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Opening the semantic space in the service of collective intelligence

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Abstract and Introduction

As the human recorded memory is progressively digitized and posted on line, the need for a common semantic coordinate system independant from natural languages and ontologies is growing. A future universal semantic addressing system, able to index all digital documents, should meet three basic requirements. *First*, each distinct concept should have a unique address. *Second*, the semantic coordinate system should be open to any concept and relations between concepts (ontologies), whatever the cultural environments where these concepts are created and transformed, without neither privileges nor exclusions. *Third*, it should support a group of mathematically defined (automatable) operations on semantic addresses, namely : rotations, symmetries and translations in the « semantic space » ; semantic compression and decompression ; set-theory operations like union, intersection and symmetric differences ; ranking on semantic criteria ; semantic pattern recognition ; semantic distances measurement ; logical inferences, etc.

Developped by an international research network led by the Canada Research Chair in Collective Intelligence at the University of Ottawa, the Information Economy MetaLanguage (IEML), allows the construction of a semantic coordinate system meeting these three constraints. Website, including the IEML dictionary, since may 2006: www.ieml.org

In Brasil, BIREME (www.bireme.br) is member of the IEML initiative.

Semantic Interoperability

The Problem

The universe of communication opened up to us by the interconnection of digital data and automatic manipulators of symbols - in other words, cyberspace - henceforth constitutes the virtual memory of collective human intelligence. Yet important obstacles hinder digital memory from working fully in the service of an optimal management of knowledge.

The obstacles are:

- the multiplicity of natural languages,

- the mutual incompatibility and poor adaptation of the numerous systems of indexing and cataloguing inherited from the print era (which were not designed to use interconnection and the computing power of cyberspace),

- the multiplicity of ontologies, taxonomies, thesauri, terminologies and classifications,

- the difficulties encountered by information engineering when it tries to take into account the *meaning* of documents by means of general methods.

This set of obstacles to the development of digitally-based collective intelligence can be called "the problem of semantic interoperability".

The proposed solution

The metalanguage of the information economy (*IEML*: *Information Economy Meta Language*) was specifically designed to address this problem. It is a system of semantic digitization that is independent of document formats, cataloguing systems, ontologies and natural languages, and that makes it possible to automatically identify, put into relation, and manipulate *concepts*.

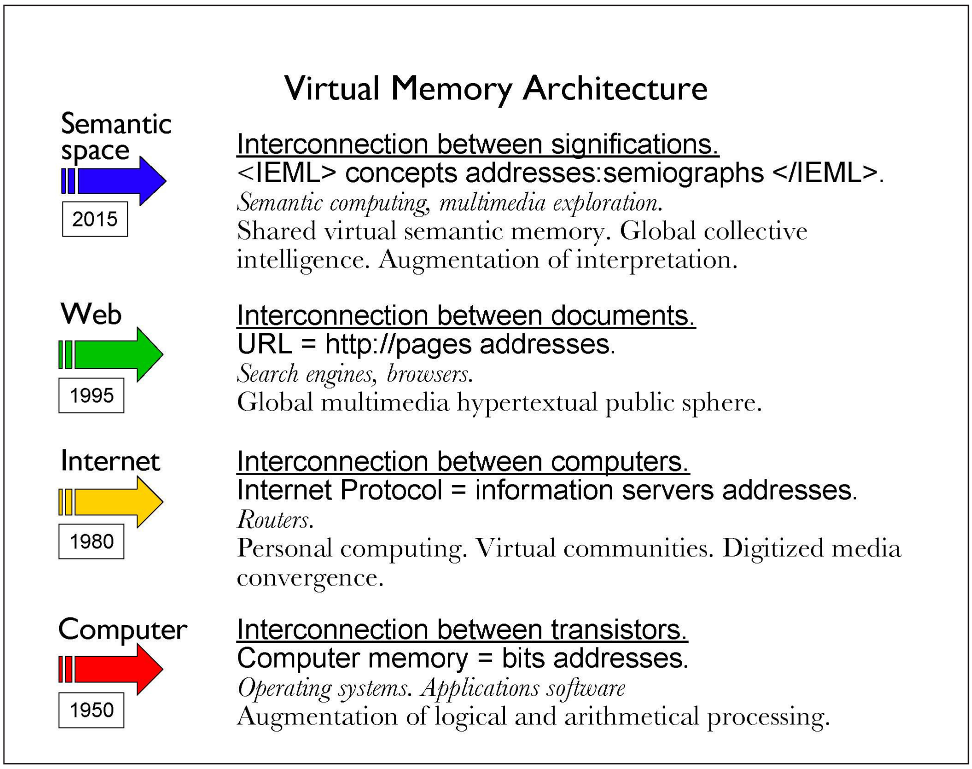
This metalanguage of the information economy authorizes a uniform *semantic computation*, no matter which subjects the flows and stocks of information involve. In so doing, the metalanguage opens the way to a program of techno-scientific research that associates the various domains of knowledge and computing: computational knowledge management. Used as a device for addressing digital memory, IEML enables the intelligent and intensive exploitation of data, using *general* methods.

The layers of digital memory addressing

In order to understand the need for a new layer of memory addressing in cyberspace, we have to analyze the arrangement of the preceding layers.

First layer (bit addressing)

At the level of the computers that compose the nodes within cyberspace, the local system for addressing *bits* of information is managed in a decentralized fashion



by various operating systems (such as Unix or Windows), then used by software applications. The development of computing in the 1950s created technical conditions for a remarkable augmentation in the arithmetical and logical processing of information.

Second layer (server addressing)

At the level of the network of networks, each *server* has an attributed address, according to the universal protocol of the Internet. IP (Internet Protocol) addresses are used by the information routing - or commutation - system that makes the Internet work. The development of the Internet in the 1980s corresponds to the advent of personal computing, the growth of virtual communities, and the beginning of the convergence of the media and telecommunications in the digital universe.

Third layer (page addressing)

At the level of the World Wide Web, the *pages* of documents, in turn, have a universal address according to the universal system of URLs (Uniform Resource

Locator), and the *links* between documents are handled according to the HTTP standard (HyperText Transfer Protocol). Web addresses and hypertext links are used by search engines and Web surfers. The popularization of the Web from 1995 onward helped give rise to a global public multimedia sphere.

Fourth layer (concept addressing)

The Semantic space takes the form of an additional layer of digital memory, resting on a universal addressing system for *concepts*: IEML. As a *coordinate system of the semantic space*, IEML makes it possible to automatically manage the relationships among the meaningful content of documents, and this independently of the languages and terminologies used to write, catalogue, or index the documents. Computational knowledge management is dedicated to the automatic manipulation of the semantic numbers that address the documentary data. In so doing, it increases human capacity for *interpretation* of the virtual memory. New devices for *multimedia exploration* of the dynamic universe of concepts could take support from semantic computing.

IEML and the Semantic Web

Semantic web tools

Some may question the need to construct a new layer of semantic addressing for data, given that we already have standards and tools from the semantic Web, coordinated by Tim Berners-Lee. Yet the "semantic" Web, contrary to what its name suggests, essentially proposes standards for the *logical* coding of information.

The primary symbolic tools of semantic Web are:

- XML (eXtended Mark-up Language), derived from SGML (Standard Generalized Markup Language) by Charles Goldfarb; XML is used to universally describe the *structure of databases*;

- RDF (Resource Description Framework) which makes it possible to *catalogue data* from the Web, together with the language Sparkl, which can be used to query the resources catalogued by RDF;

- OWL (Ontology Web Language), which makes it possible to describe ontologies, in other words *conceptual structures* from various fields of knowledge that can serve as a basis for automatic inferences.

Although the primary function of these instruments for description and marking is to encourage automated data search and automated operations by software robots, the problem of semantic interoperability is not resolved by the semantic Web, at least not in the form of general and optimal methods, for at least two reasons: the notation for natural language concepts is arbitrary, and the numerous ontologies are incompatible.

Arbitrary alphabetical notation of natural language concepts

Even if XML, RDF and OWL formalize the *relationships* between concepts in the universal and neutral language of logic, the *concepts themselves* are noted by words or abbreviations in different natural languages. And this poses a problem because (a) there are thousands of different natural languages; (b) within each of the languages, words can have several meanings; (c) the same meaning can be expressed by several words; not to mention (d) changes in meaning due to variations in context and points of view.

The numeric system of notation by position (whether in base 10, base 2 or another base) enables a universal and unequivocal interpretation of the meaning of each numeral, and of the place occupied by each numeral of the number written sequence. Thus, the concept that corresponds to the sequence of numerals (the number) can automatically be deduced from this sequence. By contrast, the alphabetical notation of words in natural languages leads to arbitrary codes - strings of characters - that can always be compared or linked to other strings of characters, yet without being able to interpret the characters or their respective disposition *per se*. Here, the basic symbols represent sounds, not elements of meaning.

In sum, for automatic manipulators of symbols, the numbers noted in the indo-Arabic ideography are directly accessible, whereas natural languages noted in alphabetical characters are semantically opaque. Even if the links between the logical tags in XML, RDF and OWL are calculable, the strings of characters that mark the tags remain *arbitrary codes* from the point of view of semantic computability.

The multiplicity of ontological hierarchies

The second reason why the semantic Web cannot alone resolve the problem of semantic interoperability is that the ontologies are mutually incompatible. They are generally structured by *hierarchies* of concepts, and of relationships between concepts, that enable the properties to be automatically inherited from upper levels to lower levels. For these hierarchies are contextual, that is, they are linked to fields of practice or to philosophical and cultural choices. It is of course possible to use upper-ontologies that are capable of organizing a large number of local ontologies, such as Cyc by Douglas Lenat or SUMO by the IEEE, and to associate, to each concept within a upper-ontology, its translation in a large number of natural languages. Yet this hardly resolves the problem of semantic interoperability, because there are *several* upper-ontologies and each of them necessarily implies philosophical choices and *particular* practices.

A universal system of addressing for concepts would need: (1) to be independent of the ontologies; (2) to allow the expression of as many distinct ontologies as desired; and (3) to authorize the measure of proximities between ontologies, without giving *a priori* privilege to any single ontological point of view.

Complementarity of IEML and the Semantic Web

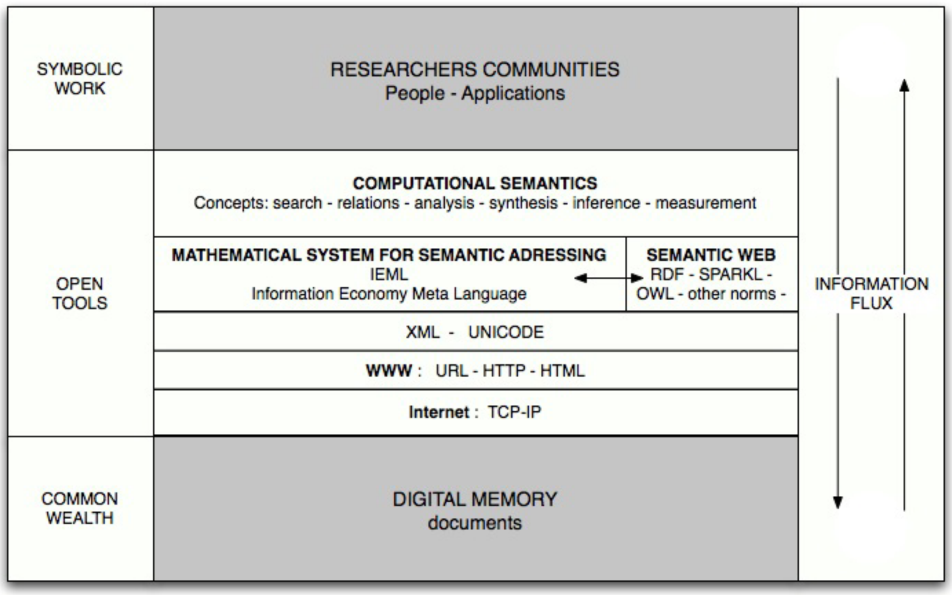
Note that I am not questioning the utility of XML, RDF or ontologies in OWL; rather, I am simply recognizing that they do not supply a universal mathematical system for addressing concepts. The tools and standards of the semantic Web are practically *necessary* for the technical implementation of a mathematical addressing of concepts, yet they are *not sufficient*. The computational semantics based on IEML will enable full use of the tools and methods produced by the semantic Web, existing with it in a relationship of complementarity and reciprocal enhancement, rather than of rivalry. We can read and write (semantically calculable) IEML phrases in the logical tags of the semantic Web, with the translation of the corresponding concepts in natural languages being provided by a multilingual IEML dictionary. Thus, the semantic Web can be considered as an *intermediary* logical device between the Web and the full Semantic space. The diagram below shows the general technical architecture of the information economy proposed by the IEML initiative.

IEML Structure

Generalities

IEML can be considered a semantic abacus that can be manipulated by computers. All phrases of the metalanguage can be recognized by a finite state machine. IEML phrases are built in a regular way by generating information flows among a handful of primitive elements according to an articulated hierarchy of structural levels. Any phrase is regularly constructed as an information flow between two or three semantic nodes of lower levels of articulation, playing the roles of source, destination and (eventually) Translator or mediator. A composition rule states that the translator is void if the destination is void and that the destination is void if the source is void.

INFORMATION ECONOMY



Elements

IEML is based on 5 basic elements that describe the component principles of meaning, as follows:

Verbal elements (O)

- Virtual U and actual A are the two *verbal* elements O, linked to processes: (O = U, A).

The virtual covers the universe of possibilities, things to come, potentials, competencies, problems, universals, classes and general types that are very often « intangible ». The virtual element is characterized by an absence of spatio-temporal coordinates.

The actual occurs in time and space. These are singular individuals, original events, born forms, solutions to problems, exemplars of the universal, phenomena and data that are perceptible.

The dialectic of action (O) organizes an exchange of information, a circulation of differences between the virtual and the actual: each actualization transforms the virtual and each transformation of the virtual generates a new actuality.

This dialectic of the *virtual* U and the a*ctual* A is found in numerous philosophical and cultural traditions: the heavens and earth of the earliest philosophies, the transcendence and immanence of theologies, the yin and yang of Taoism, the intelligible and sensible of Platonism, Kant's noumenal and phenomenal, the void and phenomena of Mahayana Buddhism, etc.

In its most abstract definition, the virtual defines a domain of variation and the actual an operator : the combination of the two roles creates a function.

Nominal elements

- Sign S (signifier), being B (signified for an interpretant) and thing T (referent) are the three *nominal* elements M, linked to representations (M = S, B, T).

The *sign* corresponds to the signifier in linguistics. It is a symbolic instrument whose primary operation is to point toward the referents of human discourse. Signs are the sounds of the word, the characters of the writing, gestures and signs, images and signals of all kinds, generally symbols that can be interpreted. "The finger points to the moon. The idiot looks at the finger", as the Zen proverb says. In this example, the finger represents the signifier (in other words, the *sign*) S, while the moon is the referent (in other words, the *thing*) T.

Now, except in the case of proper nouns that designate singular realities, it is impossible to link a signifier to a singular reference of speech, without first passing through an intermediary concept associated with the sign: the signified. In turn, the signified can only signify *for an interpretant*. This signified, which is indissociable from its subjective interpretant, is called *being* in the IEML language. The *being* accomplishes the cognitive movement that passes from the finger (the *sign*) to the moon (the *thing*) and gives a contextual value to this sign-reference relation.

The *nominal elements* of IEML (*sign* S, *being* B and *thing* T) are the three distinct and interdependent factors of representation. But attention here: they are distinguished by their function and not by their intrinsic nature. Depending on the various cognitive perspectives, a person, for example, can play the role of *sign* (the signifier of the discourse), or *being* (the interpretant of the discourse) or *thing* (the object of the discourse).

The semantic dialectic of the sign, the being and the thing were called *vox*, *conceptus* and *res* in the medieval university. In the philosphy of CS Peirce, these are translated as sign (or *representamen*) interpretant and object. Their variants in modern linguistics are the signifier, signified and referent. This semantic dialectic is found in logic (propositions, judgments, states of thing), in economics (price, ownership, utility), and in theology (teachings, community, ultimate reality). This ternary dialectic can even be detected in the *trivium* of the liberal arts in antiquity and the Western Middle Ages: *grammar* develops mastery of the language (the wielding of signs), *dialectic* offers an introduction to rational dialogue (between beings), *rhetoric* is concerned with the practical construction of discourse with a view to its memorization and real effects (in things).

Thus, the primitives of IEML - a language for the addressing of digital data according to their meaning - are, not surprisingly, the very structures of meaning. These structures have been described by ancient and numerous traditions belonging to various cultures and disciplines. I merely saw fit to gather them together up and draw connections between them.

From events to phrases

From these 5 elements, IEML deploys 4 levels of combination and articulation of the semantic numerals:

- 25 (5^2) events, or "semantic letters", which are the flows of information between two elements (the events are represented by the 25 lower-case letters in bold font in the table above, where the vowels are verbs and the consonants are nouns);

- 625 (25^2) relations, which are combinations of two letters or the "semantic syllables" of the metalanguage;

- 240 million ideas ($625^2 + 625^3$), combinations of 4 or 6 letters, representing the "words" of the metalanguage;

- an astronomical quantity (10^{23}) of "phrases" that combine 1, 2, or 3 ideas.

ieml Alphabet

OO energies	OM acts	MO mutations	MM concepts
U-->U **wo** reflect	U-->S **y** know	S-->U **j** signifier	S-->S **s** thought
U-->A **wa** act	U-->B **o** want	S-->A **g** documentary	S-->B **b** language
A-->U **wu** perceive	U-->T **e** can	B-->U **h** meaning	S-->T **t** memory
A-->A **we** reconstitute	A-->S **u** express	B-->A **c** personal	B-->S **k** society
	A-->B **a** commit	T-->U **p** referential	B-->B **m** affect
	A-->T **i** do	T-->A **x** material	B-->T **n** world
			T-->S **d** truth
			T-->B **f** life
			T-->T **l** space

The grammar of IEML have a total of 5 levels of articulation: elements, events, relations, ideas, and phrases.

The semantic space

Dimensions and perspectives

The semantic space is supposed to address a practically infinite quantity of different graphs of IEML phrases. Mathematically, a graph can be defined by a set of triples. Each triple is composed by 1) an initial node, 2) an arrival node, 3) a link between the two nodes. The IEML phrase tagging the initial node is called a source (So) phrase, the IEML phrase tagging the arrival node is called the destination (De) phrase and the IEML phrase tagging the link is called the translator (Tr) phrase. The triples composing the graphs of IEML phrases can be mathematically represented as abstract "points" of a 3D space of which the three axis are So, De, Tr.

1° dimension : source, 2° dimension : destination, 3° dimension : translator. On each dimension, the variables are the 10^{23} IEML phrases.

So, the IEML semantic space is an abstract cubic matrix containing 10^{69} basic units, or semantic pixels that are *triples* of IEML phrases.

This *semantic* 3D space can be projected into many *geometrical* 3D space, called semantic perspectives. There are as many semantic perspectives as there are strict orders between phrases on the 3 axes of the semantic space. Any possible order of phrases along the three axis produces a different 3D geometrical projection of the semantic space. A semantic perspective is not based on a point out of a 3D space but on a full 3D space out of a matrix of possible 3D spaces (the semantic space).

Semantic space addressing

As we have seen earlier, the "semantic pixel" or basic unity of the semantic space, is a triple of IEML phrases (IEML phrase So, IEML phrase De, IEML phrase Tr). This unity is called a semantic numeral. There are10^{69} triples of phrases or semantic numerals (a little less than that, in fact, because one needs a non-empty destination to get a non-empty translator and a non-empty source to get a non-empty destination). Projected in a semantic perspective, the semantic numeral becomes a geometrical point.

A graph of IEML phrase is a set of semantic numerals and defines a subset of the semantic space. It is called a semantic number. There is an astromical quantity of possible semantic numbers. Even if theoretically finite, it is practically infinite.

Projected in a semantic perspective, the number becomes a set of geometrical points, a "figure". The semantic numbers (semantic space coordinates) are common to all semantic perspectives: the sole difference is their 3D projection into a figure, which is linked to a particular semantic perspective.

Semantic data

Semantic data represent valuated and referenced concepts. A semantic datum is composed of three parts : 1) the formal concept, or semantic address, 2) the values of the concept, 3) the references of the concept

1) The unique spatial coordinate of a concept is given by a semantic number, that is to say by a set of semantic numerals, or (in other words) by a subset of the semantic space.

2) The concept values correspond to ordering (or ranking) numbers associated to a semantic number and to quantities - or cardinal numbers - associated to a semantic number. Ordinal numbers depend on explicit (if not automatic) ranking functions and cardinal numbers depend on explicit (if not automatic) measurement functions. Severals values can be associated to the same formal concept, according to various valuation functions.

3) The references are links to physical addresses of documents (URLs, for example). Several physical addresses of documents can be associated to the same semantic number, for example documents with equivalent semantic content but in different natural languages. Each physical address of documents depends on an explicit (if not automatic) indexation function. The same physical address can be associated to different semantic coordinates according, for example, to different indexation functions. Finally, a physical address can contain a semantic address (self-reference of the semantic space).

Computing semantic data

Semantic data are composed of three different parts : adress, values and réferences of a concept. Two of them, the address and the values, can always support automatic manipulations, because they are composed of numbers. The concept address - or formal concept - is a semantic number that can be manipulated by a finite machine. The values are ordinal numbers (depending on ranking functions) and cardinal numbers (depending on measurement functions). Therefore, it is always possible to define computable functions on the two first parts of semantic data.

N.B. : The reference part of semantic data depends on indexation functions that are not always computable, like, for example, the conventions resulting from the agreement of a group of human interpreters that are set down in IEML-natural languages dictionaries. Nevertheless it is possible to program indexation automata from the dictionaries.

Among the various functions that can be automatically computed on semantic data, let's quote:

- rotations, translations and symetries of formal concepts in the semantic space,

- set-theory operations (union, intersection, symmetric differences) on formal concepts

- compressions and decompressions (synthesis and analysis) of formal concepts from classifications

- automatic ranking of formal concepts according to semantic or external criteria

- truth functions (value 0 or 1),

- semantic patterns recognition

Composition of functions defines *semantic automata* reflecting the interests, interpretations and cognitive operations of a community of interpreters and augmenting its abilities of knowledge management.

Formal concepts meaning

Attribution of natural language descriptors to IEML nodes

Natural languages are multiple, ambiguous, and changing. Therefore, it is impossible to *automatically deduce* the interpretation of IEML nodes (mainly ideas and phrases) in natural languages. This interpretation can only be *conventional*. By contrast, once the interpretation of the IEML ideas is given, the interpretation of the *semantic numbers* (the "texts" of the metalanguage: graphs of phrases) can be generated automatically.

Given that the purpose of the metalanguage is to compute automatically semantic relationships, the attribution of natural language descriptors to the IEML ideas and phrases cannot be arbitrary: as much as possible, it must conform to the three main criteria listed here:

Criterion of symmetry. The *syntactic symmetries* of the metalanguage must be reflected in the *semantic symmetries* disclosed by the natural language descriptors.

Criterion of economy. The attribution of descriptors must make it possible to generate, by composition, a *maximum* of concepts through a *minimum* of IEML symbols.

Criterion of composition. The *interpretation of a combination of IEML symbols* by a natural language descriptor must correspond as much as possible (it is not always possible) to the *combination of the interpretation of these symbols*.

In order to initiate the process of interpreting IEML formal concepts, the author has translated into natural languages (French and English) the 625 relations and more than 1000 ideas covering the majority of objects and disciplines in the humanities (which are his specialty). Now, the continuation of the interpretation process will need to be an open collective undertaking, with invitations extended to: (a) the managers of ontologies, terminologies, thesauri and classifications; (b) specialists from the knowledge domains who wish to formalize their concepts in IEML; and (c) the translators who are developing the IEML dictionary. The main tool of this joint interpretation process is a multilingual dictionary WIKI called "wikimetal" (for wiki of the metalanguage) that can be found on the www.ieml.org website since april 2007.

Polysemy

In IEML, a formal concept (a semantic number) is univocal: an address of the semantic space is unique, distinct and without ambiguity. Notwithstanding, IEML has not been invented to eliminate but on the contrary to *augment* the contextual possibilities of interpretation.

In the semantic space, the multiplication of interpretations (or polysemy) is not based on the equivocity of concepts but on the immense variety of *operations* (transformation, ranking, measurement and indexation) that can be performed on concepts. *Therefore, the multiplicity of sense-generating contexts* is modeled by the multiplicity of semantic automata able to compose their operations on a semantic current. There are as many possible semantic automata (*sense-generating contexts*) as there are possible communities of interpreters.

Conclusion: the interdependence of the three problems handled by computational semantics

As we have seen, the computational semantics based on IEML proposes to handle the problem of semantic interoperability in cyberspace. To conclude this paper, I would like to underscore the interdependence between the solutions to three problems: (1) the problem of semantic interoperability; (2) the problem of decision-making support for the management of knowledge within organizations; and (3) the problem of the scientific study of the processes of human collective intelligence.

IEML and semantic interoperability

The solution to the problem of semantic interoperability supposes the use of a metalanguage that is: (1) able to give unique addresses to distinct concepts, (b) manipulable by computers; and (c) capable of translating, each into the others, the various natural languages, ontologies, and systems of classification that today fragment the *indexing of documents on the Web*. The need for such a metalanguage is starting to be recognized in the techno-scientific community that gravitates around the semantic Web. One of the most obvious repercussions of adopting such a universal semantic coordinate system would be to open the way to *customized semantic search engines*, working on concepts instead of on strings of characters.

Semantic search engines are characterized by the following capacities:

- a) to produce automatic ranking of results from semantic criteria,

- b) to calculate geometric distances between conceptual patterns according to customized semantic sensors

- c) to automatically generate, synthesis, analysis and logical inferences across ontologies.

IEML and knowledge management

Not only is IEML capable of mutually translating the various natural languages and ontologies, it also presents itself as a tool for representing and simulating the various *ecosystems of concepts* maintained by human collectivities (businesses, schools, universities, disciplines, territorial entities, associations and virtual communities of all kinds). Once the ecosystems of concepts are represented in a standard metalanguage, the semantic data can be accumulated and compared and a scientific knowledge mangement can unfold.

IEML is designed to *assist decision-making* in knowledge management, based on an explicitation of purpose from the user community and on a representation as nuanced as possible of the existing conceptual dynamics (and not as a function of methods or theories *a priori*). Thus, computational semantics is called upon to orchestrate the real-time innovative development of knowledge and the practical coordination of competencies within groups and collectives of all kinds and scales.

IEML and the scientific observation of collective intelligence

Once the problem of semantic interoperability is resolved by means of a metalanguage that is capable of representing and simulating ecosystems of concepts, it becomes possible to scientifically observe the processes of human collective intelligence. In effect, the bulk of the accumulated cultural memory, as well as a growing proportion of communication and human transactions, are hanging in the digital universe online. Thus, it is theoretically possible to use cyberspace as an instrument for observing collective human intelligence, from the scale of small groups on up to the global scale. And yet, if this possibility is to come true, we must first be able to distribute and locate the flows and stocks of information in a unified semantic space, a space that is capable of accomodating an indefinitely open variety of concepts in interaction and transformation. Within this perspective, IEML stands as a system of locating (or scientifically addressing) concepts that makes it possible to open up the semantic space - as a *nature* of the human mind - to scientific observation. And this observation will inevitably have important epistemological repercussions in the humanities and social sciences, as well as practical applications in the service of human development. In this sense, computational semantics based on IEML can be understood as an auxiliary discipline to the humanities.

The Inseparability of the three problems

In sum:

1) the idea of a common language for the Web is beginning to make headway;

2) the young discipline of knowledge management is seeking out scientific theories, methods, and tools;

3) for the past 15 years, research into - and theoretical discourse on - collective intelligence has been growing.

Computational semantics based on IEML provides these three research streams will a shared set of equipment for mathematical calculus, measurement and conceptual addressing. This equipment can: (1) resolve the problem of semantic interoperability; (2) offer a standard for the representation of ecosystems of concepts and serve as an aid to decision-making in knowledge management; (3) serve as a foundation for constructing an instrument for the distributed scientific observation of the processes of collective intelligence.

None of the three problems can be optimally resolved unless the other two are as well. Any *separate* attempts at solutions to the three problems can only lead to partial results or to failure. The occasion for a leap in collective intelligence would be missed if the common language of the Web (which will necessarily be constructed in the relatively long term, and under pressure of necessity) did not open up access to the observation of a still invisible semantic space and, in the same time, did not make possible the distributed, computer-assisted, scientific management of knowledge in the service of human development.

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About the author

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Pierre Lévy is a philosopher who devoted his professional life to the understanding of the cultural and cognitive implications of the digital technologies, to promote their best social uses and to study the phenomenon of human collective intelligence. He has written a dozen of books on this subject that have been translated in more than 12 languages and are studied in many universities all over the world. He currently teaches at the communication department of the University of Ottawa (Canada), where he holds a Canada Research Chair in Collective Intelligence. His book on the technologies of intelligence, published in 1990, forecasted the advent of the Web. As soon as 1992, he founded in France one of the first software company dedicated to knowledge management. His book on collective intelligence, published in 1994, is still inspiring young researchers. He is the author of an artificial language (www.ieml.org) able to express any concept in a computable form. IEML could become the « semantic code » of cyberspace, offering to human collective intelligence an interoperable shared memory. Pierre Lévy is fellow of the Royal Society of Canada and received several awards and academic distinctions.