On Understanding the Value of Domain Modeling

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Abstract. In the context of enterprise and information systems engineering (including enterprise architecture, business process management, etc), a wide range of domain models are produced and used. Examples of such domain models include business process models, enterprise architecture models, information models, all sorts of reference models, and indeed value models and business ontologies. The creation, administration, and use, of such domain models requires an investment in terms of resources (time, money, cognitive effort, etc). We contend that such investments should be met by a (potential) return. In other words, the resulting models and / or the processes involved in their creation, administration, and use, should add value that make these investments worth while. In the work reported on in this paper, we aim to gain a better understanding of the factors that can be used to define the value of modeling. We also look forward to raising a broader discussion on this important topic at VMBO 2021.

1 Introduction

In the context of enterprise and information systems engineering (including enterprise architecture, value modeling, business process management, etc), a wide range of models are produced and used. The used models cover, among others, enterprise (architecture) models, business process models, ontology models, enterprise architecture models, information models, all sorts of reference models, and indeed value models and business ontologies. We consider each of these kinds of models as being valued members of the larger family of *domain models* [41, 42].

The creation, administration, and use, of such domain models requires an investments in terms of time, money, cognitive effort, etc. We contend that such investments should be met by a (potential) return. In other words, the resulting models and / or the processes involved in their creation, administration, and use, should add value that make these investments worth while.

In our observation some, but not much, work has been conducted on balancing the expected return(s) of a modeling effort in relation to the involved resources. Domain modeling in practice is more than ever governed by the laws of economics, which, in our view, fuels the need for a more fundamental reflection on such cost / benefit analysis. Some authors, indeed, identify the need to more explicitly identify the purpose for modeling [45, 1, 24, 40, 14]. In some of our own earlier work, we also identified the need to reason about the Return on Modeling Effort (RoME) [37, 35, 13].

In our view, a more rigorous underpinning of such cost / benefit trade-offs is called for. In line with this, this paper reports on our joint effort to gain a better understanding of the factors that underly the value of modeling, i.e., its possible / realized return. We also hope to raise a discussion on this important topic at VMBO 2021. This paper is actually part of a broader joint research effort by the two authors, where we aim to explore and deepen the foundations of domain modeling, including the philosophical, ontological, and pragmatic aspects [41, 42]. This (discussion) paper is a first step to gain more insights into the pragmatic aspects of modeling, and more specifically the value of modeling.

The work reported on in this paper, also builds on our earlier work on the foundations of modeling [7, 16, 41, 42], quality of models and modeling [51, 9], the return on modeling effort (RoME) [37, 35, 13], as well as on a precise definition of the notion of (usage) value [8, 47, 46, 39].

In the remainder of this paper, we start (section 2) by briefly reviewing our views on the notions of domain model and domain modeling as they lay the foundation upon which we can understand the value of modeling. Section 3, then discusses some of the existing views regarding the purpose for which a model may be created in general, and in the context of enterprise and information systems engineering in particular. Based on this, we then (section 4) provide a (first sketch of a) *taxonomy of goals for modeling*.

In line with [46, 47], we take *value* to emerge from the relation between the *goals* of a *value subject* and the properties (qualities, capabilities, dispositions, affordances) that a *value entity* has and which can be enacted to satisfy those goals. So, by proposing this taxonomy here, we take a first step in identifying a relation between properties of models in different capacities and how they relate to these different goals.

2 Models and Modeling

Based on general foundational work by e.g. Apostel [2], and Stachowiak [52], more recent work on the same by different authors [45, 20, 53, 48], as well as our own work [23, 44, 16, 18, 7, 42, 41], 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 *purpose*.

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[5]). 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.

[5]The pre-noun *collective* does indeed 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.

With *domain*, we refer to “anything” that one can speak / reflect about explicitly. In an enterprise and information systems engineering context this includes 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.

Models may be produced for different *purposes*. This is where we may find the base for the value (in terms of benefits) of models and modeling. In the remainder of the paper, we will, therefore, dive deeper into the notion of *purpose* and link it to underlying goals *for* modeling.

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

An important theoretical foundation of the above definition of model is the semiotic triangle by Ogden and Richards [33], as depicted in figure 1. The semiotic triangle is often used as a base to theorize about meaning in the context of language [32, 54, 49, 12], as well as domain modeling [26, 25, 30, 21].

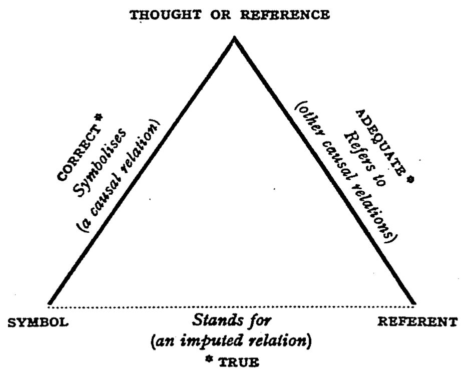

Fig. 1. Ogden and Richard’s semiotic triangle [33]

The tenet of the semiotic triangle is that when we use *symbols* (including models) to speak about “something” (a *referent*), these symbols represent (*symbolize*) our thoughts (*thought or reference*) about that something (*referent*). In the context of modeling, the notion of “thought or reference” is sometimes replaced by the notion of *concept*. The *thought or reference* is then the meaning we have assigned to the *symbols*. The *referent* can be anything, in an existing world, or in a desired / imagined world. It can involve physical phenomena (e.g., tree, car, bike, atom, planet, picture, etc), mental phenomena (e.g., thoughts, feelings, etc), as well as social phenomena (e.g., marriage, mortgage, trust, value, etc). In section 4, we will return to the semiotic triangle when discussing our suggested *taxonomy of goals for modeling*.

3 Purposes for Modeling

In this section, we discuss some of the dimensions to describe the purpose of modeling. The *purpose* of a model, and the processes involved in its creation and use, are often considered as the main discriminant in defining the added value of a model [52, 45, 53].

A first important aspect of the purpose of a model, is of course its informational payload [42, 41], in other words that what the model and modeling process should capture / focus on about the domain. Beyond the information payload, the purpose of a model can involve many other aspects.

Rothenberg [45] states: "*To model, then is to represent a particular referent cost-effectively for a particular cognitive purpose*", while also stating that modeling is generally seen as a way of "*gaining control over the world*", or of "*making decisions or answering questions about the world*". Rothenberg also suggests that the purposes for modeling are "*frequently categorized as being either* descriptive *(describing or explaining the world) or* prescriptive *(prescribing optimal solutions to problems)*". He also identifies different specific uses of models, including *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*.

Edmonds et al. [14], 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*.

In an enterprise and information systems engineering context, different dimensions have been defined to identify the *purpose* of a model and / or modeling process more explicitly. For instance, in the context of ArchiMate [29, 4], a distinction is made between viewpoints (resulting in specific models[6]) for *informing*, *deciding*, or *designing* purposes. In [34] it is proposed to explicitly add *contracting* as a purpose of enterprise architecture models, since outsourcing / procurement is an important step in the realization of large scale enterprise transformations [36]. These purposes are strongly related to the intended audience for the model [29, 4]: *deciding* towards (senior) management, *designing* towards architects and engineers, *contracting* towards procurement and contractors, and *informing* towards those who's operational work will be effected.

Depending on the specific communicative situation, these high-level purposes can be made more specific in terms of, e.g., the need for different stakeholders to *understand*, *agree*, or *commit* to the content of the model [43].

In [19], one of the authors makes the case that models play a fundamental role in the *interoperability* of information artifacts (data, software, ultimately, other models), i.e., in establishing the relation between the domain notions representing in these different artifacts. However, in order to play that role, these models must be conceived as *ontological contracts* [16], i.e., as artifacts aimed at representing as best as possible the exact ontological commitments of a given shared (i.e., *agreed upon*) conceptualization. Models, as ontological contracts, support the process of *conceptual clarification* (regarding

[6]Technically, ArchiMate makes a distinction between "the model" of an enterprise, and different views on this model, that enable designing, decision making, etc. However, in terms of the definition of model as used in this paper, both "the model" and these views are models.

domain concepts), of *meaning negotiation*, and of *fixing the ontological semantics* (aka *real-world semantics*) of the notions represented therein [19].

Since we explicitly relate our discussion on the value of modeling to both the value of the resulting model and the modeling process, it is important to note that in a specific situation, the purpose of achieving agreement among multiple stakeholders might actually imply that the *collaborative* modeling *process* is more important (i.e. contributes more value) than the resulting model. It might even be the case that the resulting model is "just" a by-product of the modeling process.

Taking an other perspective, in [38] one of the authors suggests seven high-level purposes (for enterprise models) that deal with the intention of the model with regards to a part / aspect of an enterprise: *understand* the current situation, *assess* the current situation, *diagnose* possible problems in the current situation, (re-)*design* changes to the current situation, *realize* such changes, provide guidance / direction for (human or digital) actors who *operate*[7] in the enterprise and enable regulators to express regulations in order to *regulate* the activities of the enterprise.

In [24] the authors report on some initial work on capturing the modeling purpose, in specific situations, in terms of GQM [5] and KAOS [28]. This approach is certainly compatible with our line of thinking. Regretfully, however, it seems the authors did not follow up on this work beyond the first sketches provided in [24].

4 A Taxonomy of Modeling goals

We argue that the purposes for models and / or modeling can ultimately be defined in terms of the goals of the different actors involved. As such, we see the goals *for* modeling as providing the cornerstones to ascribe value to the model and the associated modeling processes. The aim of this section is to present a first version of a *taxonomy of goals for modeling*.

Based on the dimensions of overall modeling purposes as discussed in the previous section, combined with earlier work on goals in the context of modeling [10, 9, 22], we suggest to distinguish between two top-level classes of modeling related goals: **Goals *for* modeling –** concerned with goals that should be achieved by the modeling processes (model creation & use), and / or the resulting model; **Goals *in* modeling –** concerned with operational goals used *in* the modeling process to guide the activities.

The latter should reflect the former in the sense that the goals *for* modeling provide the *why* in terms of which (quality) *requirements*[8] can be formulated on the model and the modeling processes [31, 27, 11], which can then be operationalized in terms of the goals to be used *in* modeling. Given the focus of this paper on the value of modeling, we focus our discussion on goals *for* modeling.

In order to discuss the general goals of modelers and the basic affordances of models, we will rely on an important notion borrowed from the areas of philosophy of mind and philosophy of language. This is the notion of *direction of fit* [50]. This notion is

[7] This can pertain to primary business processes, as well as secondary processes, such as administration, maintenance, etc.

[8] Also tuned / modified to the situation at hand, such as time / resources available, competences of the actors involved in the model creation & use, etc.

meant to connect the *propositional content* of intentional aspects (i.e., mental states or speech acts) to the external state of affairs of which they are about. There are basically three possible directions of fit:

World-to-Mind (or World-to-Word) – the propositional content of a mental state (i.e., a desire or intention) or of a speech act is made true by making the world such that it conforms with that propositional content. In terms of the semiotic triangle, the referent, i.e. the part of the world that the thought or symbol refers to, needs to be made conformant to the thought or symbol. For example, if John intends to go to Barcelona next summer or if Mary plans to finish her paper by tomorrow, they have to intervene in the world to make the propositional content of their intention or speech act true.

Mind-to-World (or Word-to-World) – the propositional content of a mental state (i.e., a belief) or the speech act is made true if there is something in the world that makes it true. In terms of the semiotic triangle, the thought or symbol must be articulated as such to conform to their referent. For example, if John believes Rome is the capital of Italy or if Mary states "*I am married to John*", these things are true if there is something in the world that make them true (in this case, a particular city and country with a particular legal relation between the two, and a marriage).

World-to-Word-to-World (or double direction of fit) – by uttering something, an individual can bring about some change the world, which then becomes the *truth-maker* [17] of sentences with that corresponding propositional content. In terms of the semiotic triangle, we have the situation in which an actor expresses a symbol *s* and, by doing so, brings about in the world a referent *r* that is, hence, conformant to the semantic content of *s* (thus, making *s* a truthful description of *r*). For example, if a judge utters "*I hereby declare you (John) and you (Mary) husband and wife*" this creates a marriage binding John and Mary, which then becomes the truth-maker of the proposition "*John and Mary are married*".

If we take models to be complex language acts of this form, we can then come up with the analogous categories of **(a)** ***World-to-Model***; **(b)** ***Model-to-World***; **(c)** ***World-to-Model-to-World*** directions of fit.

Models of type (a) and (c) are models *for changing the world*. In the case of models of type (c), the model itself brings about change in the world by its existence and recognition in a given community. We call these latter models **Creative Models**. Examples include a diagram in a patent file (which helps to create intellectual property rights) or a model included in a Will dividing a piece of real state among someone's heirs (in both cases, by expressing the semantic content of those rights that are henceforth created).

In the case of models of type (a), the model is an instrument through which one can bring about changes in the world. These include *designs* (e.g., a blue print for a house) that will be implemented, *plans* (e.g., a BPM model of a process TO-BE). We call these models **Prescriptive Models**. These models can be used by individuals or collective of individuals (i.e., coordination models).

Models of type (b) are called here **Descriptive Models**. These are models that represent a relation between *mental models* (abstractions, conceptualizations) [16] in the mind of proper agents and some existing external reality (the referents of the model). Notice that these two relata correspond to *Thought or Reference (TR)* and *Referent (R)* in Ogden and Richards' semiotic triangle [33], respectively.

A relevant question is: *why do we create descriptive models?* One reason is to "*shape the content of cognition*", i.e., *(TR)*. In one case, the process of creating the model itself shapes *(TR)*. In other words, by following certain methodological steps and by employing the primitives of modeling language (with their associated semantics) and its associated tools (e.g., for verification, validation), a mental model (abstraction) is formed in the mind(s) of the modeler(s). In the case of an individual modeler, this process of model construction affords *domain understanding and conceptual clarification about the domain*. In the case of a collective of modelers, the process of modeling building affords *meaning negotiation* and the formation of a "shared conceptualization" (i.e., the alignment of the mental models of the modelers involved).

Another reason for creating descriptive models is that, once done, these models can support model users in forming new beliefs *(TR)* about the world *(R)*. For example, when one uses the model for *problem-solving* and *decision-making*, as may e.g. be used in an the context of the *assess* and *diagnose* purposes identified in [38]. An example would be a commuter using a subway map for deciding on which station to exit, or when a negotiator uses a game-theoretical matrix to decide which action to take. Here, once more, tools for verification and validation (e.g., via visual simulation [6]) can support problem-solving and domain understanding via model manipulation.

A third reason is to use the model to *externalize the content of cognition* (of the modeler), i.e., the model is used by the modeler to communicate its mental models to other agents. Typically, to change the mental models of the users of the model. In other words, by using a model *for communication*, the modeler intends to elicits in the mind of model users an interpretation that is meant to recreate (to a certain degree) the original externalized mental model. The user of the model can be the modeler himself in the future, in this case, we could say that this model is used for the purpose of *documentation* (of the externalized content of *TR*).

Figure 2 summarizes this characterization in a taxonomy of modeling related goals. It is important to emphasize that these categories are not mutually disjoint. For example, a Reference Ontology [18] is typically a Descriptive Model that is build *for understanding* and *for communicating / documenting* the result of a established consensus, i.e., the aforementioned "ontological contract" [19, 16]. However, it can also be used as a basis for enabling the creation of mutual agreements which semantic content is described by that model (e.g., where parties commit to use terms with exactly those formal definitions, and a model having a particular semantics, etc.). As another example, a subway map is both a model *for communicating* and *for problem-solving*.

The taxonomy shown in figure 2 allows us to clarify *why* modeling is needed, and thus what its potential value is. However, it does not yet say anything about the actual topical focus of the model. When identifying the purpose of a specific model / modeling effort, the topical focus of the model should be identified as well.

In an enterprise and information systems engineering context, such a focus can be made more concrete in terms of e.g. an engineering / architecture framework [15].

A topical focus may also be differentiated based on the desired / needed "level of genericity" of a model. One may, for instance, aim to create a *reference* model that should be applicable across a class of (more specific) situations. For example, a reference model [55] of the processes involved in ITIL-based [3] IT infrastructure manage-

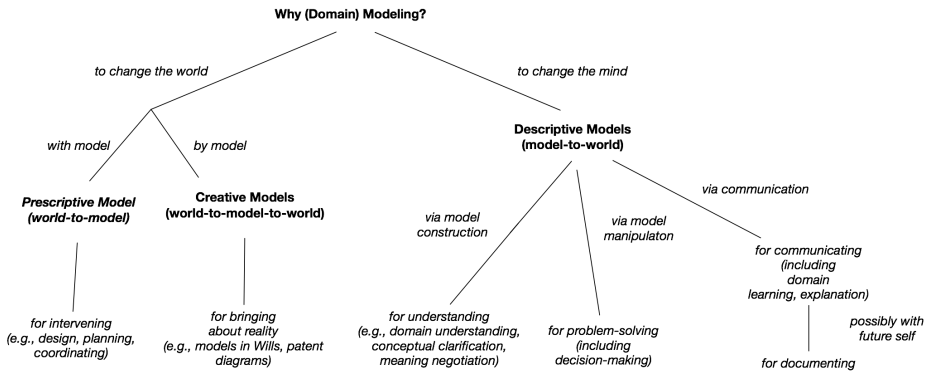

Fig. 2. A taxonomy of modeling related goals

ment. Such a reference model will be more generic than a model for a specific situation; e.g. how a specific organization manages its IT infrastructure.

For the **Descriptive Models**, where the aim is to change the mind, the goals in a specific situation can be made more specific in terms of the kind of change that is desired, and the targeted audience. Both of these will influence the goals to be used *in* modeling, and the modeling strategy to be followed in particular [43, 9].

As suggested in [43], a distinction can be made between a desire to have actors *understand* a model, *agree* to the model (and its intended purpose), and *commit* to the model in terms of its consequences for future decisions.

There maybe a need to include additional changes of mental-state, such as being *assured* regarding some concern, or being *informed*. Both of these examples could be thought of as special cases of *understand*, but each with its more specific nuances.

With regard to the intended audience, based on the exploration in the previous section, one could make a distinction between (at least): *learners*, *analysts*, *designers*, *decision makers*, *contract authorities* (actors involved in contracting of products and / or services), *developers* and *executors* (actors who need to enact / follow the model).

5 Conclusions and further research

In this paper, we explored several factors that can be used to define the value (in the sense of benefits) of modeling, i.e. its return on investment. This, more specifically, resulted in an initial version of a taxonomy of goals *for* modeling.

Next to the fact that we hope that the discussions at VMBO 2021 will provide us with further valuable insights regarding the value of modeling, we plan to complement / validate the modeling goals taxonomy by: (1) including more views on modeling purpose and value of modeling from extant literature,[9] and (2) use the modeling goals taxonomy to capture / document the desired, expected and realized value of modeling in real world modeling situations. further validation of the taxonomy. Next to that, the aim will also be to find ways to qualify, quantify, and predict the value of modeling.

[9] Including scientific literature, as well as best-practice accounts by practitioners

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