semantic web should allow us not only to search for butterflies, but also allow us to specify whether we are concerned with physical specimens, artistic images, literary versions, man-made examples or social butterflies.

This could at first seem an unreasonable goal until we recall that the discipline based approach to classification in libraries and memory institutions has already achieved such distinctions. Knowledge concerning physical specimens of butterflies is found under biology. Artistic images of butterflies are found under art. Literary examples of butterflies are found under literature etc. There is no need to re-invent the wheel. The challenge lies in integrating existing classifications of memory institutions (as a kind of metadata) into the filtering processes of search engines. Instead, of receiving a list of millions of undifferentiated hits we would get a list that shows us how many butterflies are found under biology, art, literature etc. If these lists are then subdivided by time (when), place (where), conditions (how), causes, motivations (why) as well as the usual who and what, current lists which are too long will become usable.

6. Current Limits of RDF

To achieve this the present Resource Description Framework (RDF) and its approach using triples are not sufficient. RDF currently has a list of media descriptors (screen, tty, tv, projection, handheld, print, braille, aural, all),[38] which provide a useful list of media display formats, i.e. the output side of the process. Meanwhile, IANA's MIME types, based on RFC 2046 (on Media Types), addresses the problem of media inputs[39], but these are general rather than specific. Hence, they distinguish text as a basic media type, but do not tell us whether it is a book, article, manuscript, etc. (cf. material selection and formats in the library world). A Resource Description Framework in a larger sense needs to provide detailed references about sources, which are ultimately the foundations of any scholarly claim.

RDF is based on model theory, which "tries to be metaphysically and ontologically neutral". Its basic idea is appealing:

> The idea is to provide an abstract, mathematical account of the properties that any such interpretation must have, making as few assumptions as possible about its actual nature or intrinsic structure, thereby retaining as much generality as possible. The chief utility of a formal semantic theory is not to provide any deep analysis of the nature of the things being described by the language or to suggest any particular processing model, but rather to provide a technical way to determine when inference processes are valid, i.e. when they preserve truth. This provides the maximal freedom for implementations while preserving a globally coherent notion of meaning.[40]

This is excellent for universally true[41] assertions/statements about who and what (*is a* and *has a* also called taxonomy and partonomy). The authors explain that RDF "does not provide any analysis of time-varying data". As a result, the quest for simple statements in RDF means that statements about entities (what) are privileged over possible statements about where, when, how and why.

The stated goal is to preserve truth. Paradoxically the "truth" of living beings such as humans requires that we descend from abstract concepts to specific, individual cases with a given time (when), place (where), under given conditions, using particular means (how) and usually with given motivations, beliefs, reasons, causes (why). Thus, the quest to create a machine readable code produces text a) unreadable by an average person, which b) does not capture the specificities of persons. Hence, a Web that theoretically aims at "anyone being (technically) allowed to say anything about anything,"[42] in practice requires that we limit ourselves to a small sample of possible relations (cf. Appendix 1).[43] Speaking poetically, we gain the black and white of logic and lose the rainbow colours of life. This is a long way from the universal promises made by some zealots in the field.

6.1 Triples

These limitations are built into the triples "architecture" which unites a) a subject via b) a predicate (also called a property) to c) an object. This is adequate for an assertion such as "*Gazza Ladra* is a thief" but inadequate to state precisely that: "Gazza Ladra stole the jewel from Madame Castafiore at three p.m. on Thursday at Marlinspike by hiding it in a bird's nest." And real life robberies are often more complex than those in *Tintin*.

The authors of the text on RDF semantics may speak of worlds and universes as if they admitted multiple interpretations over time but ultimately the "architecture" of a system based on abstract universals assumes a static reality that does not change over time: a "meaning" that is as constant as the laws of mathematics. This may well be what is needed for the framework. However, those in the Social Sciences and indeed all the temporal Sciences (e.g. geology, geography), have very different needs.

Partly because human beings are affected by time, place and conditions, the meanings that they assign to terms change over time. That is why we have etymological dictionaries and disciplines such as philology and historical linguistics. Modern authors of fiction may want complete freedom in annotating as they please. Meanwhile, historians have a very different task of discovering the meanings of words used by individuals in a different times and places. To achieve this, well defined RDF syntax and semantics could help us link to historical texts or sources. But we need much more if we wish to understand the meaning of those sources. The commitment to triples (or truples) needs to be expanded at least to sextuples.

6.2 New Scale and Scope of the Web

In all fairness, it is important to acknowledge that the unexpected success of the WWW has completely transformed the scale, and scope of the challenges it faces. Morover, accelerating, evolutionary, adaptablility of emerging technology convergence is about to multiply the dimensions and layers of this scale and these challenges. At the outset in 1989-1990, the WWW was effectively trying to solve problems that faced the Internet: sharing knowledge between/among small communities of researchers in High Energy Physics, Astronomy, Chemistry, and advanced researchers in other fields. This amounted to less than a million persons. Today the W3C is faced with a Web of over 1.4 billion users with approximately 20 million new users per month. In 1990, "content" was mainly in the form of e-mails and pre-prints of high level scientific papers. By 2000, an estimated 7 million pages of materials were being added daily. There are now plans, that, by 2020, the full contents of over 60 million books and documents will be available online.[44] If the Internet began as a prototype for what is now seen as E-Science, the WWW needs to become a prototype for both E-Science and E-Culture.

Apart from obvious shifts in scale, this transforms the kinds of relations that are involved. Those in computer science typically speak of 2 kinds of relations: "is a" and "has a", i.e. taxonomy and partonomy.[45] Meanwhile, the those in the field of knowledge organization speak of at least 12 basic kinds of relations (Appendix 1).[46] We need a wider vision that integrates all these relations and also brings to light their historical evolution.

6.3 Four Goals

The new scale and scope of the Web has also shifted the potential goals of the Web. In the first decade of the 20th century, Paul Otlet, Henri Lafontaine and a group of thinkers developed a vision of a World Brain (*Gehirn der Welt*), which foresaw making the whole of enduring knowledge accessible online. They also foresaw what was later called hypertext and hypermedia.[47] The American Internet (1969-) reduced this to a much narrower goal: new knowledge in the form of science (now e-science). Pioneers such as Andreas Okopenko in Europe and Ted Nelson in the US saw these developments as a new key to creative expression (literature, poetry), although visionaries such as McLuhan also warned of the dangers of electric and electronic communication.

New Knowledge	Science, new E-Science
Information, Transactions	Business, E- Business
Creative Expression and Informal Knowledge	Literature, Poetry, Art, new E-Culture
Enduring Knowledge	Memory Institutions, E-Culture, Science

Figure 1. Four goals for the Web.

The advent of the WWW in the 1990s introduced new possibilities for both a) new knowledge and b) creative expression and initially the quest for "anyone being (technically) allowed to say anything about anything", seemed an obvious and unassailable goal. Work on software systems such as Annotea seemed to support this direction. However, this widening of possibilities also posed a need to distinguish a) verified knowledge from b) creative, informal knowledge. To answer this need the W3C began by separating reason, (which could be tested by logical proof) from rhyme, which could not. Next they sought to make reason not only logical but also machine readable. This had the great advantage that it seemed to make the goals of science for new knowledge the same as the goals of business for accurate information about transactions. As this became clear in the years 1997-1999, the WWW gained the support of big business. The quests for E-Science and the E-Business seemed complementary. Both wanted a way of verifying knowledge and information.

While the rhetoric of allowing anyone to say anything about anything continued, the W3C's work on annotation software slipped into the background; as did the creative strand symbolized by figures such as Ted Nelson. The dot-com bust (2000-2001) seemed to challenge the e-Business vision, but merely eliminated companies without clear business plans. Meanwhile, the past eight years have seen an amazing rise of an international Web. In 1988, over 90% of the Internet was in the US. In 2008, the US represents less than 17% of the Web. English now represents less than 30% of the Web. If the Internet initially focused on one goal of new knowledge, the WWW now needs to address four goals: a) new knowledge of research; b) information of transactions; c) enduring knowledge of memory institutions and

d) informal knowledge and information of everyday users ranging from the frivolity of an SMS to the heated discussions, philosophical and otherwise of blogs, chats etc. (Figure 1).

One fundamental consequence[48] is that the quest for E- Science needs to be complemented by a quest for E-Culture. A combination of E-Science and E-Culture, requires that we keep intact the results of persons who have said/written things about things (and about persons) in different ways at different times. This cannot be achieved by having only one type of knowledge representation. Hence, a deeper challenge is to maintain alternative relations in knowledge structures, including some which are no longer fashionable. We need to acknowledge and sustain what Francis Bacon coined different "knowledges": different ways of thinking, different ways of ordering the world, else the Web risks imposing a colonialism of bits, which is as threatening as the earlier forms.

6.4 Evolvability on a new Scale

When Tim Berners Lee spoke of evolvability and retrospective documentation of equivalence in 1998,[49] few suspected that this would need to apply to over five thousand years of documentation but, in a world where a) the full contents of 60 million books are planned and b) there are plans for 50% of the world's population to be online within seven years, these are effectively the new system requirements. We need a new architecture that also has retrospective documentation of both equivalence and non-equivalence, different ways of ordering, classifying and understanding the world.

7. Multiple Level Links

As the Internet was being planned in the 1960s, pioneers such as Ted Nelson[50] and Andreas Okopenko[51], explored the potentials of hypertext and hypermedia. Partly due to a narrowing of goals described above, hypertext on the Web has become a much more limited concept: a hyperlink on the Web typically links us to only one other location. Ted Nelson, who coined the term "hypertext", distances himself from these recent developments.[52] There is even a "dispute over whether the Web is a hypertext system at all."[53]

The same HTML, XML and RDF, which are now being used to create only one set of one directional links, can be adapted to achieve much more. For instance, a team of young Russians, headed by Vasily and Alexander Churanov (Smolensk) have demonstrated the principle of omni-links, whereby every word in a text is a) hyperlinked and b) linked at multiple levels.[54] These principles are being further developed in a site on New Models of Culture.[55] Here a hyperlinked word can lead to a) definitions in dictionaries, b) explanations in encyclopaedias and c) titles of articles and books.

Such choices reflect basic realities of knowledge organization, which is at many levels ranging from a single term (terminology, thesaurus, classification); to a definition (dictionaries); to an explanation (encyclopaedias); to titles (library catalogues, bibliographies), to partial contents (abstracts, reviews) to full contents (full texts of articles, books etc.). In major libraries these various levels of knowledge are collected in different sections. Dictionaries and encyclopaedias are in one part of a reference room; library catalogues, book catalogues, bibliographies, citation indexes, reviews in other parts, while periodicals and books have their own stacks and in large institutions sometimes have separate buildings.

Contemporary search engines offer us random examples of knowledge and information from all these levels. Needed is a more systematic approach that offers the electronic equivalent of a library reference room. A semantic web in this deeper sense will a) allow us to navigate at will to the appropriate level of knowledge. So every hyperlink will have a one-to-many (levels) feature. Moreover, the links must go beyond nodes in hyperspace (URIs) and take us back to the original sources: i.e. new kind of references that takes us beyond a note at the foot of a page or end of a book to go beyond the book to the original text, image, object or source being cited.

We thus envisage common interfaces[56] for a multilevel approach to basic choices (Appendix 2). Earlier work[57] has explored the potentials of Virtual Reference Rooms with up to 12 levels of knowledge. These can be seen as Knowledge Choices (K Choices, Appendix 3). There would be three modes of searching. An initial Look Up Mode divided into Basic, Intermediate and Advanced would be for regular use. A Study Mode would offer further possibilities for students. Researchers would have a Research Mode. Users with basic needs would choose from one of ten Goals Choices (G Choices, Appendix 4). Researchers would have access to Strategy Choices (S Choices, Appendix 5) which reflect both Terms Choices (T Choices, Appendix 6) and Source Choices (SO Choices, Appendix 7). In such an approach, the notion of a highlighted word of hypertext linked to one other resource would be transformed into a multilayered systematic approach. [58]

As noted earlier, the W3C, and computer science generally, have focussed on “is a” and “has a” relations, mainly in the creation of new relations as annotations to modern documents. Scholars and researchers at centres of learning and memory institutions in particular have been making commentaries, annotations and relations for millennia. As the full–text contents of memory institutions become available online, larger challenges loom. How do we create seamless mappings between established systems and the new frameworks? How do we guarantee the authenticity of archived mapping and the veracity/and or completeness of mappings as they are presented to the ‘general public’. The past decade has seen numerous useful steps in this direction including SKOS.[59] Even Wiki is beginning to map its categories with Dewey[60] and Library of Congress classes. Eventually we need systems that allow us to move seamlessly between different classification systems; to be able to search for knowledge and information using any of the main kinds of relations. Two, more elusive, goals are 1) an historical system that allows us to see how world views change as access to sources moved from a few hundred to thousands, millions and now potentially billions of items and 2) an emergent system that allows us a) to visualize more clearly possible relations in new fields of knowledge and b) recognize areas of research, which have not yet been explored or deserve further attention.

8. Worlds Wide Webs

The remarkable evolution of the WWW over the past two decades has been in the context of unprecedented change. While some members of the W3C have necessarily focused on a basic infrastructure, others have explored more dramatic possibilities. For instance, at the Internet Conference (Yokohama, 2000), the visionary Professor, Jun Murai, outlined a world wherein every automobile might one day have c. 140 online connections to knowledge bases. In this approach, the Web extends far beyond the networks of wires and wireless connections and links directly with the physical world. Elements of such a vision have already been incorporated in an RDF Primer (2004):

> Like HTML, this RDF/XML is machine processable and, using URIs, can link pieces of information across the Web. However, unlike conventional hypertext, RDF URIs can refer to any identifiable thing, including things that may not be directly retrievable on the Web (such as the person Eric Miller). The result is that in addition to describing such things as Web pages, RDF can also describe cars, businesses, people, news events, etc. In addition, RDF properties themselves have URIs, to precisely identify the relationships that exist between the linked items.[61]

Describing objects in the physical world is one step. Linking to them directly via RFID chips, sensors, web cams, and other devices would mark a further step.[62] Today's WWW operates on/in the infrastructure provided by the Internet. Increasingly, the WWW is becoming intertwined with the worlds of the heavens (Space Sciences), the earth (Earth Sciences) and the oceans (Ocean Sciences) such that it makes sense to speak of a Worlds Wide Webs. These worlds include metaphysical worlds which have evolved in various cultures over time: e.g. *lokas* of the Hindus and the Buddhists and *olams* of the Essenes and Hebrews.

9. Physical World as Knowledge Interface

All this is transforming our sense of where various electronic and other worlds begin and end. A generation ago, the Internet was pictured as a cloud with IP addresses at the extremities to indicate terminals. Computers were mainframes, desktops or laptops. Today, they are also mobile devices linked with cameras and other tools. In the past, we studied the physical world and then stored the results of our studies in memory institutions, i.e. Libraries, Archives and Museums (LAM). In the past, cameras were passive devices. This is changing. We might still use a camera as if it were taking a passive image, say, of a fungus that we find on a walk, or a building we see on a tour. But then that image could be sent to a memory institution, where image recognition software scans the image; compares it with digital collections in the library and then provides us with information about that which we have just seen. In such scenarios, the old saying of "all the world's a stage" would become: all the world's an interface and unknown environments would become a context for learning in real time.[63]

10. Conclusions

Although an interest in meaning and interpretation is probably as old as language itself, the study of semantics as a science of meaning began just over a century ago; the use of semantic networks in computer science began just under a half century ago, and the vision of a Semantic Web only a decade ago. In that decade, the WWW has grown from 101 million (January 1998) to 1.463 billion (June 2008).[64]

The quest for a semantic web is intimately connected with an evolving Resource Description Framework (RDF), which aims at machine readable code. This framework makes an enormous contribution in fostering interchange of knowledge and information. To date, this framework has focused more on commentaries than on sources; more on resources as outputs than on resources as inputs; more on born-digital electronic resources than on the vast resources in memory institutions and in the physical world. The initial framework has focused particularly on the verification of nodes as Uniform Resource Identifiers (URIs). The imperative of standardised and open archive authenticity throughout the networks is a growing need.

The quest for the generality of mathematical logic has favoured abstract, universal, categories over concrete, particular, specific, and individual ones. This is excellent for the verification of nodes, which are vital for machine to machine (M2M) communication, but of more limited use in the Social Sciences and Humanities, where human to human (H2H) communication reflects the experiences of living beings for whom time, space, conditions and motivations play an important role. It is also of limited use to time bound sciences such as geology, which study long term changes rather than eternal truths. Put simply the Semantic Web thus far has focused on entities, on what and who, more than on where, when, how and why

In M2M, what and who are often enough and a limited form of hypertext that connects one hyperlinked word in one document with another hyperlinked word in another document is often sufficient. In H2H, all six questions (who?, what?, where?, when?, how? and why?)[65] are needed as are multilevel hyperlinks. Machines are content with Document Type Definitions (DTDs) which, ideally, remain unaffected by time. Humans require etymological dictionary definitions, which necessarily evolve with time.

This paper has outlined the potentials of a semantic web with multiple levels of hyperlinks. Current efforts focus mainly on a Web that is closed in the sense that it remains Web-centric even if it urges open standards. As the ITU has suggested, a next generation needs to include an Internet of things.[66] We need much more. Scholars in earlier cultures distinguished between different worlds ranging from metaphysical and mental to physical, man-made, social, and creative. These ideas need to be integrated into our plans for a semantic web such that we can search for knowledge and information at different levels. The WWW needs to become Worlds Wide Webs. We noted that the quest for M2M communication is historically linked with a quest to remove humans entirely from the decision process. Verification of nodes is very important. A commitment to truth is even more important even if it is not a requirement for the day to day functioning of machines. We must be very careful to ensure that the steps necessary to keep the machines running, do not overshadow the larger purpose for which the machines were built: to help and foster the activities and reflections of humans.

Acknowledgements

I thank warmly Jonathan Robin for reading the text and offering suggestions. I am very grateful to a circle of scholars and friends who continue to encourage my work. These include Madhu Acharya (Kathmandu), Professor Frederic Andres (Tokyo), Professoressa Giuseppina

Saccaro del Buffa Battisti (Rome), Professoressa Francesca Bocchi (Bologna), Professor Arturo Colorado (Madrid), Professor André Corboz (Geneva), Professor Edgard Costa Oliveira (Brasilia), Professor Ingetraut Dahlberg (Bad König), Professoressa Anna Dell'Agata (Pineto), David Fabish (Toronto), Ing. Udo Jauernig (Leonberg), Rakesh Jethwa (Toronto), Dr. Eric McLuhan (Toronto), Mgr. Franz Nahrada (Vienna), Nino Nien (Maastricht), Dr. Alan Radley (Manchester); Jonathan Robin (Paris), Professor Alfredo Ronchi (Milan), Dr. Sabine Solf (Maastricht), Professoressa Rossana Valenti (Naples); Professor M.P. Satija (Amritsar), whose generous invitation prompted this paper and Dr. Marie Luise Zarnitz (Tübingen).

The practical dimensions of this work would not be possible without the faithful support of Russian students led by Vasily and Alexander Churanov, and a team including Andrew Kotov Maksim Kuptsov and Alexander Sapozhkov. I am extremely grateful to them for their support in developing a new vision.

Appendix 1. Basic Relations as described by Dahlberg (Unpublished Mansucript, 2008). Note that the field of computer science typically focuses mainly on content-related relations 1 and 2, i.e. 2 of the 12 basic relations.

Formal Relations

1. Identity
2. Inclusion
3. Intersection
4. Disjunction

Categorial Relations

	Abstract entities
1. Entities	Concrete entities
	Principles
	Quantity
2. Properties	Quality
	Relation (in the sense of comparison)
	Operation (active)
3. Activities	Process (procedure)
	State (passive, zero-activity)
	Time
4. Dimensions	Space
	Position

Content related Relations

1. Generic Relation (is a)
2. Partitive Relation (has a)
3. Opposition/Complementary Relation
4. Functional Relation.

Appendix 2. Ten Basic Choices

Choices 1. Access
Choices 2. Education
Choices 3. Knowledge
Choices 4. Media
Choices 5. Quality
Choices 6. Quantity
Choices 7. Questions
Choices 8. Space
Choices 9. Time
Choices 10. Tools

Appendix 3. Choices 3 entails 12 Layers of Knowledge (K Choices)[67]

1. Terms	Classifications, Thesauri
2. Definitions	Dictionaries
3. Explanations	Encyclopaedias
4. Titles	Bibliographies, Catalogues
5. Partial Contents	Abstracts, Reviews

Primary Literature in Digital Library
6. Full Contents
Secondary Literature in Digital Library

7. Texts, Objects	Analyses, Interpretation, Criticism
8. Comparisons	Comparative Studies, Parallels,
9. Interventions in Extant Object	Conservation
10.Studies of Non-Extant Object	Reconstructions

Future Primary/Secondary Literature (Virtual Agora)
11. Collaborative Discussions of Contents, Texts, Comparisons, Interventions, Studies
12. E-Preprints of Primary and Secondary Literature in Collaborative Contexts

It is useful to compare the above model with developments in Wiki, which began as an online electronic encyclopaedia (level 3). The past three years have seen on at least six levels:

1. Terms	Wikispecies, MetaWiki
2. Definition	Wiktionary
3. Explanations	Wikipedia
4. Titles	Wikipedia: Selected Works, Works Cited, References, Further Reading
5. Partial Contents	Wikiquote
6. Full Contents	Wikibooks (including Wikijunior), Wikisource, Wikimedia Commons, Wikinews

Appendix 4. Basic searches entail Ten Goals Choices (G Choices):

1. Everyday
1a. Emergency
2.. Business
3. Culture
4. Learning
5. Environment
6. Goverment
7. Health
8. Legal
9. Leisure, Tourism
10. Religion

Appendix 5. Advanced work entails Ten Strategy Choices (S Choices)
1. Internal
2. Internet
3. Knowledge Package
4. Proprietary Database
5. Library Subjects
06. Library Classification
07. Library Networks
08. Specialist Collections
09. Relations
010. Emergence

These strategies entail:
Appendix 6. 10 Ten Layers of Terms (T Choices) in Research Mode
1. Universal Terms
2. General Terms
3. Personal Terms
4. Field Terms (in a Database)
5. Subject Terms
6. Classification Terms
7. Classifications Terms (in multiple systems)
8. Ontologies Terms
9. Relations Terms
10. Emergent Terms

They also reflect
Appendix 7: Ten kinds of Sources: (SO Choices)
1. Sample Sources
2. Organised at Random
3. Organised Informally
4. Organised in Proprietary Form
5. Organised Officially

6. Organised in 1 System
7. Organised in Several Systems
8. Organised for Specialised Fields
9. Organised with Systematic Relations
10. Organised by Emergent Patterrns

Notes

[1] Michel Jules Alfred Bréal**,** *Semantics: Studies in the Science of Meaning*, London: Heinemann, 1900. This was a translation from the French. For a discussion of the historical context see the author's: "Towards a Semantic Web for Culture," *JoDI* (*Journal of Digital Information*)**,** Volume 4, Issue 4, Article No. 255, 2004-03-15. Special issue on New Applications of Knowledge Organization Systems. See: http://jodi.ecs.soton.ac.uk/Articles/v04/i04/Veltman/

[2] The Internet began in Britain (1968) and one year later in the United States (1969). M. Ross Quilian, "Word concepts: a theory and simulation of some basic semantic capabilities", *Behavioral Science* 12, 5 (Sept. 1967), San Diego, 410-430. Cf. P.I. Breslaw, *Experiments with a semantic network,* Edinburgh : Edinburgh University, Department of Machine Intelligence and Perception, 1969; R.F. Simmons; Jonathan Slocum, *Generating English discourse from semantic networks,* Austin: University of Texas at Austin, Department of Computer Sciences, 1970; David E. Rumelhart, Donald A. Norman, *Active semantic networks as a model of human memory*, San Diego, Calif.: University of California, Center for Human Information Processing, 1973; Carl Wilhelm Welin, *Semantic networks and case grammar*, [S.l.] : University of Stockholm, 1975.

[3] See: http://www.encyclopedia.com/doc/1O27-wallah.html; William A. Woods, "What's in a Link'. Foundations for semantic Networks", In: *Representation and Understanding. Studies in Cognitive Science,* ed. D. G. Bobrow and A. M. Collins, Academic Press, Republished in Brachman and Levesque. Cf. Bill Woods, External Home Page: http://research.sun.com/people/wwoods/

[4] Entity Relationship model: http://en.wikipedia.org/wiki/Entity-relationship_model

[5] The public side of the library world associates these with Broader Term and Narrower Term.

[6] See: http://www94.web.cern.ch/WWW94/

[7]Tim Berners Lee, "Evolvability": http://www.w3.org/Talks/1998/0415-Evolvability/overview.htm

[8] Tim Berners Lee, "Semantic web Roadmap": http://www.w3.org/DesignIssues/Semantic.html

[9] Tim Berners Lee, "Semantic Web": http://www.w3.org/Talks/1999/05/www8-tbl/slide13-0.html

[10] *The emerging Semantic Web : selected papers from the first Semantic Web Working Symposium,* edited by Isabel Cruz ... [et al.]. : Amsterdam ; Oxford : IOS, c2002. This has led to an annual International Semantic Web Conference. Cf. http://iswc.semanticweb.org/

[11] Internet Usage Statistics: http://www.internetworldstats.com/stats.htm

[12] Automaton: http://en.wikipedia.org/wiki/Automaton

[13] Leibniz: http://en.wikipedia.org/wiki/Gottfried_Leibniz

[14] Prelude: http://www.cse.yorku.ca/course_archive/2006-07/F/2001/handouts/lect00.pdf

[15] Calculus ratiocinator http://en.wikipedia.org/wiki/Calculus_ratiocinator

[16] Characteristica universalis: http://en.wikipedia.org/wiki/Characteristica_universalis

[17] Consciousness Studies/The Philosophical Problem/Machine Consciousness: http://en.wikibooks.org/wiki/Consciousness_Studies/The_Philosophical_Problem/Machine_Consciousness. In more recent literature these problems have become linked with John Searle's Chinese Room Argument: http://www.iep.utm.edu/c/chineser.htm .For a another discussion of these philosophical dimensions: Harry Halpin, "Identity, Reference, and Meaning on the Web", *WWW 2006, May 23-26, 2006*, Edinburgh, Scotland. ACM 1-59593-323-9/06/0005: http://www.ibiblio.org/hhalpin/irw2006/hhalpin.html

[18] Automated Reasoning: http://users.jyu.fi/~antkaij/opetus/ap/2004/aure-ch1.pdf

[19] Other premonitions include Vladimir Odoevsky, whose novel, Year 4338 (written 1837) outlined features pointing to a Web (http://en.wikipedia.org/wiki/Runet). Paul Otlet outlined an amazingly detailed vision in his Monde (1934) (http://www.laetusinpraesens.org/docs/otlethyp.php). Also astounding was the Russian David Sarnoff (1964) (http://earlyradiohistory.us/).

[20] B. Jack Copeland, Alan Turing's Automatic Computing Engine. The Master Codebreaker's Struggle to build the Modern Computer, Oxford: Oxford University Press, 2005.

[21] Vannevar Bush: http://en.wikipedia.org/wiki/Vannevar_Bush

[22] Claude E. Shannon, *The Mathematical Theory of Communication,* , Illinois: University of Illinois Press, 1949. The preface was written by Warren Weaver, also head of the scientific section of the Rockefeller Institute.

[23] John von Neumann, *Papers*, Library of Congress, Box 33: (http://www.loc.gov/rr/mss/text/vonneumn.html): Reports
1946, "Preliminary Discussion of the Logical Design of an Electronic Computing Instrument"
1948, "Planning and Coding of Problems for an Electronic Computing Instrument" (3 folders)

[24] Norbert Wiener: http://en.wikipedia.org/wiki/Norbert_Wiener

[25] Norbert Wiener, *Cybernetics: Or the Control and Communication in the Animal and the Machine.* Cambridge, MA: MIT Press, 1948; Ibid., T*he Human Use of Human Beings*. New York: Da Capo Press, 1950. The differences between Neumann and Wiener have been explored by: Steve J. Heims, *John von Neumann and Norbert Wiener: From Mathematics to the Technologies of Life and Death*. MIT Press, 1980. Possibly because Wiener refused to become entangled in what has been called the military industrial complex there has been an ongoing strand of criticism of everything connected with cybernetics in general and Wiener in particular. For a recent example, see: Creighton Cody Jones, "How Wiener Attempted to Kill Science", *Executive Intelligence Review*, January 4, 2008 issue: http://www.larouchepub.com/lym/2008/3501wiener_killed_sci.html

[26] L'Istituto di Cibernetica "E. Caianiello" (ICIB): http://perseo.cib.na.cnr.it/cibcnr/chisiamo/. The roots of the laboratory go back to a seminar by Wiener at the University of Rome (1954) attended by Caianello.
See: http://www.iiassvietri.it/caianiel.html

[27] Joseph Weizenbaum, Computer Power and Human Reason: From Judgment To Computation, San Francisco: W.H. Freeman, 1976.

[28] Grant Fjermedal, *The Tomorrow Makers: a Brave New World of Living Brain Machines*, Redmond: Tempus Books, 1986.

[29] War Games: http://en.wikipedia.org/wiki/WarGames. *Space Odyssey* 2001 (1968), *Demon Seed* (1977) *and I Robot* (2004) are other films that explore the theme of computers taking a

path independent of their “owners”. This is leading to a genre called Cybernetic revolt: http://en.wikipedia.org/wiki/Cybernetic_revolt

[30] WOPR: http://en.wikip WOPR edia.org/wiki/

[31] Machine to Machine: http://en.wikipedia.org/wiki/Machine_to_Machine

[32] Tim Berners Lee, “What the Semantic Web can represent” (also referred to as What the Web is not: http://www.w3.org/DesignIssues/RDFnot.html

[33] Tim Berners-Lee, “The World Wide Web and the "Web of Life"”, with a paragraph on Truth: http://www.w3.org/People/Berners-Lee/UU.html

[34]As in note 30: Tim Berners Lee, “What the Semantic Web can represent”: http://www.w3.org/DesignIssues/RDFnot.html

[35] Some would argue that there are sometimes tensions between the rhetoric of letting everyone say anything about anything and the quest to have us create triples for everything we want to express.

[36] Leonardo, *Mona Lisa,* Louvre: http://www.louvre.fr/llv/activite/detail_parcours.jsp?CURRENT_LLV_PARCOURS%3C%3Ecnt_id=10134198674098115&CURRENT_LLV_CHEMINEMENT%3C%3Ecnt_id=10134198674098123&CONTENT%3C%3Ecnt_id=10134198674098123&bmLocale=en

[37] Robert Kahn, the inventor of TCP, has suggested that Digital Object Identifiers (DOIs) could be used to tag every object and living person.(personal communication, ISOC Meeting, Arlington, June 2001; cf. http://en.wikipedia.org/wiki/Bob_Kahn). Others predict that Radio Frequency Identification (RFID) could be used for such tagging. RFID is already being used in inventory control, in animals and in some human cases. The use of RFID for Human Identity Verification remains a subject of considerable debate. The same technologies being sponsored as tools for helping protect our identity also open new avenues of identity theft.. There is clearly a delicate balance between the need to track constantly rare individuals who are truly a threat to society and the equally great need to assure the continued privacy and non-tracking of a majority of citizens. Cf. Data Privacy & Integrity Advisory Committee. The Use of RFID for Human Identify Verification, Report No. 2006-02: No. 2006-02: http://www.dhs.gov/xlibrary/assets/privacy/privacy_advcom_12-2006_rpt_RFID.pdf; cf. RFID….Controversies: http://en.wikipedia.org/wiki/RFID#Controversies. Some see (RFID) as a key part of a global surveillance society: RFID: http://www.oilempire.us/rfid.html.

[38] Media Descriptors: http://www.w3.org/TR/html401/types.html#h-6.13

[39] RFC 2046: http://www.ietf.org/rfc/rfc2046.txt. See also IANA Mime Types: http://www.iana.org/assignments/media-types/

[40] RDF: http://www.w3.org/TR/2004/REC-rdf-mt-20040210/

[41] Whether such statements are indeed universally true depends of course on whether the person making the “is a” and “has a” statements has created an accurate classification in terms of taxonomy and partonomy. To illustrate the validity of their method, computer scientists invariably use an obvious case such as “John Doe is a man.” But as anyone who has worked in taxonomy or the profession of indexing knows, there are many cases when classing is not an obvious task. When carried out by non-professionals in indexing, the claims for universal truth of computer scientists are often far more shaky than their rhetoric would have us believe.

[42]As in note 30: Tim Berners Lee, “What the Semantic Web can represent”: http://www.w3.org/DesignIssues/RDFnot.html

[43] “*Contents-related relations* are likewise fourfold and can be grouped into 1) generic, 2) partitive, 3) opposition/complementarity, and 4) functional relations.” Dahlberg (unpublished manuscript, 2008). Cf. the fundamental study by I. Dahlberg, *Grundlagen universaler*

Wissensordnung. Probleme und Möglichkeiten eines universalen Klassifikationssystems des Wissens. München: K.G.Saur Verlag, 1974.
[44] For a fuller discussion see the author's: "Framework for Long-term Digital Preservation from Political and Scientific Viewpoints: Rahmenbedingungen der digitalen Langzeitarchivierung aus politischer und wissenschaftlicher Sicht, " *Digitale Langzeitarchivierung. Strategien und Praxis europäischer Kooperation, Deutschen Nationalbibliothek, anlässlich der EU-Ratspräsidentschaft Deutschlands, 20-21. April 2007*, Frankfurt: National Bibliothek, 2007 (In Press).
http://www.sumscorp.com/articles/pdf/2007_From_Recorded_World_to_Recording_Worlds.pdf
[45] While logic is constantly mentioned, not everyone in the field of computer science is always clear about the precise differences even between *divisio* and *partitio*. Woods (1991) saw subsumption and taxonomy as a basis for a new framework. William A. Woods, "Understanding Subsumption and Taxonomy: A Framework for Progress," in John Sowa (ed.), *Principles of Semantic Networks: Explorations in the Representation of Knowledge*, San Mateo: Morgan Kaufmann, 1991.
[46] Categorial relations are directly linked with the definitions of words, terms and concepts. So a first challenge lies in linking every word we use with its various meanings. This need is all the more pressing since those in recent fields such as computer science, and cognitive science insist on using familiar terms with a long history of meaning in completely different ways such that true interdisciplinary discussions are increasingly difficult.
[47] Anthony Judge, "Paul Otlet's 100-year Hypertext Conundrum ?", laetus inpraesens, 28 May 2001, Brussels: UIA: http://www.laetusinpraesens.org/docs/otlethyp.php.
[48] Another consequence is that, while the semantic web strives for a single framework, the four goals imply four different sets of criteria for the Web. Just as we already distinguish between .com, .org etc., we need to distinguish accept that some goals require verification while others do not.
[49] A decade ago, some individuals in the United States assumed that they were destined to decide how this might be done. Today, in a world where the U.S. represents less than 17% of world users, this is no longer obvious, especially if the same country wishes to uphold claims for democratic decisions by majorities.
[50]Ted Nelson: http://ted.hyperland.com/
[51] Ted Nelson has been credited with coining the term (1965) but the first practical demonstrations were probably by Andreas Okopenko in Vienna (1968-1970). For a discussion and further references see the author's *Understanding New Media* under Hypertext: http://www.sumscorp.com/kavai/newmedia/
[52] Ted Nelson: "The World Wide Web (another imitation of paper) trivializes our original hypertext model with one-way ever-breaking links and no management of version or contents.": http://www.xanadu.com/xuhome.html
[53] Robert Cailliau, Helen Ashman, "Hypertext in the Web - a History", *ACM Computing Surveys* 31(4), December 1999:
http://www.cs.brown.edu/memex/ACM_HypertextTestbed/papers/62.html
Cailliau cites: [Nürnberg 1999] Peter J. Nürnberg and Helen Ashman. "What was the Question? Reconciling Open Hypermedia and World Wide Web Research" in Proceedings of ACM Hypertext '99, Darmstadt, Germany, 83-90, February 1999. For one discussion of other

possibilities: Douglas Tudhope and Daniel Cunliffe, "Semantically Indexed Hypermedia: Linking Information Disciplines", *ACM Computing Surveys* 31(4), December 1999: http://www.cs.brown.edu/memex/ACM_HypertextTestbed/papers/6.html.
Traditional concordances distinguished between Key Words In Context (KWIC) and Key Words Out of Context (KWOC). The Web has both Cross References In-Context (XRIC) and Cross References Out-of-Context (XROC), with a reported preference for XRIC. Cross-Reference: http://en.wikipedia.org/wiki/Cross-reference. Another problem with current hyperlinks is that they are typically highlighted in blue, which traditional readers often find distracting.

[54] This is available as CD Rom and online in an experimental demonstration See: http://www.sumscorp.com/kavai/newmedia_cd/

Choose: Books, then New Media, then Omnilinked. The text appears as it does in a regular publication with no highlighted words because every word is linked. So if , for instance, we choose the word Augmented in the Title we immediately have access to 49 titles relating to augmented and 14 keywords: including Augmented Objects and Experiences, which takes us to a publication on Augmented Animals. Alternatively if we choose Full Text Search in New Media we are given a list which shows how often the word Augmented was used in each chapter. Chapters with no occurrences remain not highlighted. Clicking on the highlighted chapter names takes us to those occurrences.

Full text search: Augmented

1. Preface (1)
2. Introduction (1)
3. Acknowledgments
4. Computers (3)
5. Mobility (2)
6. Miniaturization
7. Production (1)
8. Services (4)
9. Institutions (4)
10. Organizations
11. (Knowledge) Management (1)
12. Learning (1)
13. Personal Knowledge
14. Collaboration (5)
15. Enduring Knowledge (21)
16. Challenges
17. Synthesis (30)
18. Conclusions (13)
19. Epilogue 1
20. Epilogue 2 (1)
21. Appendices (1)
22. Illustrations (1)
23. Abbreviations (2)

If we go back and choose Other Definitions the system goes to One Look Dictionary, which then finds 18 definitions for Augmented in a range of online dictionaries.

[55] New Models: http://sumscorp.com/kavai/newmethods/

[56]At present, every medium tends to have its own remote control. We are told that, by 2015, these various media will all be connected within one digital framework. We need a common interface for such devices. The author's home has different remote (controls) for 1) regular television, 2) digital channels 3) video, 4) DVD ; 5) computer and 6) telephone . For a more detailed discussion of these trends see the author's *Understanding New Media*, Calgary 2006.

[57] See the author's: "Access, Claims and Quality on the Internet: Future Challenges", *Progress in Informatics*, Tokyo, no. 2, November 2005, pp. 17-40.
http://www.nii.ac.jp/pi/n2/2_17.pdf.;
Understanding New Media. Augmented Knowledge and Culture, Calgary: University of Calgary Press, 2006.

[58] A preliminary demo is available at: http://sumscorp.com/kavai/newmethods/. A new multilingual version is being developed.

[59] SKOS: http://en.wikipedia.org/wiki/SKOS

[60] List of Dewey Classes: http://en.wikipedia.org/wiki/List_of_Dewey_Decimal_classes

[61] RDF Primer: http://www.w3.org/TR/REC-rdf-syntax/

[62] Radio Frequency identification: http://en.wikipedia.org/wiki/RFID. Potential dangers to privacy through implanting such chips and tracking devices in humans remain a matter of concern.

[63] This scenario has been further explored in the author's: "The New Book of Nature", *eARCOM 07. Sistemi informativi per l'Architettura Convegno Internazionale,* Con il Patrocinio di UNESCO. Ministero dei Beni Culturali, CIPA, Regione Marche, Ancona-Portonovo Hotel La Fonte, 17-18-19 Maggio 2007, Ancona: Alinea Editrice, 2007, pp. 659-669.Cf: http://www.sumscorp.com/articles/pdf/2007_New_Book_of_Nature.pdf

[64] Nua: http://www.dns.net/andras/stats.html#users; Internet World Stats:
http://www.internetworldstats.com/stats.htm

[65] Dahlberg, (2008) unpublished manuscript has shown that there are at least 17 questions in knowledge organization. So even the six questions now associated with journalism via Kipling are a simplification.

[66] ITU Report: *The Internet of Things*, Geneva, 2005:
http://www.itu.int/osg/spu/publications/internetofthings/. Cf the Conference. *Internet of Things. Internet of the Future*, Nice, October 2008:
http://www.internet2008.fr/spip.php?article9

[67] This first part of this list is adapted from figure 2 in the 2005 publication listed in note 45 above.