On Domain Conceptualization

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Abstract. The growing role of models across the life-cycle of enterprises, and their information and software systems, fuels the need for a more fundamental reflection on the foundations of modeling. Two of the core theories of the discipline of enterprise engineering (*Factual Information* (FI) theory and the *Model Universe* (MU) theory) aim at contributing to these foundations.
The latest versions of the FI- and MU-theories have recently been published. Offering an analysis and criticism to them enables us to continue the important debate on the semiotic, ontological, and general philosophical foundations of domain modeling and enterprise modeling in particular.
A core concept in the field of domain modeling is the conceptualization of the domain. In this paper, we specifically focus on the development of a deeper understanding of domain conceptualizations, while reflecting on the way this notion is positioned in the FI- and MU-theories.

1 Introduction

Models have come to play an important role in all stages of the life-cycle of enterprises, as well as their information and software systems. This life-cycle includes their development, improvement, maintenance, operation, as well as their regulation, while the models used cover amongst others enterprise (architecture) models, business process models, ontology models, organizational models, information models, software models, etc. In this paper, we consider each of these kinds of models as being valued members of the larger family of *domain models*.

In our view, the increasing role of domain models fuels the need for more fundamental reflection on the foundations of domain modeling. These foundations have certainly been studied by different scholars (see e.g. [1, 69, 65, 44, 20, 35, 52, 51, 70, 66]), as well as by ourselves (see e.g. [41, 63, 25, 30, 26, 7, 27, 6, 28, 29, 13, 76, 5, 50, 40, 59, 23]). At the same time, many challenges remain. Some of these challenges have been discussed in e.g. [63, 27, 29, 5].

The *Factual Information* (FI) and *Model Universe* (MU) theories aim at contributing to these foundations, and are considered by the enterprise engineering community to be among the core theories of the field [14]. The latest versions of these theories have recently been published in [15].

In this paper, we offer a partial analysis and criticism of these two theories. We focus on the development of a deeper understanding of domain conceptualizations in particular, which we see as a core concept in the field of domain modeling. This allows us to continue the important debate on the semiotic, ontological, and general philosophical foundations of domain modeling. In doing so, we follow the philosophical approach of developing arguments based on logical reasoning, while also synthesizing and incorporating results from different scholars.

In line with this, the remainder of this paper is structured as follows. In section 2, we start by visiting the semiotic roots of modeling. This enables us to then, in section 3, investigate the notion of domain conceptualizations. Before concluding, section 4 then discusses our understanding of models and modeling, based on this.

2 Semiotic foundations

We view domain modeling primarily from a communicative stance. Models are created by / for actors (be it human or IT-based actors) to communicate about different aspects of a domain. As a result, the semiotic triangle by Ogden and Richard [56] is a foundational element in our thinking about modeling.

In line with this, the aim of this section is to briefly explore the semiotic roots of modeling. In doing so, we will discuss: (1) the semiotic triangle [56] itself, (2) the fact that communication generally involves multiple actors, (3) the exchange of information between the involved actors, and (4) compositionality of symbols.

2.1 The semiotic triangle

The semiotic triangle by Ogden and Richard's [56], depicted in figure 1, is often used as a base to theorize about meaning in the context of language [53, 73, 67, 12]. Several authors, including ourselves, use it to reason about the foundations of (information) systems modeling (see e.g. [44, 43, 49, 36]).

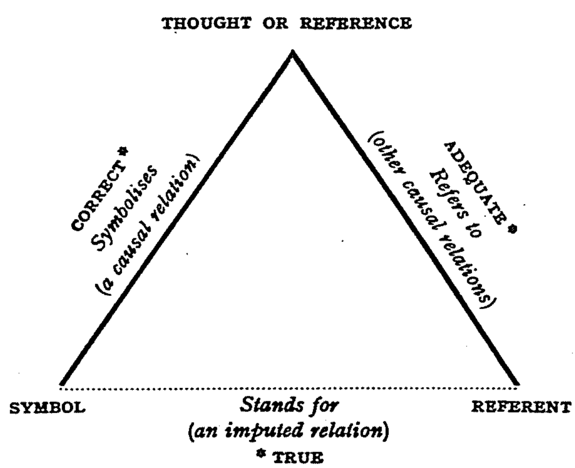

Fig. 1. Ogden and Richard's semiotic triangle [56]

The semiotic triangle, as shown in figure 1, is concerned with the way we assign meaning to *symbols* (utterances in some language). The tenet of the semiotic triangle is that when we use *symbols* to speak about "something" (a *referent*), these symbols represent (*symbolise*) our thoughts (*thought or reference*) about that something (*referent*). 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, document, picture, etc), mental phenomena (e.g., thoughts, feelings, etc), as well as social phenomena (e.g., marriage, mortgage, trust, value, etc).

It is important to keep in mind that [56, pp. 11–12]: "*Symbol and Referent, that is to say, are not connected directly (and when, for grammatical reasons, we imply such a relation, it will merely be an imputed as opposed to a real, relation) but only indirectly round the two sides of the triangle.*"

In the context of modeling, the notion of "thought or reference" is sometimes replaced by the notion of *concept*. This, implies the assumption that a "thought or reference" pertaining to some referent that is to be modeled, takes the form of a *concept*. The latter assumption is certainly relevant in the context of modeling. At the same time, we should realize that, in the more general situation, symbols are also used to refer to things that may not correspond to clear concepts, such as tastes, smells, feelings, etc. Consider, for instance, the textual description of the taste of a good wine, where one uses terms such as a "fruity taste" or "hints of liquorice". While "taste" in the general sense can easily be regarded as a concept, the *actual* taste sometimes cannot. In communicating about the taste of wine, we use terms like "fruity taste" and "hints of liquorice" as placeholders (i.e. *symbols*) to symbolise the actual taste we think to experience when savouring a sip of wine.[4] Reading these terms, the symbols, in the description of a wine, then triggers our thoughts / memories of the taste. However, we prefer not to call these latter thoughts actual concepts.

A more fundamental change which some authors make, is to replace the "stands for" relationship with a solid line / arrow, seemingly ignoring its *imputed* status. Unless nuanced explicitly, such a replacement suggests there to be an objective binary relation between a referent and a symbol *only*, independent of a given conceptualization. Doing so would be a denial of the key message of the original semiotic triangle.

The "*slightly adapted version*" [15, page 51] of the semiotic triangle as included in the latest version of the FI-theory actually makes three (implicit) changes to the original triangle. Firstly, "thought or reference" is replaced by "thought" only. Secondly, "symbol" is replaced by "sign".[5] These could, indeed, be classified as "slight" changes. However, it also replaces the "stands for" dotted line with a solid arrow labelled (with

[4] These internal experiences such as particular perceptions of color or taste are termed *Qualia* in the philosophical literature [72]. For an interesting discussion on the nonconceptual content of perception, one is referred to [11]. Authors such as [21] provide a precise formulation for concepts in spaces such as color and taste, namely, as a convex region in those geometric space. So, we are not denying that things like taste can be associated with concepts. However, we would like to allow for the existence of experiences that can be (partially) symbolised but that are not conceptual. As an obvious example, think of a patient trying to communicate to their attending physician an experience of pain. Given the private nature of these experiences, communicating them with other agents is an obvious challenge.

[5] We actually agree on this replacement, as *sign* is a more generic way to refer to any form of "information carrying artifact" [60].

the stronger) *denotes*. On the positive side, [15, page 52] does indeed state: "... *although the relationship between a sign and its referent is completely determined by their being connected through the thought, it is often also indicated separately: the sign is said to* denote *the referent.*", which provides some nuance regarding the "solidity" of the line. Nevertheless, the "*it is often also indicated separately*" does seem to indicate an intention to regard the original "stands for" relationship as an independent binary relationship, rather than an imputed one from the "symbolises" and "refers to" relations.

2.2 Communication between actors

Even though it was created from a communication oriented perspective, the semiotic triangle on its own is "single sided" in the sense that it only refers to one actor.

In the context of communication, it is important to acknowledge the fact that there are at least two actors involved.[6] Any language utterance (such as, in our discipline, models) has both a *writer* and a *reader* [67]. In terms of the semiotic triangle, this implies that both the author and writer have their own thoughts about the symbol, in the context of (possibly) the same referent.

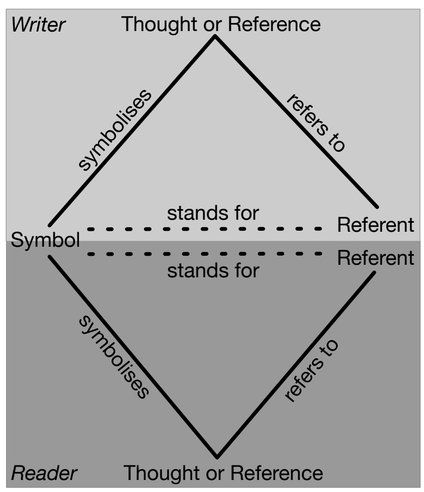

Fig. 2. Writer and Reader with their own semiotic triangles

This is illustrated in figure 2. Both reader and writer harbour their own thoughts, while using the same symbol to symbolise these. Even when both reader and writer think they are "talking" about the same referent, this may actually not be the case (hence the presence of two "Referents" in figure 2).

If the referent is a physical thing in the existing world, reader and writer have a chance of indeed looking at the same referent. When the referent is a physical thing in a possible / desired future world, it already becomes more challenging to ensure that they

[6]Where writing a note to / for oneself could be seen as an extreme case, since the actor who reads the notes is not completely the same as the actor who wrote the note. The general mental state of the reader will still be different from the one of the writer.

are considering the same referent. When the referent is not a physical thing, but rather a social thing, or even a mental thing, matters become even more challenging. The latter kind of situations might be mitigated by more meta-communication [39] between reader and writer, e.g., involving the description of their focus, paraphrasing, or using a domain-independent system of ontological categories to calculate the relations between their individual conceptualizations [31].

At a more general level, it is important to acknowledge that communication requires the actors to share their understanding using a broad *stream of symbols*. This stream of symbols may "meander" between the communication of the intended "message", as well as a clarification of the precise meaning of the symbols used (i.e. meta-communication [39]).

2.3 Information exchange between actors

The strict separation between the *thoughts*, the *referents* these thoughts pertain to, and the *symbols* used to symbolise the thoughts, also enables us to make a clear distinction between the symbols we use to communicate and the actual "informational payload".

When a reader "reads" a symbol (including data, documents, models, etc), then, assuming they understand the language used, they will form thoughts in their mind. If these thoughts are new, then the symbol has provided them with *information*.[7] Conversely, writers, in "writing" the symbol, presumably aim to convey their thoughts to others. These thoughts-to-be-conveyed are the intentional informational payload of the symbol. As such, the information that is (to be) carried by a symbol is in "the eye of the beholder". We experience this on a daily base, as we all know that a document may provide different information to different readers.

The latter view on information is in line with the perspective taken in e.g. the FRISCO report [17], cybernetics [37] as well as work in the context of information science and information discovery [3, 60]. In this context, [37] also refers to the "*difference that makes the difference*".

With regard to information, the FI-theory, [15, page 51] currently states: *Because minds cannot communicate directly, a vehicle is needed to accomplish it, and this vehicle is called information.* This seems to suggest that the vehicle *is* the information, whereas, as argued above, it seems more natural (and better aligned to the extended semiotic triangle as depicted in figure 2) to acknowledge the fact that the information that is actually *carried* by the vehicle is in the eye of the beholder.

Even more, when stating "*This makes information a dyadic notion: it has both content and form, inseparably connected*" [15, page 51], we immediately run the risk of turning a blind eye to the fact that communication involves multiple actors, each with their *own* thoughts about the symbol / vehicle used to communicate. As such, we would argue it to be a quadratic relation, involving: (1) form (the symbol), (2) meaning (the

[7]For some authors such as, e.g., Floridi [19], *information* must be *truthful semantic content*, i.e., it is semantic content back up by the proper *truthmakers* in reality. For the sake of simplicity, we do not make this distinction here.

thought or reference) as harboured in the mind of (3) an actor, pertaining to some (4) referent as "seen" by the latter actor.[8]

2.4 Compositionality of symbols

A document, consisting of many sections, sentences, images, tables, etc, can be regarded as a "composed symbol". Models, as artifacts, can also be regarded as "composed symbols". Such composed symbols are likely to also relate to composed thoughts, while referring to a composed referent. In terms of the semiotic triangle, this triggers the question if the relations included in the triangle scale from basic symbols to increasingly composed symbols. Most authors (as well as ourselves) who apply the semiotic triangle in the context of modeling, essentially *implicitly* assume that these relations indeed scale in the above sense.

We are not arguing here that this would be a wrong assumption to make. However, we do consider it to be important to take note of this assumption, and reflect on its potential consequences. Especially since, in the context of domain modeling, we are usually dealing with *composed* referents, thoughts and symbols.

3 Domain conceptualizations

In moving from the general discussion regarding the semiotic triangle towards modeling, we first need to further elaborate on the notion of *domain conceptualization*. To this end, this section will address: (1) distinction between perceptions and conceptions, (2) domain conceptions (such as enterprises), (3) the role of the purpose of a communicated artifact (such as a model), (4) the role of "normative frames" (such as philosophical stance, language definitions, design philosophies, etc).

3.1 From perception to conception

In the context of modeling, we suggest to make a distinction between two kinds of (composed) thoughts: *conceptions* and *perceptions*. When an actor observes a (composed) referent, they will obtain (through their senses) a *perception* (indeed, including e.g. the taste of a good wine) of that referent. They may than be able to interpret, structure, and / or further abstract, this *perception* to form a *conception* in terms of concepts and their relations.

In *perceiving*, and *conceiving*, the many facets and nuances of the world around us, we will need to apply filters[9]; if only to deal with the complexities and richness of the world around us. When creating a conception, from our perception, we tend to filter even further, consciously leaving out details to be able to focus on what we think to be important (in particular when creating models). This is also where we apply our "hard-wired" ability to classify our observations and make generalizations [45, 46].

[8]Which is also aligned to the semiotic tetahedron as put forward in the IFIP 8.1 FRISCO report [17].

[9]For an interesting paper on the role of goal-driven attention in perception and its relation to perception blindness, one can refer to [68].

In the remainder of this section, we will come across three classes of such filters (that are relevant to domain modeling): *domain conceptualizations*, *purpose* and *normative frames*.

3.2 Domain conceptualizations

In the context of domain modeling we assume a conception (of something to be modeled) to involve a set of *domain concepts* [26]. For example, the domain of genealogical relations (taken from [26]), includes the domain concepts: Person, Man, Woman, Father, Mother, Offspring, being the father of, being the mother of, etc. This part of a domain conception is what we prefer to call the *domain conceptualization* as it defines the fundamental concepts in which one creates one's conception of the world.

As also discussed in [26], a *domain conceptualization* then allows the actor to create *domain abstractions* of certain facts in an existing / imagined reality. The use of the word *abstraction* stresses the point that they are not the actual facts in the observed world, but rather abstractions thereof. An example would be the (representation of the domain abstraction of the) fact that a man named John is the father of another man named Paul. Domain abstractions are also (part of) domain conceptions, but rather at the instance level.

Needless to say that it is possible to take e.g. DEMO-modeling [15], ArchiMate-modeling[10] [47], or Fact-based modeling [34] as the domain of interest as well. In such a case, the *domain conceptualization* would pertain to the modeling constructs (Fact, Role, Actor, Process, realizes, etc.) where this would then enable enterprise engineers to create *domain abstractions* corresponding to the respective modeling languages. In this case, the *domain conceptualization* would actually be a *meta domain conceptualization*.

The MU-theory actually uses the term *conceptual schema* instead of *domain conceptualization*. We prefer to continue using the term *conceptualization*. Firstly, as it (see [26]) predates the use of the term *conceptual schema* to refer to the same. Secondly, the term *conceptual schema* may actually result in confusion with its use in the context of conceptual database design [42], where it refers to "*the description of the possible states of affairs of the universe of discourse including the classifications, rules, laws, etc., of the universe of discourse*" (stress added by us).

Given a domain conceptualization, an actor may imagine / observe different domain abstractions that are compatible with the conceptualization. This implies that the domain conceptualization essentially constitutes an (ontological) commitment when perceiving and conceiving of more specific situations / aspects of the observed referent. This commitment enables the actors to "carve out" different domain abstractions, where the domain conceptualization acts as a *filter* on how the actor can perceive and conceive a referent. Note that this also implies that when an actor would observe the same referent, using a different domain conceptualization, they will most likely arrive at different domain abstractions.

[10] ArchiMate is a registered trademark of The Open Group (`http://www.opengroup.org`)

3.3 The influence of purpose

We argue that a symbol, in the sense of the semiotic triangle, is always selected / authored / uttered for a purpose. In the case of a model, this is even more obvious. As such, there will always be some communicative purpose involved, if only to communicate with oneself (e.g. note taking). This overarching communicative purpose may be (situationally) refined in terms of the underlying reasons for the communication [62]. This may be related to a desire to e.g, convey an understanding about the world, make changes in the world, analyze a potential problem, etc.

Consider for instance a situation in which an enterprise engineer needs to create a high level view of the transactions between the main actor roles regarding a the pizzeria "Perla del Nord" (taken from [57]). Imagine that the target audience of the model is not fluent in DEMO [15], but rather well versed in the use of ArchiMate [2]. Given this purpose, i.e. to communicate a high level view of the transactions between the main actor roles to an audience which is not fluent in DEMO but rather in ArchiMate, the enterprise engineer may decide to create the model as depicted in figure. For this purpose, the enterprise engineer has decided to not use ArchiMate as-is, but rather use DEMO's transaction symbol for the transactions.

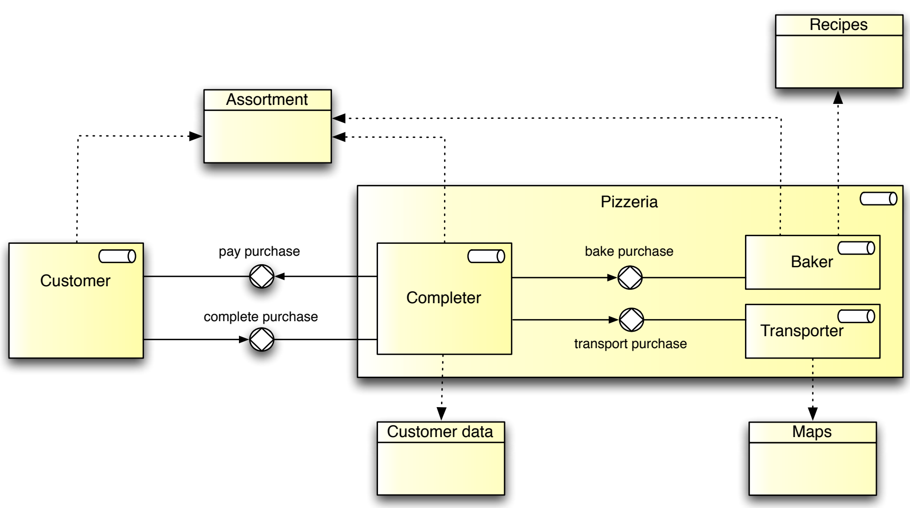

Fig. 3. High level construction model of pizzeria "Perla del Nord"

In the context of enterprise modeling, [58] suggest (at least) seven high-level purposes for the creation of enterprise models: *understand*, *assess*, *diagnose*, *design*, *realize*, *operate* and *regulate*.

The purpose may also be (situationally) refined in terms of e.g. properties of the target audience [62]. This includes, for instance, the interests / concerns, of the target audience, their background, cognitive abilities, etc.

The communicative purpose will influence the way an actor shapes their thoughts (i.e. their perception and conception) regarding a referent / domain, and their selection / creation of a (composition of) symbol(s) to symbolise these, and as such act as a filter.

In the example of figure 3, the enterprise engineer used a DEMO-based conceptualization to study the domain of pizzeria “Perla del Nord”, to then produce a domain abstraction that resulted in the model shown in figure 3. In representing the domain abstraction in terms of a model, the enterprise engineer decided to use primarily to ArchiMate models to bridge to the background of the target audience. However, for another audience, the enterprise engineering may have decided to use drastically different artifacts in the role of models of the pizzeria, including animations or games [22]. As illustrated in figure 4, one may choose to use the “My Pizza Shop”[11] computer game (left illustration) to communicate the workings of the pizzeria, or even use a more *tangible* form using, e.g., Playmobil[12] (the right two images).

Fig. 4. Alternative ways to capture models of the pizzeria[11,12]

3.4 The influence of (normative) frames

When we observe the world (not just when modeling), we consciously, or subconsciously, apply certain (normative) frames. These frames provide filters on the way we perceive and conceive the world, controlling that what we (within the capacity of our senses) allow ourselves to “see”.

The earlier discussed domain conceptualizations are a first class of examples of such frames. As such, the enterprise engineer who produced figure 3 used the DEMO-based conceptualization as a normative frame shaping their domain abstraction, while using ArchiMate as a normative frame in producing the representation. However, there are more frames that play a role when we observe domains, and thus influence the way we (are able to) model.

These frames may be the result of what we learned at an early stage in our lives [46], but may also be based on our cultural environment, the language(s) we use, our upbringing, our educational background [50], and our philosophical stance. Some of these frames may have an explicit normative character, e.g. reflecting societal, cultural and / or professional norms.[13]

[11] By Tapps Games (`http://tappsgames.com`).

[12] Playmobil is a registered trademark of geobra Brandstätter Stiftung & Co. KG (`http://company.playmobil.com`).

[13] Nisbett [55] is an example of an author who discusses the influence of social and cultural norms in perception, conceptualization and reasoning. It is important to highlight that he talks about cultural *effect* (or *influence*) on thought without committing to *linguistic relativism* (and neither do we make such a commitment).

Quite often, we may not even be aware of the (normative) frames we use. An interesting quote in this regard, attributed to Poincaré, can be found in [56]: "*We have to make use of language, which is made up necessarily of preconceived ideas. Such ideas, unconsciously held, are the most dangerous of all.*"

In [59] we already identified some of the normative frames that may influence us when creating domain models. Modeling frameworks, paradigms, metaphors, (foundational) ontologies, classification / typing mechanisms, taxonomies, dictionaries, domain conceptualizations, etc, can all be seen as (normative) frames.

(Normative) frames have possible advantages and disadvantages. They enable us to make sense of the world around us, manage its complexities, and focus the way we observe the world. That also empowers us to express / gather knowledge, while making communication easier as they can provide us with a common background. The communicative purpose (see above) also leads to the selection / use of a specific (normative) frame. At the same time, there are moments where such frames may actually act as a straitjacket, disabling us to innovate or see the real problems. A key challenge is, to be aware of the (normative) frames we use [59], and use them wisely.

One may also identify a certain hierarchy among the used frames. For instance, a domain conceptualization may be compliant to a specific modeling language, which in itself may be compliant to a foundational ontology. It is also interesting to not that the ArchiMate language was actually designed in terms of multiple layers of increasingly more specific modeling concepts [48] (mirroring the work on meta-model hierarchies as reported in [16]), potentially also enabling modellers to apply a process of step-wise selection of interpretation (in terms of an increasingly more specific meta-model) when modeling a domain [64].

In terms of the semiotic triangle, (normative) frames obviously have a (positive and / or negative) influence on the way an actor shapes their thoughts (i.e. their perception and conception) regarding a referent / domain, and their selection / creation of a (composition of) symbol(s) to symbolise these.

With regards to the current version of the FI-theory [15] it is relevant to observe that it bases itself strongly on the theory of Mario Bunge [9]. In particular concerning the things the world is composed of. As such, this implies the adoption of a specific view on the composition of the world; in other words, the adoption of a specific frame. By positioning the FI-theory as an explicit cornerstone of enterprise engineering, it (together with the TAO, PSI theories), becomes a normative frame towards enterprise engineering.

The goal of this paper is not to argue if that would be a good choice for enterprise engineering or not. We do, however, think it is important to make such a choice explicit.[14]

4 Domain models

In this section, we discuss the notion of model itself. In doing so, we will: (1) discuss our current understanding of model, (2) clarify that modeling involves the alignment

[14] For example, one of us has argued at length elsewhere against the adequacy of Bunge's ontology as a foundation for conceptual modeling [25, 24, 33].

of multiple conceptions, and (3) discuss the need to distinguish between conceptual models and computational design models.

4.1 Defining the notion of model

The MU-theory [15, page 73] bases its notion of model exclusively on the definition provided by Apostel in [1]: "*The foundations part starts with this definition of model: any subject using a system A to obtain knowledge of a system B is using A as a model of B.*" What is interesting to note is that in [1], Apostel provides this definition as a summary of the discussion provided in that paper. More specifically, immediately before providing the above definition, Apostel states [1]: "*This will be our final and most general hint towards the definition of model*". This definition should, therefore, not be seen as the final word of what a model is, but rather as an intermediate state in an ongoing debate. A debate to which other scholars [69, 65, 44, 20, 35, 52, 51, 70, 66], as well as ourselves [63, 27, 29, 5], have, or endeavoured to, contribute to.

Based on these foundations, our current understanding of the definition of the notion of *domain model* is:

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

Each of the stressed words in this definition requires a further explanation, where *domain* and *purpose* have already been discussed in the earlier sections.

A model is seen as a *social artifact*. It is a social artifact in the sense that its role as model should be recognizable by a collective agent.[15] Moreover, for this reason, it should exist outside of our minds. In other words, in the view defended here, a model *generically depends* on some external medium in order to exist [71].[16] In "our" field of application, this artifact typically takes the *form* of some "boxes-and-lines" diagram (see e.g. figure 3). These diagrams, expressed (again, typically) in some form of concrete visual syntax, can have its grammar specified by a set of rules (e.g., a meta-model, a graph grammar [75]), and its semantics defined by a mapping to a mathematical structural (*formal semantics* [38]) or to an ontological theory (*ontological or real-world semantics* [13]).

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 (also see our earlier discussion regarding figure 4).

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[15]Notice that, unlike [8], we do not require the model *type* to be recognizable *a priori*. For example, the aforementioned Playmobil set is not a type of modeling grammar for modeling pizzerias. Nonetheless, a particular use of that set to model a specific pizzeria can be shared and recognized as such by a particular collective agent.

[16]In [54], John Mylopoulos also defends the view that models are social artifacts. His main argument is that models typically represent shared conceptualizations of collective agents, which have to be produced through a social dialectic process from the individual conceptualizations of the members of those collectives. Once more, in order for that to be possible, for all realistic conceptualizations, a concrete representation existing outside the mind of those members must exist.

When the modeled *domain* pertains to a part / perspective / aspect of an enterprise, then we can indeed refer to the resulting domain model as an *enterprise model*.

In requiring a model to be an artifact, we deviate from the definition suggested in the MU-theory, where a model can be (in terminology of the MU-theory) a "symbolic complex", a "concrete complex" (in the tangible sense), or a "conceptual complex" (in one's mind). Of these, the "symbolic complex" and a "concrete complex" are artifacts. As such, in our definition, the "conceptual complexes" are (consciously) left out.[17] The motivation for this lies in the observation that for models to be used in a context involving (often asynchronous) communication, and collective problem-solving between humans (including, e.g. enterprise engineering efforts), specially when dealing with complex abstractions, they must exist as concrete artifacts. In this way, we can point at them, we provide them explicit identities, speak about their authors / creators, preserve them, etc.

This does not mean, as we will discuss below, that the notion of "conceptual complex" does not play a role. We only suggest not to consider these to be (able to play the role of) *models*.

As it is ultimately the observer who needs to *acknowledge* the fact that an *artifact* is indeed a model of the domain, it actually makes sense to treat *their* conception of the domain (involving a domain conceptualization and compatible domain abstractions) as the de-facto "proxy" for the domain. It also, in line with [1], points at the fact that *being a model* (in the eyes of an observer) is a *role* of an artifact.[18]

We should also realize that the *observer* observes the model (as artifact) as well, which therefore also creates a conception (in their mind) of the model. As a consequence, the observer needs to validate the alignment between their conception of the model and their conception of the domain, where the *purpose* of the model determines the alignment criteria. For instance, in creating the model shown in figure 3, or creating

[17] A potential counterexample is the case of *Blind Chess*, in which two players play the game without physical chess boards or pieces. In this case, we have individual conceptions, which are updated by a sequence of explicit and mutually acknowledged utterances. One could argue the sequence of these utterances *is* the model of the game, since the game could be completely reconstructed from the shared initial state plus that sequence (in a way that is analogous to the *event sourcing* (`https://martinfowler.com/eaaDev/EventSourcing.html`) notion of a domain representation). However, even the log of utterances in this case only exist in the players' minds. For the sake of this paper, we consider this as a case of a *shared conception* but not a model.

[18] Authors such as [8], defend that although artifacts must be created by acts of intention, preexisting entities that are not artifacts can become constituents of artifacts via intentional acts of creation. For example, if one decides to use a pebble as a paper weight, then a new entity is created (that paper weight), which is then constituted by the original pebble. According to this view, a "box-and-lines" drawing (or a Playmobil set) *constitutes* an artifact (model) due to an intentional act of creation - as opposed to saying that the diagram (Playmobil set) *plays the role* of a model. This view is also adopted in [74], in which, for example, a program is said to be constituted by a source code. We ignore this detail here and simply speak of an artifact playing the role of a model in a looser sense. However, according to the former view, we could also have non-artifactual entities playing the role of (or constituting) a model. Take for example the situation in which we use a grass field and a set of pebbles as a model of a football game. Again, for the sake of simplicity, we ignore this case here.

a computer-based game or game involving physical objects, to enable stakeholders to experience the "working" of the pizzeria "Perla del Nord" (as hinted at in figure 4), the modeler needs to align the creation / structuring of the model (the artifact) and the domain abstraction it needs to capture.

4.2 Alignment of conceptions

A model is the representation of an *abstraction* of the domain [41, 26, 28, 5]. This implies that, in line with the *purpose* of the model, some "details" of the domain are consciously left out. As a corollary to this definition, it implies that an observer (when acknowledging that that some artifact is indeed a model of the domain), must also be able to identify ("carve out") details in the domain that are *not* represented in the model.

In the context of domain modeling, four important flavors of abstraction are [4]: (1) *selection*, where we decide to only consider certain elements and / or aspects of the domain; (2) *classification*; (3) *generalization*; and (4) *aggregation*. In our field of application, selection typically leads to frameworks of aspects / layers by which to model an enterprise, but also to mechanisms for view extraction, as well as clustering and model summarization [18, 32]. Classification, typically leads to some class-instance and / or type-instance relationships, including type-instance relationships between types and higher-order types, i.e., multi-level structures [10]; generalization leads to the formation of specialization / generalization *taxonomies*, in which sub-types specialize properties of super-types; aggregation leads to the formation of *partonomies* of various kinds in which entities, seen as integral wholes, can be decomposed into parts. Parts, on the other hand, hang together bound by some unity criterion that forms the whole [30].

As a consequence of the above, an observer actually needs to harbour (at least) four conceptions: (1) a "full" conception of the domain (as they "see" it), (2) a conception of the purpose for the model, (3) an abstracted conception of the domain, (4) a conception of the artifact that is (to be) the model representing the latter abstraction.

It is important to realize that each of these four conceptions involves its own domain conceptualization (and associated set of possible domain abstractions); each with different (yet connected) domains as their focus. In the case of the *conception of the domain* this involves the actual domain to be modeled. In the case of the *abstracted conception of the domain* this involves the domain of possible abstractions on the domain to be modeled. For the *conception of the artifact*, the domain pertains to the constructional properties of the artifact in relation to the domain to be modeled. For the *conception of the purpose for the model* the domain involves the possible purposes for modeling the domain to be modeled.

Figure 5 provides an overview of the involved conceptions, where the conception of the purpose modifies the abstraction(s) and the alignment between the conceptions of the model and the desired abstraction. We should also not forget that the (normative) frames as discussed in the previous section influence the formation of all four conceptions.

When the model-conception corresponds to the abstraction-conception, then the observer would agree that the artifact is a model of the domain for the given purpose. As a consequence, different models (as artifacts) may indeed result in the same model-

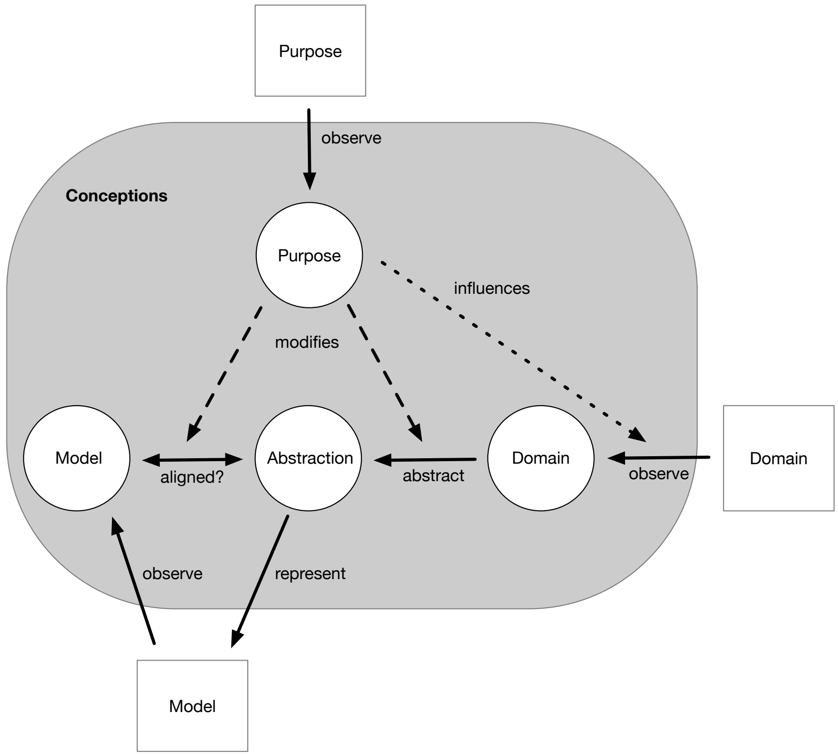

Fig. 5. Conceptions involved in domain modeling

conception, in which case (for the observer) they are equivalent models of the same domain (for the same purpose).

If the observer is "the modeler", i.e. the person creating the model, they also need to "shape" the model in such a way that it best matches their *desired* model-conception.

What is not shown explicitly in figure 5 is the fact that the normative frames as discussed in the previous section, influence the way an observer creates (and aligns) the four conceptions shown in figure 5. This specifically also includes the modeling languages we use. Even more, when the observer has an explicit understanding of the normative frames they (consciously or unconsciously) use, these understandings lead to conceptualizations in themselves. For instance, a conceptualization of (their understanding of) the DEMO method or the ArchiMate modeling language.

Returning briefly to the discussion above, where we limited our understanding of models only, i.e., leaving out what the MU-theory suggests to refer to as "conceptual complexes", we can now observe that both abstraction-conception and model-conception are "conceptual complexes" in terms of the MU-theory.

4.3 Conceptual models and utilization design models

In line with the above discussion, a domain model should be (the representation of) the abstraction of (the conceptualization of) a domain. At the same time, for different (1) *computational* purposes, such as the ability to use the model as a base for simulation, computer-based reasoning, execution, or database design, and / or (2) *experiential* purposes, such as the ability to touch, interact with, or feel the model (see, e.g., the examples shown in figure 4), it may be necessary to include "features" in the domain model that are not "true" to the original domain.

These "features" result in a model that does *not* correspond to (an abstraction of) the original domain. One could even say that it has been "compromised" in order to provide some computational and / or experiential *utility*, effectively also implying that the resulting model captures a (slightly) different domain.

This is where we suggest to make a distinction between *conceptual models* and *utilization design models* in the sense that a *conceptual model* is defined as:

> *A model of a domain, where the purpose of the model is dominated by the ambition to remain as-true-as-possible to the original domain conception*

while a *utilization design model* includes "compromises" to enable some computational and / or experiential (such as a game; see figure 4) *utility*.[19]

Note the use of the word *ambition* in the definition of conceptual model. As discussed in [61], we are not suggesting there to be a crisp border between conceptual models and utilization design models. However, the word *ambition* also suggest that a modeler / observer, as their insight in a domain increases, should be driven to reflect on the conceptual purity of their conceptualization and of the resulting model.

Utilization design models certainly have an important role to play. However, it is important to be aware of the "compromises" that had to be "designed into" the original domain conceptualization, to obtain the desired computational / experiential utility of the model. As such, it is also possible that one conceptual model has different associated utilization design models, each meeting different purposes.

5 Conclusion

In this paper, we reflected on the semiotic roots of domain modeling (and enterprise modeling in particular), the important notion of domain conception, and models themselves. We positioned domain conceptions (with their underlying domain conceptualization and associated domain abstractions) as a bridge from the semiotic roots to the world of domain models.

In our discussions we also reflected on the current versions of two of the core theories of the discipline of enterprise engineering (*Factual Information* (FI) theory and the *Model Universe* (MU) theory).

We regard this paper as part of an ongoing "journey", with the aim of deepening our insights into the foundations of domain modeling. We certainly do not claim this paper to be a fully finished work. It provides a snapshot of our current understanding, and we hope that debates with our colleagues will aid us in continuing our journey.

[19] An example is the case of the so-called *Operational Ontologies* in Description Logics, which trade *domain appropriateness* for certain computational properties (e.g., decidability) [26].

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