Modeling for Enterprises; Let's go to RoME ViA RiME

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Abstract

In this position paper, we are concerned with the role of modeling in an enterprise context. In general, the creation, management, and use of models comes at a cost. We content that, especially in an enterprise context, it becomes increasingly important to make explicit trade-offs between the costs related to modeling and some return in relation to the goals of the enterprise. To better reason about such trade-offs, we propose three concepts: *R*eturn on *M*odeling *E*ffort (RoME), a model's *V*alue *i*n *A*ction (ViA), and the need to manage the *R*etent*i*on of *M*odeling *E*ffort (RiME). In doing so, we also suggest some of the avenues we intend to follow in further researching these concepts. By means of this position paper, we also hope to engage more colleagues in this fundamental line of research.

Keywords

Domain Modeling, Enterprise Modeling, Conceptual Modeling, Return on Modeling Effort, Value in Action, Retention of Modeling Effort

1. Introduction

In the context of enterprises, a wide range of models are produced and used. This includes, among others, enterprise (architecture) models, business process models, ontology models, enterprise architecture models, information models, value models, business ontologies, as well as different kinds of reference models. We consider each of these kinds of models as being valued members of the larger family of *domain models* [1, 2].

From a general perspective, we would argue that modeling is a natural thing for humans to do. Whenever there is a need to explicitly reason about, study, or discuss, some part of an existing/imagined domain, we do so in terms of an abstraction of this *domain of interest*. When representing such an abstractions in terms of some artifact, the resulting artifacts are (used as) *domain models* as they 'stand model for' the domain of interest (in relation to the need at hand) [1, 3].

Whatever the domain of interest is, and irrespective of whether it is part of the digital, social, or physical world, domain models have a potential benefit towards the understanding, assessing, (re)designing, etc, of the domain of interest. Depending on the needs at hand, models may need

PoEM 2022 Forum, 15th IFIP Working Conference on the Practice of Enterprise Modeling 2022 (PoEM-Forum 2022), November 23-25, 2022, London, UK
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to meet different quality criteria [4, 5], including the needed level of specificity, level of detail, scope, etc. This is where we start to see a difference between (domain) modeling as a 'natural thing to do' and as an activity requiring an explicit (and methodical) *effort*.

In an enterprise context, domain models (potentially) have an important role to play. More specifically, in Software Engineering, Information Systems Engineering, Business Process Engineering, and Enterprise Engineering in general, a wide range of domain models are produced and used to meet many different purposes. As suggested in [6], high level purposes for modeling in an enterprise context include: *understand* the current affairs on the enterprise, *assess* the current affairs, *diagnose* possible problems in the current affairs, (re-)*design* changes towards the future, *realize* such changes, provide guidance/direction for (human or digital) actors who *operate* in the enterprise, and enable regulators to express regulations in order to *regulate* the activities of the enterprise. At a more general level, Rothenberg [7] suggests different uses of models in general: *projection* (in the sense of conditional forecasting), *prediction* (in the sense of unconditional forecasting), *allocation* and *derivation* (of e.g. resources or services), as well as the *testing of hypothesis*, *experimentation*, and *explanation*, each of which carries a clear potential benefit in an enterprise context. Edmonds et al. [8], from a social science perspective, suggest that models may be created for the purpose of: *prediction*, *explanation*, *description*, *theoretical exploration*, *illustration*, *analogy*, and *social learning*, which again all carry a potential benefit in an enterprise context.

In general, modeling related efforts, including the creation, administration, and use, of models, require investments in terms of time, money, cognitive effort, etc. We contend that such investments should be met by a (potential) return, especially in an enterprise context where domain modeling efforts are more than ever governed by the laws of economics. Therefore, in our view, a more rigorous underpinning of such cost/benefit trade-offs is called for.

In our observation, some but not much work has been conducted on balancing the expected return of a modeling effort in relation to the involved effort. Some authors, indeed, identify the need to more explicitly identify the purpose for modeling [7, 8, 9, 10, 11]. In some of our own earlier work, we already identified the need to reason about the *R*eturn on *M*odeling *E*ffort (RoME) [12, 13] as well as to more explicitly reason about the value of modeling [14].

In this position paper, we discuss three concepts that are intended to enable us to start reasoning more explicitly about such trade-offs: the earlier mentioned *R*eturn on *M*odeling *E*ffort (RoME), a model's *V*alue *i*n *A*ction (ViA), and the need to manage the *R*etent*i*on of *M*odeling *E*ffort (RiME). In discussing these concepts, we also identify some of the research questions in further exploring and elaborating these three concepts.

This paper is actually part of a broader joint research effort of the two authors, where we aim to explore and deepen the foundations of domain modeling (in general), including the philosophical, ontological, and pragmatic aspects [1, 2, 14]. The work reported on in this paper, also builds on our earlier work on the foundations of modeling [1, 2, 15, 3], quality of models and modeling [16, 17], the return on modeling effort (RoME) [12, 13, 18], as well as on a the notion of (usage) value [19, 20, 21, 22]. By means of this position paper, we also hope to engage more colleagues in this fundamental line of research.

In the remainder of this paper, we will start in section 2 with a summary of our current understanding of what domain models are. This sets the scene for the introduction of the concepts of RoME, ViA and RiME in sections 3, 4, and 5 respectively, while also identifying some of the research challenges we see related to the further elaboration of these concepts.

2. Domain Modeling

Based on foundational work by e.g. Apostel [23], and Stachowiak [24], more recent work on the same by different authors [7, 25, 26, 27], as well as our own work [28, 29, 3, 30, 15, 2, 1], we currently understand a *domain model* to be:

> A *social artifact* that is *acknowledged* by a *collective agent* to *represent* an *abstraction* of some *domain* for a particular *cognitive purpose*.

With *domain*, we refer to 'anything' that one can speak and/or reflect about; i.e. the domain of interest. As such, *domain* simply refers to 'that what is being modeled'. In an enterprise and information systems engineering context this includes (but is not limited to) business processes, information structures, business transactions, value exchanges, etc. Furthermore, the domain could be something that already exists in the 'real world', something that is desired to exist in the future, or something imagined.

A model is seen as a *social artifact* in the sense that its role as a model should be recognizable by a *collective agent* (e.g. people[1]). In the context of enterprise and information systems engineering, such an artifact typically takes the *form* of some 'boxes-and-lines' diagram. More generally, however, domain models can, depending on the *purpose* at hand, take other forms as well, including text, mathematical specifications, games, animations, simulations, and physical objects.

The *collective agent* observes the domain by way of their senses and/or by way of (collective) self-reflection, and, based on this, should acknowledge/accept the artifact as indeed being a model of the domain (for a given purpose).

A model must always be created for some *cognitive purpose*[2]; i.e. to express, specify, learn about, or experience, knowledge regarding the modeled domain. As a direct corollary to this, one can conclude that a model, being a *social artifact* must therefore be a language utterance, as such implying it to be a *social-linguistic artifact*.

Finally, a model is the representation of an *abstraction*. This implies that, in line with the *cognitive purpose* of the model, some (if not most) 'details' of the domain are consciously filtered out.

In the context of enterprise and information systems engineering, a specific class of domain models has grown to play an important role, namely, *conceptual models*. In the traditional information systems engineering view [31], a conceptual model captures the essential structures of some *universe of discourse*. In this context, conceptual models are used to express the

[1]The pre-noun *collective* does suggest that it it would require to involve multiple people. We do, indeed, acknowledge the use of domain models by an individual person as well, but prefer to treat this as a special case concerning a 'self-shared' model.

[2]In earlier work, we did not include the explicit focus on *cognitive purpose*, but rather spoke about some *purpose* in general. In retrospect, we think this was an omission. Adding *cognitive* clarifies the role of models as a way to express, specify, learn about, or experience, knowledge regarding the modeled domain. We would like to thank Jan Schoonderbeek for making us aware of this omission.

concepts, and their (allowed) relations, of the *universe of discourse* (while avoiding the inclusion of implementation/storage details).

In our current understanding (based on [2, 32, 3]), a *conceptual model* is:

> A domain model, where
>
> 1. the purpose of the model is dominated by the ambition to remain as-true-as-possible to the *conceptualization* of the domain by the collective agent, while
> 2. there is an explicit *mapping* from the elements in the model to the latter *domain conceptualization.*

The *domain conceptualization* identifies the fundamental concepts in terms of which the *collective agent* create(s) their conception of the world. This mapping specifies the real-world semantics of that model and characterizes its *ontological commitment* [30].

A conceptual model, therefore, provides an explicit – human understandable – representation of a theory about the entities and their ties that are assumed to exist in a given *domain of interest* (the ontological commitment), as such explicitly capturing descriptive and/or prescriptive selected aspects of the modeled domain. As a result, conceptual models enable us to explicitly clarify the things we talk and reason about (at a chosen level of abstraction and from a desired perspective).

In an information systems engineering context, the ambition for a conceptual model to *remain as-true-as-possible to the conceptualization of the domain by the collective agent*, has a direct correspondence to the *conceptualization principle* as put forward in the well known ISO report on the design of information systems [31].

The field of information systems engineering, indeed, provides a fruitful application area for conceptual modeling. At the same time, however, we suggest to avoid 'framing' our understanding of what a conceptual model is to this application area only. The ambition to *as-true-as-possible to the conceptualization of the domain by the collective agent* is not only applicable in the context of information systems engineering. For instance, Guarino et al. [3] already stated that the history of conceptual modeling can be traced back to at least the 60s [33]. Furthermore, ontology engineering [30] also involves the construction of conceptual models representing a (domain) ontology.

At a more generalized level, we also observe that in many different endeavors in which we (as humans) aim to understand the workings of some domain and/or aim to express/study design alternatives, we actually do so in terms of (purpose and situation specific) domain models. This includes many examples across science and engineering at large. We also argue that in these cases, a deepening of our understanding of the essential mechanisms leads to a natural drive to create domain models that remain as-true-as-possible to the original domain (and our conceptualization thereof), i.e. conceptual models.

Identifying conceptual models as a specific class of domain models, does raise the question regarding the role of 'other' domain models that are 'not conceptual'. In [2] it is suggested to, next to conceptual models, also identify *computational-design models.* These latter models may involve 'conceptual compromises' (with regard to the ambition *to remain as-true-as-possible to the original domain conceptualization*) to cater for highly desirable computational considerations to, e.g., support simulation, animation, or even execution of the model. In [32] it is suggested to generalize this towards *utility-design models*, to cater for the fact that 'conceptual compromises' may not only be introduced for *computational* purposes, but also for e.g. *experiential* purposes, such as the ability to touch, feel, or even 'enact' a model.

An interesting analogy, which certainly needs further investigation, is the notion of *surrogate modeling* in the context of simulation [34] of real-world systems[3]. The level at which a simulation model reflects all (relevant) properties of a (planned/existing) real-world system is referred to as the *fidelity* of the simulation model: "Fidelity in the modeling context refers to the degree of the realism of a simulation model" [34]. Likewise, one can speak of being as-true-as-possible-to a given domain as a sort of *conceptual fidelity*. Conceptual fidelity, also frequently called *domain appropriateness*, represents the level of homomorphism between a given representation and the underlying domain conceptualization it commits to. In the ideal case, this representation artifact is not only isomorphic to the structure of that conceptualization (i.e., it represents in a univocal and non-redundant way all its constituting concepts and only them) but it also only allows for interpretations that represent state of affairs deemed acceptable by that conceptualization [35]. As, in the case of simulation models of real-world systems, the involved high fidelity models may be too computationally intensive to simulate as a whole, one uses so-called *surrogate models* [34] that are computationally more efficient, while approximating the high fidelity model good enough to meet the (optimization) purpose at hand.

It is important to note that we do not argue that non-conceptual models would be bad; far from it. However, it needs to be clear what the 'conceptual deviation' are of a non-conceptual model in relation to the conceptual model of the same domain, and what the benefit are of these deviations in terms of e.g. computational efficiency. As such, it might quite well be the case that one conceptual model has different associated non-conceptual models catering for different needs [36].

3. Return on Modeling Effort

As mentioned in the introduction, we take the view that a more rigorous underpinning is needed of the costs and benefits involved in domain modeling, as well as the associated trade-offs; i.e. the Return on Modeling Effort (RoME). A more explicit thinking in terms of modeling effort, and the potential return on these efforts, is likely to already help to guide (scope, time-box, select an appropriate level of formality, etc) modeling efforts in an enterprise context.

Returning briefly to the distinction between conceptual models and non-conceptual models, we postulate that the RoME of a conceptual model is at least as high as the sum of the RoME of each of the non-conceptual models that have been derived from it.

The ambition to further elaborate, and underpin, the concept of RoME results in the following main research questions, which will guide us in our future research.

- *What are the factors that define modeling effort; i.e. the effort needed to create, manage, and use models. How to measure these?*

[3]We would like to thank Carlos Kavka, from the Luxembourg Institute of Science and Technology, for pointing us in the direction of the notion of *surrogate models*.

- *What are ways to potential limit/reduce modeling effort, while retaining the same (potential) returns?*
  Information technologies can potentially help in reducing the modeling effort. For instance, in terms of hybrid mixes of human and artificial intelligence [37, 38]) to help derive/infer domain models from different sources of data pertaining to the domain of interest. Process mining [39] can be regarded as specific illustration of this point.
- *What are the factors that define the value of models. How to measure these?*
  The discussion in section 4 regarding ViA already tries to take first steps in understanding the value of models.
- *What are ways to increase the (potential) value of models; i.e. increase their return.*
  Model-driven software engineering (including low-code), as well as the use of models as operational/executable artifacts in, e.g., rule engines, process engines, and even gaming engines, are illustrations of ways in which information technology can be used to increase the value of models. An example of the use of operational models to increase the value of legacy data without the need to migrate databases to different formats and platform is the ODBC (Ontology-Based Data Access) (also called Virtual Knowledge Graph) strategy [40, 41].
- *How to make trade-offs between modeling effort and its (potential) return in relation to specific contexts and purposes?*

To answer these questions, a combination of theory-driven and practice-driven work is needed. The desire to gather empirical data from real-world situations, in order to help answer the above research questions, was one of the drivers for the Models-at-Work initiative[4]. The idea of this initiative is to gather a library of cases in which domain models have played an important role, while also documenting their RoME. The aim is to, for each of these cases, gather insights into questions such as:

- *Purpose & requirements* – What was the intended purpose (and audience) of the model and/or its creation? What were specific requirements on the model?
- *Context & challenge* – What was the social and/or technical context in which the model was created and/or used. What was specifically challenging? What were uncertainties? Were there any social and/or technical complexities?
- *Activities & effort* – What were the activities involved in creating the model? How much effort (time, budget, people/roles involved, etc) was needed to create the model? What tools and methods were used? How was the validity (in relation to the goal & requirements) of the model managed and assessed?
- *Resulting model* – What kind of model was produced? Did the model have to include 'quality compromises' for strategic/political reasons? Was the developed model a refinement of a standard or published/known model? Was a specific modeling language and/or tool used?
- *Return on modeling effort* – In line with the intended purpose, what was the expected return on modeling effort? What was the materialized return on modeling effort? Which stakeholder(s) made the investment in modeling, and which stakeholder(s) reaped the benefits?

[4] https://www.models-at-work.org

4. Value in Action

When considering the *return* on modeling effort, it is necessary to consider both models and modeling, from a value oriented perspective. In doing so, we take the value proposition ontology as defined in [21] as a base. In particular the notions of *value bearer* (that what potentially has value), *value ascription* (the act of assigning value to the value bearer), *value beholder* (a role of the actor who ascribes value) and *value beneficiary* (a role of the actor who reaps the benefits of the value bearer). In actual trade-offs between the expected return on the investments in the creation and use of a model, it will be necessary to distinguish between the ex-ante *expected* value and the ex-post *realized* value.

In the case of models and modeling, there seem to be three potential value bearers:

1. *Value in creation* – The *process* of (co-)creating a domain model.
   Such a process may e.g. result in the added value that those who are involved in the modeling process[5] develop a deeper and/or more consistent (joint) understanding of the modeled domain, and also have the chance of building shared terminology based on that understanding.
   In this case, the *value beneficiary* (and *value beholder*) can pertain to those actor(s) who are directly involved in the (co-)creation process, and/or those who stand to benefit from an increased (joint) understanding of the latter actor(s).
2. *Value in use* – The operational *usage* of the model (in line with its purpose[6]).
   This may, e.g., involve the use of the model to support decision making, give prescriptive/descriptive guidance towards development processes and/or operational processes, etc.
   In this case, the *value beneficiary* is the user of the model, while the *value beholder* may indeed be the same user of the model, but may also be the actor who has a more overall role/interest (such as the transfer of design knowledge from requirements engineering, via design, to implementation).
3. *Value in transaction* – The (ownership of the) model itself.
   This pertains to e.g. reference models, etc, capturing generalized knowledge that can potentially be re-applied in different situations.
   In this case, the *direct* value beneficiaries are the actor who uses the model to support them in their own activities, while the *indirect* value beneficiaries are the actors who have the original owners of the model. The latter actors are *indirect* value beneficiaries who receive the value of the model via a transaction (e.g. transfer of ownership of the model, or the right to apply the model). In line with this, the *direct* value beholders are the actors ascribe value to the usage/application of the model in a concrete situation, while the *indirect* value beholders ascribe value to the model by way of its potential value in (future) transactions. More generally, in [14], we have discussed the potential of 'models acts' as *complex language acts* (in the sense of *speech act* theory [42]). 'Creative speech acts' (speech acts with a double direction of fit) can bring about the existence of things in the world when uttered in a certain context. Some models can then describe the propositional

[5] Which could be a group of actors, but can also be a single actor expressing their thoughts about an existing/future domain.

[6] One could indeed also gain value from a model by (ab)using it beyond its intended purpose.

content of these creative model acts, which bring value by bestowing the model owners with rights associated with the propositional content that said model describes.

At a more fundamental level, we would argue that ultimately *value in creation* and *value in use* are the root/direct value bearers of models. The *value in transaction* is derived from the potential of a model's future *value in use*. The combination of *value in creation* and *value in use* is what we refer to as the *Value in Action* (ViA) of models.

In the work we reported in [14], we provided a goal structure in terms of taxonomy of modeling related goals. This taxonomy distinguishes between models with a prescriptive purpose (interven*ing*, plann*ing*, coordinat*ing*), a creative purpose (bring*ing* about changes in reality), and a descriptive purpose (understand*ing*, problem-solv*ing*, communicat*ing*, and document*ing*), each time involving models that receive their value in action.

In future research, we aim to further operationalize the different dimensions for model value. To some extent, this can be based on expert interviews, and theoretical analysis. However, empirical data based on case reports in line with the aforementioned Models-at-Work initiative.

5. Retention of Modeling Effort

Based on the premise that models provide value in action, models as artifacts embody a potential value in the future; i.e. when they are taken 'into action'. This potential value may need to be 'safeguarded' in terms of e.g. the digital/physical integrity of the model (as an artifact), as well as its security in the sense of undesired (reading/writing) access by third parties.

Next to that, models may be subject to a 'shelf life' in the sense that they may lose their potential value. For instance, if the gap between its creation and use (model in action) becomes too large, the purpose for which the model was intended may have lost its *relevance*. Furthermore, when a model pertains to a domain that may change of time (such as business processes, application portfolios, IT infrastructures, etc.) the model may lose *actuality* with regard to the state of affairs of the modeled domain[7].

As such, we argue that the *retention* of the potential value of a model needs explicit management. The activities involved in the retention of this potential value are likely to also add extra effort to the modeling effort as a whole, and thus need to be balanced against the (remaining) potential value. Further elaboration of the factors involved in the retention of modeling effort can be based partially on expert interviews, and theoretical analysis, but also needs more in depth analysis of real world cases.

6. Conclusion

In this position paper, we zoomed in on the role of domain modeling in an enterprise context from a value perspective. When modeling in the context of enterprise, it becomes more important to

[7]The need to create modeling management processes and infrastructures that secure that models remain actual w.r.t. to their referent appears in the literature of enterprise modeling since at least the 90's as *Living Enterprise Models*[43], somewhat also reflect in conceptual modeling in the notion of *Active Models* and, more recently, also in the notion of *Digital Twins*[44]

relate the costs involved in modeling activities to some return in relation to the goals of the enterprise. This requires explicit trade-offs between the costs and benefits of modeling.

To better reason about such trade-offs, we proposed the connected concepts of RoME, ViA and RiME. We think that these concepts would already be beneficial in creating awareness for the needed trade-offs in practice. At the same time, as also discussed, we realize that much more research is needed towards the further elaboration of these concepts. As such, the discussion in this paper also provide a starting point for (our own) further research, where we hope to engage colleagues to join us on this journey; *Let's go to RoME ViA RiME.*

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