A Framework for Natural Enterprise Modelling

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***Abstract*—Within enterprise modelling, models are typically needed for a range of different purposes, ranging from vision and strategy development to computer-aided analyses. It is well-known that model's content and form need to be adapted to its purpose. This typically concerns the tuning in terms of granularity, visualisation, precision and formality of the model, as well as in terms of the concepts/language in which the model is expressed. However, typical modelling tools lack such support. A number of empirical observations points at a lack in flexibility of tools and underlying modelling languages to aptly fit the needs of specific modelling situations. For instance, it is observed that fixed metamodels make it difficult to align the language with e.g. organisation-specific domains/concerns. This often leads to the different levels of discipline in which a fixed modelling language is obeyed to, or even the use of home-grown notations instead of fixed standard ones. Likewise, to compensate the lack of flexibility in dedicated modelling tools, classical drawing tools or paper are used as modelling support. Once models created this way transition to the more formal tasks, a lot of redundant work and increased effort is needed to ensure consistency and coherence among different enterprise models. As a result of an ongoing research, this paper discusses the need to adapt the models and modelling environments to specific modelling situations. In particular, we explore the concept of natural enterprise modelling, as a strategy for enabling the flexibility while also ensuring the coherence in modelling. We also sketch potential high-level design of a flexible modelling infrastructure supporting natural enterprise modelling, and indicate some promising future research directions.**

I. Introduction

In enterprise modelling efforts, models are typically used for a range of purposes: the analysis of the current situation of the enterprise and its challenges, development of vision, strategy or new organisational design, change management, knowledge management, stakeholder communication, etc [1]–[4]. We use the term *enterprise modelling landscape* or simply *modelling landscape* to refer to the variety of models and corresponding modelling languages used in these efforts. The need to tune models to a stakeholder and concern-oriented focus, vocabulary and representation [5] is often present within such landscapes. This usually means that models of different qualities [6] will be needed within a single enterprise modelling project, typically ranging from high-level, informal and visual models for decision-makers, to formal models for various computer-assisted analyses.

Many operations of model management are and may be automated by sophisticated CASE tools. Their focus on automation is strong, and reflects rather a techno-centric view on modelling. We refer to this view as *formal modelling*[1]. These modelling infrastructures do not cater for less formal and exploratory modelling in early phases of enterprise modelling projects. The empirical observations however indicate the need for better support of informal modelling and its better integration with formal modelling tasks [3], [4], [7], [8].

For instance, many practitioners of enterprise modelling share the observation that standard notations and dedicated modelling tools are rather rigid: metamodels and rules are fixed and unable to fix specific domains, tools have insufficient support for different model visualisations, do not facilitate stakeholder communication, lack support for collaborative work, etc. Likewise, the lack of support for early, exploratory phases by standard notations and dedicated tools is observed in [4]. In the mentioned study, business architects express a clear preference for home-grown, semi-structured models, since they offer flexibility in terms of re-factoring, delayed commitment to syntax, and closer fit to the inherent way of thinking in these phases. The preference for Office drawing tools over usual modelling tools is also indicated in [2], [8].

We will argue that the needs stemming from empirical observations reflect a more anthropo-centric view on modelling, which favours flexibility and underlines modelling pragmatics [9], i.e. what models and modelling languages are for, how they are used, by whom, for which purposes and in which circumstances. In previous work, we have already used the term *natural modelling* [10], [11] to refer to this view on modelling. The concept of natural modelling will be discussed in more details further in the paper.

The need for both natural and formal modelling practice is present in enterprise modelling efforts. While formal modelling is well supported with dedicated modelling tools, natural modelling is usually done with the help of paper and usual drawing tools. This necessitates a lot of redundant work. As semi-structured and informal models are usually created on paper or in Office tools, it asks an additional effort to 're-enter' them in a dedicated modelling tool when they transit to more formal tasks. Likewise, models in a 'standard' modelling language need to be distilled into 'boxology'[2] to be communicated back to stakeholders [7]. This gap in adequate tool support also makes assuring properties such as consistency, coherence, traceability etc., lot more difficult within the models of the modelling landscape.

[1]The term *formal* used here refers to the fact the syntactic-semantic restrictions are enforced on the modelling language, with the ambition to make models machine-readable.

[2]This term was used by one of the enterprise architects in exploratory interviews to refer to the informal diagrams created on the basis of more elaborated models for the purpose of stakeholder communication.

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While both natural and formal modelling practice are needed within enterprise modelling efforts[3], they are suited for different *purposes*, and, ideally, both these practices should be adequately instrumented with tools. In this paper, we will argue that the key to providing an adequate modelling support for each modelling situation requires a fundamental understanding of the factors underlying the concept of purpose. We will discuss our current understanding of the concept of purpose and, in particular, its role in shaping/adapting modelling language *in use*. Based on this understanding, the paper explores the concept of natural enterprise modelling. Natural enterprise modelling essentially proposes a strategy to enable flexibility of support for a range of different modelling practices, and at the same time ensure the coherence between different enterprise models. As such, natural enterprise modelling advocates for an increased flexibility of modelling infrastructures, whose potential high-level design will be sketched in the paper.

The paper is structured as follows: Section II develops our theoretical understanding of model purpose and of its role in shaping modelling landscapes. Natural (enterprise) modelling is discusses in details in III, while the related modelling infrastructure is discussed in IV. This is followed by the conclusion.

II. Theory for Enterprise Modelling Landscapes

While the need to adapt the content and form of models to different purposes is put forward by research work investigating enterprise modelling practice, e.g. [3], [4], [7], [12], modelling infrastructures taking this into account are scarce. In our view, the lack of a clear understanding of drivers and factors behind this need for tuning very often leads to inappropriate design of modelling infrastructures. The ambition of our ongoing research, reported on in this section, is to build an explanatory theory [13] of the driving forces and challenges related to modelling and linguistic variety within modelling landscapes. An initial paper [14] motivated such a research effort in the context of modelling (in general) and model integration (in particular). In this section, we focus primarily on defining the model purpose concept (Section II-A) and on understanding its role in shaping/using modelling languages (Section II-B).

A. Understanding the Concept of Purpose

In our work, and based on the previous research e.g. [15]–[18] we adopt a fundamental view on models as essentially the means of communication about some domain of interest, and the process of modelling as a communication-driven process led by some pragmatic focus [19]. The very notion of model as a *purposeful* abstraction of some domain of interest involves this pragmatic dimension. While the importance of purpose is widely acknowledged, e.g. [20] [21], the dimensions underlying this concept are rarely explicitly defined. We propose to see the **purpose** of a model as a combination of: (1) the **domain** which the model should pertain to and (2) the intended **usage** of the model (e.g. analysis, sketching, contracting, execution, etc.) by its intended **audience**. In other words, the *purpose* of a specific model is to capture some *domain* to enable some *usage* by its audience.

[3]The scope of a particular enterprise modelling effort may be only one project, cross-project considerations, the entire enterprise etc.

The notion of **domain** comprises any part or aspect of the “world” under consideration [15]. In enterprise modelling context, this refers to, for instance, governance domains, or design domains, i.e. different cells of enterprise architecture/modelling frameworks [22]–[25]. The relevance of these domains is highly situation-dependent, that is, different domains may be of relevance for different enterprises, or different projects within the same enterprise; and new domains may become relevant with the evolution of enterprise, etc.

Models are created with an intended **usage** in mind, e.g. analysis, sketching, contracting, simulation, execution, etc. The intended usage of the model by some audience will have a direct impact on the requirements for the modelling language used to capture the model.We thus suggest to identify the following language dimensions influenced by the purpose:

Restriction of notation: refers to the level of restriction put on the notation that is used to represent the model on a medium. The medium can be restricted to a specific form, e.g. graphical, textual, or video, but it can also be restricted in terms of fonts, icons and layout rules.

Restriction of syntax: concerns the level of syntactic restrictions that may be put forward by the modelling language used. For example, one might consider “free format” drawings or text on one hand, and UML diagrams or text-based specification languages on the other extreme.

Restriction of semantics: refers to the extent to which a language is to be used with formalized semantics.

In line with [3], [26], [27], we argue that purpose should be the primary driver of shaping a model, modelling process, and (the choice of) modelling language. Some related work embraces this view regarding model and language quality assessment [28] and modelling processes [18]. We explore this position with regards to the construction and use of modelling languages. We expect that, taken in synergy, these efforts may provide a solid theoretical foundation for the design of modelling infrastructures catering for modelling pragmatics.

B. Observable Consequences in the Language Use

Models are expressed in a system of (visual or textual) signs, i.e. a language. We look at the language as an instrument, whose primary functions are those of supporting reflection and communication. This view is in line with functional perspective [29] or action tradition on language [30]. From this perspective, we are interested in how well the language symbols support the modelling for a given purpose, in particular emphasizing how they are *used*.

Ideally, a model is created in a *purpose-specific modelling language*, which tunes the constructs the constructs of the language to the domain to be modelled, as well as adjusts the precision/form of the medium, syntax and semantics of the language to the intended usage and audience of the model. The notion of purpose-specific modelling language is certainly related to the notion of domain-specific modelling language [31]. We however argue that not the only domain as to be considered. For instance, depending on the audience and the intended usage, some domain may be modelled at different levels of *granularity* and expressed using different *vocabularies*.

In practical modelling situations, it is possible to observe that, depending on the purpose at hand, generic modelling language (e.g. UML [32] or ArchiMate [24]) is used in different ways with regard to the "discipline" with which the syntax and semantics of the language is obeyed to [7]. In our view, this essentially leads to purpose-specific "variations" of the same original generic modelling language (differing in their syntactic and semantic restrictions). In the case of ArchiMate language, this has resulted in the suggestion to distinguish between a 'sketching' and a 'designing' variation of the notation (using more sketchy lines and more informal looking fonts). This variation can even be combined in one model to differentiate between the status of different parts of the model. Likewise, the repeated use of semi-structured models and the emergence of underlying languages discussed in [4] is in our view clearly the example of an emerging purpose-specific modelling language.

The need for purpose-specific tuning of the language for a given communication situation is a rather natural principle, and indeed corresponding to the way humans normally use natural language [29]. In that sense, the communication situation - the goal, the intended message, its addressee, and the communication context - influences the choice of the form used to transfer the message [29], [30]. For instance, reaching common understanding on some domain between heterogeneous stakeholders is needed, the use of simple, visual and intuitive notations is commonly considered most suitable. The aspects such as syntactical correctness, completeness, formality etc. are less of support and even a burden [8] for the situation at hand. On the contrary, in situations where the addressee is a computer and the model should be machine-readable, e.g. for formal analysis and simulation, formality and correctness are of particular importance.

Indeed, we posit that the practitioners' need for the flexibility of modelling tools and languages, discussed in the introduction, is driven by the need for the language (qualities) suitable for the communicative task at hand. Based on the above considerations, we also posit that a purpose-specific 'variation' of the original language (i.e. originally imposed on the modelling process for any reason) will emerge to compensate for this lack of suitability.

At the same time, there is a potential downside to the notion of purpose-specific language: each increase in a model/language diversity is likely to have the fragmenting effect on the modelling landscape [14]. Generally, this purpose-specific fragmentation is considered to be a negative thing, as it is likely to have a negative impact on traceability across models, the ability to do cross-cutting analysis, and to ensure overall coherence of the landscape. A traditional approach of dealing with this kind of fragmentation is to create an integrated modelling language such as UML or ArchiMate. However, in actual use, the 'standardising' and 'integrating' effect of such languages erodes, and we have argued that this is due to the "natural behaviour" of a language.

In order to support purpose-specificity, but still be able to keep inter-model and -language links across the landscape, we suggest that languages might have to be constructed in a rather flexible way so as to, where needed, allow for their adaptation to the varying contexts, i.e. purposes for which they may be used. As our next step, we aim to explore this hypothesis by analysing the available instruments for modelling language design/integration with regards to the potential of their improvement in order to support purpose-specific language adaptations. The instruments of our particular interest are: megamodel [33], viewpoint [34], metamodel hierarchies [15], metamodel inference [8] etc. We can observe that ArchiMate incorporates some of these considerations, e.g. with the viewpoint mechanism that enables to filter the metamodel concepts and to tune the model visualisation. However, the viewpoints in ArchiMate still rely on the same set of concepts, while we do not intend to be that restrictive.

III. Natural Enterprise Modelling

In this section, we elaborate in more details the concept of natural modelling, and consider its relevance in the context of enterprise modelling. We first discuss, based on our previous work, the background and the key principles of natural modelling in III-A. This is then followed by the discussion of how natural modelling fits the needs and challenges raised by the practitioners of enterprise modelling.

A. Natural Modelling Vision and Principles

The concept of natural modelling is drawn from a fundamental understanding of the historical evolution of modelling practices, which is elaborated in [10], [11]. The space limitation does not allow us to provide here the details of this modelling retrospective. It follows the evolution and formalisation of symbols and languages used in modelling, depending on the modelling purposes, the needs of stakeholders and complexities of underlying social structures. Based on this, two fundamentally different, yet complementary, views on modelling are distinguished, namely formal and natural modelling (Figure 1). On the one side, *formal modelling* reflects the techno-centric view on modelling, and is focussed on automation, i.e. manipulation of models by machines. On the other side, *natural modelling* reflects a more anthropocentric view, and it focuses on the use and utility of models and languages for communication, collaboration and knowledge sharing. Therefore, it puts forward the modelling pragmatics. Based on [10], [11], the basic principles of natural modelling are:

Fig. 1. Modelling and Linguistic Continuum

Natural symbol interaction: Humans intuitively create and interact with modelling language symbols in modelling situations. As most of the modelling stakeholders are not experts in modelling techniques, the interaction with models/symbols should be as intuitive as possible.

Language flexibility: The need for compromises between flexibility and formality in modelling is rather natural. Informal and formal modelling are rather complementary, taking place in combination and alternation. Indeed, they are just extremes on the modelling and linguistic continuum (Figure 1). Depending on the modelling situation and purpose, the modelling stakeholders intuitively choose the right level of linguistic restrictions to be used.

In the modelling retrospective, it is possible to observe the natural emergence of (modelling) languages, which got established in a lengthy (modelling) process. It started by intuitive creation of model(s), whose structure got stabilized due to repetitive use in alike modelling situations. While it got gradually stabilized, the language remained flexible in the use. Interestingly enough, the same pattern of stabilisation of the modelling language through the repetitive use of intuitively created drawings is observed in modelling experts' practice in [4].

Collaborative modelling: Modelling act is considered as a social act in which knowledge about the observed phenomena gradually becomes shared between stakeholders, and "collective" model becomes a media to drive collective intelligence. In that sense, communication between modelling stakeholders is seen as an essential driver for modelling, and fostering communication and collaboration is seen as crucial for discussing different views, reaching consensus and accepting decisions taken in modelling.

These three principles are interrelated, and they should be considered not separately but in synergy.

B. Relevance of Natural Enterprise Modelling

Enterprise modelling efforts require successful capturing, consolidating and documenting the relevant knowledge of some enterprise domain(s). The collective knowledge creation is particularly important for the purpose of developing vision and strategy, scoping the problem, and high-level business design [3]. It is widely acknowledged that such efforts require participatory and collaborative modelling approaches [35], [36], as these better accommodate learning and creation of shared understanding between stakeholders than the analyst-dominated modelling process [3], [35].

At the same time, the practitioners report that, as most stakeholder do not have modelling expertise, the means used for modelling (i.e. language, tools) are required to be simple, intuitive, and corresponding to the natural interaction that occurs in such situations [3], [35]. In most of the cases, some kind of informal "dialect" of standard modelling notation [3], or home-grown language is used as support. We have provided a possible explanation of the reasons why these variations of languages/notations occur in the Section II.

As already indicated, the lack of adequate modelling support for these phases creates a lot of additional effort by modellers to maintain (in particular) the consistency and coherence of models created within the modelling landscape. The knowledge and the models resulting from the vision, strategy and business design usually serve as input for detailed enterprise and information systems designs. The input models get gradually 'translated' into more structured and more formal models, which are expressed in specialised modelling languages. As there will usually be several iterations until the strategy, architecture and detailed design of enterprises are fully settled, maintaining the links between the range of such models is clearly beneficial and even necessary.

Based on discussions so far, we envision that *natural enterprise modelling* both as a strategy and an infrastructure may support both the 1) intuitive interaction, knowledge creation and involvement in modelling within stakeholder-intensive tasks, and 2) facilitate inferring, maintaining and manipulating links between models of different levels of formality within the modelling landscapes. In the following section, we will discuss the required characteristics of a modelling infrastructure supporting natural enterprise modelling.

IV. Natural Enterprise Modelling Infrastructure

The naturalness of natural enterprise modelling infrastructure consists in the assumption that any technology used for modelling should support the natural way people interact within modelling situations. This vision is inspired by Weiser's vision of "disappearing computers" [37]. Weiser suggests that interactive systems should be "hidden" so that stakeholders can interact freely with them. Inspired by such a vision, we reflect in this section on the modelling infrastructure needed to support natural (enterprise) modelling. We provide a potential high-level design of such an infrastructure, and suggest some promising research directions for the future. The Figure 2 illustrates the main components of natural (enterprise) modelling infrastructure.

From the stakeholder's perspective, the entry point consists in Natural User Interface (NUI) component. This component provides different modalities of interacting with models to stakeholders. For instance, it may provide support for surface (2D) modelling, tangible (3D) modelling, and different combinations of multi-modal interaction (e.g. surface and voice). The point here is in "augmenting" (with technology) the means commonly used in modelling situations, such as papers or white board, in order to support the most intuitive and the least intrusive way of using modelling technology. This way of interaction may indeed have an important effect on the stakeholder involvement. For example, the idea of tangible process modelling [38] has been explored and it demonstrated better embodiment of stakeholders into the modelling activity. Ideally, the choice between different interaction modalities should be dependent on stakeholders' preferences.

Another main responsibility of NUI component consists in the recognition and basic (interface-related) manipulation of symbols of the language (visual, spoken or tangible), and in passing this 'raw' modelling data to **modelling session manager**.

To realise NUI component, various developing technologies may be reused, for instance: (1) Intelligent Paper techniques [39] enable to recognise handmade writing and shapes; (2) Magic Paper [40] enable to recognise diagrams and interact dynamically with models (3) Multimodal annotation and interaction with models [41]; (4) Natural language processing technologies for modelling [42] etc.

The **modelling session manager** component manages the modelling data of the session, and is capable of managing multiple models and languages within the same session. It is responsible for interpreting 'raw' modelling data and managing of the model/language elements being manipulated within the session: the concrete and abstract syntax as well as semantic or domain concepts. Together with flexibility engine and the repository, this component enables the modelling language flexibility. By continuously checking the models(and underlying languages) growing within the session, the modelling environment may suggest to reuse or adapt parts of models or languages/symbols used in similar sessions. This check is done against the data of previous modelling sessions stored in repository, and based on the similarity of purposes, concerns, stakeholders, language concepts and visual/tangible symbols, etc. In such a manner, the environment can, in the background, gradually construct a kind of enriched language hierarchy, which could facilitate, in the later stages, maintaining the inter-model properties such as consistency, traceability, coherence etc.

To construct the hierarchy, different atomic actions on languages can be supported within the **language flexibility engine**: language refinement, restriction, degeneration [15], or even more complex operations such as language merge and embedding [43]. Based on different sets of (pre-defined or dynamically created) similarity rules, it can identify similar modelling situation (to the current one) and identify the linguistic elements from the repository that might be reused. The flexibility engine can discern the language structure (of the modelling content being created) based on (fixed or adaptable) rules (i.e. inference rules). It can also incorporate the adaptable logic based on which the engine decides when to create new language and how to link it within the existing hierarchy (i.e. evolution rules).

Some related work regarding language flexibility, and in particular emergent metamodels, can be found in e.g. [8], [44]. Emergent metamodels [44] are inferred from the previously (freely) constructed models, inferring the language structure from the language examples. The notion of flexibility is not however limited to the meta-model emergence, just as well the "pre-defined" modelling languages might enter the process of re-factoring and adaptation, in order to tune them to the particular purpose. This adaptation is usually focussed on the abstract syntax and semantics of the modelling language (while driven by its pragmatics), but the concrete syntax is not excluded.

The **repository** of models is structured as a cartography of all modelling sessions, and realised as a **megamodel** [33]. The data of the modelling session contains relevant model and language elements, but also the relevant pragmatic information of the session (e.g. kind of modelling session, involved stakeholders, etc.). This information is used by the flexibility engine to retrieve the model/language elements potentially interesting for reuse.

As most of this pragmatic information cannot be detected automatically, modelling facilitator may, for instance, take charge of adding it throughout the session. This functionality is provided by a specific **control panel** dedicated to the modelling facilitator. This panel may offer a set of actions for e.g. stimulating discussions between stakeholders. For instance, the facilitator can bring some concept up in a model, or modify/highlight some model element on the modelling interface, etc. The control panel may also enable the facilitator to search for previous similar modelling situations in the repository and reuse some of it in the new session, etc.

The **administration and configuration** component provide a control on the degree of malleability of the infrastructure. Thus it can be tuned or restricted regarding the intended audience, their purpose, etc. For instance, in some particular contexts, where language emergence is not supported, inference mechanisms could be "turned off".

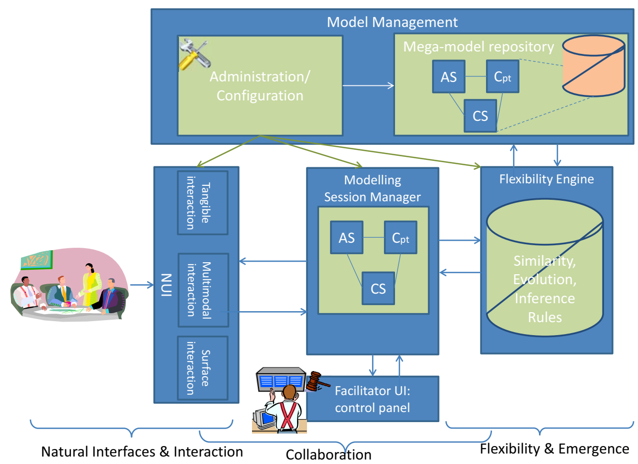

Fig. 2. Natural Enterprise Modelling Infrastructure - Conceptual Architecture

V. Conclusion

This paper discusses two fundamentally different modelling practices, i.e. natural and formal modelling, within enterprise modelling efforts. While formal modelling is quite well supported by many CASE tools, this is not the case with natural modelling. Instead, natural modelling seems to usually be done with the help of paper, or typical drawing tools, which as a consequence necessitates additional efforts in managing modelling landscapes. Supported by the results of a number of empirical studies, we suggest that there is an added value in adequately instrumenting the continuum between natural and formal (enterprise) modelling. For this to happen, we appreciate that it is first necessary to understand a particular shaping of models, languages and infrastructures within the context of especially natural modelling. In this paper, we have suggested a framework for such an understanding, consisting of a developing theoretical body of knowledge. We also discussed the requirements of an (ideal) modelling infrastructure for natural enterprise modelling, as well as its initial conceptual architecture. We are aware that a considerable amount of work still needs to be done, both on theoretical and practical plan, for realising such an infrastructure. The paper is a first step in this direction. The major contribution oh the paper consists in demonstrating the relevance of natural enterprise modelling concept, both from theoretical and practical/empirical side. In the future work, we aim to deepen the theoretical understanding of cognitive and linguistic aspects underlying (natural) modelling, in parallel with the evaluation of the theory. On the practical side, the future work will consist in refining the infrastructure requirements, its conceptual architecture, exploration of relevant existing instruments/technologies, and later on, developing prototype for further experimentation.

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