Adding 'Sense' to Conceptual Modeling: An Interdisciplinary Approach

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Abstract: In this paper, our aim is to widen the prevailing foundations of conceptual modeling theories and practices, particularly in the context of information systems development. The approach shifts the focus from the link between a model and the modelled reality to the link between human cognition and the model. Our approach combines theoretical issues of different disciplines relevant to conceptual modeling. We shall make an explicit distinction between individual *conceptions* and interpersonal *concepts* and show how this distinction could be utilized to have conceptual models of a better consistency. We wish that this article could also serve as a starting point for a profound scientific discussion on the real sources of conceptual models, i.e. the human mind.

1 INTRODUCTION

In this paper, our aim is a step towards the unification of thought and language (see Almog, 2005) in the context of conceptual modeling. Practically, the target is to improve the logical consistency of conceptual models by ensuring that the *individual interpretations of reality* form a more consistent whole.

It is widely acknowledged that conceptual modeling (CM) is a crucial part of information systems development (e.g. Clarke et al., 2016; Wand & Weber, 2002). Especially, modern complex IT applications, like big data systems, require solid CM tools and practices (see Storey & Song, 2017). Attempts to build a conceptual model of an enterprise architecture, for example, may be an extremely complex task (Halttunen et al.,2006).

While numerous models are needed before a complex system is in action (see Wand, 1996), it can be extremely difficult to have a shared view of what all the models mean or even what they should represent. So far, the researchers' main concern has been the accuracy and consistency of the modeling language. Instead, human thinking and conception as the starting point for, and the content of, a conceptual model has gained less attention. This is surprising, since the conflict not only between the modelers' perceptions but also between modelers' conceptions is evident (see Easterbrook, 1991).

Considering conceptual modeling as semantic modeling (e.g. Wand et al. 1999) implies that it is not only a matter of detail-hiding or abstraction but also of carrying meaning, or sense-making. While formalization of conceptual models is an important issue in the IS field (e.g. ter Hofstede & Proper, 1998), it is necessary to understand, how formalized models could be produced from human cognition (see Siau and Tan, 2005).

We suggest that the formalization of conceptual models should start from the very first communicative phases of an ISD process (e.g. see Chen et al., 1999). Actually, there are several severe attempts to take the social and communicative perspectives into account, e.g. Soft Systems Methodology by Checkland (1981), ETHICS by Mumford (1983), speech act based methods like SAMPO by Auramäki et al. (1988) as well as tools and methods based on communicative genres (e.g. Päivärinta, 2001). More philosophical discussions can be found in Hirschheim et al. (1995), Lyytinen (1985), and Hanseth and Monteiro (1994), for example. Nevertheless, none of these contributions deals thoroughly with the link between the informal specifications and the more formal ones.

When considering the development of conceptual modeling there are three relevant, interacting worlds: the physical world, the individual world(s) and the

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interpersonal world(s). To describe and clarify the three worlds and the linkages between them we shall utilize both philosophy and linguistics. Especially, we make use of the theories of meaning. We combine semantics of ordinary language (e.g. Lyons, 1971) with a more formal approach called possible worlds semantics (e.g. see Copeland, 2002).

The rest of the paper is organized as follows. We start by describing the problem. Next, we shall provide the foundational concepts upon which we build our approach. In Chapter 4, we consider human consciousness as a philosophical-linguistic concern. In Chapter 5, we present a simple conceptualization model. In Chapter 6, we provide preliminary ideas how traditional conceptual models can be extended by features that help to link thinking and talking about a domain to more formal specifications. Finally, we sum up the ideas of the paper.

2 SEARCHING FOR THE BUILDING BLOCKS OF THE BRIDGE

In order to get semantically rich, yet logically consistent models of a domain, the modeling process should ensure (1) that the sense of the concepts is understood and agreed by the relevant parties of the domain, and (2) that the agreement is conceptually consistent. Our assumption is that the easiness and the quality of interpersonal target-oriented communication is dependent on how consistent and reasonable the individuals' interpretations are. When the worlds of individual conceptions are not logically consistent, it is not possible to build a consistent whole, while a consistent and inclusive individual world can correct and complete other individual worlds. Consider the following example.

Let there be four persons A, B, C, and D. Let there also be two **things** with *attributes*: a *red* **car** and a *green* **book**. One of the persons, say D, suffers from red green color blindness. While perceptions of red light for A, B and C are mapped to their conceptions in a way that there is a correspondence between the perceptions and the concept of 'red', for D the concept of 'red' is purely abstract having no particular content of perception. This is because he cannot say, for example, whether the car is red or green, what the color of the book is or, how the colors differ from each other. This knowledge must be communicated to him. However, D knows through language that there are red and green things and that these colors can be used, for example, to define other concepts. Thus, he can build even a large conceptual net in which part of the concepts has no correspondence to his experiential world. In this case, the shared concept of 'red' has referent in the real world, while the conception of 'red' for D does not have. The D's conception of 'red' is based on the others' descriptions of 'red', and has the reference only in the interpersonal mental world.

Even when the world of individual conceptions has a direct link to the world we can hear, see, and feel ─ physical world ─ the individual world is more or less ambiguous, since it is based on (1) physical phenomena, (2) internal cognition, and (3) social construction. The last viewpoint is extremely important (e.g. von Braun et al., 2000). The social construction means that our internal mental states are strongly affected by communicating and compromising the individual conceptions of fellow creatures.

3 FOUNDATIONAL CONCEPTS

Communication among human beings is a result of a sequence of cognitive and linguistic actions. Falkenberg et al. (1998) and von Braun et al. (2000) talk about perceptions, conceptions, and representations. Perceptions can be seen as patterns of visual, auditory or other sensations of one's mind, whereas conception is a result from the process through which a human actor interprets a perception in his mind. In order to communicate these conceptions one needs communicative constructions (representations).

Our foundational concepts in this paper include *perception, conception, concept, meaning, and sense*. In the rest of the article, we use them in the following way.

Perception is a product of human mind that is limited to a single event or, more strictly, to a physical phenomenon that can be realized by human senses. Observation could be used as a synonym for perception.

Conception is a product of human mind that could also be called an idea or a thought that has conceptual content. When a perception starts to be communicative, it "turns into" a conception in the human cognitive system.

While a conception is a mental thing that can be communicated with other people, it can be distinguished from a concept (see Macià, 1998). Whereas a *concept* can be seen as a carrier of shared meaning for a group, a conception is a carrier of meaning of this particular concept for an individual.

Thus, a conception can also be called an individual interpretation of a concept, and, vice versa, a concept can be seen as a consensus on individual conceptions at a certain point of time. Both conceptions and concepts are "named things". They are referred to by their names, which we call words. The meaning and the name together form a sign that is used in communication (see Lyons, 1971).

The difference between a conception and a concept is in the meaning of the sign. Hereafter, when we refer to the meaning at individual level, we use the word *meaning*. Instead, when we talk about meaning at the interpersonal level, we use the word *sense*. Getting closer to the meaning helps us to get more stable, accurate and consistent sense for concepts, and thus, conceptual models of a higher quality. The better quality could benefit ontology engineering, for example, since ontologies can be seen as explicit and formal specification of shared conceptualization (Studer et al., 1998).

Like abilities to perceive are dependent on the observer's senses, "interpreting abilities" are dependent on the interpreter's whole history as an intellectual being. Therefore, conceptions cannot be considered static but sensible to all chances in circumstances.

4 HUMAN CONSCIOUSNESS – A PHILOSOPHICAL-LINGUISTIC PROBLEM

People differ from other creatures in that we are aware communicators implying that can use symbols to discuss symbols (Stacks et al. 1991). Furthermore, we can refer to different things that are far from the situation: we can talk about what happened in the past or what would possibly happen in the future, we can talk about abstract things that nobody has ever observed, we can talk about meanings or meanings of meanings etc. People have the ability of thinking not anchored to a particular perceptual context (Katzafanas, 2005, p. 9).

Indeed, language is a core feature of humankind. As Brand (2004, p. 317) puts it: "Language interpenetrates the human; it is not distinct from either thought or world, but it is thanks to language we have on one hand a subject capable of thought, and on the other, a meaningful world."

Popper's thesis of three worlds provide a useful tool for our purpose. The three worlds are: (1) the physical world or the world of physical states, (2) the mental world or the world of mental states, and (3) the world of intelligibles or of ideas in the objective sense (Popper 1972, p. 154). The last one is what Popper calls the third world, which he also describes as "world of possible objects of thought".

The physical world is very much what we, in ordinary speaking, call reality. The second world is subjective. It consists of individual consciousness. The third world is populated by human products, which are purified by critical argumentation. Popper (1972, p. 107) says that "…inmates of this world are critical arguments, and what may be called… the state of a discussion…" The first and the third worlds cannot interact directly but only through the second world.

In the following, we consider human communication from the viewpoint of semantics, in general, and possible worlds semantics, in particular.

4.1 Theories of Meaning

Meaning as a linguistic issue has interested both philosophers and linguists. In linguistics, it is primarily seen as a matter of semantics, but also pragmatics deals with meanings (Hudson 1984, p. 4).

Semantics as a term is quite new. It can be traced back to the late 19th century (Lyons 1971, p. 400). Around that time a German philosopher and mathematician Gottlob Frege made remarkable philosophical work (Frege, 1892) that helped to consider 'meaning' as both an ontological and a linguistic issue. His aim was to unify language and thought, but it is not clear how four-square he believed in his own ideal (Almog, 2005)

In short, Frege (1982) made the well-known distinction between reference (Bedeutung) and sense (Sinn). Frege talks about references and senses of signs (i.e. names, combinations of words, letters). The reference of a sign is the thing the sign refers to. Defining the sense of a sign is a more complex task. The easiest way may be to make use of the notion of 'idea' (Vorstellung). Frege says that the idea is an internal image of the reference. It is always subjective. According to Frege the sense is something that is between an idea and the reference: it is not subjective like the idea, but it is not the object of the sign (= the reference) itself either.

It is obvious that without a notion similar to Frege's 'idea', "the human factor" of information systems design is limited to, and by, lingual elements that can be identified and (pre-)defined (those that carry senses). Although CM is about modeling the senses of concepts of a domain, and we therefore need pre-defined concepts, a high quality model of a non-

trivial domain require good understanding of individual conceptions on the domain.

Lyons (1971, p. 427) says that "by the sense of a word we mean its place in a system of relationships which it contracts with other words in the vocabulary" (also see May, 2006). This way of thinking, in turn, means that since the relationships are between the vocabulary-items, there are no presuppositions about the existence of objects or properties outside the vocabulary of the language. This makes it possible to discuss abstract things to the extent of the coverage of the vocabulary. The vocabulary is, however, changing all the time and, as an artifact, it is totally dependent on (1) individual cognitive processes, and (2) communicative processes between individuals (see Katzafanas, 2005).

So far, we have discussed the meanings/senses of single signs or symbols, which in an ordinary language are written or uttered words. Pragmatics is a branch of semiotics that deals with the relation of signs to interpreters (Levinson, 1983). Its emphasis is on language usage (Levinson, 1983, p. 5). Utterances and speaker's intentions are important notions in pragmatics. Communication is seen as "a complex kind of intention that is achieved and satisfied just by being recognized" (Levinson 1983, p. 16).

Pragmatics goes further from knowing the meanings of words. In doing so, pragmatics can be seen as complement to semantics as a theory of meaning. As Lehrer (1980, p. 6) puts it, "[T]he meaning of the words is one thing and their use another." Furthermore, "understanding an utterance involves the making of inferences that will connect what is said to what is mutually assumed or what has been said before." (Levinson 1983, p. 21)

Based on the views of Wittgenstein and Dewey, Medina (2004) state, that "the meaning of words is not whatever is agreed upon their users", and, "[t]he relation between meaning and agreement is more indirect: agreement is the background condition for the emergence of meaning." In other words, while agreement cannot change the facts around us, they are a necessary means to human interpretations on the facts. This idea is very important when trying to bridge the conceptual gap discussed before.

Higginbotham (1998) distinguishes three levels of meaning (of a word):

(1) merely possessing a word, or having it in one's repertoire, and so being able to use it with its meaning,

(2) knowing the meaning of the word, and

(3) having an adequate conscious view of its meaning.

In terms of our thinking, all these levels consider the meaning at the individual level.

Higginbotham (1998) talks conceptual competence, which can be seen as a result of a gradual process in which the grasp of a concept one already possesses can be perfected. Thinking in this way makes it necessary to distinguish the concept itself and the conception of the things that fall under the concept. According to Martí (1998) the significance of this distinction may be very radical, if it is interpreted that there are "concepts which are such that no one possessing them will ever be in position to obtain an adequate conception of the kind of things the concept applies to".

Since concepts are essential to, and characteristic of, communication and since they live in communications, they have to be considered as being partly outside individuals (e.g. Higginbotham, 1998). Instead, as the meaning of an utterance is at least slightly different to the sender and the receiver of a message (see Levinson, 1983), it is reasonable to say that both communicators have their own conceptions of the concept. Concept are, thus, communicative entities that are tied to language on one side (sense carrying words defined by theirs relations in vocabularies) and to mental states of individuals (conceptions of concepts).

In the following sub-chapter we provide a brief introduction to possible worlds semantics that could help in building the bridge between informal and (semi-)formal descriptions of a domain.

4.2 Possible Worlds Semantics

Possible worlds is an interesting notion that can be used to describe different kinds of imaginary systems. A possible world is a world with internal consistency that makes it possible in logical sense (see Girle, 2014). Our reality, the physical world around us, is one of the possible worlds, since it exists and is, therefore, most obviously possible. According to Hintikka (1982, p. 87) the basic idea of the notion 'possible worlds' is that it covers "everything" that is possible.

Let us symbolize a real world domain, which is to be modeled conceptually, by D, and the conceptual model of D by M. Taken that D is one of the possible worlds, in order to build a good model of D, we should set the same requirement for M, too. In other words, when M is logically consistent (a possible world), it is *possible* that it is an exact model of D. If M was not possible, how could it be a candidate for a good model of D?

Hintikka (1982) interprets that Frege's 'sense' (Sinn) is a function the value of which is the reference. He also argues (p. 86-87) that the arguments of such functions of meaning are the possible worlds. Concepts (their senses) are, thus, functions from possible worlds to references (objects the concepts refer to).

Since the world of individual conceptions may not form a possible world, the world of concepts for a group of individuals would remain more or less ambiguous. However, the conceptions can be refined to be more consistent, leading to more consistent use of the corresponding concepts. This would make it possible to have strict definitions for the concepts of a domain.

If the meaning/sense of a particular lingual element (concept/conception) is dependent on individual interpretation, how much formality can be applied, when trying to catch the meaning/sense? Taken that so-called intentional concepts are functions whose arguments the possible worlds are (Hintikka, 1982, p. 20), an individual conception, in fact, can be seen as a function that have "conceptual state of things" as its arguments. In the first case, the function returns the reference (the object in the possible world referred to by the intentional concept) as its value, whereas in the second case, the function returns the concept as its value (the concept in a conceptual network that is referred to by the conception). In different conceptual states of things, this function returns a different value.

When the conceptual state of things (i.e. how conceptions are related to each other) is inconsistent, it cannot represent reality that is consistent (possible) by its nature. Therefore, the first step should be to check and ensure that the individual worlds (of modelers modeling the domain) are consistent. In following, we shall provide a model dealing with the issue.

5 A SIMPLE CONCEPTUALIZATION MODEL

According to Katzafanas (2005, p. 6) the shift from an unconscious state to a conscious state is the process of conceptualization. In other words, a state becomes conscious once its content has been conceptualized.

In the following, we present a simple conceptualization model which consists of three worlds: (1) the world of real entities which the concepts refer to (in ordinary speaking: reality), (2) the world of concepts that we call the interpersonal world, and (3) the world of conceptions that we call individual world.

To go further we make three basic assumptions:

Assumption 1: There is an objective world *W* independent of the observer. This is the world of real entities.

Assumption 2: The observer (individual) can gain information about *W* directly through his/her senses (perceptions) or indirectly though communication with other people.

2.1. Information about *W* is always limited to and/or biased by perceptual and cognitive abilities. Therefore, part of information (theoretically) available is lost during observation.

2.2. Concepts (words and their senses for capturing perceived or abstract things), which are needed for communication, are interpreted by individuals and they relate to individual conceptions. When an individual conception is "externalized" through communication, part of its meaning remains hidden. Similarly, when a concept is "internalized" by an individual, part of its sense may not be conceived by the individual.

Assumption 3: In interaction with each other, all the three worlds change continuously.

On the basis of the above assumptions, we present a simple model (Figure 1). There are three worlds in the model: The Objective World, The Interpersonal World and The Individual World. In terms of Frege's meaning concepts these worlds correspond to reference (Bedeutung), sense (Sinn), and idea/internal image (Vorstellung).

The interacting yet separate three worlds consist of different things. The Objective World consists of real entities. The Interpersonal World consists of concepts. By concepts we do not mean only words and their senses but also, and particularly, all complex structures that are built upon them: ontologies, taxonomies, vocabularies etc. And finally, the Individual World consists of perceptions, conceptions and tacit knowledge. Although tacit knowledge is out of our scope, we have included it in our model to remind that besides observations about the Objective World (i.e. perceptions) and conceptions, there are also third kinds of cognitive things of human mind. They, on one hand, carry more complicated information than perceptions do, but, as contrast to conceptions, they remain unconscious to an individual. For example, when an individual can accomplish a complex procedure but cannot explain

(conceptualize) how she has done it, we talk about tacit knowledge (e.g. see Nonaka et al., 1996).

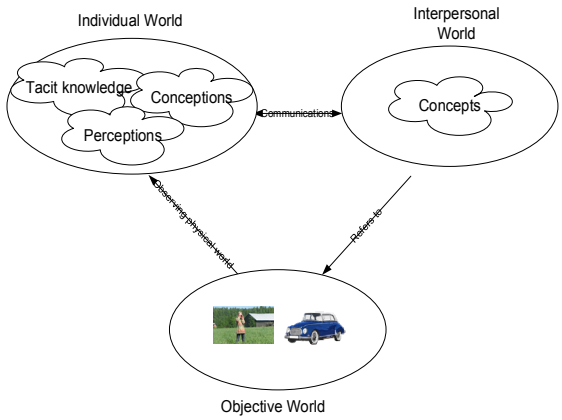

Figure 1: A conceptualization model.

Typically, conceptual modeling has dealt with elements that fall into the categories of concepts and their references. They are things that are named, often rather well-defined, and purified from conflicting material. Excluding a few exceptions, conceptual modeling seems to ignore the fuzziest area of modeling, human conceptions.

We argue that what needs to be done in conceptual modeling is to build a bridge between conceptions and concepts. An easy way to build such a bridge is to combine informal elements and formal elements in one picture. A good starting point could be typical ER modeling. Modifications that need to be done include:

1. The concepts must not be considered as symbols for real world entities but rather as carriers of senses that are linked to the individual conceptions (meaning of concept to an individual). E (entity) in ER modeling is replaced by C (concept) resulting in Concept Relationship modeling (CR modeling).
2. According to (1), we are not interested in the properties of real entities (i.e. attributes attached to entities) at this stage but rather in properties of the conceptions. We call these attributes conceptual attribute.
3. Attributes attached to concepts need to clarify individual conceptions on the concepts being discussed. The most important one of such attributes is *definition* (for expressing personal definition for a concept, i.e. how the concept would relate to other concepts in the individual's mind).
4. Relationships between concepts are not those that are observed, but those that are expressed by an individual modeler (through the definitions of concepts). In other words, a concept is related to another concept, if someone says so. This is what personal conceptions are all about. Inconsistencies are identified and removed later.

A CR model combines two levels of formality in one picture. On one hand, there are normal language expressions (conceptual attributes), and on the other hand, there are graphical expressions that follow a certain formality (concepts and relationships). In the next chapter, we present a modest example how a modeling effort could proceed.

6 MODELLING CONCEPTS/CONCEPTIONS IN PRACTICE

Traditionally, there have been three phases in concept modeling of a domain: (1) to find entities (concepts) that cover the domain, (2) to analyze the relationships between the entities, and (3) to add attributes to the entities. This works fine when one aims at a model for implementation. However, the procedure may not work very well when trying to form a consistent picture of the concepts that individuals use to describe a domain (conceptions and their relationships). We believe that the best way is to talk about the individual views and conceptions. This, in turn, requires that we can use natural language and that the natural language is smoothly tied to a more formal representation like a graphical model. In this part, we shall describe how traditional ER modeling can be enhanced by a new modeling level.

Conceptual models, like ER models, refer to the real world domain, which they represent (Figure 2). Thus, the concept CAR in an ER model refers to the class of cars in the real world and the concept PERSON refers to the class of persons in the real world. The entities relate to each other through relationships. Furthermore, attributes are attached to entities. When we talk about attributes attached to CAR, we actually talk about the properties that are shared by the entities of the class of cars. Some key attributes may explicitly identify an entity within the class of similar entities.

But, what if we are primarily interested in the consistency of the domain model? Who says that the concepts CAR and PERSON are relevant concepts is that domain? And further, if they are, how can we be sure that everyone modeling the domain understand the concepts CAR and PERSON in a similar way?

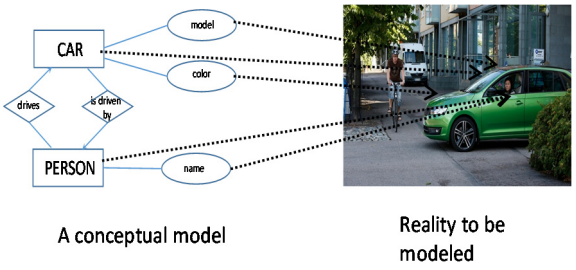

Figure 2: A typical ER model.

In this simple case, it is obvious that no misunderstandings will happen, but what if the domain was a complex one, like an enterprise architecture, or a model of climate change? While such a modeling task would require several models produced from different viewpoints, how can we be sure they form a model, which would be both covering, non-redundant and consistent at the same time?

In Figure 3 we describe, how "CR" modeling differs from ER modeling. When modeling a real world domain, a modeler uses the concepts just like in ER modeling. However, she does not define the concept through the attributes of the entities referred by the concept, but through the definition in which the concept relates to other concepts. Each modeler has finally her/his own view of the relevant concepts of the domain. Before the individual models are integrated into a common model (external consistency), their internal consistency must be checked by the rules of logics (e.g. possible world logics). If the world of individual conceptions form a possible world, it is a candidate for representing the real world domain being modelled. It should be reminded, however, that a consistent individual world in not necessary a good model of the domain. This must be evaluated in the later phases of conceptual modeling.

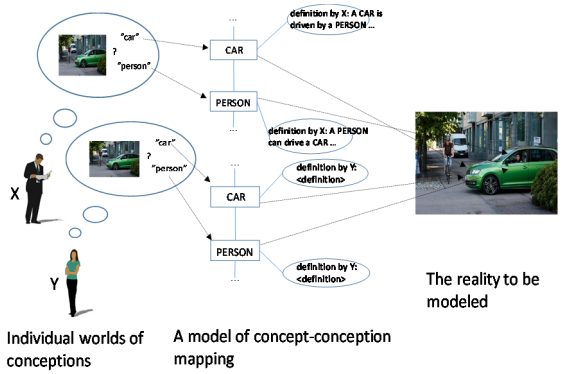

Figure 3: A simple example of CR modeling.

7 CONCLUSIONS

In this article, we have provided a conceptual modeling approach that puts emphasis on individual conceptions and how they relate to interpersonal concepts. The presented approach differs from the prevailing conceptual modeling in a remarkable way, since it sees concepts not only as abstractions of real world entities, i.e. symbols that refer to the entities of the domain being modelled, but also as references of individual conceptions. Thus, the new approach builds a bridge between individual thinking and formal models of a domain, and helps to get the models more consistent.

A main part of the article consisted of presenting theoretical constituents of several disciplines relevant to conceptual modeling. Based on these constituents, we have built a conceptualization model, and presented a modest application of it. We acknowledge that the work is just at the beginning and that the usefulness of the model and of the CR modeling is still very much on a theoretical basis. Hence, a lot of further work is required to show how the approach works in practice.

Nevertheless, we are quite sure that the new solutions for bridging the conceptual gap between human thinking and formal modeling should be searched for in the direction we have described in this article. It is obvious that since the applications of artificial intelligence improve as rapidly as they do today, the "conceptual attributes", especially the definitions of concepts, can be quite easily analyzed automatically. If the individual conceptions of concepts could be presented in an ordinary language, and their consistency checked automatically, utilizing possible world semantics, for example, we would have taken a big step towards higher quality conceptual modeling.

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