Intertextual Semantics: A Semantics for Information Design

Yves Marcoux
GRDS-EBSI, Université de Montréal, C.P. 6128, succ. Centre-ville, Montréal, Québec, Canada H3C 3J7. E-mail: yves.marcoux@umontreal.ca

Élias Rizkallah
Desjardins Centre for Studies in Management of Financial Services Cooperatives, HEC Montréal, 3000, chemin de la Côte-Sainte-Catherine, Montréal, Québec, Canada H3T 2A7, GRDS-EBSI, Université de Montréal. E-mail: elias.rizkallah@hec.ca

In most discussions about information and knowledge management, natural language is described as too fuzzy, ambiguous, and changing to serve as a basis for the development of large-scale tools and systems. Instead, artificial formal languages are developed and used to represent, hopefully in an unambiguous and precise way, the information or knowledge to be managed. Intertextual semantics (IS) adopts an almost exactly opposite point of view: Natural language is the foundation on which information management tools and systems should be developed, and the usefulness of artificial formalisms used in the process lies exclusively in our ability to derive natural language from them. In this article, we introduce IS, its origins, and underlying hypotheses and principles, and argue that even if its basic principles seem remote from current trends in design, IS is actually compatible with—and complementary to—those trends, especially semiotic engineering (C.S. de Souza, 2005a). We also hint at further possible application areas, such as interface and interaction design, and the design of concrete objects.

Introduction

Overview

In most discussions about information and knowledge management, natural language is described as too fuzzy, ambiguous, and changing to serve as a basis for the development of large-scale tools and systems. Instead, artificial formal languages are developed and used to represent, hopefully in an unambiguous and precise way, the information or knowledge to be managed. Intertextual semantics (IS; Marcoux, 2006; Marcoux & Rizkallah, 2007a, 2007b, 2008) adopts an almost exactly opposite point of view: Natural language is the very foundation around which information management tools and systems should be developed, and the usefulness of artificial formalisms used in the process lies exclusively in our ability to derive natural language from them. Thus, the artifacts used to manage information and knowledge are considered meaningful and useful not in themselves but only in as much as they can be interpreted, or "read out" in natural language by users.

In large-scale systems, most artifacts are not crafted individually but rather produced through "molds," or models (e.g., database or XML schemas), that specify the shape of an object, but not its contents. In that way, a large number of morphologically similar objects are created which can be managed in a uniform, easily automated, manner. For example, in an online store, the home page might be crafted individually, but the information about individual items will typically be stored in a relational database table (and rendered "on-the-fly"). All rows (i.e., records) of such a table have the same form and are entered, validated, and rendered in the same way.

How can an information artifact conforming to some mold be read out in natural language by a user? IS suggests that this interpretation must be actively prepared ahead of time by the creator of the mold (i.e., the modeler, or designer). This should be done by assigning, to each part of the mold, text segments that can be combined with the actual contents of an artifact to yield a natural-language passage. The assignment of text segments to the various parts of the mold constitutes the *IS specification* of the mold while the natural-language passage resulting from combining those segments with the actual contents of an artifact constitutes the *IS of the artifact*. Thus, specifying the IS of a mold when it is created allows the IS of individual conforming artifacts to be generated later automatically.

It is important to stress that the IS preoccupations are not at the interface level. While the IS of an artifact could be

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shown in a user interface, its main purpose is to serve as the intended or reference interpretation of the artifact. Such a reference interpretation can help in the development of the interface, to make sure the latter conveys the right messages (typically through a mix of iconic and verbal languages), but it will not necessarily be displayed directly in the interface (except perhaps upon explicit request from the user). The main interest of the reference interpretation is that it allows everyone (modelers, authors, readers, analysts, information managers, etc.) involved in the life cycle of the artifact to have at their disposal a common understanding of the object with which they are interacting.

In the remainder of this article, we introduce IS, its origins, and underlying hypotheses and principles, and argue that even if its basic principles seem remote from current trends in design, IS is actually compatible with—and complementary to—those trends (especially de Souza, 2005a). We also hint at further possible application areas, such as interface and interaction design, and the design of concrete objects.

Related Work

IS originates from the field of structured documents, where it was introduced as a semantics for facilitating the communication between modelers (i.e., writers of document models or schemas) and authors of documents, but it also has strong links with the fields of human-computer interaction (HCI) and information design. Therefore, the following literature review of the last 10 years covers both work in structured documents and work in HCI and information design. For space considerations, we mainly present the differences between IS and the reviewed approaches.

Standard structured-document modeling methodologies (Glushko & McGrath, 2005; Maler & El Andaloussi, 1996; Travis & Waldt, 1995) do not in general include a full-fledged, formal semantic framework. Rather, the semantic aspects of modeling are treated in pragmatic terms through discussion of human-readable documentation and application development. Semantic properties and usability of models and of conforming documents, although recognized as crucial, are treated as side effects of those pragmatic considerations.

Renear, Dubin, and Sperberg-McQueen (2002, pp. 121–122) proposed a formal semantic approach for structured documents. The basic premise is that natural-language descriptions are insufficient and must be supplemented by a separate, formal apparatus. Our approach (IS) does not share that premise; in a way, we aim at operationalizing natural-language descriptions in such a way that they can support document creation and other operations on documents. We do not replace natural language; we frame it with mechanisms that make it supportive of interactions between humans and documents.

Wrightson (2001, 2005) introduced another semantic approach for structured documents. There is much in common between Wrightson's preoccupations and ours; in particular, she has analyzed human legibility of raw XML documents. However, there are important differences with our approach (IS). First, her approach is based on situation semantics (Barwise & Perry, 1983; Devlin, 1991) whereas ours is based entirely on natural language. Second, she has concentrated on the communication between authors and readers while we also address the communication between modelers and authors.

Another approach with which we have much in common is that of Sperberg-McQueen, Huitfeldt, and Renear (2000). These authors developed a framework for structured-document semantics based on sentence skeletons and deictic expressions. Similar concepts can be found in our framework (or possible extensions). However, even if these authors mentioned the possibility of using natural-language sentence skeletons, the bulk of the discussion—and all the examples—use a formal language, namely Prolog predicates. The goal of their framework is more to allow automatic inferences on documents than to present the semantics of documents to humans, which is essentially IS's goal.

From a more global perspective, the idea—found in our approach—of using text-related techniques to improve information systems design is not new. Smith (1994), for example, wrote that "[t]alk, theorized as conversation and analyzed as discourse, may provide the models of interaction that we need, in order to improve the design of hypertext systems and to extend the reach of its applications" (p. 281). Well-known examples of text-related techniques for systems development are Donald Knuth's WEB system and literate programming in general (Cordes & Brown, 1991; Knuth, 1984, 1992), the Text Encoding Initiative's ODD (One Document Does it all; e.g., Cover, 2005), and Sperberg-McQueen's (1996) SWEB.

In the fields of HCI and information design, several theoretical frameworks have affinities with our approach; in particular, de Souza (2005a, 2005b; de Souza & Cypher, 2008) and, to a lesser degree, Norman (1998, 2004a, 2004b, 2005), Nardi and O'Day (1999), and McCarthy and Wright (2004).

The HCI approach by far closest to ours is the semiotic engineering of de Souza. Indeed, de Souza's standpoint is that, with computer systems, the encoding of perceived problems and solutions is essentially linguistic (i.e., based on a system of symbols—verbal, visual, aural, or other—that can be interpreted by consistent semantic rules), and that they can only be used by people who understand this encoding and who can express themselves through this language system (de Souza, 2005b, 320). The semantic range is broader than ours, in that it encompasses every kind of sign that can take part in a semiosis, while we limit our sign system to natural language. We agree with de Souza and Cypher's emphasis on the importance of the communication functions of interfaces, without some of which "users can't even begin to achieve their goals" (de Souza & Cypher, 2008). Our aim is a little broader than what has been de Souza's so far, in that we consider the communication taking place at different times and between different actors of an information system (modelers, rendition designers, authors, readers), not just between designer and user at interaction time through the messages embedded in the interface.

The primacy given to communication between the various actors of an information system is the main difference between IS and several other approaches to design, such as those of Norman (1998), Nardi and O'Day (1999), and McCarthy and Wright (2004). In our opinion, inexplicit and ambiguous semantics of an artifact will always impair its use, no matter how well it may be designed and rendered on the cognitive (Norman, 1998), ecological (Nardi & O'Day, 1999), and experiential (McCarthy & Wright, 2004) levels. We believe that no matter how useful the Gibsonian concept of affordance may be for interface design, it does not exclude completely its textual counterpart. We also think that before becoming an aesthetic experience (McCarthy & Wright, 2004), the use of technology by any kind of user (e.g., rendition designer, author, reader) should enable them to understand what the system has to tell them, what it can offer them. That being said, we share many of the premises of the aforementioned approaches, such as the need to design a system that is easy to learn, pragmatic in the sense of Bakhtin and Dewey (McCarthy & Wright, 2004), and adapted to the information ecologies of the target community.

Basic Principles and Hypotheses

A View of Human Communication

The main fundamental hypothesis behind the IS approach to the design of information systems is that at least some form of communication between humans can be viewed as the preparation, transmission, and in some cases, storage and management, of information-bearing objects (IBOs), some of which are decoded (or interpreted) by readers (or users) who make sense of them. Actual communication usually takes place in sequences of such exchanges, which can be called *dialogues* or *conversations*. Each step of a dialogue, or conversation, contributes to the context of the upcoming exchanges and thus influences how readers decode the IBOs involved. As a whole, a conversation is itself situated in a broader context, which influences how the entire sequence of exchanges is interpreted. For example, an overheard conversation may lead one to think that someone is angry, but if it appears that the conversation was part of a performance by actors, it will be understood that the anger was simulated.

IBOs can be concrete, material objects such as a book or a DVD, but also can be nonmaterial (i.e., abstract) objects such as words, sentences, database records, icons, or moving images. Nonmaterial objects, when interacted with, become physically perceivable through renditions. Thanks to the transient image- and sound- (and, more recently, tactile and olfactory stimuli) production capability of technologies such as screens and loudspeakers, renditions appear to the reader as consultations of material IBOs, in virtually every respect but materiality. Thus, in reasoning about information and information systems, it is actually possible to consider material IBOs as particular renditions of nonmaterial ones, which results in helpful unification and simplification.[1] In the remainder of this article, we will be concerned mostly with nonmaterial IBOs.

Interpretations of Renditions

Renditions can use a variety of semiotic systems (i.e., systems of signs used for communication). First, there is a choice of modalities; that is, whether the rendition uses text, images, moving images, sound, and so on. A rendition also can be multimodal, in that it simultaneously uses more than one modality. A moving image accompanied by subtitles or a soundtrack is an example; an icon with a text label is another. Second, there is a choice of signifiers among those possible in the chosen modalities. We use the word *signifier* in the sense of de Saussure (1968), even if what we mean by it could correspond as well to the "representamen" in the work of Peirce (1965). References to semiology (de Saussure) or semiotics (Peirce) in information science have been made by Pearson (1980), Warner (1990), and more recently by Raber & Budd (2003) and de Souza (2005a).

A signifier—or signifying element, or representamen—is anything in a rendition that contributes to the sense-making process in readers. It can be an individual component (e.g., icon, word, sentence, video clip, etc.) or a relationship between components in a rendition. For example, in renditions using a visual modality, geometry can play a role in conveying meaning. Family trees, organization charts, and conceptual maps all use relative geometric positioning of text labels to convey an essential part of their message. In the spoken-text modality, characteristics such as the tone of voice and the speech rate influence how the user makes sense of the rendition.

There is no a priori delimitation of what the sense made by an individual of a signifier can be. Furthermore, every "reading" of the same signifier occurs in a distinct context and can thus give rise to a different "sense." Since sense making is so individual and contextual, and because it is impossible to directly access either its process or its outcome in people, there is no sensible way in which we could say that different people have the "same" interpretation of a signifier.

It is possible, however, to define an intuitive and informal notion of uniformity of interpretations by imagining that the persons are allowed to discuss extensively, without a time limit, what the signifier means for them (possibly in a given context). If the outcome of the discussion is that it means

[1]Note that there are situations where material IBOs cannot be surrogated by abstract ones. For example, researchers dealing with historical documents might be interested in measuring the thickness and chemical composition of the paper substrate of a document or in how the document appears under ultraviolet lighting. Those "readers" could not care less about a high-resolution scan of the original, let alone a transcription; they need the material IBO. But those situations are few and only genuinely require the material IBO for "first readings," in the sense that once the special reading is performed, its value can be recorded and added to the abstract (usually digital) surrogate of the document, for example, as descriptive metadata.

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pretty much the same for everyone, then they have uniform interpretations of the element; otherwise, they have diverging or scattered interpretations.[2]

In an analogous way, if, in the scenario, the people are asked to discuss whether two signifiers mean the same, we get an informal and intuitive notion of two signifiers having similar interpretations for a given group of people.

In a given community of users, signifiers (e.g., icons, relative geometric positioning, etc.) may or may not have uniform or similar interpretations. For example, a given icon may have highly uniform interpretations in a given community, but widely scattered interpretations in some other community. The uniformity or similarity of interpretations may also be context-dependent.

The notions of uniformity and similarity of interpretations can be defined for "atomic" signifiers (e.g., individual icons or a specific geometric relative positioning), but also for compound elements such as whole windows with icons and textual elements positioned in specific geometric relationships to one another.

The notions of uniformity and similarity of interpretations are intuitive, and must not be understood as "binary" (yes/no) notions. Interpretations are not either uniform or scattered, or either similar or dissimilar, but uniform or similar to a certain degree.

Uniformity and similarity of interpretations are notions related to what could be called the "measure of meaning." The quest for such a "measure" is widely documented in empirical quantitative research, from as far back as the "semantic differential" of Osgood (1952; Osgood, Suci, & Tannenbaum, 1957) to the current statistical indicators (e.g., Cohen's or Fleiss's κ) of the agreement between raters or participants. In our framework, these tools could serve as a "reality check" for presumed or suspected uniformity of interpretations of certain signifiers.

It is generally recognized, in semiotics, that interpretations given by a certain community to a signifier tend to gradually drift over (macroscopic) time (de Saussure, 1968), partly as a result of the element being used in different contexts (Eco, 1976). Each use of a signifier modifies subtly its interpretation in future readings. Thus, for example, a signifier with uniform interpretations could start having scattered ones, and vice versa. This phenomenon involves, among other things, a learning process on the part of the community of readers. It also applies to natural languages, which are known to be "alive" and evolve through time.

Designing Renditions

In designing a rendition, a designer must first choose one or more modalities, then signifiers, to convey his or her "message." He or she must do this based on their own comprehension of how signifiers operate in the sense-making process for the community of users they have in mind. Such a comprehension can stem from introspection, intuition, personal experience, or empirical-experimentation results.

In some cases, ending up with a rendition that has uniform interpretations in the target community is *not at all* a design goal. This would be the case, for example, with works of art for which the scattering of possible interpretations is desired, or in computer games where the process of converging towards a "final" interpretation is meant to be iterative and gradual, even for a single user.

However, we claim that in applications where communication is first and foremost a matter of conveying facts or triggering actions—which we think applies to most business applications— *having renditions with as uniform interpretations as possible should be a design objective*.

Intended Interpretations

Another fundamental hypothesis of IS is that:

> Natural languages are the semiotic systems in which renditions can have the most uniform possible interpretations.

In fact, we believe that natural languages offer the widest possible range of uniformity of interpretations, from widely scattered to highly uniform. After all, natural languages can be vague and ambiguous (Black, 1937; Riemer, 2006; Sjöberg, 1982), if desired. But they also can be very precise and unambiguous (Smedslund, 2004; Wierzbicka, 1992), and that is their interesting aspect for IS.

According to the previous hypothesis, when uniform interpretations are considered desirable, renditions should be in some natural language suitable for the target community of users. However, various reasons may make this impossible or undesirable, such as display size, user literacy, ease of perception, ensuring a minimal level of aesthetic experience (McCarthy & Wright, 2004) or of fitness to a local information ecology (Nardi & O'Day 1999), and so on. The following thus seem to be more reasonable prescriptive corollaries of the hypothesis:

> **Prescription 1:** In situations where uniform interpretations are desirable, when a designer conceives of a rendition using a semiotic system that is not natural language, he or she should first specify a natural-language passage that he or she expects will have interpretations similar to those of the rendition for the target community.

We call this natural-language passage the *intended interpretation*, or the IS of the rendition.

> **Prescription 2:** In situations where uniform interpretations are desirable, whenever a rendition that is not in natural language is presented to a user, it should be possible for he or she to access its intended interpretation.

Note that we did not say it must be possible for the user to see (or hear) the intended interpretation *directly in the same*

[2]Of course, in such a scenario, the unconscious or subliminal aspects of sense making (sometimes crucial, for example in publicity) would not be taken into account. In practice, those aspects could still be identified, by empirical experimentation, and leveraged by designers in their creations. We claim the proposed scenario is nevertheless useful for conveying an intuitive idea of what is meant by uniform interpretations.

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interface as the rendition (although it sometimes might be an interesting feature). The main point is that the intended interpretation should be available to the user (or his or her representative, if he or she does not have sufficient literacy), should he or she wish to clarify or verify his or her interpretation of the rendition.

Prescriptions 1 and 2 serve as guiding principles in IS, but it seems that much of the benefits are obtained even if Prescription 2 is dropped and, in Prescription 1, the designer is required only to "be prepared to specify" the IS of the rendition rather than to actually specify it (this will be discussed in the *Impact on Modeling* subsection).

In practice, should the interface allow viewing (or playing) the intended interpretation, the operation could be realized through various mechanisms such as pop-up windows or tool-tips, and triggered by user actions such as mouse-hovering, button-clicking, or direct menu selection.

In the remainder of this article, we will only consider cases where intended interpretations are either written or spoken, but a priori, other modalities would be possible (e.g., tactile renderings such as the Braille encoding for the blind).

Note that in the remainder of this article, unless otherwise stated, whenever we refer to the intended interpretation or IS of a rendition, we assume implicitly that the rendition occurs in a situation in which uniform interpretations are considered desirable.

Multimodality

From the outset, representing the meaning of any rendition by a natural-language passage may sound like a strange idea given that as noted, the rendition may use semiotic systems that have, at least at first glance, nothing to do with natural language (e.g., drawings, icons, or musical excerpts). Note, however, that natural language is an *extremely versatile communication vehicle*, in that, in particular, it is *very easily extensible*, without prior notice, while remaining fully understandable. For example, we claim that it is entirely legitimate to consider the following sentence as natural language:

> To select the erasing tool, click on the  icon.

Note that such "sentences" are routinely found in help texts or user's manuals, and even in scientific literature (see for example, the typography in de Souza & Cypher, 2008).

For sonic semiotic systems, spoken natural language can likewise be extended with sonic elements that are not natively part of it, as in bird-song catalogs, where one can find utterances that could be transcribed as:

> The Baltimore Oriole (1-second silence) chirp-chirp

If we admit multimodal performances of natural language, then the extensibility is even clearer. For example, a performance of Beethoven's 6th Symphony can be "converted" to natural language by having an associated text zone announcing that "You are currently listening to Beethoven's 6th Symphony."

Are we saying that any rendition, regardless of the semiotic systems it uses, can be considered natural language, and therefore the prescriptive elements presented earlier are always trivially satisfied? No. We distinguish between *essential* and *accessory* (or *nonessential*) occurrences of non-natural-language signifiers in a rendition. A non-natural-language signifier occurrence is essential if it cannot be replaced by one or more verbal signifiers (i.e., words) without the rendition losing its essential meaning. The following example will illustrate the idea.

Suppose the purpose of the rendition is to present Leonardo da Vinci's *Mona Lisa*. Then, the image of the painting is essential to the rendition. However, if the same painting is used in a rendition to indicate that "clicking here will take you to the art gallery," then the use of the image is accessory since it can be replaced (just as we did in this sentence) by text.

Having made this distinction, we complement the first prescriptive element presented above (Prescription 1) by adding:

> **Prescription 3:** The intended interpretation of a rendition should contain no accessory occurrence of a non-natural-language signifier.

Meaning Conveyed by Geometry

One aspect of visual semiotic systems is that meaning is conveyed not only by individual components but also by the geometric relationships between components. For example, in a computer system interface, it is usually the case that all operations represented by icons in one toolbar belong to the same general class. Thus, the geometrical placement of an icon with others in a given toolbar conveys something about the meaning of that icon.

Purely sequential natural language lacks the possibility of expressing meaning by any relative geometrical positioning other than linear ordering. For example, in purely sequential natural language, a simple table like the one shown in Figure 1 must be expressed by something like this:

> The city of Denver has a population of 850,000 and an annual snowfall of 23 inches. The city of Rochester has a population of 240,000 and an annual snowfall of 88 inches. The city of Palm Springs has a population of 48,000 and an annual snowfall of 0 inches.

This example, adapted from Travis and Waldt (1995), was taken from Marcoux (2006).

IS recommends that only *essential* occurrences of non-natural-language signifiers be used in the intended interpretation of renditions. Thus, nonessential uses of relative

City	Population	Annual snowfall (in.)
Denver	850,000	23
Rochester	240,000	88
Palm Springs	48,000	0

FIG. 1. A simple table.

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geometric positioning must be "converted" to natural language.

Purely sequential natural language can be considered here a hindrance or an advantage; a hindrance because it disallows exploiting geometric positioning of textual elements (except ordered sequence) to express meaning, but an advantage because it forces the designer to completely make explicit *in natural language* what he or she wished could have been conveyed by geometric positioning.

As a kind of trade-off, IS allows partially geometrized text in intended interpretations, namely written text with line and paragraph breaks, as well as indentation (Marcoux, 2006; Marcoux & Rizkallah, 2007a, 2007b). Considering more richly geometrized text is on the research agenda. However, part of the interest of IS lies in the simplicity of the language used to express meaning. If too-sophisticated constructs are added, it may lose its explanatory power. Thus, increasing the richness of the semantic domain (i.e., the language of intended interpretations) must be done with great care.

Natural Language as Meaning

Clearly, a framework for meaning based on natural language would not satisfy those wishing to give meaning *to* natural language—the usual endeavor in semantics. But here, we are preoccupied by the meaning that artifacts, not natural language, can have for people. In this setting, representing meaning by natural language (for people who understand it, of course) is not inherently circular.

From a philosophical viewpoint, admitting natural language as the ultimate foundation for the representation of meaning is quite in line with the "natural semantic metalanguage" of Anna Wierzbicka (1972, 1992) in linguistics, and with the "psycho-logic" of Jan Smedslund (1988, 1991, 1997, 2002, 2004) in psychology. It can also be found in various forms in Wittgenstein's (1953, 1958) thought and in the discursive approach of Rom Harré (1995, 1999; Harré & Gillett, 1994). We briefly discuss the frameworks of Wierzbicka and Smedslund, which are, among those mentioned, the most in line with our proposal.

We fully agree with this affirmation by Wierzbicka (1972): "Artificial languages are not self-explanatory. They arise from natural language, and in the last resort are only comprehensible through it" (p. 2). In her method of semantic analysis, called "reductive paraphrase," she excludes the use of any non-natural-language sign (e.g., technical terms, neologisms, logical symbols, or abbreviations), and to capture meanings, she uses a variant of natural language made up of *universal primitive terms*,[3] complemented by local natural-language grammar (also expressed in natural language; Durst, 2003, p. 164), to be understood by everyone, including children. This relies on the hypothesis that natural language is self-explanatory, that it meets a certain psychological reality, and (a point beyond our endeavor) that the simplest sense of "lexical universals" can be matched across languages.

Smedslund (1998, 1991, 1997, 2004) speaks more of "ordinary language" and "common sense" than of "natural language." For him, psychological common sense is built into ordinary language, and the clearest expression of common sense is as a set of axioms which he called psycho-logic. As of the 1997 edition of psycho-logic, Smedslund began to use the primitive terms of Wierzbicka (1972, 1992) in the formulation of his axioms, and 7 years later (Smedslund, 2004), almost all the axioms were formed of primitive terms (Smedslund, 2004, pp. 174–177). He also believed that defining ordinary language terms is relatively useless because it leads to endless discussions, and suggested defining only terms that do not belong to ordinary language (Smedslund, 1997, pp. x–xi).

Note that in our framework (IS), we do not restrict the natural language used in the expression of intended interpretations, aside from the fact that it must be understood by the target community (or, at least, the users' representatives).

[3]Universal primitive terms are defined by Wierzbicka (1972) as "expressions in natural language which themselves are impossible to satisfactorily explicate, but in terms of which all other expressions (utterances) *can* be explicated" (pp. 12–13, emphasis in original).

Information Systems and Renditions

In Absentia Conversations

Information systems usually—and almost by definition—involve some form of storage and management of IBOs, such as database records, unstructured (word-processor) documents, and XML (structured) documents. The operation of the system includes automatic "on-the-fly" assembly of new IBOs from basic building blocks and "molds" (e.g., skeletons, schemas, models, etc.), their storage and management on some persistent medium, and their "on-the-fly" rendering into renditions for presentation to—and interaction with—users (rendering is the process, and rendition the outcome).

We distinguish the following human roles in the design, construction, deployment, and operation of an information system:

- *Modelers or information designers* devise the molds, basic building blocks, and assembly methods for new IBOs.
- *Rendition or interaction designers* devise the renditions that interact with users.
- *Authors* are particular kinds of users, who interact with IBOs with the possibility of modifying them (so to speak, with "write permission").

When we refer to "users" without further qualification, we mean "readers"(i.e., users who interact with IBOs for consultation only).

Of course, more than one role may be assumed by the same person at different times, in different contexts, or for different types of IBOs. In practice, also, there would likely be more than one "status" for authors and readers (e.g., an information manager may be allowed to modify metadata in documents, but nothing else). Finally, more roles are actually involved in the design and development of an information system (e.g., defining the business rules governing the processing of managed IBOs and the actual programming of those processes).

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For purposes of our discussion, we will limit ourselves to the aforementioned roles.

Information systems coordinate the automatic presentation of sets and sequences of renditions to users who interact with them; that is, they orchestrate *conversations* and *dialogues* with users. But conversations and dialogues between users and whom? As de Souza (2005a, pp. 89–95) noted, information systems in operation mediate conversations between designers and users (and we add authors), but in absentia of all but one of the parties. Modelers and interaction designers take part in the conversations mediated by their systems, *but only indirectly, through the artifacts they have created earlier, at design time*.

The *in absentia* character of conversations mediated by information systems accounts for part of the difficulty of designing "good" information systems, and in a nutshell, the goal of IS is to facilitate those conversations.

Nonexisting IBOs

One difficulty for producing "good" renditions of managed IBOs in information systems stems from the fact that those IBOs *do not exist yet at rendition-design time*; they exist only in modular "blueprint" or "mold" form. Static IBOs already may exist (e.g., fixed titles or subtitles in a report; the home page of a Web site), but managed IBOs will be generated on-the-fly, at system-operation time. Thus, most renditions also only exist in modular blueprint form at rendition-design time.

A mild form of a problem that can arise from this constraint is slightly nongrammatical textual renditions, such as in "You have 1 new messages," where the plural is used systematically in the "blueprint" version of the rendition. More serious problems can arise if not enough attention is paid to cases where null values or other forms of missing information are possible, or where a wide variation in the format of the stored information is possible.

However, a more important source of difficulty is that the IBO blueprints themselves are expressed in unnatural semiotic systems (i.e., artificial languages). This is necessary because the creation of IBOs and their processing (including rendering) during system operation must be automated. These blueprints, or molds, are documented, but the documentation could take any form or shape and is, for all practical purposes, unpredictable. Thus, the rendition designers must try their best to understand the morphology of the IBOs that the mold can generate, to understand the relationships between the "shape" of a generated IBO and its meaning, and to translate these relationships into modular rendering of IBOs capable of producing renditions that convey an appropriate meaning for all IBOs.

The IS Approach

The IS Apparatus

The IS approach recommends that the preparation of the intended interpretations of managed IBOs be *an integral part of the modeling process*. The recommended preparation consists more precisely in assigning *text segments* to each "part" of the molds that will be used for generating IBOs during system operation. Those segments are constructed in such a way that during system operation, they can be combined with the actual contents of any IBO to yield its *intended interpretation* or IS (note that it is here the intended interpretation *of an IBO*, not of a rendition). The exact nature of a "part" and the exact combination rules depend on the type of mold (i.e., on the underlying data model: relational, textual, XML, etc.). An example will be given shortly using XML schemas.

The assignment of text segments to the various parts of the mold is called the *IS specification* of the mold. Thus, specifying the IS of a mold at the time it is designed allows the IS of individual conforming IBOs to be automatically generated later.

Note that in the setting just described, the preparation of the IS of renditions is actually assumed by the modeler, not by the rendition designer, as Prescription 1 suggests.[4] In a sense, one could say that the IS of renditions comes first, and it is the job of the rendition designer to arrange for "on-the-fly" generated renditions to conform to this IS.

Thus far, in the development of IS, the text segments associated to the various parts of molds—whether XML schemas or database schemas—have been simple "peritexts,"[5] namely "text-before" and "text-after" segments, which are used as prefix and suffix, respectively, to the actual contents of the IBO in that part of the mold. Both XML schemas and database schemas possess an ordering of their parts.[6] That ordering determines the order in which the contents of the various parts of the mold, together with affixed "text-before" and "text-after" segments, are collected to form the IS of the IBO.

More sophisticated IS-generation mechanisms can be imagined, and it is part of our research agenda to investigate some of them. For example, mechanisms similar to the "mail merge" function of common word processors (which generates customized bulk letters from a database of contacts) could be viewed as IS-generation mechanisms for databases (they would, of course, need to be integrated to the database management system). However, parsimony is indicated, as too powerful mechanisms might impair the usefulness of the approach by allowing too large a "distance" between the "looks" of an IBO and of its IS. Too large a distance may not be a problem for the users, but it may be for the developers (in particular, programmers) who have to express operations and manipulations of IBOs based

[4]Prescription 1 continues to apply for renditions of individually crafted IBOs.

[5]The term "peritext" was coined almost at the same time (in 1987) with two different meanings, by Gérard Genette (1987) and Marcel De Grève (1987). Our use of the term is closer to Genette's, for whom it designates segments around a text, in the space of a single document, such as a title, a foreword, or even footnotes "inserted in the chinks of the text." For us, however, these segments also must have sequential compositionality with the text around which they appear.

[6]In relational database theory, the fields of a database table are not ordered; however, in implementations, they are de facto ordered.

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on the understanding they have of its structure, and IS is exactly supposed to provide an adequate understanding for that purpose.

An Example

The example is adapted from Marcoux and Rizkallah (2007b). In this example, the IS apparatus is applied to XML schemas as "molds," and XML documents as IBOs. The schema (omitted) is very simple, consisting of the declaration of a top-level element (billing) containing a sequence of four mandatory subelements. It represents a tiny portion of an actual schema used in a data-exchange project.

Figure 2 shows an example of a conforming XML document. The reader easily can imagine what a typical visual rendition of that XML document would look like.

The IS specification for an XML schema takes the form of a table giving, for each element declared in the schema, two "peritexts:" one "text-before" segment and one "text-after" segment. Figure 3 shows the IS specification for the schema of the example.

Figure 4 shows the IS generated for the conforming XML document shown in Figure 2 (the peritexts are shown as normal text while the actual contents of the XML document are shown on black background). As noted earlier, the IS is expressed as moderately geometrized text, with line breaks and subelement indentation.

```
<billing>
  <amount-burial>1205.47</amount-burial>
  <payable-burial>D</payable-burial>
  <amount-cremation>788.00</amount-cremation>
  <payable-cremation>F</payable-cremation>
</billing>
```

FIG. 2. XML document conforming to the schema.

Target Communities and Multiple Renderings

The design of an information system is always done with some given target community of users in mind. Identifying the target community is a prescribed step in IS, as in many extant systems design methodologies. However—and this also is widely acknowledged in systems design methodologies—there is seldom a single target community. In fact, there could be up to one target community for each of the various roles that humans can take in the operation of the system (discussed earlier). This could imply that several distinct renderings of the same IBOs are necessary.

This raises the question of whether all possible renderings of an IBO should have the same IS. It seems intuitively desirable to have just one IS for any given IBO. If two renderings of the same IBO are so different that a single IS cannot apply to both, then we suggest considering the renditions as renditions of two *different* IBOs, one being automatically derived from the other.

For example, consider a relational database table, and a (relational) view, suitable for a certain category of users, obtained from the table by extracting (i.e., projecting on) specific columns. Here, the column-extraction mechanism could not be considered as part of the rendering mechanism because a single IS could not possibly apply to records with and without certain columns. Thus, the full table and the view (as well as corresponding records in the two tables) should be considered as different IBOs.

In contrast, two renderings of a list, with the items arranged in a column and in a line, respectively, would be considered two renderings of the same IBO because the same IS could apply to both renderings.

Element	Text-before	Text-after
billing	"This section gives the billing information for this order."	"End of billing information section."
amount-burial	"Amount charged for the burial service: "	" canadian dollars;"
payable-burial	"this amount is payable by: "	" (D = Funeral director; F = Family)."
amount-cremation	"Amount charged for the cremation service: "	" canadian dollars;"
payable-cremation	"this amount is payable by: "	" (D = Funeral director; F = Family)."

FIG. 3. IS specification of the schema.

```
This section gives the billing information for this order.
    Amount charged for the burial service: 1205.47 canadian dollars;
    this amount is payable by: D (D = Funeral director; F = Family).
    Amount charged for the cremation service: 788.00 canadian dollars;
    this amount is payable by: F (D = Funeral director; F = Family).
End of billing information section.
```

FIG. 4. IS of the document shown in Figure 2.

Linguistic Competences and Multilingualism

Obviously, if we posit that making available to users natural-language equivalents of IBOs or of arbitrary renditions can increase uniformity of interpretations, we are assuming that the target community is sufficiently competent in the specific natural language used. But there are cases where this assumption is not realistic. For example, in a multilingual target community, it is possible that no single language is understood by all users.

Those cases could be dealt with in two ways in IS. On one hand, we could consider that the intended interpretations are addressed to a *representative* of the user, who can translate or otherwise explicate them to the user. On the other hand—and this is probably the most realistic and practical approach—distinct IS specifications could be developed in parallel. Their elaboration would then fall under the realm of *localization*, a field which has links to systems design, but is largely a discipline of its own.

Grammaticality and Style

Because the generation of intended interpretations is automatic and because the mechanism to generate them is intentionally simple, the question arises whether the intended interpretations must be grammatically correct (strictly grammatical formulations are harder to generate automatically than are nongrammatical ones).

Because the eventual readers are known to be human, with high "fault tolerance," there is actually no reason to require intended interpretations to be strictly grammatical. The meaning of a nongrammatical passage may still be clear and unambiguous for humans; however, if grammatical defects are severe (e.g., if there are sentences without a verb), ambiguity may arise since each individual reader is likely to supply his or her own version of the missing elements, resulting in possibly widely diverging "actual meanings." As much as possible, style should be direct and clear, and adapted to the target community, even if strict grammaticality is not required.

Natural language without strict grammaticality is also found in Wierzbicka's (1972) "reductive paraphrases," which are constituted of primitives combined in natural-language *sentence-like* expressions, and in Wrightson's (2005) "quasi-natural language," in a structured-document setting.

Nonlinguistic Competences and Hyperlinks

Often, specific competences, over and above linguistic competences, are assumed from the target community. For example, in systems custom made for an organization, it often will be assumed that the target community is familiar with the administrative structure of the organization, and with its "culture." In finance, statistics, or law applications, it will be assumed that the target community possesses a certain level of knowledge in finance, statistics, or law. We use competence in a generic sense, which includes skills, ability, knowledge, and so on.

Identifying the presupposed competence from the target community helps designers decide if the elaboration of help and training is necessary, and if so, what the baseline for those should be. The principle is simple: Any competence that is not presupposed from the target community and that is necessary for proper usage of the system will have to be acquired by the target community.

Those extra requirements may be general for the system, but some may apply specifically to the consultation of certain types of IBOs. In those cases, it would be useful to alert the user of the extra competence required for consulting the IBO, and even to point to any help or training that may have been developed to acquire this competence.

To allow the IS of the IBO to play this role, while remaining self-contained, a simple convention for embedding *hyperlinks* in intended interpretations is included in the IS framework. In previous work (e.g., Marcoux, 2006), this has been accomplished by giving certain characters a special "hyperlink-delimitation" status in the peritexts of the IS specification. The idea is that when consulting the IS of an IBO, the user can dynamically traverse the hyperlinks by clicking on them (or through some equivalent action). In spoken natural-language incarnations of the framework, sonic conventions for delimiting hyperlinks, and actions for triggering their traversal, would have to be established.

Levels of Granularity

IBOs based on common data models are structured hierarchically. This is true at least of relational and textual databases, and of structured (XML) documents. In the rendition interface of such hierarchical IBOs, it would be possible to permit viewing the IS not only of the entire object but also of sections of the object. The user would be able to select a "branch" at some point in the hierarchy and ask for the IS of that branch only. This would make the "navigation" through the IS of large IBOs much easier (Marcoux & Rizkallah, 2008).

Applications and Benefits

Conversation Facilitation in Information Systems

In itself, specifying the IS of a mold at the time of its design does not entail that the mold (i.e., model, schema) itself becomes readable in natural language. The IS apparatus only guarantees that an intended interpretation can be generated *for objects conforming to the mold*. However, we claim that the IS specification implicitly and indirectly reveals the "meaning" of the mold and thus can facilitate in absentia conversations between modelers and rendition designers (discussed earlier in the *In Absentia Conversations* subsection).

There are (at least) two ways in which the IS specification of a mold can yield insight into its "meaning." First, the IS specification can be consulted directly. Since it contains natural-language segments and because the composition rules

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are fixed and simple, a comprehension of the "role" of each part of the mold can be gained in this way. Second, fictive toy instances of conforming objects can be constructed and their IS examined, demonstrating how each part of the mold behaves and interacts with the others. This can help develop or confirm an understanding of the respective role of the various parts of the mold.

We also claim that the IS specification of a mold facilitates the conversation between modelers and *authors*, who populate with contents newly created IBOs or update existing ones. Indeed, the possibility of consulting at any time the intended interpretation of the object the authors are working on allows them to constantly verify that their contents will actually be interpreted in the way they think. The potential benefits of IS for modeler-author conversations have been discussed in previous work (Marcoux 2006, Marcoux & Rizkallah, 2007b).

Impact on Modeling

There have been few applications of IS (Marcoux & Rizkallah, 2007a, 2007b, 2008), but in all cases, the main benefit has been the impact *on the modeling process* of having to think about intended interpretations right at modeling time. Having to write an IS specification together with a model, for example, can reveal ambiguities and useless distinctions in the model as well as defects in its structure, or uncover "hidden" or avoidable dependence of the sense-making process on distant information not already known by the target community of users (e.g., a table of codes). Such dependence would typically show up as hyperlinks in the IS specification.

In short, the complexity of the IS specification of a model is commensurate with the sense-making effort that people interacting with conforming IBOs will have to expend for "understanding" them.

What we believe is going on is that writing the IS specification while building a model orients the modeler's mind towards making the "right" choices for the conforming IBOs to be understandable because it brings the modeler to think of *what* he or she wants the IBOs to tell the users rather than *how* the IBOs should be structured. Structure becomes secondary, and the message, expressed in the plainest possible way, becomes primary.

Actually, IS suggests a new approach to modeling, in which the modeler first writes the desired IS of representative IBOs, infers from that the IS specification of the model, and finally, fills out the details to obtain the model itself. We call this approach "literate modeling," echoing Knuth's (1984, 1992) "literate programming."

IS and literate modeling can help choose appropriate names for the various "parts" of a model (e.g., database field names or XML element names). A judicious choice of part names can have an impact on the perennity of conforming IBOs, which may then remain understandable, even if isolated from their original creation context (Marcoux & Rizkallah, 2007a).

Other Applications

The general IS approach can help clarify the implicit inherent semantics of certain constructs in data models because it requires specifying composition rules for generating the intended interpretation of conforming IBOs. For example, XML attributes were analyzed from this angle in Marcoux and Rizkallah (2007a). We believe IS also could provide intuitive understanding of certain design constraints associated with data models; for example, some of the normal forms for relational databases (Date, 2004). Yet other possible application areas were mentioned in Marcoux (2006).

Interface and Interaction Design

In this subsection, we consider only nonmoving visual interfaces. One way to look at interface design is as the direct design of renditions rather than through the definition of a model (i.e., mold) that series-produces IBOs. In the IS framework, thus, Prescriptions 1 and 3 apply. One particularity of visual interfaces is that they rely heavily on relative geometric positioning of components. According to Prescription 3, those signifiers have to be expressed in sequential natural language by the designer.

Just as we argued that writing the IS specification of a model orients the modeler's mind toward the "right" choices, so we think that having to write the IS of a rendition should orient the designer's mind towards the "right" choices by bringing him or her to think of *what* he or she wants the rendition to tell the user rather than *how* it should be structured. We believe this could be the main benefit of the IS approach to interface design.

The possibility of interaction can be introduced in various ways, depending on the type of interaction. For example, the possibility of triggering arbitrary operations by "point-and-click" type of actions could be handled by generalizing the hyperlink traversal operation already present in the IS framework. It would suffice to introduce a convention in the semantic domain (the language of intended interpretation) so that certain passages are recognized as "controls" that can trigger operations (those controls could even be activated while consulting the IS, if the interface allows such a consultation).

Keyboard data entry can be treated as the creation of a tiny document, with the user assuming the role of the author. Thus, the user would see right at data-entry time the exact textual context in which the information he or she supplied is going to be interpreted. This could reduce the risk for misinterpretations, wrong formats, or inaccuracies.

Design of Concrete Objects

There are two ways in which IS could be applied to the design of concrete objects. The first one is to analyze a concrete object as a rendition, in which the various affordances of the object (Norman, 1998) correspond to components (or controls) in the rendition, and the geometric relationships

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(this time, 3D) between physical affordances correspond to geometric relationships between the controls in the rendition. Just as the geometric relationships between components in a rendition must be given a natural-language explication in IS, so also would the relationships between affordances. Such an IS "reading" of the object would constitute a part of the documentation of the object.

The second way IS can apply to concrete-object design is for information appliances (e.g., watches, music players, telephones, etc.), which have display (or playback) capabilities. For such objects, it is only natural that the documentation of the object (e.g., user manual, etc.) be integrated in the object itself, where it becomes an extension of the interface, and of the set of physical affordances of the object. One thus can imagine the IS of an object displayed (or performed) "live" on the object's very affordances.

Note that from this perspective, the issue of writing with style (documentation) blends in a continuum with that of designing (a concrete object) with style.

Conclusion

In this article, we presented the origins of the IS approach to information design and the underlying hypotheses and principles. We argued that even if its basic principles seem remote from current trends in design, IS is actually compatible with—and complementary to—those trends (especially de Souza, 2005a). Finally, we hinted at further possible application areas such as interface and interaction design, and the design of concrete objects.

Much work remains before IS can present itself as a complete framework for full-fledged information-architecture projects. Among other things, the framework itself has to be refined, more powerful mechanisms for IS generation must be considered, and the role of geometry in the semantic domain (the language of intended interpretations) must be better understood.

There is no doubt that (as noted in Marcoux, 2006) working out the IS specifications of new and existing models, as well as deploying IS in general, can be a considerable task; however, we are convinced that in many cases, the benefits of greater usability and efficiency in the future justify the efforts.

We are just starting to experiment with the IS approach in the area of interface and interaction design. We are currently working on the search interface of a virtual library, and expect to derive useful guidelines from this experience.

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