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MODELLING AND THE REPRESENTATION OF REALITY: SOME IMPLICATIONS OF PHILOSOPHY ON PRACTICAL SYSTEMS DEVELOPMENT

Ole Hanseth

Norwegian Computing Center, Ole.Hanseth@nr.no

Eric Monteiro

University of Trondheim, Norway, Eric.Monteiro@ifi.unit.no

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Ole Hanseth

Norwegian Computing Center
P.O.Box 114 Blindern, N-0314 Oslo, Norway
Ole.Hanseth@nr.no

Eric Monteiro

Department of Informatics at University of Trondheim
N-7055 Dragvoll, Norway
Eric.Monteiro@ifi.unit.no

Abstract

A conceptual analysis of modelling is undertaken. The major challenges posed by the growth of open and integrated systems prompts a careful rethinking of the basis of modelling. Particular attention is paid to object-oriented modelling. Our approach is characterized by an analytic framework borrowed from the philosophy of language called theories of reference (ToRs). This body of theories aims at accounting for how expressions of language may actually refer to the real world, very much the same task as in modelling. As opposed to most of the related work in the literature, we see this body of theories as a rich class. We argue that a number of the alternative approaches to modelling should be acknowledged to have important and relevant similarities with a rich body of ToRs.

Our principal aim, besides the more immediate one to correct what we argue are philosophically inaccurate interpretations, is to encourage a more fruitful discussion regarding modelling. Working out a basis for modelling should not be performed after identifying short-comings in the most simplistic version of ToRs. This strategy is even less appealing when we know that these short-comings have been identified—and to a large extent even solved—a long time ago within the philosophy of language. We ought to learn to appreciate each of the ToRs and use them whenever appropriate; each of them has its merits. The relationship between theoretical discussions of modelling and the practice of systems development is also commented.

1. Introduction

Modelling is at the core of most software development techniques. A development method is to a large extent determined by its approach to modelling. A principal aim of this essay is to analyse implicit and explicit assumptions within modelling techniques concerning reality, the nature of human knowledge and the relationship between the model and what is modelled. The main motivation for this analysis is that the considerable—and rapidly growing—challenges for modelling caused by the trend towards open and integrated systems prompt a careful rethinking of the very task of modelling.

The modelling techniques considered are data and object-oriented modelling. Data-flow modelling and knowledge representations are, for reasons of clarity, not discussed explicitly. We are particularly concerned with modelling based on object-orientation (OO). There are a number of good reasons for this. OO has gained momentum lately and therefore deserves special attention. OO is one, not to say the, approach to modelling with a conscious attitude towards the very task of modelling. We argue that the "naturalness" often referred to in connection with OO is readily understood within a conceptual framework of the kind we employ in our analysis.

The heart of our analysis, then, is to compare modelling with a body of theories known from the philosophy of language as theories of reference (ToRs). They all deal with the same basic problem as in modelling. As the fundamental problem addressed in modelling and ToRs is comparable, it seems reasonable to analyze modelling by relating it to the older and more elaborate ToRs.

This idea of explicitly comparing and discussing modelling with ToRs is, as such, not original. (Lyytinen 1987, Klein *et al.* 1992, Stamper 1987, Winograd *et al.* 1986) all do this. But—and this we will argue is crucial—they all discuss only *one* ToR, the most naive representative of the body of theories comprising ToRs. We draw several implications from this. First, correcting philosophically misguided interpretations found in the literature has a certain value of its own. But it becomes vastly more important when these misconceptions are found, albeit less explicitly, in much of the analysis of modelling. Second, we argue that these philosophically inaccurate interpretations are, as an immediate consequence of discussing only the simplest member of the body of ToRs, quite unsatisfactory when analyzing certain modern OO modelling approaches. Third, and most importantly, we sincerely believe that to learn about and understand the major challenges facing modelling one should strive to relate the different positions to each other. To learn from others presuppose the existence of at least some common grounds. Generally speaking, there are two strategies when presenting a body of theories: to underline their continuity or to highlight their points of discontinuity. By discussing ToRs as a body of theories, we are pursuing the former of these strategies. This may be read as a claim that there are no essential differences among them. We would like to warn against such a reading. Rather, we believe that underlining the continuity may serve an important pedagogical function in encouraging a more open discussion. To us, it also seems to be a more promising strategy within modelling than to keep looking

for "the correct" philosophical theory. It is, after all, primarily the practice of modelling, not its philosophical foundation, that need to be altered.

The remainder of this essay is organized in the following manner. Sections 2, 3 and 4 present and discuss three different ToRs. They are two-levelled ToRs, three-levelled ToRs and phenomenology, respectively. For each we give (i) an outline of the core of the theory, (ii) identify which kind of modelling it corresponds to and (iii) discuss the limitations of the theory. Sections 5 and 6 present alternative theories which have been suggested as a basis for modelling elsewhere in the literature. These are hermeneutics, social construction, speech acts and language games. We indicate how at least parts of these alternative theories may be viewed from the point of phenomenology. Implications for modelling are simultaneously discussed. The conclusions of our analysis falls in two categories and is given separately in sections 7 and 8. In section 7 we criticize related work on conceptual analysis of modelling. Section 8 spells out what we see as the lessons relevant to modelling of open and integrated systems. Section 9 offers a few concluding remarks.

2. Two-levelled ToR

Theories of reference have been developed within the philosophy of language to explain how linguistic entities (words, sentences, propositions, …) accomplish the truly extraordinary task of *referring*, i.e. to point to the essentially non-linguistic entities of our surrounding world. ToRs represent a contribution to an account of human knowledge in the fol-

lowing sense. Linguistic behaviour is assumed to be systematically based on a shared (and reasonable equal) knowledge of the meaning of the expressions involved. An important component of this knowledge is what the expressions refer to in the world. Exactly this property of expressions is it ToRs try to account for. To give a semantics for a language, on this basis, amounts to two things: to explain how expressions refer and to explain how communication is possible.

2.1. The contents of the two-levelled theory

A ToR is intended to account for the referential aspect of all kinds of expressions. For the present purposes, however, it suffices to restrict attention to proper names and singular designators, i.e. expressions of the form: "John", "London", "the king of Norway", etc.

The simplest, but in many respects the most natural, variant of a ToR is the two-levelled one. It is old; it dates back to Plato (Harrison 1979, p. 23). The basic idea is simple and intriguing. The names and designators are viewed as labels which attach to objects in the world. The expression "John", for instance, is associated with the object (or rather: person) John. This labelling relationship between "John" (the expression) and John (the person) is what is known and exploited by the participants engaged in linguistic behaviour. The meaning of compound expressions containing "John" is then recognized as a label for John; recognition of these labels is what makes it possible to speak *about* non-linguistic objects like John (the person). The two-levelled theory provides an appealing and intuitive explanation of how (this part of) language functions. Our

mastering of (this part of) language amounts to nothing but a capacity to know and recognize which labels do, or do not, attach to which objects; we recognize a set of links.

Two-level ToRs are related to realism, which we, for the purpose of the present discussion, define as follows. It amounts to the view that there exists, perfectly independently of human cognitive capacity or activity, a world of objects. As this world exists independently of human cognition, these objects have to be objective, i.e. perceived equal for all human beings; one perceives *the* object. Two-levelled ToRs makes it conceivable to set up a one-to-one correspondence (more precisely: a bijection) between the names and the objects which subsequently makes all objects accessible via language.

2.2. Two-levelled theory and modelling

The question, then, is which kind of modelling corresponds to two-levelled ToRs. The answer is, as a number of people have noted, data modelling. Data modelling employs a wide range of techniques, methods and notational apparatus. We focus on the entity-relation (E-R) modelling technique. In this respect we follow (Klein *et al.* 1992, p. 206) and (Lyytinen 1987, p. 9) who also gloss over possible differences among modelling approaches.[1]

E-R models lend themselves to a quite straightforward interpretation as a two-levelled ToR (Klein *et al.* 1992, p. 207). The named "entities" correspond to the objects of the real-world and are identified through attributes (properties). The relations (in the E-R model) simply record relationships holding between the real-world objects.

2.3. Limitations of the two-levelled theory

Two-levelled ToRs have an attractiveness, due to the intuitive idea of attaching labels, which should not be neglected. It is also a fact that it took roughly two thousand years before someone came up with an essentially better explanation. During this time, a number of problematic issues were raised. They may be viewed as a set of challenges or puzzles which the two-levelled ToRs fail to answer. It is well beyond the scope of our discussion to deal in any detail with these.[2] We point out only two such issues which should make it clear that the two-levelled ToRs are too simple-minded to capture a sufficient portion of the relevant aspects related to referring. The first problem is how to explain the meaning of names with no object. The second problem is how to associate multiple names with one object. The first is often illustrated by the following example: what does "Pegasus" refer to? As the object Pegasus (the mythical horse with wings) does not exist, how is it possible to maintain that linguistic behaviour involving "Pegasus" is based on the mutual recognition of its meaning, i.e. what it refers to? Two-levelled ToRs simply have no satisfactory answer. The problem with multiple names is that one gains absolutely nothing which one did not have already with a single name. Consider a case where both "John" and "the man in the corner" both refer to John (the person). But in compound expressions either of these names exactly the same happens: both names are simply placeholders which are immediately filled by John (the person). In both cases the placeholder or label merely serves to import the object and the overall effects are

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identical in both cases. Such objections, as (Klein *et al.* 1992, Lyytinen 1987, Stamper 1987) note, are equally valid for data modelling in general and E-R modelling in particular.

3. Three-levelled ToR

Three-levelled ToRs should be viewed as a response—or even a solution—to a number of the weaknesses of two-levelled ToRs. Three-levelled ToRs are due to Frege (Geach *et al.* 1952). What follows below draws upon (Dummett 1973, Dummett 1981, Harrison 1979). Frege's ToR clearly has a historical and conceptual value of its own. We will, however, do little to pay justice to this. Our interest focuses on how this theory resolves the problems encountered with the two-levelled theory and discuss modelling corresponding to three-levelled ToRs. In so doing, OO modelling will play an important role.

3.1. The contents of the theory

The basic move in the three-levelled ToRs is to change from the situation on the left (two-levelled ToRs) to the one on the right i Figure 1.

In addition, it is stipulated that the recognized meaning which we rely upon in communication is the *sense* of the expression. Recall that what a two-levelled ToR relies on is the recognition of certain binary relations holding between pairs of expressions and objects. With the three-levelled theory, primacy is placed on the sense. The meaning of an expression is its sense. We return later to the question of exactly what the sense is. What is clear is that one—but not every—aspect of sense is the capacity to produce the reference.

This alone is sufficient to resolve a number of the difficulties experienced with two-levelled ToRs. Again, we will give only an outline of this, which suits our purposes related to data modelling. We only discuss the two problems cited in section 2.3 above: non-existing references (objects) and multiple names.

FIGURE 1. Difference between two-levelled and three-leveled ToR

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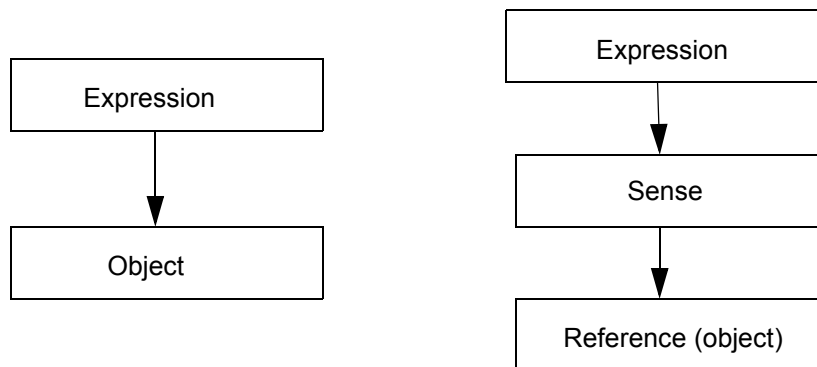
The problem with names with no reference, like the case of "Pegasus", is straightforwardly resolved. The sense of "Pegasus" is what is communicable. This is communicable despite the fact that one aspect of the sense, its capacity to produce a reference, is not possible to realize in this case.

The issue with multiple names—and thereby multiple senses—having the same reference was important to Frege. A famous example of his was to consider the two designators "the morning star" and "the evening star". Each expression has a definite, but distinct, sense. They do, however, both refer to the same object—the planet Venus. The two senses represent two distinct perspectives of the same object. The ability to maintain different perspectives—which vary from person to person, and over time—of one and the same object was essential to Frege. That the two senses both refer to Venus is by no means evident from the senses themselves (which indicate planets appearing at different times of the day); it was in fact the result of a not-too-distant astronomic discovery.

Due to the importance Frege placed on the sense of an expression, it would be reasonable to expect a relatively thorough treatment of what the sense is. Frege was, however, rather reluctant to provide any information on this vital issue. He insisted that the sense of a complete sentence was a *thought*. A thought is the fundamental unit of communication.[3] The senses of the constituents of an expression are given (indirectly) by stipulating that sense was compositional, that each part of the expression contributes systematically to the sense of the complete expression.[4]

Frege had high expectations for his theory. Not only was it to account for how expressions referred, it was also intended to explain how communication is possible. We give a sketch of his explanation as this is illuminating for our later discussion, especially in connection with speech act theory in section 6.

Frege wanted to ensure that his explanation of communication did not rely upon essentially private or individualistic mechanisms. The problem is to devise an inter-subjective criteria or condition prevailing under successful communication, i.e. to characterize what it amounts to understand the communicated message. This characterization will, as Frege was well aware of, vary with the kind of sentence (or speech act: assertion, imperative, promise, …). Frege's answer for the kind of sentences he was primarily interested in—the declarative ones which make up the subject matter of mathematics and logic—was two-fold. Firstly, he claimed that the relevant characterization or condition was that such a sentence did have a definite truth value, true or false. Secondly, he insisted that the capability to recognize the truth conditions of a declarative sentence is an universal, human capability. It is this inter-subjective capacity, Frege held, which ensures that declarative sentences are communicable.

3.2. Three-levelled theory and modelling

OO modelling, i.e. OOA & D, is in a number of ways similar to data modelling. In what follows, we address two issues which deviate from ordinary modelling and contribute in giving OO its distinctive flavour:

- the appeal to the "naturalness" of OO modelling;
- the possibility of going beyond (what corresponds to) two-levelled ToRs with OO;

Let us first inquire closer what the alleged "naturalness" of OO modelling amounts to, and, more specifically, characterize the basis of this claim.

Our suggestion may be stated within our analytic framework of ToRs: the "naturalness" of OO modelling rests on a kinship with two-levelled ToRs. In OO modelling one only needs one kind of entity—the object.

To back up our suggestion that the naturalness of OO modelling stems from its affinity with two-levelled ToRs, what is required is to document how OO modelling makes appeal to the small "semantic gap" between an object in the world and an object in the model.

As a recent handbook puts it:

"A good way of thinking of an object-oriented system is of a space which contains many independent objects. (...). This view of *a system is intended to match, or in some sense model, the system as it might appear as a collection of cooperating physical objects, or indeed people, in the 'real world'*" (Atkins *et al.* 1991, p. 39/3, emphasis added).

Similarly, from a well-known text book in OO:

"In this manner, each object in our solution embodies its own unique behaviour, and each one models some object in the real world. From this perspective, an object is simply a tangible entity which exhibits some well-defined behaviour. Objects do things, and we ask them to perform what they do by sending them messages. Because our decomposition is based upon objects and not algorithms, we call this *object-oriented* decomposition." (Booch 1991, p. 15)

which continues:

"(A)n object-oriented view of the world, (with) objects, as abstractions of entities in the real world" (Booch 1991, p. 17)

or:

"More realistic modelling. OO analysis models the enterprise or application area in a way that is closer to the reality than conventional analysis" (Martin 1993, p. 34)

What this all adds up to, then, is that OO is "natural":

"Indeed many people who have no training in computer science and no idea how a computer works find the object-oriented model of problem solving quite *natural*." (Budd 1987, p. 4, emphasis added)

and:

"The OO way of thinking is more natural for most people than the techniques of structured analysis and design. After all, the world consists of objects." (Martin 1993, p. 31)

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Recalling the serious limitations of two-levelled ToRs exposed earlier, our claim about OO modelling is disturbing. The problems, for instance regarding multiple names, are so immediate that one has found ways to cope with them—but not at the level of modelling. For instance, having two distinct pointers pointing to one and the same object is a solution, not at the level of modelling, but at the level of programming. Multiple inheritance in OO programming languages falls in the same category. Our concern lies with how to handle these problems systematically at the level of modelling.

A recent survey of OO modelling is utterly pragmatic about these issues. Due to the presence of OO programming languages with multiple inheritance (and hence a lattice of inheritance relations), OO modelling should also permit a corresponding modelling lattice (Monarchi *et al.* 1992, p. 40). This survey does not, however, include the ability to handle perspectives among the "critical components" of OO modelling (Monarchi *et al.* 1992, p. 39), but grant that this problem belongs to "future research" (Monarchi *et al.* 1992, p. 45).

There has, however, been some work within OO in attempting to overcome the limitations of two-levelled ToRs by systematically introducing notions of "perspective" (or "roles", or "views", etc.) at the level of modelling. Even if this development is conceivable also outside of OO, it is fact that it has been most thoroughly addressed within OO modelling.[5] As explained in section 2.2, this represents an essential step beyond two-levelled ToRs—in the direction of three-levelled ToRs. OORAS, for instance, is an attempt to systematically incorporate the concept of perspective at the level of

modelling (Reenskaug *et al.* 1992). In OORAS a collaborating set of objects is grouped into a role. One role corresponds to one perspective. Two or more roles may subsequently be "synthesized" into one while maintaining two perspectives. Given two models which, say, give two perspectives on the role "person", one as an employee-in-a-firm and one as a leader-of-a-project, these two perspectives may be synthesized. This synthesis gives rise to a new model, an employee-and-project leader model. But simultaneously the two original ones are kept accessible. As a consequence, when modelling a specific person one may chose which of the three perspectives to employ: the employee, the project leader or the employee-and-project-leader. OORAS does not correspond to two-levelled ToRs.

3.3. Limitations of the three-levelled theory

The ability of three-levelled ToRs to incorporate different perspectives at the level of modelling is a significant advance over two-levelled ToRs. But the theory has its limitations. The number of different perspectives are finite and given. It cannot account for an "open" situation with an indefinite number of perspectives or aspects, i.e. a context, background or horizon. This brings us to the third class of ToRs which is Husserl's phenomenology, a full-fledged epistemological framework.

4. Phenomenology

There are interesting structural similarities between Husserl's phenomenology and Frege's three-levelled theory which

FIGURE 2.

Act

Noema

Object
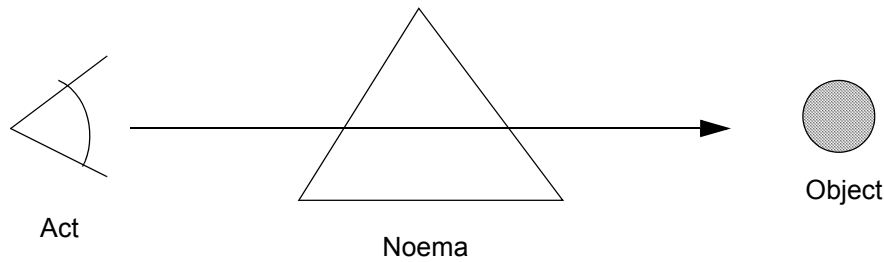
are often over-looked.[6] The basic claim is that phenomenology may be viewed as an elaboration—in width and depth—of Frege's three-levelled theory. In width because it generalizes from linguistic acts to acts in general (perception, thinking, imagining, physical movement, …), and in depth because Husserl goes a lot further in describing the structure and underlying mechanisms of (what corresponds to) Frege's sense. We proceed by discussing the features of phenomenology most relevant to our purposes.

4.1. The contents of phenomenology

An essential aspect of phenomenology is the view that all acts share a deep structural similarity. To uncover this structure is the real subject-matter of phenomenology. This leads us to the act of perception. Perception is at the same time a representative act within phenomenology and a relevant act in connection with modelling.

The three-levelled theory of Frege has acounter-part in phenomenology, see Figure 2. The middle one, the so-called *noema*, is what corresponds to Frege's sense. The noema structures acts so as to make them meaningful. It is the structure of our cognitive activity which gives meaning to passive sense data. This structuring is immediate: it is not the case that we first receive sense data and then structure or interpret them subsequently as an object is recognized. On the contrary, we are always "thrown" into an interpretation or way of structuring (in short: have a noema). We are, furthermore, normally not aware of the prevailing, current noema. Only through an effort may the noema be thematized by directing our attention towards it (through acts of reflection).

The structuring by noema functions as a pattern of anticipations. Perceiving something as a cup, for instance, corresponds to having a noema containing anticipations about the cup such as that it is round, what it would feel to touch it, what would happen if we were to pour coffee into it, etc. The anticipations concern what may later take place in the subsequent sequence of acts directed towards the object. The components of this pattern of anticipations may be viewed as a horizon against which we understand the surrounding world.

An essential concept in Husserl's phenomenology is that of evidence. Despite its connotations (in both English and German "Evidenz"), it should not be read in an uncompromising sense, signalling complete certainty. The evidence

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of an act is simply the set of components of the anticipations or horizon which already has been confirmed by carrying out acts. E.g. that, by turning the cup around, we have established that our anticipation about the cup being round did, indeed, hold true. Even though Husserl on numerous occasions wrote about achieving "absolute certainty" and the necessity of providing a secure "basis for all of science", it was fundamental for Husserl that evidence for a given noema was normally partial or incomplete—that we may always be mistaken.[7] More specifically, in acts of perception of physical objects, a highly relevant act in connection with data modelling, Husserl held that one could never achieve complete evidence. The reason is that such objects—like that bulk of our everyday objects—contain an inexhaustible supply of anticipations which may never be completely confirmed.[8] Our everyday objects, according to phenomenology, allow for an infinite number of perspectives. Our knowledge of these everyday objects is essentially incomplete. We learn to conduct our lives based on the finite approximations we already have acquired.

Anticipations need not be confirmed in the course of carrying out subsequent acts; they may be frustrated. This causes a re-structuring of the noema (it explodes, or to use the term of (Winograd *et al.* 1986): a "break-down" occurs). The re-structuring may be more or less profound. It may result in a simple modification a few of the other anticipations of the noema—or it may produce such a dramatic re-structuring that it makes good sense to talk about a new noema.

4.2. Phenomenology and modelling

There do not exist modelling techniques directly based on phenomenology. An hypothetical example would be to analyze the users' noemas and thereby uncover the true reality. The closest real example would be frames from AI. But even if frames were proposed to mimic anticipations, they only contain a finite number of perspectives. Even if phenomenology has not been used directly as a basis for modelling, there are a number of approaches to modelling which may, at least partly, be understood from a phenomenological point of view (see sections 5 and 6 below). As the approaches presented in these two sections are supposed, e.g. in (Winograd *et al.* 1986, Lyytinen 1987, Klein *et al.* 1992), to have absolutely nothing in common with ToRs, particularly the two-levelled ones, our claim is not obvious; it has to be argued. There is thus a non-negligeable element of irony in the fact that these approaches are worked out just because ToRs have been found useless.

4.3. Limitations of phenomenology

Granted that phenomenology is considered a full-fledged theory of the conditions and contents of human knowledge, it follows that phenomenology, in principle, has no limitations. This does, of course, by-pass the question of how accurately phenomenology does indeed account for human knowledge, and whether phenomenology is useful for actually accounting for specific instances of human knowledge.

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5. Hermeneutics and Social Construction

We discuss now efforts to base modelling on philosophical hermeneutics and social construction. Instead of presenting these as two approaches unrelated to ToRs in general and the two-levelled theory in particular (Klein *et al.* 1992, Lyytinen 1987, Dahlbom 1992), we indicate how some elements of hermeneutics and social construction could be viewed from phenomenology.

We discuss two issues within hermeneutics (Gadamer 1976). Firstly, in philosophical hermeneutics it is stressed that knowledge and understanding is contextual—that it takes place against a background, pre-justice or horizon (Gadamer 1976, p. 9). There is no such thing as an empty horizon; understanding can only take place against an horizon of pre-understanding. Secondly, through reflection, it is possible to gain access to, to become aware of, elements of our horizon, to uncover certain of its taken-for-granted elements.

Both of these issues, the necessary pre-understanding and the possibility of uncovering, have a counterpart inside a phenomenological framework. Firstly, the noema, which induces meaning upon the acts, is structured as a pattern of anticipations—a horizon. Knowledge is always contextual or relative to this horizon. A necessary pre-condition for understanding during an act is the active structuring by the noema. The set of anticipations, the horizon, may impose a varying degree of structure depending on how much evidence has been accumulated in support of the noema. But the noema is never empty in the sense that it does not contain the anticipations, the horizon. This situation should be carefully distinguished from the one where no evidence is provided yet. This latter case corresponds to the situation immediately after engaging in a new act: we have anticipations, but no one has been confirmed or frustrated yet. Secondly, through an act of reflection, as depicted below, it is possible to make the object of a new act (with noema-2) be the original noema (noema-1). See Figure 3.

A special kind of reflection, the phenomenological reduction,[9] was intended by Husserl as a route towards uncovering the general structure of noema. It involves two steps: the eidetic reduction whereby the original object is "bracketed" and the transcendental reduction whereby one directs attention towards noema-1. Bracketing in phenomenology

FIGURE 3.

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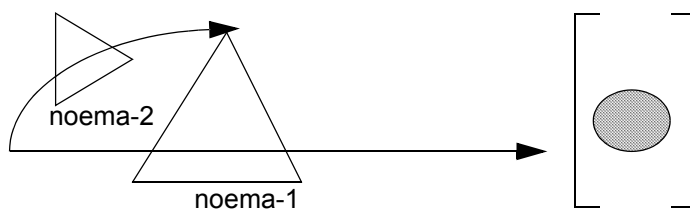
thus has a quite definite meaning, namely as one phase of the phenomenological reduction, and is not the kind of non-committing activity of choosing to overlook certain aspects of an act which one could be led to believe in (Klein *et al.* 1992, p. 214).

A, if not *the*, primary source for the concept of social construction is the work of Berger and Luckmann. They write:

> "The method we consider best suited to clarify the foundations of knowledge in everyday life is that of phenomenological analysis." (Berger *et al.* 1966, p. 34)

The fundamental claim of social construction is that the way we perceive and think: acquire knowledge, about the surrounding world is essentially social. It is shaped and modified through social interaction. This amounts, from the phenomenological point of view, to nothing but a claim that the always present (cf. remarks on hermeneutics above) set of anticipations, the horizon, is socially shaped. This is consistent with Husserl's views on the inter-subjective character of noema. He coined the term Lifeworld for the huge set of socially and culturally established components of the noema. Especially in the later phases of his writing Husserl underscored this aspect of the noema.[10] In (Dahlbom 1992) the origins and contents of the idea of social construction are traced. Social construction is discussed and related to an impressing number of recent positions, but without bringing in phenomenology. We find this unfortunate, not because (Dahlbom 1992) does not contain a sufficient number of positions already, but for pedagogical reasons. Explaining how social construction may be related to ToRs, as opposed to representing a completely independent position, could, hopefully, make the communication between the two camps easier.

Having underlined the kinship between phenomenology and social construction, it must be acknowledged that the rapidly growing stock of literature on documented cases of the minute mechanisms whereby this social construction actually takes place goes far beyond what Husserl ever described, see e.g. (Bijker *et al.* 1989 and 1992).

6. Speech Act Theory and Language Games

Speech act theory and language games are sometimes argued to be completely different from ToRs, see e.g. (Winograd *et al.* 1986, Kensing *et al.* 1991). We agree that these two approaches have a somewhat different aim in that referring is not the principal focus of interest. Still, insofar as they are accounts of linguistic behaviour, which necessarily also includes the ability to refer, they cannot side-step referring altogether. Furthermore, there are issues where speech act theory do share similarities with Frege's three-levelled theory which should be acknowledged. We believe it is somewhat inaccurate to portray speech act theory and language games as completely unrelated to ToRs.

Searle, an important contributor to speech act theory, quite explicitly describes his theory not as an alternative but as:

> "(...) (A) study of the meaning of sentences (such as ToRs) is not in

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principle distinct from a study of speech acts. Properly construed, they are the same study" (Searle 1969, p. 18).

This holds for his "principle of expressibility" as well, stating that whatever is meant (by a person) may, in principle, be stated (Searle 1969, p. 19). As mentioned earlier, Frege focused on, to use Searle's terminology, the illocutionary act of asserting. The corresponding perlocutionary act, i.e. the corresponding effect the illocutionary act has upon the hearer/reader, was that of the recognition of truth conditions. Frege did, however, identify other aspects of an expression relevant to its meaning *not* captured by the sense which he called tone (German: Beleutung) and colouring (German: Fär-bung). But he did not do very much to characterize the inter-subjective mechanisms whereby these parts of the expressions' meaning may be communicated. Speech act theory goes a far way towards a remedy for this.

An important reason for the interest in speech act theory is due to the expectations that this theory could provide an approach to the essential problem of contexts in modelling. Searle is concerned with this problem, not so much in the most widely cited book (Searle 1969), but more in for instance (Searle 1980). A treatment of context—or background—very much in the spirit of phenomenology (Dreyfus 1982, p. 4–9).

As for speech act theory, language games have attracted interest partly because they supposedly allow for an alternative role and explanation of context (Rommetveit 1983). Our practical experience and awareness of different language games constitute the context

against which expressions acquire meaning. Much has been said and written about the different phases of Wittgenstein's work and about the (dis)continuity of the early and late Wittgenstein. We have absolutely no intention of getting involved in the details of this controversial issue. That would take us well beyond the scope of this essay. Languages games are usually regarded to have little or nothing to do with ToRs. Nevertheless, there exist interpretations which do connect language games with Frege's ideas (Hintikka *et al.* 1986, Harrison 1979, p. 208 and 249).[11]

7. Critique of Related Work

7.1. *Two-levelled vs. three-levelled ToRs*
Two- and three-levelled ToRs differ on a number of essential issues. These issues are not only of scholastic interest, they are highly relevant to modelling. One should accordingly be careful to distinguish between the two theories. This, however, does hardly seem to be case. We have expressed dissatisfaction with elements of the related work of (Lyytinen 1987, Klein *et al.* 1992, Stamper 1987). Important objections against this work have, nevertheless, not yet been presented. Within our analytic framework of ToRs, these may quite precisely be stated as follows: (i) their arguments only apply to two-levelled ToRs; and, furthermore, (ii) they confuse the distinction between two-levelled and three-levelled ToRs. Our critique does, of course, not imply that we disagree with all of their views; they certainly contain valuable insights. It simply means that we focus on points of disagreement,

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points which we consider important enough to deserve attention. In what follows we primarily concentrate on (Lyytinen 1987).

Lyytinen describes an approach to information modelling, called "reality mapping" (RM), which he maintains capture most approaches to modelling. He then sets out to criticize RM and concludes that RM cannot provide a basis for modelling. Our first task is to relate the position called RM by Lyytinen to our analytic framework: which kind of ToR is RM? The answer is simple. It is a two-levelled ToR. This is immediate from the implications Lyytinen draws from the RM position:

> "The principle of *correspond-ance* states that every sentence in the UoDD (universe of discourse description) corresponds to users' observations about entities. The UoDD presents these and there is a one-to-one correspond-ance between the (information system) and the UoD" Lyytinen 1987, p. 11).

and:

> "(RM) would not be able to make distinctions between referential and purposeful meaning: it would make the meaning of terms like 'a morning star' and 'an evening star' synonymous, though they are not." (Lyytinen 1987, p. 12)

His criticism of RM does not apply to three-levelled ToRs. This is obvious from his remarks on intentional (or opaque) contexts. A very fundamental motivation for Frege for developing his theory was to explain—not to ban—intentional sentences:

> "So-called *intentional sentences* are excluded. They relate propositions about facts to subjects; they express propositional attitudes such as 'A thinks that it is true that p'. The truth-values of such senteces are opaque; i.e. they cannot be composed from the truth-values of their components. Accordingly, they do not mean anything." (Lyytinen 1987, p. 11)

Frege's explanation was to employ the distinction between sense and reference. In non-intentional contexts one may substitute expressions as long as the reference is constant. One may, for instance, pass from 'I see the morning star' to 'I see the evening star' without altering the truth-value. In intentional contexts one cannot, as Lyytinen notes, simply substitute expressions so as to preserve the reference. Frege was well aware of this. He even proceeded to give a solution: in intentional sentences the sense also has to be preserved. From 'I believe that I see the morning star', it is thus not appropriate to state 'I believe that I see the evening star'.

The fact that Lyytinen's argument applies only to the simplistic two-levelled ToRs, an argument put forward with a considerable amount of extravagance, is made still more problematic by the fact that he fails to distinguish between two-levelled and three-levelled ToRs. As we have already pointed out, the short-comings of two-levelled ToRs which Lyytinen identifies are well-known; indeed, three-levelled ToRs came about in order

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to solve them! It is thus quite misguided to write:

> "The basic tenets of the reality mapping originate from analytic philosophy and mathematical logic. In particular, such scholars as Frege (...), Wittgenstein (...) and Tarski (...)" (Lyytinen 1987, p. 10)

—without discriminating among these. Tarski's account of semantics, the model theoretical one underlying classical logic and (most) use of formalisms in computer science, is a two-levelled ToR.[12] But Frege's theory is definitely not.

7.2. Systems development and "multiperspective reflection"

An important, perhaps even distinguishing, feature of the Scandinavian approach to systems development is the emphasis on the need for shifting or varying perspectives. The concept of "multiperspective reflection", the willingness and ability of systems developers to systematically adopt different perspectives when approaching a situation, is obviously a desirable skill in systems development. The problem, however, is how this multiperspective reflection comes about. In phenomenology it is emphasized that one normally would not be aware, much less able to chose, the perspective; we are "thrown" into a perspective. It is only through an effort of reflection one may thematize our own perspective, that our perspective becomes accessible to us. This kind of reflection is a skill which has to be established or perfected—it cannot simply be stated.

8. Discussion: Complexity and Limitations of Modelling

In what follows, we attempt to spell out relevant implications from our earlier discussion related to modelling strategies, in particular strategies for the development of open systems and systems integration. We consider this latter issue to be a primary one in systems development in the years to come when National Information Infrastructures and Trans-European Information Infrastructures together with systems supporting globalization strategies of private companies are to be implemented.

The philosophical positions we have described are seemingly ordered linearly: Two levelled ToRs gives the most simplistic picture of the world, the following ones give richer and more complex pictures. Each offer solutions to shortcomings in the previous, with hermeneutics and social constructivism as the most complex. Accordingly, it can be argued that hermeneutics and social constructivism are the (most) correct positions. On this basis, a plausible conclusion could be that we should work out modelling approaches based on this correct position. This conclusion has been drawn by some scholars. Winograd and Flores conclude that the technical-rational approach is "faulty" and should be replaced by hermeneutic ones (Winograd *et al.* 1986). They propose one such based on speech act theory. So far, this approach has not been an unambiguous success (Suchman 1993).

Klein and Lyytinen suggest that one should give up trying to model the reality (Klein *et al.* 1992, p. 211). They propose that one should rather model user languages, and that this modelling should

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take place within a hermeneutic meta-theoretical framework. We are sympathetic to the latter part of their conclusion, but cannot see how modelling user languages instead of "real objects" can help. Languages are used to describe reality, but they are also indeed part of reality in itself. All problems involved in ordinary modelling are likely to pop up when following this recommendation, and possibly some additional ones.

It thus seems that the strategy of reforming the practice of systems development by starting from a "correct" philosophical position, say social construction, is less than effective. In order to work out a more effective strategy, one is lead to consider at least the following issues:

1. how should we now understand notions such as "theories" and "models";

2. which status has other philosophical positions from a constructivist perspective;

3. what is the relation between philosophical positions and practical systems development?

The two first issues have been discussed to some extent within the social constructivist studies of science and technology community. It is referred to as the "reflexivity" problem, i.e. the problem of applying the same perspectives on one's own work as on others. It raises the question of whether there is any privileged positions from where to study the others. This issue is a rather controversial one, see for instance (Woolgar 1988, Collins *et al.* 1992). The upshot of it, for the present purposes, is that theories, models and philosophical positions are also social constructions. They are true because

a community agrees they are within the context of their use and based on the shared background of the members of the community. Accordingly, it is impossible to develop a social constructivist approach to modelling which may help us overcome the problems with existing modelling approaches. Believing that such an approach is possible is a contradiction, it presumes the premises of naive realist positions rejected by social constructivism.

The third issue involves both conceptual and a pragmatic considerations. Let us here focus on the latter, the pragmatics of influencing the practice of systems development through improved understanding of their philosophical underpinning. There is obviously a link between (improved) understanding and (improved) practice. The question, however, is not the *existence* of such a link but its *strength*. To improve practice through improved understanding presupposes a strong link. A conceptual argument against such strong link can be made, but we refrain from this here. From a pragmatic point of view, the cases listed above related to (Winograd *et al.* 1986, Suchman 1993, Klein *et al.* 1992) all count as evidence for the weakness of this link in systems development.

Philosophical criticism of modelling approaches may be useful. It may help us, not to develop new philosophically correct approaches, but to better understand the *limits* of modelling, and how we can apply it more successfully. Both the theoretical analysis given above and practical experience indicate that both traditional modelling and two or three-levelled ToRs are powerful tools. They are suitable for a number of tasks. The challenge is to learn to recognize their

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limitations. From the simplistic conception in two-levelled ToRs, with its pairs of labels and objects, three-levelled ToRs allows for *perspectives*, and in phenomenology all knowledge is *contextual* (relative to the horizon of the noema).

In the seventies Management Information Systems (the MIS concept) was considered the systems concept of the future. This concept was proposed as an answer to problems related to the fact that the different information systems within an organization contained partially the same data, leading to inconsistencies, redundancies and unnecessary work (registration of the same data several times). The core of the MIS concept was one, shared data model for the whole company, implemented as a corporate data base. The concept turned out to be a failure. In (Marche 1993) parts of the reasons for this fact is empirically documented to be the lack of stability in data models. But the need for integration has grown due to the rising number of information system—and the MIS concept is currently revitalized, but this time under the name Enterprise Data Modelling (Scheer *et al.* 1992).

Technology and organizational development support—and are supported by—the spreading of open and integrated systems. Even if the limitations of modelling based on two-levelled ToRs has always been present, the inherent complexity of open and integrated systems makes these acute today. Integration is important not only within a company, but across organizational borders as well. This is illustrated by the growing interest for inter-organizational systems and EDI. Cross-organizational communication is likely to grow in response to a trend in organizational change from hier-

archical corporations towards (global) collaborative networks (Reich 1991). Integration through shared data models is a strategy for developing closed systems. Enterprise Data Modelling implies that the enterprise is considered a closed world with its specific data model. A system can neither be integrated with one in another enterprise, nor with a system which is bought from an outside vendor. Integrating systems across organizational boundaries through shared data models implies one data model for the whole world, which obviously is unrealistic.

Here, too, OO is called upon. Some see OO as a new way to establish an "enterprise model" (Martin 1993, p. 9 and 29). Especially within the two-levelled ToRs which (Martin 1993) is based upon (cf. section 3.2), this seems naive and disturbingly similar to the previous efforts concerning MIS mentioned above.

The only strategy to cope with complexity is to split the "world" into separate independent parts in a way that makes the interaction and interfaces between the parts as simple as possible. In the world of information systems, the concept of open systems is an attempt to implement this strategy. Open systems means that most organizations have several systems, each considered separate and independent, and at the same time it may, in principle, be integrated with any other through standardized interfaces. Such an interface could be a protocol for exchanging EDIFACT messages. Each separate system in this open world should focus on areas where the complexity is not beyond what can properly be understood in terms of two- and three-level ToRs, and they can be developed using traditional modelling techniques.

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In more technical terms, this splits the "world" into manageable sub-worlds which allow modelling according to two- or three-levelled ToRs. The overall picture, the world of open systems, could, if required, be interpreted according to hermeneutical and social construction frameworks.

9. Conclusion

Our aim is, of course, not just to point out that what (Lyytinen 1987, Klein *et al.* 1992, Stamper 1987) criticize is two-levelled ToRs. That their critique have serious shortcomings from a philosophical point of view is, in itself, not necessarily a relevant objection in the context of information modelling. If all modelling adheres to two-levelled ToRe, the argument, even if philosophically misguided, could be relevant in informatics. But this is not the case. There are modelling disciplines, such as the OO ones discussed earlier, which are not two-levelled ToRs. It is reasonable to expect that challenges for modelling posed by open and integrated systems will at least call for three-levelled ToRs. The crucial point is that by criticizing only two-levelled ToRs, one is left completely without an answer when confronted with situations more challenging than two-levelled ToRs can cope with.

There is a strong, but unfortunate, tendency to polarize the discussion regarding modelling. The work we have concentrated on, i.e. (Lyytinen 1987, Klein *et al.* 1992, Stamper 1987), is not odd pieces. A rather typical scheme seems to be to argue that (what corresponds to) two-levelled ToRs is without value and subsequently come up with an alternative which is supposed to have nothing in common with the simplistic ToRs. Winograd & Flores (86) attack the "rationalistic" approach which may be seen to be based on a two-levelled ToR. Likewise in (Gregory 1993), where one argues against the so-called "ideational" theory which boils down to two-levelled ToRs.

We have argued that this framework, this body of ToRs, provides a conceptually more appealing and rewarding standard for comparing and analyzing modelling. One should, however, take care not to be tempted to regard this as some kind of one-dimensional axis ranging from (largely) "untrue" to increasingly "truer" ones. In a sense it is clearly so that moving along this axis one gets a richer picture. It should come as no surprise that elaborate epistemological frameworks solve more problems than simplistic ToRs. But modelling is bound to be less ambitious than epistemology.[13] We have to be capable of coping with modelling, we are necessarily making simplifications. The real challenge is to learn more about exactly which simplifications are appropriate in which situations. One should rather learn to appreciate each of the ToRs and use them whenever appropriate; every one of them has its merits.

Embarking upon a conceptual analysis of modelling quickly involves sophisticated theories, many of which belong to philosophy. Having gone in some detail into a few of these ourselves, we are obviously not hostile to such endeavors. There is, nevertheless, precisely because these theories are so academically challenging, a danger that they could absorb all interest. In the present situation, with a considerable number of suggested bas-

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es for modelling—we have run across two- and three-levelled ones, phenomenology, hermeneutics, social construction, speech acts and language games—it is, we believe, time to take the practice of modelling and its contribution to the overall systems development project more seriously. Adding items to an already long list of philosophical theories need not be the most effective of strategies for enabling an altered practice. For this strategy, seeking "the correct" philosophical basis, to influence practical modelling and systems development, this new theory has to lead to insights which are not only new, but which also enable practical action. This, however, seems less than likely.

Notes

[1] Our remarks on the E-R technique apply to most traditional modelling techniques, we believe. For instance, the widely used Jackson system development (JSD) is probably an even clearer proponent of two-levelled ToRs (Jackson 1983, Pressman 1992). This is so because, in addition to identifying entities and entity-structures in much the same manner as E-R, one is explicitly encouraged to set up a one-to-one relationship between entities in the real world and entities in the model. More precisely, the "initial model step" employs so-called "system specification diagrams" (SSD) to achieve exactly this correspondence. One has even incorporated this at the level of notational conventions: suffix 0 after the name signifies the real world object, whereas suffix 1 after the name signifies the corresponding model representation one.

[2] They include: how to generalize to other linguistic expressions than names and designators (what does a sentence refer to?), indirect speech and other opaque contexts, how the reference is established, how to cope with multiple labels, what if the object does not exists,... For a more elaborate discussion consult e.g. (Harrison 1979, Kripke 1972, Martin 1988, Monteiro 1992).

[3] Frege did not by this intend to deny the presence of other mental entities like pain, feeling, mood, etc., only the impossibility of communicating these.

[4] Employing a technical notation, writing stands(J, c) for "John stands in the corner", the principle of compositionality may be explained more precisely. Because the fundamental unit is a thought, the sense of a sentence, s, is known in:

sense_(stands(J,c)) = s = sense_stands (sense_J, sense_c)

The question of what sense_J, the meaning of "John" is, is then given by:

* (sense_J,?)

which is s with two "holes" * and ?. sense_J is then the entity which systematically produces a thought when the two holes * and? are filled in (saturated). This book-keeping of holes and notation for functions is what we today know as (untyped) lambda calculus.

[5] An interesting question, then, is the following. Is it a pure coincidence that this takes place within OO modelling? One could, perhaps, imagine that this was because OO techniques are employed in particular complex and rich situations. This, however, is a problematic and question begging position, especially from an empirical point of view. After all, the vast majority of existing computer systems—including highly complex ones—where constructed without OO. We would rather be tempted to speculate that exactly because OO modelling, as outlined above, relies so heavily on the intuitiveness/ naturalness of the two-levelled theory, the issue receives attention.

[6] The outline we give of phenomenology having structural similarities with Frege owes much to the interpretation of Dagfinn Føllesdal (Føllesdal 1969 and 1979, Dreyfus 1982, Føllesdal 1989). It is fair to say, however, that his interpretation has "led a whole generation" (Dreyfus 1982, p. 2). This interpretation is, of course, not unanimous. (Bell 1990), for instance, argues forcefully against it. To discuss this question in any detail is well beyond the scope this essay. It should rather be viewed as one of the locations where we, albeit not uncontroversial, underline the continuity—rather than the discontinuity—of ToRs. Dreyfus interpretation of Husserl as an early contributor to AI (Dreyfus 1982, p. 17) is likewise out of line with what we present.

[7] Føllesdal argues forcefully for the interpretation that Husserl in fact held that complete evidence was never attainable (Føllesdal 1989). Our discussion does not require this kind of strong thesis; we concentrate on perception of physical objects which clearly could attain only incomplete evidence according to Husserl.

[8] A more accurate description would be the following: One never attains complete evidence for such acts because new anticipations are being generated

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at least as fast as old ones are confirmed during the sequence of subsequent acts. (The number of anticipations in the noema is thus potentially—not actually—infinite). A problematic and highly debatable feature of Husserl's phenomenology is the fact that Husserl viewed noema as not having an inexhaustible supply of anticipations! In other words, he maintained that it was in principle possible to have complete evidence about a noema. He claimed that the phenomenological reduction, a special form of reflection, produced exactly this. We leave this question aside as it has little bearing upon the thrust of our argument. This is an essential—as opposed to merely terminological—difference with Heidegger. Heidegger never accepted thesis about the noema.

[9]Despite Husserl's continued effort to explain his phenomenological reduction, it still remained somewhat of a puzzle—even to his close students (Becker 1970).

[10]For further, including critical, remarks on our presentation of the relationship between phenomenology and social construction see (Spielberg 1959, p. 255-256) and (Waldenfels 1992, p. 78-79).

[11]Hintikka and Hintikka develop an intriguing argument of how to understand the phases of Wittgenstein's work (Hintikka *et al.* 1986). In relation to our discussion, one of the most interesting claims is one to the effect that Wittgenstein was continually concerned with achieving one, principal aim, namely to account for how expressions refer to objects and how they function communicatively. In the Tractatus, his answer was the picture theory relying on ostensive definitions. In the Investigations, this aim was not abandoned—only the means. Language-games, as the argument goes, is not a completely revised framework, it is simply his revised proposal for how the reference is fixed. Frege was close to the only philosopher Wittgenstein cited with approval. And this does not apply only to the Tractatus (Harrison 1979, p. 208, Dummett 1981, page 31). There are interpretations of how language-games could be viewed within ToRs (Hintikka *et al.* 1986, Harrison 1979, p. 208 and 249).

[12]This could be stated even sharper. The whole idea underlying model theory, namely the possibility to stand back and, so to speak, ascribe meaning by defining a function from the language to the model (typically a suitable mathematical structure), was quite alien to Frege. He, as did Wittgenstein, regarded language as an universal medium which one could never step in and out of. This renders the model theoretical approach impossible (Hintikka *et al.* 1986, p. 3).

[13]Others, e.g (Klein *et al.* 1992, Lyytinen 1987, Stamper 1987), effectively assume that it is obviously that modelling necessarily is ambitious, that it aims at representing reality. (Chen 1976) is often cited in support of this. Chen, however, explicitly states that:

> "It is impossible (and, perhaps unnecessary) to record every potentially available piece of information about entities and relationships."
>
> (Chen 1976, p. 11).

References

Atkins, M. C. *et al.*, (1991). Principles of object-orientated systems. In J. A. McDermod, editor, *Software engineer's reference book*. Butterworth-Heinemann.

Becker, O., (1970). The philosophy of Edmund Husserl. In R. O. Elveton, editor, *The phenomenology of Husserl. Selected critical readings*. Quadrangle Books.

Bell, D., (1990). *Husserl*. Routhledge.

Berger, P. and T. Luckmann, (1966). *Social construction of reality. A treatise in the sociology of knowledge*. Penguin Books, reprinted 1984 edition.

Bijker, W.E., T. P. Huges, and T. Pinch, (1989). *The social construction of technological systems*. MIT Press.

Bijker, W.E. and J. Law, editors, (1992). *Shaping technology/ building society.* MIT Press.

Booch, G., (1991). *Object-orinted design with applications*. The Benjamin/ Cummings Publ.

Budd, T., (1987). *A Little Smalltalk*. Addison-Wesley.

Chen, P.P.S. (1976). The entity-relation model—toward a unified view of data. *ACM Transaction on database systems*, 1(1):9–36.

Collins, H. and S. Yearley, (1992). Epistemological Chicken. In (Pickering 1992).

Dahlbom, B, (1992). The idea that reality is socially constructed. In C. Floyd, R. Budde, R. Kheil-Slawik, and H. Züllighoven., editors, *Software developement and reality construction*, pages 101 – 127. Springer–Verlag.

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Dreyfus, H.L., editor, (1982). *Husserl, intentionality and cognitive science*. MIT Press.

Dummett, M., (1973). *Frege : philosophy of language*. Clarendon Press.

Dummett, M., (1981). Frege and Wittgenstein. In I. Block, editor, *Perspectives on the philosophy of Wittgenstein*. Basil Blackwel.

Føllesdal, D., (1969). Husserl's notion of noema. *The Journal of Philosophy*, pages 680–687. (also reprinted in (Dreyfus 1982)).

Føllesdal, D., (1979). Husserl and Heidegger on the role of actions in the constitution of the world. In E. Saarinen, R. Hilpinen, I. Niiniluoto and M. P. Hintikka, editors, *Essays in honour of Jaakko Hintikka*. D. Reidel.

Føllesdal, D., (1989). Husserl on evidence and justification. Manuscript.

Gadamer, H.G., (1976). *Philosophical hermeneutics*. University of Califorinia Press, 1976.

Geach, P. and M. Black, editors, (1952). *Translations from the philosophical writings of Gottlob Frege*. Basil Blackwell.

Gregory, F. H., (1993). Soft systems methodology to information systems : a Wittgensteinian approach. *Journal of Information systems*, 3:149–168. Special issue on SSM.

Harrison, B., (1979). *Introduction to the philosophy of language*. MacMillan.

Jackson, M. A., (1973). *System development*. Prentice-Hall.

Kensing, F. and T. Winograd, (1991). The language/ action approach to design of computer—support for cooperative work : a preliminary study in work mapping. In R.K. Stamper, R. Lee, P. Kerola and K. Lyytinen, editors. *Collaborative work, social communications and information systems*, pages 311 – 333. North-Holland.

Hintikka, M. B. & J. Hintikka, (1986). *Investigating Wittgenstein*. Basil Blackwell.

Klein, H.K. & K. J. Lyytinen, (1992). Towards a new understanding of data

modelling. In C. Floyd, R. Budde, R. Kheil-Slawik, and H. Züllighoven.,*Conferance on software developement and reality construction*, pages 203–220, Springer-Verlag.

Kripke, S., (1972). *Naming and necessity*. Harvard University Press.

Lyytinen, K., (1987). Two views of information modelling. *Information and management*, 12(1):9–19.

Marche, S. (1993). Measuring the stability of data models. *European Journal of Information systems*, 2(1):37–47.

Martin, R., (1988). *The meaning of language*. MIT Press.

Martin, J., (1993)*Principles of object-oriented analysis and design*. Prentice-Hall.

Monarchi, D. E. and G. I. Puhr, (1992). A reseach typology for object-oriented analysis and design. *Communications of the ACM*, 35(9):35–47.

Monteiro, E., (1992). *Perspectives on proof theory: logical, computational and philosophical*. PhD thesis, Univ. of Oslo. Research report no. 171, Inst. of Informatics.

Pickering, A., (1992). *Science as practce and culture*. University of Chicago Press.

Pressman, R.S., (1992). *Software engineering. A practioner's approach*. McGraw-Hill.

Reenskaug, T. *et al.*, (1992). OORAS: Seamless support for the creation and maintenance of object oriented systems. *Journal of Object-oriented programming*, 5(6).

Reich, R. B., (1991). *The work of nations*. Alfred A. Knopf.

Rommetveit, R., (1983). In search of a truly interdisciplinary semantics. *Journal of Semantics*, 2:1 – 28.

Scheer, A.-W. & A. Hars, (1992). Extending data modeling to cover the whole enterprise. *Communications of the ACM*, 35(9):166 – 172.

Searle, J.R., (1969). *Speach acts*. Oxford University Press, 1985 edition.

Searle, J.R., (1980). The background of meaning. In J. R. Searle *et al.*, editors,

Speach act theory and pragmatics, pages 221 – 232. Oxford University Press.

Spielberg, H., (1959). *The phenomenological movement. A historical introduction*. Kluwer Academic Publ., third revised and enlarged edition, 1982 edition.

Stamper, R., (1987). Semantics. In R. J. Boland Jr. & R. A. Hirshheim, editors, *Critical issues in information systems research*, pages 43–78. John Wiley & Sons.

Suchman, L. (1993). The politics of categories? The Language/Action Perspective Reconsidered. In G. DeMichelis, C. Simeone and K. Schmidt, editors, *Proceedings of the Third European Conference on Computer-Supported Cooperative Work—ECSCW '93*. Kluwer Academic Publishers, Dordrecht.

Waldenfels, B., (1992). *Einführung in die Phänomenologie*. Wilhelm Fink Verlag, München.

Winograd, T. and F. Flores, (1986). *Understanding computers and cognition*. Addison–Wesley.

Wittgenstein, L., (1958). *Philosophical Investigations.* Basil Blackwell, Oxford.

Woolgar, S., (1988). *Knowledge and Reflexitivity: New Frontiers in the Sociology of Knowledge.* Beverly Hills, Sage.

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