

## PDF hosted at the Radboud Repository of the Radboud University Nijmegen

The following full text is a publisher's version.

For additional information about this publication click this link.

<http://hdl.handle.net/2066/112645>

Please be advised that this information was generated on 2019-09-15 and may be subject to change.

# Formal Modelling as a Grounded Conversation

S.J.B.A. Hoppenbrouwers, H.A. Proper, and Th.P. van der Weide

Institute for Computing and Information Sciences, Radboud University Nijmegen

Toernooiveld 1, 6525 ED Nijmegen, the Netherlands

{stijnh,e.proper,tvdw}@cs.ru.nl

## Abstract

In this paper we discuss a LAP-related view on the phenomenon of general (formal) modelling (including conceptual modelling, business modelling, but also software modelling). We view formal models as the result of a specialized sort of conversation within a system development conversation at large, in which participants need to bridge the gap between informal (NL-based) and formal (mathematics-based) representations and interpretations. We provide an initial communication-based analysis of the formal modelling process, and discuss why it is crucial that the (formal) structures in the various kinds of models are somehow *grounded* in the structures of agreement/commitment that underlie the development conversations. We explain how looking at modelling as communicative *behaviour* (action) may help achieve grounded models, thereby improving their validity in context.

**Keywords:** Modelling, Formalization, Dialogues, Validation, Grounding

## 1 Introduction

In this paper, we explore an aspect of a LAP-related approach to the field of system development (information systems, but also software systems in general) as a cooperative, communicative process. We view system development as analogous to general organization, but with some specific and highly interesting issues of its own. We focus on a prominent, even fundamental issue in system development that so far does not seem to be subject of much discussion within the LAP community: the “informal-formal divide”. With this term we refer *not* to well-known, paradigmatic differences concerning the nature of language use and language meaning (for this discussion, see (van Reijswoud, 1996; Winograd and Flores, 1986) among others), but to related aspects of language functionality and use that play a central role in system development practice: the widespread parallel (even overlapping) use of “informal” and “formal” languages in information system / software development. This issue is most acutely raised where “informal descriptions” are to be “formalized”. This is where in some cases, LAP-like (functionalist, subjectivist) ways of thinking clash violently with their “representationalist”, “positivist” counterparts, causing practical problems that originate in fundamental differences between methods and forms of communication and cooperation.

In LAP literature, ample work exists that, directly or indirectly, aims to support or improve system development. Also, the LAP community has brought forth several methods/techniques related to information system development at a conceptual and/or action level. For example, the DEMO method (van Reijswoud and Dietz, 1999; van Reijswoud et al., 1999) is basically a method for business process modelling/engineering, but it does provide many explicit and useful links to information system development. In particular, the combination of DEMO with ORM (Halpin, 2001) is relevant in this respect (Dietz and Halpin, 2004). Another example of a relevant approach can be found in (Goldkuhl and Agerfalk, 1998). More generally, many fundamental issues (mostly language- and communication related) concerning information and computer systems have been discussed within the LAP over the last decade.

However, to our knowledge the LAP has never been applied directly for analysis of (information) *system development processes* as such. With this we refer to the whole of activities related to the creation of socio-technical systems: conception, definition, design, construction, deployment, and management of information systems (usually computerized) and the environment they function in (i.e. the people that use them and the organizations they support). Importantly, this *includes* highly technology-oriented domains and activities in the development process, and in relation to those, a view and use of language that is very different from the one advocated under the LAP (Hoppenbrouwers, 2003, p85-7). In a way, we thus inverse the typical (and quite acceptable) LAP attitude of turning away from the positivist/representationalist interpretation of language and communication, and thereby from the technical fields that still embrace this view. Taking the LAP, we consider what can be contributed to bridge the gap between the LAP and the positivist/representationalist perspective. We attempt to apply the LAP to the activity of *formal* modelling. We explore “the modelling of formal modelling”. We realize this focus is new within the LAP community, and believe it may be a missing link in thinking about system development. Our main aim here is to open up the discussion and deepen our still modest insights in the fundamental issues involved.

The diverse languages used in system development, and the use made of them, relate to a heterogeneous group of stakeholders, including project managers, (prospective) users acting as informants, information architects, but also software engineers and programmers. For an actual computerized system to emerge, all of these stakeholders, and all the communication and languaging their work involves, have to play their unique part. Taking a strictly fundamental (typically “cybernetic”) point of view, we can even include “automated agents” in our view; for example, compilers or CASE tools. We firmly acknowledge that there is a crucial and at times problematic difference between “language” as “used by” a program/compiler and, say, a system user. However, given that the science of computational machinery and its use of (formal) languages undeniably has its own merits, we believe that in the context of the system development process, it is more useful to study the complicated pragmatic relations (and possibly, similarities) between the two views rather than to emphasize the differences between them, crucial though such emphasis has been –and still is– for emancipatory reasons and for creating awareness of the complex issues at hand.

In principle, then, we include in our ongoing study of system development *all communication and language use* (i.e. in the broadest sense) taking place in some “system development community” (Hoppenbrouwers, 2003, p79-82). However, in this paper we put central formal languages and their use in system development. Programming languages, with their relation to both “socio-cognitive” and “operational” semantics (Hoppenbrouwers, 2003, p85) are a traditionally prominent example that springs to mind, but also in less technology-oriented domains of analysis (extending to enterprise modelling and organizational engineering), formal languages are used (increasingly so), e.g. for definition of formal ontologies, formal process models, formalized business rules, etc. (Hoppenbrouwers, 2005). In the remainder of this paper, we will generally refer to “formal modelling”, but use this term in the sense of “formal description” in general, hence in principle *including* coding in programming languages.

Communication is not only a fact of life in system development practice, it determines for a large part how development processes take place and whether or not a system turns out successful (Hoppenbrouwers et al., 2004). We believe it is indeed a good idea to view/study

system development from a communicative (language action) perspective. The basic arguments behind this belief are the following.

3. **Combine various approaches to (the functionality of) language** – Many language or information related issues lie at the core of understanding system development, including the clash between (both the creation and the use of) *formal* (say, mathematics-based) and *informal* (say, natural language-based) descriptions. This concerns central issues of (different approaches to) syntax, semantics, and pragmatics. Note that though, for the sake of the argument, we assume that indeed there *is* a fundamental difference between the formal and informal approach to language, the study of the nature of this difference, and ways of bridging the supposed gap, is part of our fundamental interests.
4. **System development as a form of social construction of reality** – Cooperation and interaction between participants/stakeholders in system development can be fruitfully approached from a LAP perspective. This emphasises the social interaction, agreement, and knowledge sharing aspects involved: system development as a process of cooperative development of very specific, *grounded* representations with very different underlying requirements and goals (again including the informal/formal divide).
5. **Combine different theoretical issues under one framework** – Issues falling under 1 and 2 are ultimately intertwined (see section 2.4 below). To understand and possibly solve them, the theoretical frameworks applied should preferably be compatible (if not similar). The LAP, possibly in combination with various flavours of semiotics, seems a promising candidate framework for such an approach. Central are aspects like the crucial link between agreement about the *validity* of statements and agreement about the *meaning* of statements (Hoppenbrouwers and Weigand, 2000; Hoppenbrouwers, 2003), and combining the *representational* view on some meaning (a meta-linguistic representation) with a *behavioural* view on language and meaning (i.e. what people do when they discuss it and reach agreement about it). This, we feel, is also very much a LAP approach.
6. **Combine organizational communication and system development issues** – Along similar lines, integration of issues of information and communication in organizations (the mainstream LAP focus) should ultimately be integrated with information system *development* in particular (this concerns, for example, feedback loops and evolutionary development (Hoppenbrouwers and Proper, 2004)). Again, the LAP plays a key role in enabling the required integration on a fundamental level.

In section 2, we further clarify our view of system development as a conversation. This paves the way in particular for a discussion of arguments 1-3. Next, the 1st argument will be elaborated on (in section 3), after which we briefly present our basic view on modelling as a dialogue (section 4). This discussion will again touch issues related to argument 3. In section 5, the 2nd argument will be focused on (this is where the “grounding” of the conversations comes in). Finally, we present some plans for further research. Note that argument 4. is not further elaborated on in this paper.

## 2 System Development and Modelling as a Conversation

As said, we base our study of (information) system development on the idea that system development processes are long, complex, and multi-faceted *conversations*, or, if you like, many interlinked sub-conversations (Hoppenbrouwers et al., 2004). At the centre of our

current analysis lie *modelling conversations*, but other types are also included in our general way of thinking.

In the past we have already taken a communication-driven perspective on modelling activities in (information) system development (Derksen et al., 1996; Hoppenbrouwers et al., 1997; Frederiks and van der Weide, 2004; Bleeker et al., 2004; Proper and Hoppenbrouwers, 2004), as well as on the act of system development at large (Veldhuijzen van Zanten et al., 2004). We are certainly not alone in doing so (Nijssen and Halpin, 1989; Embley, 1992; Halpin, 2001). Our main point of reference currently still is the ORM method for *domain modelling*. ORM is also extensively used in business rule formulation and requirements engineering. It is a formal modelling language (“way of modelling”) that is rooted in, and can be mapped to, set theory (van Bommel et al., 1991) and predicate logic (Halpin, 1989). ORM includes a rather elaborate “way of working” that involves expressions in normalized NL phrases. This way of working has been our starting point in exploring communication-based modelling as *behaviour* (crucially involving language action). We intend to later expand our analysis to various other flavours of formal modelling, including full blown predicate logic. We consider formal domain modelling to be an excellent “step up” for this, because traditionally it often is a first step in the formalization process.

The communication taking place during system development leads to the creation and dissemination of *knowledge*. In essence, we regard system development as a communication-driven *knowledge transformation* process whereby conversations are used to share and create knowledge pertaining to the system being developed as well as the development process as such (Hoppenbrouwers et al., 2004). We do *not* claim that viewing information system development as a knowledge transformation process is new (Mylopoulos, 1998). Our ultimate aim (beyond this paper) is to use this perspective on system development to better understand, for example, the strategies that (should) drive system development conversations, and even the requirements that should be set for modelling languages (Hoppenbrouwers et al., 2004).

## 2.1 Knowledge in System Development

The actors in a system development community will (typically as a consequence of their personal *goals* and *stakes*) have some specific interests with regard to the system being developed. The system development community harbours knowledge about the system being developed. Communication occurring within a system development community essentially aims to create, further, and disseminate this knowledge.

During the development of a system, the knowledge about the system and its development will evolve. New insights emerge, designs are created, views are shared, opinions are formed, design decisions made, etc. Consequently, the knowledge as it is present in a development community can be seen to evolve through a number of *knowledge states*. We identify three dimensions for the knowledge states of the development community: (1) topic, (2) level of sharing, and (3) level of explicitness. The topical dimension is not further discussed in this paper; the other two will be elaborated on below.

Knowledge needs to be *introduced* into the development community first, either by creating the knowledge internally or by importing it from outside the community. Once knowledge has been introduced to a community, it can be *shared* among different knowledge carriers. The sharing of knowledge between different actors may progress through a number of stages. We distinguish three major stages:

**Aware** – Actors may become *aware* of (possible) knowledge by way of sharing by another actor (possibly from outside the community), or by creating it themselves.

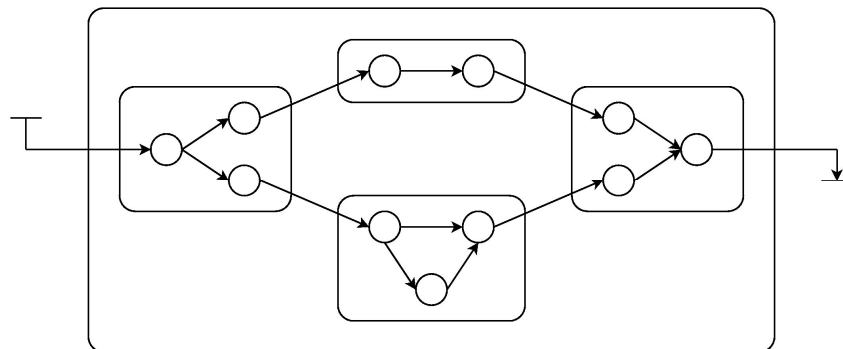
**Agreed** – When shared, actors can make up their own minds about the shared knowledge, and decide whether or not to *agree* on the knowledge shared.

**Committed** – Actors who agree to a specific knowledge topic may decide to *commit* to this knowledge: they may decide to adopt their future behaviour in accordance to this knowledge.

The actual knowledge that is harboured by a knowledge carrier can not be taken into account *explicitly* since the knowledge that is available from/on/in a knowledge carrier is subjective and context-dependent by nature (Peirce, 1969). The harbouring of a knowledge topic by some knowledge carrier may occur at different levels of formality, completeness, executability, etc. Our focus is on the communication of system development knowledge by way of *explicit* representations. In other words, *explicit knowledge*, where the representations pertain to an existing or future system; its design, the development process by which it was/is to be created, the underlying considerations, etc.

## 2.2 System development conversations

The knowledge transformations discussed above are brought about by conversations. The scope of these conversations may range from “atomic” actions involving a small number of actors, via discussions and workgroups, to the development process as a whole. This has been illustrated informally in figure 1.



**Figure 1:** Example Sequence of System Development Conversations

The design conversation at large starts off with some initial (sub-)conversation, which leads to further conversations (each with their own specific goal and participants). Generally, the main conversation first diverges (“branching off”), then converges. Importantly, the conversations can only for a limited part be planned; which conversations are to follow up previous ones largely depends on the intermediate results, which cannot be predicted.

Each (sub-)conversation is presumed to have some *knowledge goal*: a knowledge state which it aims to achieve (or maintain). This knowledge goal can best be regarded as a multi-dimensional vector, positioning (as mentioned) the knowledge topic, the level of explicitness of the knowledge, and the level of sharing. In achieving a knowledge goal, a (sub-)conversation will follow a *conversation strategy*. Such a strategy is needed to achieve the goal of the (sub-)conversation, starting out from the current state:

**Knowledge goal** – A desired knowledge state which the conversation will aim to achieve/contribute towards.

**Initial state** – The initial knowledge state as it holds at the start of the conversation.

Conversations take place in some situation in which resources may or may not be available for execution of the conversation. A conversation situation may be characterised further in terms of *situational factors* (Franckson and Verhoef, 1999); elaboration on specific situational factors goes too far for the current discussion.

A conversation strategy should typically cover at least the following elements:

**Execution plan** – As mentioned before, a conversation can be composed of sub-conversations. Each of these sub-conversations focuses on a sub-goal, but they all contribute towards the goal of the conversation as a whole. The execution plan of a (composed!) conversation consists of a set of sub-conversations, together with a planned execution order.

**Description languages** – The description languages to be used in the conversation(s).

**Media** – The kind of media to be used during the conversation(s).

**Cognitive mode** – The *cognitive mode* refers to the way in which knowledge is processed/gathered by the collective of actors involved in a conversation. Typically, a distinction is made between an analytical and experimental approach.

**Social mode** – The *social mode* is the way in which the actors executing the system development process collaborate with the actors from the business domain. We distinguish between an expert-driven and a participatory approach.

**Communication mode** – A small number of basic patterns of communication can be distinguished, as covered by combinations of the some basic factors: speaker-hearer ratio, requirements on hearer response, allowed time-lag, locality, and persistency. Combinations of these factors can be used to typify many different modes of communication, which can have a major impact on the resources required for communication and the likelihood a knowledge goal is achieved.

### 2.3 The Role of (Formal) Modelling in System Development

At various stages in system development, formal descriptions (data structures, formal protocols, process models, computer programs, etc.) may play a role. From a functional perspective, there are two main, interrelated reasons why they may be needed:

1. Because a formal description is to be used as input for, or otherwise as part of, a computation
2. Because a formal descriptions is used in a context that requires rigid logical or mathematical description and “thinking”, reflecting a desire to achieve (within some clearly delimited domain or activity) a very high degree of certainty and predictability (arguably, rationality).

Quite obviously, reason 1 is for a large part the result of technology and engineering based on 2. However, in many cases the use of computational technology seems to have become a goal in itself, detached from its mathematical/rational roots.

There is an important link between “formality” and the *level of explicitness* (the third dimension of knowledge states); formal descriptions are a special flavour of highly explicit knowledge representation. Many different sorts of models and formalisms (i.e. formal languages) exist and may be used. Importantly, some formalisms are very “heavy” (for example, require a completely formalized, i.e. mathematics-based *semantics*), whereas others are much “lighter” (for example, they may just require a well-defined syntax that can be mathematically captured, but without a formally described semantics). We refrain from discussing detailed classification of formalisms here, but a typical light formalism is XML; heavier ones are predicate logic or C++. Both light and heavy formalisms serve *operational* goals in system development, and are “texts” delivered as part of the actual development process, usually by specialist modellers (arguably including programmers) that are members of a system development community.

## 2.4 Uncertainty Reduction as a Chief Goal

Another word now about the goals of conversation and strategies deployed to achieve those goals. Identifying and resolving “vagueness” is a major part of the refinement task in system development and modelling (Veldhuijzen van Zanten et al., 2004). Consequently, many conversation strategies aim for *uncertainty reduction* of some sort. Two main *types of uncertainty* can be relevantly identified (Regan et al., 2002), each raising a different class of questions within the modelling conversation:

**Epistemic uncertainty** – This uncertainty exists in the mind of the individual expert, and reflects the incomplete knowledge a domain expert has of the domain. The uncertainty is a result of limited mental resources and limited time to investigate the domain (Anderson, 1990).

**Linguistic uncertainty** – This is uncertainty introduced in communication between participants, occurring when an expression in common language has more than one possible interpretation. For flexible common languages, such as natural language, this may occur frequently. Very constrained languages, on the other hand, may prevent the occurrence of multiple interpretation, at the expense of limited expressive power.

## 2.5 General Solutions

Although precise methods for handling the various types of uncertainty depend on the situation, several general approaches can be distinguished. (Lipshitz and Strauss, 1997) investigated how decision makers handle uncertainty; they found that four general ways occurred:

**Reduction of uncertainty** – Collect additional information, e.g. by asking.

**Assumption based reasoning** – Fill gaps in knowledge by making plausible assumptions.

**Weighing pros and cons** – of various alternatives.

**Suppression** – Ignore uncertainty, at least for a while.



We view these four approaches as basic *strategies* for dealing with uncertainty in modelling.

### 3 Bridging the Informal-Formal Divide in System Development

We have already briefly discussed the differences between “formal” and “informal” languages (section 1). We will not enter here into an elaborate discussion of the different cultural and theoretical opinions and practices underlying these two main flavours of use and description of language and meaning. Instead, we focus on a possible direction for creating not just peaceful coexistence but actual synergy between the two views, if not on a fundamental then at least on a pragmatic level.

#### 3.1 Basic Options for Resolving the Informal-Formal Divide

For the informal-formal divide to be dealt with, there are three hypothetical options:

**Formalize the “informal” world** – This is exactly the sort of approach that has led to counter-reactive approaches like the Language Action Perspective. The representationalist/positivist view on language ignores some crucial issues that are vital in a “human-oriented” context (subjective, contextualized, social, and also more oriented on realistically human cognition). Also, there are great practical limitations to formalization of the “informal” world.

**Reject the formal world, i.e. “informalize” the formal world** – In its radical form, this is indeed only a hypothetical option, since it would entail, among other things, rejecting all computer technology. This would be throwing away the child with the bath water. A less radical version, however, is much more realistic:

**Separate informal from formal and hide the formal world** – We might try to place formalized structures “out of sight” and not bother “regular people” with them. In fact, this of course amounts to what has since long been practiced in system development and use. In an idealized and naive version of this idea, “intelligent machines” should “simply” perform the translation (formalization) for us –which in fact is highly problematic. A more down-to-earth view leaves real formalizations to a relatively small group of experts and generally makes do with very light formalisms in system development, accepting the limitations and problems this entails.

It may not come as a surprise that we too pursue a viable version of the third option, integrated it the system development process. What this boils down to is encouragement, where relevant and productive, of an optimally rational way of system development without use of actual formal languages where possible, complemented with support for the problematic process of formalization where required. It is the latter we focus on in the rest of this paper.

#### 3.2 The Danger of Using the Translation Metaphor in Formalization

An important misconception underlying many naive approaches to bridging the formal-informal divide in system development stems from a limited understanding of the nature and functionality of formal languages and formalizations. This misconception is reflected in the term “translation” as in “translation from informal to formal language”. Still assuming that formal and informal descriptions are fundamentally different because of the nature and use of their respective underlying semantics, both systems of semantics can perhaps be respected and *partially linked*, in a non-deterministic and *pragmatic* fashion, without imposing one on

the other in any absolute sense. This is essentially different from “rephrasing an expression from one language in another, retaining the original meaning” –which is what most people associate with “translation”.

Formalization has its own, specialized functional context, which is rather different from that of natural language use. We propose to study how those two functionalities can be best combined in system development (and, ultimately, use), making optimal use of the strong points of either functionality. However, above all we propose (in a LAP-like fashion) to open the black box of the act of “formalization” (or, perhaps more correctly, “formal modelling”) and study it in terms of *behaviour* and *action*. The LAP is our paradigm of choice for this approach. Formalization, viewed as a conversation, can thus be linked with and brought closer to other communicational activities, without the need for informal-formal “translation” in the narrower, misguided sense.

In addition, from a purely practical point of view, it would be highly beneficial to system development in general if formalization came within the reach of non-specialists, or at least became a less specialist task. Also, formalization might be made more efficient and effective, and the quality of formalizations (both in terms of validity and correctness) “better”.

## 4 Our View of the Formal Modelling Process

Under our “behavioural” approach we aspire to explicitly express “modelling behaviour” as part of (communicative) behaviour in general. Therefore, it includes modelling strategies just as it includes conversation strategies; in fact, it views modelling strategies *as* conversation strategies. Our current analysis is rooted in *domain modelling*: the ORM “way of working”.

In line with section 2.2, under our analysis a model is constructed with a more or less specific *knowledge goal* in mind. The goal determines the required properties of the model: its topic, explicitness, and level of sharing. Strictly speaking, a model is a representation of a *mental model* belonging to a particular *viewer* of a domain, instead of the domain itself. The domain expert perceives the domain, and constructs (conceives) a mental model of that domain. Therefore, the information provided by a domain expert is always subjective and reflects only the structure of the domain *as seen by the domain expert* (Bosman and van der Weide, 2003). However, it is often the case that various participants share a similar view, and hence can agree on a single model.

### 4.1 Modelling as a Dialogue

We view the modelling process as a goal-driven *dialogue* between a number of participants. Questions and answers are exchanged. Each participant has her particular view (conception) of the domain. The only way the participants can achieve their respective modelling goals is to communicate with each other, and remember and build on what has been discussed. An explicit way to do this is to keep “modelling minutes” that are agreed on by the participants (Veldhuijzen van Zanten et al., 2004).

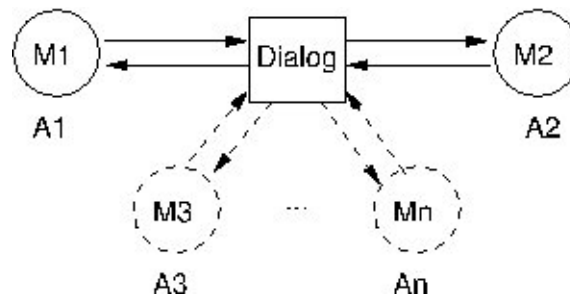
In early approaches, the modelling process has been portrayed as an asymmetric flow of information from domain expert to system analyst. More recently, the role of the analyst has also been considered, with a focus on the interaction of the participants in the modelling process (Frederiks and van der Weide, 2003): the analyst knows the demands posed by the

formalism used, and how to fulfil them. Under such an approach, the modelling dialogue is a *symmetric* exchange of knowledge in which:

- The domain expert transfers *expert knowledge* to the system analyst
- The system analyst transfers *analysis knowledge* to the domain expert

Both domain expert and system analyst are experts in their own field, contributing knowledge to the common model.

In general, a modelling process then is a dialogue involving a set  $\{A_1, \dots, A_n\}$  of participant actors (see figure 2). Each actor has an internal model  $\{M_1, \dots, M_n\}$ . For human actors, this is a mental model. The modelling process may be typically seen as a collaborative activity to develop a common and agreed model. To achieve this common model, the participants perform a goal-driven dialogue. Under our approach, formal modelling is captured by recording restricted aspects of communication between participants.



**Figure 2:** Symmetric view of the modelling dialogue, with two or more participating actors.

#### 4.2 Using Controlled Language in the Modelling Dialogue

Formal and informal language may be hard to fully reconcile, but a classic meeting point between natural and formal language lies in similarities between the basics of their grammar and meaning, in particular in predicates and predication. It has since long been recognized that when we use simple, elementary sentences in natural language, we can relatively easily bridge the gap between formal and informal (Frederiks, 1997; Hoppenbrouwers et al., 1997), even if the bridge can only bear very light traffic. Such simple, elementary language can be described by a relatively simple grammar and can yet be realistically used in a modelling conversation. We refer to it as *controlled language*. Our notion of controlled language is related to that of *simplified English*; see (Farrington, 1996; AECMA, 2001).

Importantly, the information covered by a single statement in controlled language will be quite limited. A formalization requires a fairly large number of interrelated, well validated statements to reach a degree of explicitness and agreement adequate for the target formalization.

#### 4.3 Explicit Statements with Various Implicit Interpretations

We presume a participant not only to be able to represent (parts of) her conception of the universe, but also to be able to represent (relevant parts of) the language/concepts they use in producing their conception of the universe. Taking a communicative perspective on information modelling, the goal of the modelling process can thus be described as: trying to reach a state where all participants agree that they have some degree of common understanding. The participants try to reach consensus about a group semantics of the model

that is based on, and is compatible with, the semantic systems and the interpretations of all group members.

Participants will be convinced this goal has been achieved if they have validated their assumptions to contentment of everyone involved. For example, a system analyst will be convinced that the derived model is complete if the model has been validated against the real situation. In our view, this means that the domain expert, harbouring the semantics of her conception of the universe, has positively responded to the description of the model provided by the system analyst, which may be rooted in a formal language. Various semantic systems and interpretations come into play; the shared, controlled language (which may in part cooperatively constructed as part of the modelling process) performs an intermediary function.

The goal of the dialogue can thus be seen as the construction of (1) a grammar for representations that are acceptable to all participants, and (2) semantic interpretation(s) in terms of some model(s). The grammar produced in the interaction is a generative device; the grammar is correct when all possible (valid) sample sentences can be generated. In addition, the grammar can be used as a parsing device. From the point of view of the system analyst, the target model is restricted by the (formal) semantics of the modelling technique used. From the point of view of the domain expert, validation of the model may be seen as assigning meaning (interpretation) to the representations generated by the system analyst. A more symmetric way of putting this is that for each party (*a*), the other party (*b*) agrees with the controlled language statements provided by party (*a*).

#### 4.4 Sketch of the Dialogue Structure

Because of editorial limitations on this paper, we cannot discuss modelling strategies or the structure of modelling dialogues at any length here. We can only say that we distinguish six straightforward dialogue actions, (closely related to various existing speech act classifications):

<b>Propose</b> ( <i>a, s</i> )	Actor <i>a</i> proposes statement <i>s</i> . It does not become part of the common model until every actor accepts it.
<b>Withdraw</b> ( <i>a, s</i> )	Actor <i>a</i> withdraws statement <i>s</i> . Withdraw is the opposite of propose.
<b>Accept</b> ( <i>a, s</i> )	Actor <i>a</i> accepts statement <i>s</i> as a valid statement; it may eventually become part of its internal model $M_a$ . A statement can only be accepted after it is proposed.
<b>Reject</b> ( <i>a, s</i> )	Actor <i>a</i> rejects statement <i>s</i> , because <i>a</i> finds <i>s</i> unacceptable even for further consideration. Reject is the counterpart of accept.
<b>Ask</b> ( <i>a, q</i> )	Actor <i>a</i> asks question <i>q</i> , to be answered by some actor. Queries can be withdrawn or answered.
<b>Answer</b> ( <i>a, q, s</i> )	Actor <i>a</i> answers question <i>q</i> with statement <i>s</i> ; an answer functions as a special <b>Propose</b> .

As a mere illustration of the principle, consider this very simple example, that reflects a core aspect of domain modelling: application of what we might call the “delayed specificity” strategy. A more elaborate, formalized analysis of this strategy can be found in (Bosman and van der Weide, 2004).

The ORM formalism requires relational structures to be *specific*: enough information about entities must be provided, including of what *type* an entity is. Compare the first, “specific” sentence with the second, non-specific one:

- 1) person with name John lives in city with name Nijmegen
- 2) John lives in Nijmegen

The first sentence may be preferable from the point of view of the formalism, but it is a highly unlikely statement to be produced in one go by a domain expert. If a 1:1 translation from an NL statement to the formalism were required, sentence 2) would be unacceptable. However, another way out is a guided dialogue which leads to step-wise approach to gathering of the information needed:

- Detect non-specific statement (the grammar/parser can be of help here)
- Solve non-specificity by asking the domain expert for missing information
- Alternatively, solve non-specificity by assuming the missing information. This requires the sub skill of creating plausible information; suggestions (to be validated!) could be provided by means of a generic lexicon/ontology.

Note that the approach above relates to some basic strategies for uncertainty reduction mentioned in section 2.4. A complete example dialogue may then be as follows (keeping to the traditional roles in domain modelling, “DE” is domain expert, “SA” is system analyst):

```

propose (DE      John lives in Nijmegen)
ask (SA      What kind of thing is John?)
propose (DE      John is a person)
ask/propose (SA  Do we distinguish John from other persons by
means of his name?)
accept (DE,SA   Yes [we distinguish John from other persons
by means of his name])
ask/propose (SA  Do you agree that John is a person with name
John?)
accept (DE,SA   Yes [John is a person with name John])

```

For each “accept”, both DE and SA are registered as agreeing with the statement. In two cases, the action of asking and proposing is collapsed in one statement. As a result of this small sub-dialogue, the statement “John is a person with name John” is added to the separate set of “agreed statements”, on the basis of which a complete formalization can later be compiled. In addition, by means of the “defoliation strategy” (typical for “fact based modelling”), a generalization can be derived, suggested, and confirmed:

```

ask/propose (SA  Do persons generally have names?)
accept (DE,SA   Yes [persons generally have names])

```

## 5 The Importance of Grounding Formal Models in the Social World

Let us now briefly consider how the modelling dialogues sketched in the previous section relate to the grounding of models. In the representationalist/positivist tradition, formal models are generally supposed to be decontextualized (and therefore unambiguous). This is a

disputable view at best. If in addition, we view system development as a conversation, then not only are models undeniably produced and used in context and with some goal, but the specifics of a context are known and can be recorded alongside the models. Assuming that a model is built up through the gathering of statements, and that it is somehow recorded who puts forward each statement and who agrees with it (or even commits to it), we can place formal models in a *social context* –which opens up all sorts of possibilities, both practically and theoretically. We believe this is a crucial yet mostly ignored aspect of improving the quality of formal models in system development.

### **5.1 Validity of Models**

The quality of formal models is generally considered to be determined by two main factors: their *correctness* (checked by means of verification) and their *validity* (checked by means of validation). Where the literature on formal verification is absolutely vast, from a representationalist/positive perspective, not much can be said about, nor done about, validity. Most approaches boil down to “letting a participant read a description (possibly translated to NL), and letting her decide whether it is valid”. A dialogue-based, contextualized approach enables us in principle to deal with validation in a nuanced, varied, goal-driven, and controllable way. It is arguably an attempt to achieve for validation what representation-based grammar checking and proofing techniques have achieved for verification. Though no “absolute” validation can be achieved because of the fundamentally subjective nature of the validation process, detailed and contextualized validity of a model can be systematically constructed, checked, and re-checked.

### **5.2 Some basic aspects of Validity**

The LAP literature provides many interesting links to validity issues in modelling. Most prominently, the *validity claims* (Power, Truth, Sincerity, Justice, Comprehensibility –or some comparable constellation) as distinguished by Searle and Habermas (among others; see van Reijswoud, 1997, p51) apply to modelling statements just as they do to other sort of statements, and can be used to create and select specific strategies for specific sorts of validation. Note that when validation/agreement on the semantics of statements is concerned, the claim to comprehensibility can be challenged and discussed. For more on this, see (Hoppenbrouwers, 2003, p60-70). In addition, the stages/levels of knowledge sharing listed in section 2.1 can be included. Within LAP literature, a relation presents itself between those levels and, for example, illocutions as distinguished in (van Reijswoud, 1997) or the DEMO method. In fact, van Reijswoud's analysis of business conversations as reflected in his Transaction Process Model (in particular, its discussion layer) provides an interesting framework for further understanding and even guiding of modelling dialogues.

Importantly, a behavioural approach working towards validity (and possibly even to formal correctness) of a model does not necessarily “look back” on a completed (part of) a model, it strives to guide the modelling process and *along the way* creates a valid/correct model. This means the process itself is, at many levels and in many different ways, geared towards “quality” –as defined in context. It also suggests that that processes for valid/correct modelling can more easily be integrated in dynamic approaches to system development. In view of the whole system development process as an integrated conversation, the bottom line is that not just some insular (formal) models (being *representations*) are developed on the basis of “rational” strategies, but that the whole process can be shaped as an optimally “rational process” (Veldhuijzen van Zanten et al., 2004; Wupper and Mader, 1999). Note that in current modelling practice, this is not the case. Assuming increased rationality (where

relevant) is a good thing, the process will have to be *changed* in order to bring about the situation suggested above, and the entailing quality improvement we aim for.

### 5.3 Including Design/Modelling Rationales

An aspect we have not considered in any depth yet, but that seems relevant enough, is that of recording *rationales* (argumentation) behind modelling decisions. In system development, these often are design decisions, and keeping track of them is a long cherished wish in design and system development. Indeed it seems quite possible to add a particular set of strategies to modelling dialogues that elicit and record such rationales, and whether there is agreement or even disagreement about them, and what alternatives were considered, and who took the final decision. Within LAP literature, an inspiring framework that could well be used for structuring and categorizing rationales (and, possibly, the semantics of modelling dialogues in general, though we have to refrain from discussion of that issue here) is that of Weigand and de Moor (Weigand and de Moor, 2004), who provide a formal framework (argumentation semantics) in context of communicative action. This framework is partly based on Conklin's Issue Based Information Systems (IBIS) paradigm (Conklin, 2003).

## 6 Towards an environment for studying and supporting formal modelling

We have presented our over-all view on information system development and modelling as a multi-faceted conversation within the development community, grounded in knowledge sharing, agreement, and commitment. Thus, we take a Language Action Perspective on the system development process, viewing representations produced in the process as texts that reflect ongoing, social interaction between participants. If such texts include *formalizations*, then the functionality of both formal and informal texts and languages should be taken into account, and somehow combined. We have suggested a dynamic way of achieving this, based on dialogues, and provided a simple example of how we might analyse an aspect of domain modelling as a focused information gathering conversation.

We are now in the process of deepening our analysis and formalizing part of it. This has already provided us with a preliminary conceptual framework for describing modelling *dialogues* and *strategies*. We are also making some initial progress in applying our framework to various flavours of modelling, including information modelling, pre-negotiation ontological modelling, architecture modelling, and requirements modelling. All this will be reported on before long.

One of our core goals is to extensively study modelling strategies for various sub-fields of information system development (indeed, for such a study we need a sound conceptual framework). The conceptual framework, but in particular the strategies, will have to be studied and validated *empirically*. In order to make this possible, we are planning to create an experimental *environment for studying modelling dialogues*. By studying how participants in the modelling process interact, we first hope to discover and confirm how modelling dialogues work, and in particular what strategies are used in them. Once we have a sufficient grasp of the strategies involved, we intend to add some functionality to the environment enabling it to actively *guide* the dialogues (in view of particular modelling goals). Eventually, it is not unthinkable for our environment for studying and guiding modelling dialogues to evolve into an environment for the support of modelling conversations in practice. This would possibly amount to a hybrid system, part Groupware (CSCW, including negotiation issues), part CASE tool, part Truth Maintenance System. In some general respects, it would resemble systems like, for example, the Negoisst system (Schoop et al., 2003), yet it would very

specifically address matters of conceptualisation and formalization. Whether we ever be able to employ our ideas to supporting formal modelling in practice remains to be seen, and it is not currently our primary target to support actual modelling dialogues in an applied setting.

## References

- AECMA - THE EUROPEAN ASSOCIATION OF AEROSPACE INDUSTRIES (2001) *AECMA Simplified English - A guide for the preparation of aircraft maintenance documentation in the international maintenance language*. Brussels, Belgium, EU, January 2001. Issue 1, Revision 2. <http://www.aecma.org>
- Anderson JR (1990) *Cognitive psychology and its implications*. W.H. Freeman and Company.
- Bleeker AI, Proper HA, and Hoppenbrouwers SJBA (2004) “The Role of Concept Management in System Development - A practical and a theoretical perspective”. In J. Grabis, A. Persson, and J. Stirna, editors, *Forum proceedings of the 16th Conference on Advanced Information Systems 2004 (CAiSE 2004)*, pages 73-82, Riga, Latvia, EU, June 2004. Faculty of Computer Science and Information Technology, Riga Technical University, Riga, Latvia, EU.
- Van Bommel P, Ter Hofstede AHM, and Van Der Weide THP (1991) “Semantics and verification of object-role models”. *Information Systems*, 16(5):471-495.
- Bosman S. and Van Der Weide THP (2003) “A case for incorporating vague representations in formal information modelling”. In *Conferentie Informatiewetenschap 2003*, TU Eindhoven, The Netherlands.
- Bosman S and Van Der Weide THP (2004) *Towards formalization of the information modeling dialog*. Technical report, Computing Science Institute, University of Nijmegen, Nijmegen, The Netherlands.
- Conklin J (2003) *The IBIS Manual: a short course in IBIS methodology*. Touchstone.
- Derksen CF, Frederiks PJM, and Van Der Weide THP (1996) “Paraphrasing as a Technique to Support Object-Oriented Analysis”. In R.P. van der Riet, J.F.M. Burg, and A.J. van der Vos, editors, *Proceedings of the Second Workshop on Applications of Natural Language to Databases (NLDB'96)*, pages 28-39, Amsterdam, The Netherlands.
- Dietz JLG and Halpin TA (2004) “Using DEMO and ORM in Concert: A Case Study”. In *Advanced Topics in Database Research*, Vol. 3, pages 218-236.
- Embley DW, Kurtz BD, and Woodfiled SN (1992) *Object-Oriented Systems Analysis - A model-driven approach*. Yourdon Press, Englewood Cliffs, New Jersey, USA.
- Farrington G (1996) *An Overview of the International Aerospace Language*.
- Franckson M and Verhoef TF (1999) *Managing Risks and Planning Deliveries. Information Services Procurement Library*. Ten Hagen & Stam, Den Haag, The Netherlands.
- Frederiks PJM (1997) *Object-Oriented Modeling based on Information Grammars*. PhD thesis, University of Nijmegen, Nijmegen, The Netherlands, EU.



- Frederiks PJM and Van Der Weide THP (2004) "Information Modeling: the process and the required competencies of its participants". In F. Meziane and E. M'etais, editors, *9th International Conference on Applications of Natural Language to Information Systems (NLDB 2004)*, volume 3136 of Lecture Notes in Computer Science, pages 123-134, Manchester, United Kingdom. Springer-Verlag, Berlin, Germany.
- Goldkuhl G and Agerfalk PJ (1998) "Action Within Information Systems". Technical Report 1998-2, Jonkoping International Business School. *Accepted to the Fourth International Workshop on Requirements Engineering: Foundations of Software Quality (REFSQ'98)*, June 8-9 1998, Pisa, Italy.
- Halpin TA (1989) *A logical analysis of information systems: static aspects of the data-oriented perspective*. PhD thesis, University of Queensland, Brisbane, Australia.
- Halpin TA (2001) *Information Modeling and Relational Databases, From Conceptual Analysis to Logical Design*. Morgan Kaufman, San Mateo, California, USA.
- Hoppenbrouwers JJAC, Van Der Vos B, and Hoppenbrouwers SJBA (1997) "NL Structures and Conceptual Modelling: Grammalizing for KISS". *Data & Knowledge Engineering*, 23(1):79-92.
- Hoppenbrouwers SJBA (2003) *Freezing Language; Conceptualisation processes in ICT supported organisations*. PhD thesis, Radboud University Nijmegen, Nijmegen, The Netherlands, EU.
- Hoppenbrouwers SJBA *Formele Informatiekunde: overbrugging tussen de informele en de formele wereld*. Technical report, Computing Science Institute, University of Nijmegen, Nijmegen, The Netherlands, EU.
- Hoppenbrouwers SJBA and Proper HA (2004) "A Communicative Perspective on Second Order Information Systems". In G.E. Lasker, editor, *Proceedings of the 16th International Conference on System Research, Informatics and Cybernetics*, Baden-Baden, Germany. IIAS.
- Hoppenbrouwers SJBA, Proper HA, and Van Der Weide THP (2005) "Understanding the Requirements on Modelling Techniques". Technical report, Radboud University Nijmegen Institute for Computing and Information Science, 2005. Accepted for publication in *the proceedings of the 17th Conference on Advanced Information Systems Engineering (CAiSE'05)*, 13-17 June 2005, Porto, Portugal.
- Hoppenbrouwers SJBA and Weigand H (2000) "Meta-communication in the Language Action Perspective". In *Proceedings of the Fourth International Workshop on the Language Action Perspective on Communication Modelling (LAP 2000)*, Aachener Informatik-Berichte, Aachen, Germany, EU. RWTH Aachen.
- Lipshitz R and Strauss O (1997) "Coping with uncertainty: a naturalistic decision-making analysis". *Organizational Behaviour and Human Decision Processes*, 2(69):152-154.
- Mylopoulos J (1998) "Techniques and Languages for the Description of Information Systems". In P. Bernus, K. Mertins, and G. Schmidt, editors, *Handbook on Architectures of Information Systems*, International Handbooks on Information Systems. Springer, Berlin, Germany, EU.
- Nijssen GM and Halpin TA (1989) *Conceptual Schema and Relational Database Design: a fact oriented approach*. Prentice-Hall, Sydney, Australia.

- Peirce CS (1969) *Volumes I and II - Principles of Philosophy and Elements of Logic. Collected Papers of C.S. Peirce*. Harvard University Press, Boston, Massachusetts, USA.
- Proper HA and Hoppenbrouwers SJBA (2004) “Concept Evolution in Information System Evolution”. In J. Gravis, A. Persson, and J. Stirna, editors, *Forum proceedings of the 16th Conference on Advanced Information Systems 2004 (CAiSE 2004)*, pages 63-72, Riga, Latvia, EU, June 2004. Faculty of Computer Science and Information Technology, Riga Technical University, Riga, Latvia, EU.
- Regan HM, Hope BK, and Ferson S (2002) “Analysis and portrayal of uncertainty in a food web exposure model”. *Human and Ecological Risk Assessment*, 8(7):1757-1777, 2002.
- Van Reijswoud VE (1996) *The Structure of Business Communication: Theory, Model and Application*. PhD thesis, Delft University of Technology, Delft, The Netherlands, EU.
- Van Reijswoud VE and DIETZ JGL (1999) *DEMO Modelling Handbook*, volume 1. Delft University of Technology, 2nd edition.
- Van Reijswoud VE, Mulder JBF and Dietz JLG (1999) “Communication Action Based Business Process and Information Modelling with DEMO”. *The Information Systems Journal*, 9(2):117-138.
- Schoop M, Jertila A and List T (2003) “Negoisst: a Negotiation Support System for Electronic Business-to-Business Negotiations in E-Commerce”. In: *Data & Knowledge Engineering* 47 (2003) 371-401.
- Veldhuijzen Van Zanten GE, Hoppenbrouwers SJBA, and Proper HA (2004) “System Development as a Rational Communicative Process”. *Journal of Systemics, Cybernetics and Informatics*, 2(4), 2004. <http://www.iiisci.org/Journal/sci/pdfs/P492036.pdf>
- Weigand H and De Moor A (2004) “Argumentation semantics of communicative action”. In M. Aakhus and M. Lind, editors, *Proceedings of the 9th International Working Conference on the Language-Action Perspective in Communication Modelling (LAP 2004)*. Rutgers University, New Brunswick, USA, June 2004.
- Winograd T and Flores F (1986) *Understanding Computers and Cognition*. Ablex Publishing, Norwood, New Jersey, USA.
- Wupper H and Mader AH (1999) *System Design as a Creative Mathematical Activity*. Technical Report CSI-R9919, Institute for Computing and Information Science, Radboud University Nijmegen