On Model-based Coordination of Change in Organizations

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Abstract. Change seems to be an inherent property of organizations and the enterprises they undertake. During such changes, *coordination* among the different actors involved is key, in particular when there is a need to consider the longer term impact of change.
When the complexity of an organizations, and / or the context in which it operates, is high, the need emerges to use "represented abstractions" of the organization and its context to support coordinated change. These "represented abstractions", taking the form of e.g. sketches, narrative descriptions, diagrams, spreadsheets, or formal specifications, are used for informed decision making about changes, as well as to coordinate changes among the different actors that may be involved. We take the stance that these "represented abstractions" are all forms of *models*. Doing so, does requires us to look beyond the "boxes-and-lines" metaphor that seems to be the traditional way of looking at models in our field.
Meanwhile, the transition to the digital age has resulted in organizations to be (and operate in) a complex and hybrid mix of human and digital actors, while the pace of change has increased as well. This also puts more pressure on the *coordination* of the changes, and as a direct consequence also puts more pressure on the use of *model-based instruments*.
The goal of this paper is to explore some of the challenges that these *model-based instruments* will need to meet (while indeed looking beyond the "boxes-and-lines" metaphor). To this end, we will start with a discussion of our current understanding of the notion of model. We then zoom in on the use of models in the coordination of change. Using this as a base, we finalize with a discussion of some of the main challenges we see in improving the use of model-based instruments for the coordination of change in organizations.

Keywords: coordination of change · enterprise modeling · conceptual modeling

1 Introduction

Change seems to be an inherent property of organizations and the enterprises they undertake. These changes may be related to internal factors, such as the constellation of human actors involved in an organization, the build-up of experience / organizational knowledge, etc. Most changes, however, will find their ultimate cause in external factors, such as changes in the socio-economical context, changes in the environment, as well as technological developments.

When the complexity of an organizations, and / or the context in which it operates, is high, the need emerges to use "represented abstractions" of the organization and its context to support coordinated change. These "represented abstractions", taking the form of e.g. sketches, narrative descriptions, diagrams, spreadsheets, or formal specifications, are used for informed decision making about changes, as well as coordinate changes among the different actors that may be involved. As we will discuss in more detail in section 2, we take the stance that these "represented abstractions" are essentially *models*. This does, indeed, require us to look beyond the "boxes-and-lines" metaphor that seem to have become the traditional way of looking at models in our engineering-oriented field.[3] Organizational scientists may argue that there are more design related artifacts used in organizations than may meet the engineer's eyes [43]. Or as Junginger [34] puts it: "*Naturally, they [engineers] are looking for forms and practices of design they are familiar with.*" Junginger [34] also states: "*Design literally shapes organizational reality.*", which resonates well with concepts such as "organizational design" [42], "sensemaking" [79] and the "authoring of organizations" [73]. In line with this, we argue that, depending on the situation at hand, texts, sketches on the back of napkins, spreadsheets, formal specifications, etc, or even animations and simulations, can all act as models.

Periods of great change in human society have often been driven by the emergence of disruptive technologies, such as the introduction of the printing press, the steam engine, the car or the telephone [43]. Such technology-driven impacts tend to start slowly, but as soon as the technology matures, the pace and depth of their impact on society and organizations increases rapidly. Our society is now, driven by the development of information technologies (IT), transitioning from the industrial age to the "digital age".

The role of IT in organizations started by mainly being a "mere" supportive tool for administrative purposes, resulting in the "automation of information processing activities". The emergence of e-commerce (indeed, also powered by the emergence of the world-wide-web) resulted in a stronger role of IT as a key actor in business processes, sometimes even fully replacing human activities. The increased use of artificial intelligence (AI) also enables a further "automation" of (business) processes, while "big data" fuels this with the necessary data. Finally, the further maturation of IT in terms of e.g. increased interoperability across organizational boundaries, the usage of standardized platforms, and the adoption mobile device in society, has now even resulted in the emergence of IT-based business models. Companies such as Amazon, AirBnB, Uber, Netflix, Spotify, and Bitcoin, provide examples of the latter. The CEO of a major traditional bank can even be quoted as stating "*We want to be a tech company with a banking license*" [22].

The transition to the digital age now drives organizations to change faster and more fundamentally. These changes impact the complete "design" of organizations and the enterprises they engage in; from their business model, the definitions of the actual products and services offered to their clients, via the business processes that deliver these products and services, and the information systems that support these processes, to the underlying IT infrastructure.

[3] Business Informatics, including organizational engineering, enterprise engineering, and enterprise architecture

In general, change in organizations goes by different names, including *business transformation*, *enterprise transformation*, *business innovation*, *digital transformation*, etc. These latter forms of organizational change, generally pertain to top-down initiated forms of change. In other words, change that is initiated explicitly under the auspice of senior management. At the same time, change in organizations may also occur in terms of emergent / bottom-up change. This includes minor changes to processes and rules to "make things work" [2], organizational drift [44], as well as the creation of Shadow-IT [23].

For an organization, in particular in relation to the enterprises it may pursue, it is important to ensure alignment / coherence of its key aspects [26, 78], including e.g. business strategy, IT, organization, culture, marketing, etc. To improve, and maintain, such coherence it is important to ensure there is *coordination* of change among the involved actors [64]. Both in the case of bottom-up and in the case of top-down initiated change.

As mentioned above, when the complexity of the organization itself, and / or the contexts in which it operates, is high, the need emerges to use "represented abstractions" (i.e. models) to enable enable informed decision making about, as well as the coordination of change. The transition to the digital age puts more pressure on the *coordination* of change, and as a direct consequence also puts more pressure on the use of *model-based instruments*.

The goal of this paper is to explore some of the challenges that these *model-based instruments* will need to meet, while indeed looking beyond the "boxes-and-lines" metaphor. To this end, we will start (in section 2) with a discussion of our current understanding of the notion of model. In section 3, we then zoom in on the use of models for the coordination of change. Using this as a base, section 4 finalizes the paper with a discussion of some of the main challenges we see in improving the use of model-based instruments for the coordination of change in organizations.

2 Domain Models

In the context of software engineering, information systems engineering, business process management, and enterprise engineering & architecting in general, many different kinds of models are used. We consider each of these kinds of models as being valued members of a larger family of *domain models*. As the words *model*, and *modeling*, have different connotations in daily discourse, we prefer to use the term *domain model* instead.

2.1 The notion of domain model

Based on general foundational work by e.g. Apostel [3], and Stachowiak [70], more recent work on the same by different authors (e.g. [66, 24, 75, 19, 20, 67] as well as our own work (e.g. [32, 63, 7, 59]), we consider a *domain model* to be:

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

With *domain*, we refer to "anything" that one can speak / reflect about explicitly. It could be "something" that already exists in the "real world", something desired towards the future, or something imagined. The *observer* observes the domain by way of their senses and / or by way of (self) reflection. What results in the mind of the observer is, what is termed a *conceptualization* in [20], and what is called *conception* in [13].

Models are created to serve a *purpose*. In other words, the model is to be used for some goal, by some actors, in some context. The purpose of a model, ultimately paves the way for its ***R****eturn* ***o****n* ***M****odelling* ***E****ffort* (RoME, see Chapter 4 of [52]).

We consider a model to be an *artifact*. It is something that exists outside of our minds; i.e. a "represented abstractions". In our fields of application, one tends to limit such an artifact to the "boxes-and-lines" metaphor, while within the field of e.g. software engineering in particular, one has developed the implicit assumption that models are artifacts with a highly controlled structure (syntax) and mathematically defined semantics [24]. However, as mentioned above, models can take other forms as well, such as texts, sketches on the back of a napkin, spreadsheets, formal specifications, animations, physical objects, etc [55, 43]. Which form is the most effective, depends on the *purpose* for which the model is created.

At an overall level, we suggest to distinguish between two main (mixable) flavors for the *form* of a model:

1. Models can be of a *lingual* nature, involving e.g. text, graphical symbols, or a mathematical formalism.
2. Models can be of an *experiential* nature, involving e.g. the use of physical elements, animations, simulations, or tactile sensation.

A model is the representation of an *abstraction* of an observed domain. This implies that, in line with the *purpose* of the model, some (if not most) "details" of the domain are consciously filtered out by the observer. For domain modeling [59], important abstraction flavors are [6]: (1) *selection*, where we decide to only consider certain elements and / or aspects of the domain; (2) *classification* (including typing); (3) *generalization*; and (4) *aggregation*.

2.2 Semiotic roots

The semiotic triangle by Ogden and Richard [51], as depicted in figure 1, is often used as a base to theorize about meaning in the context of (natural) language [49, 77, 69, 11]. Several authors, including ourselves, use it to reason about the foundations of (information) systems modeling (see e.g. [36, 35, 38, 27]).

As shown in figure 1, the semiotic triangle expresses how an actor (in using a language to communicate) assigns meaning (a *thought or reference*) to the *combination* of a *symbol* and a *referent*, where the former is some language utterance, and the latter is something that the actor can refer to. 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 [51, pp. 11–12]: "*Symbol and Referent, that is to say, are not connected directly (and when, for grammatical reasons, we imply such a*

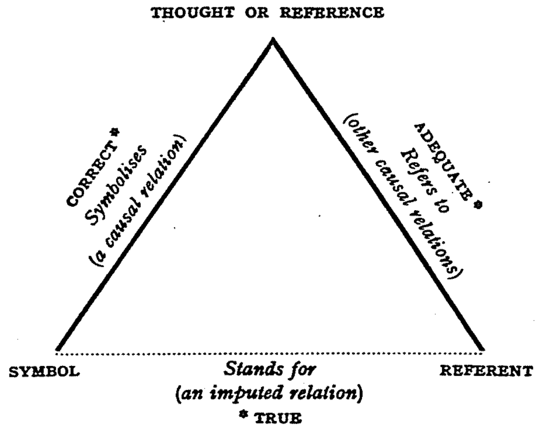

Fig. 1. Ogden and Richard's semiotic triangle [51]

relation, it will merely be an imputed as opposed to a real, relation) but only indirectly round the two sides of the triangle." The latter implies that the connection between the symbol and the referent always goes by way of a thought in the mind of some actor.

2.3 It takes two to communicate

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, specifically including the coordination of change in organizations, it is important to acknowledge the fact that there are at least two actors involved. Any language utterance (such as domain models) has both a *writer* and a *reader* [69]. In terms of the semantic triangle, this implies that both the author and writer have their own thoughts about the symbol, in the context of possibly the same referent.

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 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 [31] 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 [21].

2.4 Generalization to models

In applying the semiotic triangle in the context of modeling, one should be careful as it was originally intended to be used in the context of natural language communication via written symbols. Some of the resulting concerns are discussed in e.g. [53, 27, 57, 59].

One concern we would like to raise explicitly is related to the fact that models can, based on the definition given above, be of a *lingual* as well as an *experiential* nature. As such, this would require the postulation of a generalized version of the semiotic triangle, where *symbol* is replaced by the more generic notion of a (meaning carrying) *artifact* (or sign). The suggested adaption is shown in figure 2.

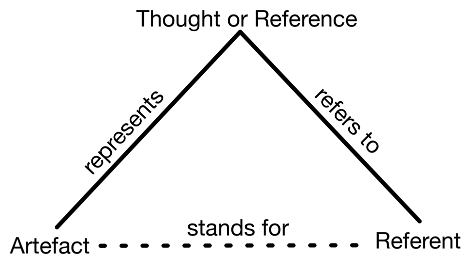

Fig. 2. Generalized semiotic triangle

In figure 2, we specifically use the word *artifact* and not model. Not every artifact that on observer may see as "standing for" the referent necessarily has to be model (see subsection 2.6). Conversely, following our definition, every model is indeed required to be an artifact.

2.5 Conceptual models vs. 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, 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*.

This is where we suggest to make a distinction between *conceptual models* and *utilization design models* in the sense that (in line with [59]) 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 *utility*.

Note the use of the word *ambition* in the definition of conceptual model. As discussed in [59], 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.

2.6 Instantiations of models

As a consequence of the fact that a domain model is an *abstraction* of the domain, it must be possible (for an observer) to identify multiple "situations" that provide different (more specific) *instantiations* of the model [59].

This enables us to introduce a *qualifier* on the relationship between a model and a set of possible instantiations. For instance, the relation might have an *epistemic* intentions in the sense that the set of instantiations corresponds to the set of observable situations in "reality", which mean that the model represents knowledge about the existing world. An example of such a model, would be a domain model pertaining to a "law of nature".

The relationship between the model and the possible instantiations might also have a *deontic* intention in the sense that the set of instantiations corresponds to the desired, obliged, or required situations. This is where we find models in the role of guidelines, protocols, rules, designs, etc.

In the context of designing and engineering parts of organizations and their enterprises, this distinction also allows us to move from analysis to design.

2.7 Modeling happens naturally

Whenever we study, or reflect about, complex phenomena such as constructions, processes we observe in nature, information systems, business models, organizations, etc, we tend to use an *abstraction* (in our mind) of the actual phenomenon. When we externalize this *abstraction* in terms of some artifact, then this artifact is a model (to us, as an individual) of the observed phenomenon. As such, modeling happens naturally.

Of course, when the requirements regarding different qualities of the model [36, 9] increase, more cognitive effort will be needed to create (and understand) the domain abstraction and the model. The (extra) effort should, of course, be in line with the (expected) earlier mentioned RoME (Return on Modeling Effort).

This has also triggered studies into the competences needed from modelers in order to produce models [14, 80, 41]. It also formed the base of work towards more natural forms of modeling [8, 81], as also echoed in more recent ideas on *grassroots* modeling [67].

3 The Role of Models in Coordinating Change

In this section, we explore the use of models in the coordination of change in organizations and the enterprises they engage in. We start from the perspective of *informed decision making* regarding the directions of change. We then shift the focus towards the use of models for *informed coordination* of change.

3.1 Informed decision making

Different aspects of an organization, including its structures, purpose, value proposition, value propositions, business processes, stakeholder goals, information systems, etc, can be captured in terms of (interconnected) models. Just as senior management uses financial modeling to *enable* decision making from a financial perspective, models of the other aspects of an organization can be used to enable informed decision-making regarding the other aspects as well [25, 62, 55]. The informative value (indeed, RoME) of such models comes even more to the fore when the models are interlinked, thus providing a coherent perspective on all relevant aspects, also enabling "cross-cutting" analysis [33, 52].

In [56], it is suggested that, in the context of organizations and their enterprises, there are (at least) seven high-level purposes for the creation of models of systems / organizations:

1. *Understand* – Understand the working of the current affairs of an organization and / or its environment.
2. *Assess* – Assess (a part / aspect of) the current affairs of an organization in relation to a e.g. benchmark or a reference model.
3. *Diagnose* – Diagnose the causes of an identified problem in the current affairs of an organization and / or its environment.
4. *Design* – Express different design alternatives, and analyze properties of the (desired) future affairs of the organization.
5. *Realize* – Guidance, specification, or explanation during the realization of the desired affairs of an organization.
6. *Operate* – Guidance, specification, or explanation for the socio-cyber-physical actors involved in the day-to-day operations of an organization.
7. *Regulate* – Externally formulated regulation on the operational behavior of (an) organization.

In specific situations, 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 [61], or for a computer to be able to interpret the model in order to e.g. automatically analyze it, use it as the base of a simulation / animation, or even execute it. Furthermore, depending on additional factors, such as the abilities of the actors involved in the creation and utilization of the model, the intended usage of the model, the need for understanding / agreement / commitment to the model from different stakeholders, etc, these overall purposes can be refined even further [58].

The specific purpose of a model that is to be used in a specific context, also provides us with possible requirements on a model as an artifact, including the required level of precision, completeness, format, etc. As argued before, a sketch, of e.g. a new business process, on the back of a napkin can already be regarded as a model; assuming that for the purpose at hand a sketch suffices. If, however, there is a need to simulate the new business process, the sketch will not suffice. As such (see subsection 2.7), the purpose of a model also has a direct relationship to its RoME.

Orthogonal to the above discussed high-level purposes two other classes of high-level purposes we would like to mention are:

1. *Design knowledge* – Reference models (as also mentioned above in the *assess* purpose) can be used to capture (opinion or evidence-based) design knowledge.
2. *Harmonization* – Meta-models and / or (foundational) ontologies [20] can be used to "harmonize" or even "standardize" the way we observe, abstract from, and create models of, the world / organizations around us.

3.2 Informed coordination of change

Changes in organizations are ultimately the result of the decisions taken by the actors involved in / with the organization, as well as the actions that follow from these decisions. This may pertain to top-down initiated changes, as well as bottom-up up initiated changes, where *governance mechanisms* may be in place to define the "rules of the game" [30, 64]. This may involve both formal rules defining how decisions are made, their authority, needed compliance, etc, as well as informal rules about the way changes are made.

For an organization, in particular in relation to the enterprises it may pursue, it is important to ensure alignment / coherence of its key aspects [26, 78], including e.g. business strategy, IT, organization, culture, marketing, etc. To improve, and maintain, such coherence it is important to ensure there is *coordination* of change among the involved actors [64]. Both in the case of bottom-up and in the case of top-down initiated change. As argued in [64, 78], such coordination requires (different levels of) shared understanding of, agreement on, and commitment to: (1) what the overall strategy of the organization and its enterprise(s) is, (2) its the current affairs, i.e. the current situation, as well as the relevant history leading up to it, and possible trends towards the future, (3) the current affairs of the context of the organization, and (4) what (given the latter) the ideal future affairs of the organization and its enterprise(s) are.

When combining (1) the need for coordination between the actors involved in change, (2) the need for informed decision making (see subsection 3.2), (3) the notion of *design conversations* [34], and (4) the notion of *authoring of organizations* [74], we arrive at what one might call *informed coordination*, where models are the information carrier enabling informed decision making and coordination among the actors involved.

When considering the role of models in the context of *informed coordination*, it is also important to acknowledge their potential role of models as boundary objects [40, 1] in the communication among the different actors involved. The concept of boundary objects originated from organizational sciences [71]. An early approximation of this concept in the "world of engineering" can be found in terms of *views* and *viewpoints* [39] that enable the communication on the design of an organization (and its different aspects) with different groups of stakeholders [61].

Here, we should also re-iterate the role of models (in terms of meta-models and ontologies) with the purpose of *harmonizing* the way we capture, and speak about, changes to the organization.

4 Challenges on the Use of Models

It is important to reiterate the fact that in this paper we take the view that whenever we start using "represented abstractions" to support us in informed coordination, we start using models. The driving challenge then becomes how to make the use of these models more effective and efficient, and improve the RoME in particular. So, the question is not whether to use models or not, but rather how to make their use more effective and efficient. In this section we will discuss some of the main challenges we see in making the use of models for the coordination of change more effective and efficient.

In earlier work we also identified challenges for domain modeling in general [57], as well as challenges on the use of an existing enterprise modeling language (i.c. ArchiMate [4]) in the context of digital transformations [16]. In this section, we draw on these earlier discussed (research) challenges, while also focusing more specifically on challenges in relation to informed coordination.

4.1 Semantic grounding of models

Models used in the context of informed coordination should be understandable to the the actors who are involved in their creation and use, in particular in situations where the model needs to act as a *boundary object* [1]. We therefore posit that a domain model should be grounded in the terminology as it is actually *used* (naturally) by these latter actors.

Most existing enterprise modeling languages (e.g. process models, goal models, value models, architectural models, etc.), only offer a "boxes and lines" based representation, which, by its very nature only provide a limited linkage to the (natural) language as used by a model's broader audience.

While these notational styles enable a more compact representation of models, they *generally* offer no means to provide a "drill down", or "mouse over", to an underlying grounding in terms of e.g. natural language verbalizations. As such, they leave no room for situation specific nuance that is especially needed when models are used as boundary objects [1]. A first challenge is therefore more specifically:

- *How to ground enterprise models in terms of natural language like verbalizations, without loosing the advantages of having compact notations (as well).*

4.2 Creating shared understanding

Coordination of change involves multiple actors. Therefore, for coordination to be effective, these actors should have a (good enough) shared understanding the the models they use to coordinate changes. Based on Ogden and Richard's semiotic triangle [51], we can identify two main challenges related to achievement of a shared understanding:

- *How to ensure that different creators / readers of a model relate it to the same domain / referent?*
- *How to ensure that different creators / readers of a model have the same understanding (thought) of the model, assuming they relate it to the same domain / referent?*

The first of these two challenges is an important topic in the context of collaborative modeling, where groups of people are expected to e.g. jointly create an model [72, 68, 5].

The second challenge relates directly to the question of model understanding. For instance, empirical studies have shown that diagrams can easily be misunderstood [28, 29, 50], which is likely to lead to problems of understanding and use [65, 45, 10].

To improve the understanding of models, several authors have already been able to elaborate evaluation criteria to obtain a better quality in the design of these languages and the diagrams that accompany them. The most recognized, and the most successful to date, are the nine Moody criteria [47], based on the concept of *cognitive effectiveness*. These criteria have been applied in many projects [48, 17].

A final challenge pertaining to shared understanding, which is related to RoME, is:

- *How to measure the "depth" of shared understanding, and how much shared understanding is necessary?*

Using techniques like paraphrasing, one may indeed be able to obtain some insight into the "depth" of shared understanding one has reached. At the same time, this adds to the *effort* of modeling, so this has to be weighed against the expected returns. Collaborative modeling approaches tend to integrate the assessment of a shared understanding, in relation to the modeling goals, into the actual modeling process [72, 68, 5].

4.3 Aligning normative frames

As discussed in [57], when modeling (in particular when creating our abstractions of a domain), we are influenced by our normative frames. More specifically, these normative frames influence what we consider to be observable, thinkable, and changeable, about (the design of) an organization.

Examples (see [57]) of such normative frames are: (1) the *philosophical stance* (e.g. objectivist, subjectivist, etc.) of the actors involved, (2) *cognitive biases* which the actors involved in modeling may have developed during their professional, educational, and private lifes, (3) *self interests* which the actors may have regarding the domain being modeled, (4) the *design frameworks* we use in the context e.g. enterprise architecture, and (5) the conceptual structures that are "hard-wired" into the modeling language(s) and conventions one may use.

When coordinating change, it will be necessary to ensure that the normative frames of the actors involved are "aligned enough". Without such alignment, achieving a shared understanding will likely to be very difficult. The need for alignment should also be seen in relation to the purpose of the coordination, and the purpose of the model that is being created. The general challenge can be summarized as:

- *Which normative frames exist?*
- *How to ensure that all actors involved are aware of the role of the normative frame(s)?*
- *How to ensure that the normative frames used by the actors involved are aligned (enough), among them, and in relation to the coordination and modeling purposes?*

4.4 Agility vs. coordinated change

Organizations in the digital age need to thrive and operate in a highly complex and dynamic environment. As a result, modern-day organizations need to be agile in order to survive. In the context of IT, the need for more agility has triggered the emergence of software development approaches, such as Agile, DevOps, etc. One of the key messages from these approaches is to avoid a big-design up front (BDUF), which could be at odds with the need to ensure enterprise-wide alignment of key concerns.

If the *sketch on the back of a napkin* of a new business process and its underlying IT support, suffices as a design document for an agile project, then this might be fine for the immediate sponsor of the agile project. At the same time, however, one might wonder if a pile of such "sketches" would suffice to conduct an organization-wide cyber-risk analysis, or to conduct a compliance check to e.g. the EU's GDPR.[4] As such, while a "sketch" might suffice the project goals of an agile project, it might not meet the overall goals of the enterprise, and its ongoing transformations, as a whole (such as coherence management, risk management and compliance).

Whatever the outcome of such a debate, it leads to the need to define situational factor, which define the purpose, the available resources for modeling efforts, and the potential return on modeling effort. The resulting challenge is therefore:

- *To provide the means to identify what kind of modeling is needed in specific situations, including the ability to make a conscious trade-offs between local project needs and more organization-wide needs to coordinate across changes.*

4.5 Orientation of models

The tension between the (agile) needs of projects, and the need to manage a portfolio of projects as part of a larger (portfolio) of transformations, also result in a need to reflect on the modeling concepts to be used in the different situations.

For example, at an organization-wide level, it might be better to use so-called architecture principles [18] to express the overall *direction of change*, rather than the more detailed boxes-and-lines diagrams such as used in ArchiMate [37] models. At the same time, the latter type of models are a prerequisite to conduct a detailed impact analysis, or a thorough GDPR compliance check.

As such, we observe (for now) there to be two overall strategies a model may exhibit with regards to its (intended) relation to its instantiations (e.g. an epistemic or a deontic intention; see subsection 2.6):

1. Models following an *extensional* style in the sense of containing explicit representations of domain concepts, such as, in the case of organizational design: actors, roles, processes, resources, etc.
2. Models following an *intensional* style such as design constraints or architecture principles, stating more general rules / properties.

The terms *extensional* and *intensional* are borrowed from set theory. For instance, an extensional definition of the even numbers, would require one to list all numbers individually:

$$\{2, 4, 6, 8, 10, \ldots\}$$

[4] `http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0679`

while an intensional definition would be:

$$\left\{ n \times 2 \,\middle|\, n \in \mathbb{N} \wedge n > 0 \right\}$$

We would argue that modeling languages such as ArchiMate and UML are more geared towards the *extensional* strategy, while architecture principles are more geared towards an *intensional* strategy. As such, further challenges are:

– *When is an intensional or an extensional strategy most effective, in relation to the speed of change in an organization, as well as the considered scope of change (e.g. organization-wide, or business-unit specific).*
– *What are good modeling languages to express models following an intensional or an extensional strategy respectively*.

4.6 Model management

When limiting one's definition of model to "boxes-and-lines" only, most organizations will already have to deal with the need to manage a large collection of models that describes parts of the as-is and to-be situation. Some authors even suggest to use the term *enterprise cartography* to (a.o.) manage such a collection of models [76].

When taking a broader perspective on the notion of a model, then the set of models to be managed becomes even larger, including, e.g. a traceable path from informal / textual models to more formal models. Examples of this can be found in the context of requirements engineering [54], as well as regulations [46, 15, 12].

Managing the resulting set of models as a whole seems akin to a mission impossible. As a result, some RoME-based triage needs to be made. At the same time, IT-based approaches [76, 56] can be used to support the management of the resulting models at differentiated levels of integration and traceability.

The resulting challenge is therefore:

– *How to manage the portfolio of models created when coordinating change in an effective way, possibly using modern-day IT-based solutions*.

5 Conclusion

The goal of this paper was to explore some of the challenges that *model-based instruments* will need to meet to support the informed coordination of change, in particular now that we have entered the digital age, resulting in an even higher pace of change.

We started with a review of our current understanding of *model*, which also took us beyond the "boxes-and-lines" metaphor. Based on this, we explored the role of models towards *informed decision* making regarding change, as well as *informed coordination* of change. We then discussed six (clusters of) challenges for the practice of modeling: semantic grounding, shared understanding, aligning normative frames, agility vs. coordinated change, orientation of models, and model management. Each providing ample opportunities for future research.

With regards to the latter challenges, we also explicitly made the point that (since modeling happens naturally) it is not the question whether to use models or not, but rather how to make their use more effective and efficient.

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