Combining Top-down and Bottom-up Enterprise Modelling

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Abstract. Modeling approaches started to be used in a large scale around 40 years ago, using simple diagrams. Still the main focus in modelling is for intermediaries to document the knowledge as held by different stakeholders for further use, rather than for people that has the core knowledge themselves to use modeling for their own needs. Although top-down modeling by experts is useful e.g. for enterprise architecture and systems development, for modeling to have a larger effect in the representation and reuse of knowledge in organizations, we propose to enable all knowledge workers to be active modelers. This paper provides an overview of interactive models for knowledge articulation combined with supporting knowledge maturing as an approach to support bottom-up modeling, and gives an overview of the how this can be supported in an existing enterprise modeling environment. We also discuss necessary future development to make this a reality on a large scale.

Keywords: Enterprise process modelling**,** bottom-up modeling

1 Introduction

According to [18] enterprise modelling is typically done by only a few people in the organization who are specially trained to use modelling methods for knowledge representation. What is captured in models, often in a top-down fashion, by this small group and made available for organizational purposes is only a fragment of the enterprise knowledge that potentially could be captured, discussed and communicated. Many people actually develop some kind of models without thinking upon it as such [6]. Examples are spreadsheets[1] used to capture essential features of products and their dependencies, presentation slides with architecture and process descriptions, or sketches in drawing tools defining the information flow in a business service. The content of such files can be highly valuable, but difficult or even impossible to retrieve.

(Enterprise) models are used for many different purposes [10] such as model mapping, human sense-making [20], communication among stakeholders, model simulation and analysis [16], quality assurance, model deployment and activation, systems development, model implementation and standardization. Many traditional applications of

[1] Much data relevant for engineers and other business professionals is developed and resides in office automation tools like Excel [5].

modelling are limited to one usage area, and thus provide limited value. A larger effect of modelling in and across organizations can be observed when one uses models over a longer time, but also across domains [4]. For this to work, though, one has to have the long-term use in mind from the start. When trying to build upon models meant originally for sense-making in a limited group and turning them into organizational memory, one will often experience limitations in the original modelling approaches and modelling tools used [11]. Thus one needs to be able to *mature* informal models in a sensible way. Few people retain ownership over these models over a long time span so models gradually decay, unless appropriate mechanisms are put into place to keep them alive and up-to-date as organizational practice. *Architectural Thinking* (AT) [21] offers an interesting perspective on how to widen stakeholder involvement in modeling of organizations. AT is understood as a way of thinking and acting throughout an organization, i.e. not restricted to architects and system developers, that considers holistic, long-term system aspects as well as fundamental system design and evolution principles in day-to-day decision making enabling modeling of, by and for the people [8].

For modelling to have a larger effect for knowledge representation and reuse than when only doing planned top-down modeling, we propose a move of technologies and approaches to also enable 'normal' knowledge workers to be active modelers, both by perform model-based adaption of the applications they are using to support their daily work tasks and by providing support for specific non-routine situations. A model-based working environment [17] empowers information carriers and enterprise architects to collaboratively and incrementally develop and manage a model in a bottom-up fashion.

As stated above, modeling is done for a large number of different purposes. In particular we focus on the role of interactive and active models. Interactive modeling and model knowledge maturing are further described in Section 2. An approach to support combined top-down and bottom-up modeling based on integrating top-down modeling with interactive models and knowledge maturing from practice is briefly described in Section 3. Section 4 summarizes the paper pointing for the need of further empirical evaluation of the approach.

2 Background on Approaches to Bottom-up Modeling

One approach towards bottom-up modeling is the application of what we term *interactive models* supporting the evolution of interaction machines [19]. The use of interactive models is about discovering, externalizing, capturing, expressing, representing, sharing and managing enterprise knowledge. A model is *active* if it directly influences the reality it reflects, i.e. changes to the model also change the way some actors perceive reality [12]. *Model activation* is the process by which a model affects reality. Model activation involves actors interpreting the model and to some extent adjusting their behavior accordingly. This process can be

- *Automated*, where a software component interprets the model and acts accordingly
- *Manual*, where the model only guides the actions of human actors, or
- *Interactive*, where prescribed aspects of the model are automatically interpreted and ambiguous parts are left to the human users to resolve (through modeling in a restricted environment).

That a model is interactive entails a co-evolution of the model and its domain, although the effects are first typically local on an instance-level. Several approaches to interactive models exist, including Hybrid Wikis [17] and AKM – Active Knowledge Modeling [15]. AKM's enable workers to express situated work-sensitive knowledge, building rich-context workspaces and multi-dimensional knowledge spaces.

Interactive models allows us to capture and benefit from situated, work-generative knowledge that otherwise will only be captured as tacit knowledge in the minds of those involved if at all. A long-term goal is that everyone (not only 'modelers') are involved in developing and activating models made in adapted modelling language presented in generated workplaces that fits the individual user or group of users collaborating.

The choice of modeling practice includes deciding what methods, languages and tools are to be used for the development and evolution of the models. The need of formality may differ based on the context and on the expected value identified. The development of a model to be included in an enterprise architecture requires greater formality in terms of methods, tools and languages compared to modeling for informal communication in a small group, where the model might serve as a short-living artifact only.

Whereas new knowledge often arises in collaborative sense-making tasks on the individual and (small)-group levels, it is in many cases also relevant to spread and mature the knowledge established at this level to a higher organizational level, migrating knowledge across workspaces [15]. To examine this in greater detail, we base the discussion on the work on knowledge maturing from the MATURE project. The following is based on [13, 14].

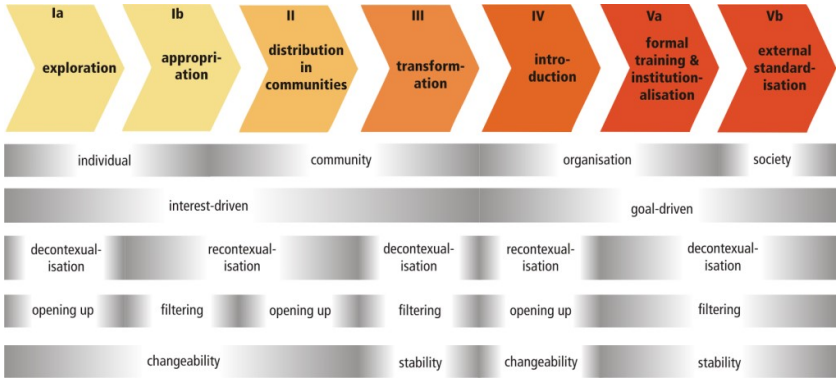

Fig. 1 Framework for knowledge maturing (from [13])

The Knowledge Maturing Model outlines the following phases (see Fig. 1):

- Ia. Exploration: New ideas and insight are developed by individuals.
- Ib. Appropriating ideas (individuation): New ideas that have been enriched, refined, or otherwise contextualized with respect to their use are now appropriated by the individual. On both these levels we are in the personal workspace

- II. Distributing in communities (community interaction): This phase is driven by social or work-pragmatic motives such as belonging to a preferred social group or the expectation of reciprocal knowledge exchange within the community or project. A common terminology for individual contributions is developed and shared among community members, and simple (process) models of the situation might be articulated for supporting communication within the community. (Innovation workspace).
- III. Transformation: More structured documents and models are created in which knowledge is made more transferable, and context is made explicit with the purpose of easing the transfer of knowledge to people other than those in the originating community or project. This connects to the business networking workspace.

From Phase IV on, there are two alternative paths of knowledge maturing:

- IV_1. Ad-hoc training followed by formal training (instruction)).
- IV_2. Piloting (implementation): Experiences are deliberately collected with a test case stressing pragmatic action and trying a solution before a larger roll-out of a product or service to an external community or new rules, procedures, or processes to an internal target community such as project teams or other organizational units.
- $V2_a$. Institutionalizing (introduction): Within an organization, formalized models and documents that have been learned by knowledge workers are implemented into the organizational infrastructure in the form of common business rules, business processes or standard operating procedures.
- V_b. Standardizing (incorporation):

In the knowledge maturing process, models originally developed for other purposes can act as guidance, being more or less fully reused and adapted to the case at hand. The breath of learning and experiences to bring forward will often need to be more restricted the more widely one wants to share the knowledge. It is important to clarify the level of knowledge maturity that you have achieved and the ambitions for increasing the level of maturity. Aiming too high (too far to the tight in Fig. 1) will result in waste due to extra processing, and aiming too low might result in waste through under-communication, with possible results being waste due to unnecessary searching, interpretation work and misunderstandings.

3 An Approach to Support Top-down and Bottom-up Modeling supported by Knowledge Maturing across Workspaces

By using the AKM (Active Knowledge Model) approach we can integrate the more traditional top-down modeling using e.g. IDEF0 notation as an example of a POPS-notation (Product, Organization, Process, System), with the bottom-up practical modelling of Workplaces in IRTV (Information, Role, Task and View) notation [15]. POPS and IRTV are used within different interrelated enterprise knowledge spaces supported by AKM [15], combining models of different perspectives [9].

To enable modeling in the large [7], organizational models exist on 4 levels of generalization/abstraction and details/instantiation as seen in Fig. 2:

1. Strategic "Ought-to-be" level: A generic "Best Practice" model laying out the strategic plans for how the enterprise should operate in the future (long-term). Having this level gives the business management and business architects more influence and

control and a more effective way to specify how the IT functions should support the business processes [2].

2. Tactical "Agreed-to-be" level: A generic normalized process model. The Business Strategy Managers/Architects and the Operational Managers/Architects have to agree upon a common normalized process definition (stereotype). This definition will act as the requirement specification for the operational implementation.
3. Operational "As-is/To-be" level: A generic typical activity model. The operational managers/architects and the IT Systems-architects will model the processes in detail. This is the procedural level detailing the actual performance of the processes in a typical way, and is presented to the users as process guides or procedures.

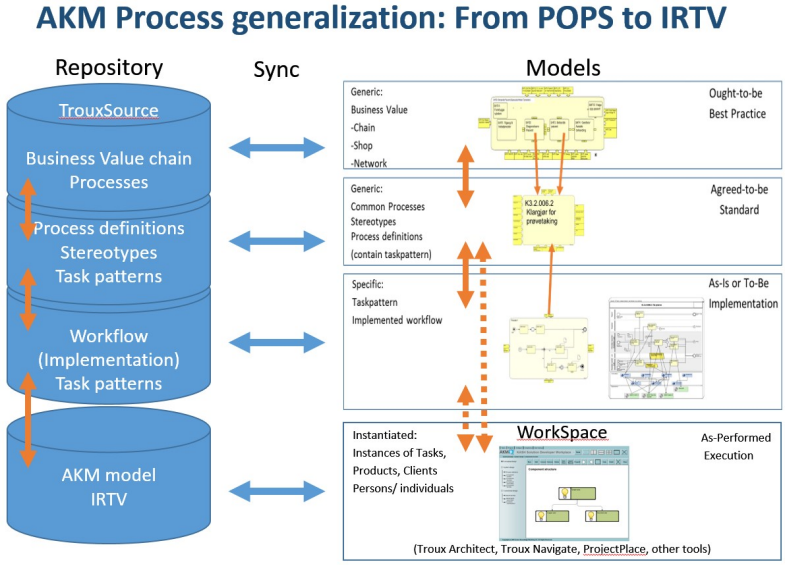

Fig. 2 Model repository support across model levels

4. Operational "As-Performed" level: A guide/procedure generated from the level above is used when executing the individual tasks. This means that the typical task is here instantiated for this specific task for a specific item, place and time. Each time this activity is performed it creates a new process instance, and additional learnings on this level can be articulated if the provided models are interactive.

Fig. 2 shows the implementation of this modelling approach using Active Knowledge Models (AKM) in different enterprise knowledge spaces using Troux by Planview modelling tool. The upper 2 levels use Troux BPM modelling template representing AKM POPS with IDEF0 notation. The 3rd detailed workflow level is modelled using the BPMN notation [1]. The 4th bottom "Workspace/Workplace" level is modelled using the AKM IRTV notation. Here all instances of the executed tasks are represented and traced, so we can follow the execution of each instance in the model. Model based Workspaces and practical Workplaces are generated based on reflective models

and all roles involved or affected by the designed item (design, engineering, construction operation, demolition), will have their specialized workplace.

All the different level of models can be stored/synchronized with TrouxSource repository, making the content available for all modelers with access rights. The different levels can be linked, which can be used to align the models.

This way we can integrate the more traditional top-down modelling of POPS with the more practical modelling of Workplaces in IRTV.

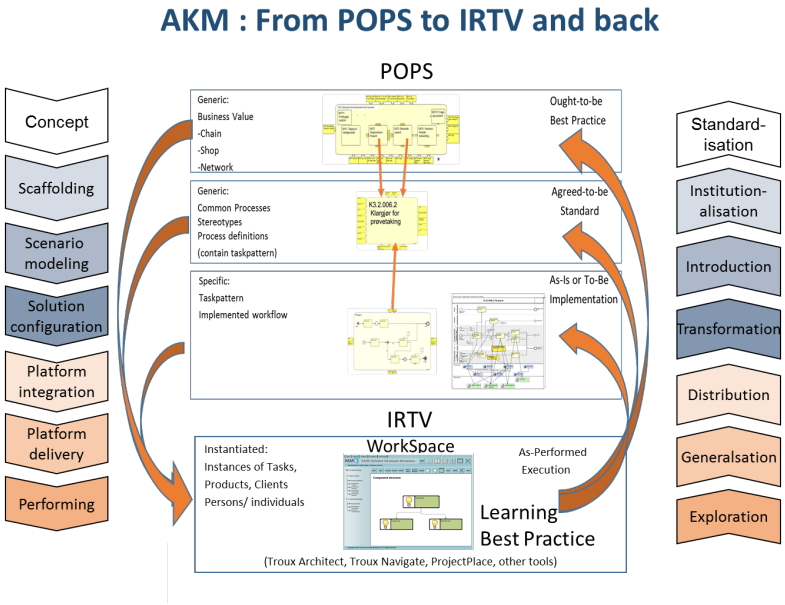

Fig. 3. Combining top-down and bottom-up modeling through knowledge maturing

Fig. 3 shows the process going from POPS to IRTV and back to POPS and then back through a new design circle to IRTV supporting knowledge maturing and reuse.

On the left side the top-down CS3P3 process for introduction of AKM in an organization is depicted [15]. Following the knowledge maturing depicted on the right side of Fig. 3 there is a potential for that during the usage of the IRTV based workplaces a best practice task pattern with product structures etc. will emerge.

The organization can learn from this by exploring the different scenarios and generalize, distributing the result for discussion to be implemented as enterprise best practice. Then it can be transformed to the enterprise process notation (e.g. IDEF0) and introduced for implementation in the new Ought-to-be model.

In discussion and adaption with the current operating processes, a new normalized/standard process might be defined. New To-be workflow may then be prepared and implemented as new operational procedures.

Going downwards a new design is prepared by defining the concept and building a scaffolding model, from scratch if totally new, or by extracting parts of the POPS model as a starting point. Scenarios may be explored from this and solutions defined from se-

lected scenario. Then the selected solution will be integrated with the selected implementation platform to be delivered to the performing production organization.

4 Conclusion and Further Work

Most organizations do modelling by using professional model builders, whereas engineering and industrial users are rarely involved apart from being participants in time-limited workshops if one uses participatory modeling techniques [3]. This is partly due to the user experience of the EM tools, but also relates to the value contributed by the modelling process. If EM is meant to be externalizing and sharing knowledge, then it should be rooted in the people possessing the core enterprise knowledge as this is developed through work in practice.

Involvement of stakeholders in sharing knowledge and data is a key issue. Think of inter-relating all stakeholder perspectives and life-cycles views from requirements, expectations and constraints on design to maintenance and decommissioning or re-engineering. Being able to interrelate and analyze, build this "big picture" and make it active and drive execution depends mainly on three conditions:

1. The designers and engineers must work with real customer product deliveries, and
2. The product and process are designed/modelled and worked out (executing tasks) in concert by the real users.
3. Newly discovered knowledge can not only be represented directly as part of work, but can also be matured if useful to be part of the overall enterprise model guiding future work.

This implies closing the gap between modeling and execution. Many might argue that modeling is inherently difficult, and thus cannot be expected to be done by all knowledge workers. We agree that modeling on the *type* level, where you try to perceive a large number of cases in the future, is difficult, and this has to be done in specific facilitated sessions e.g. including facilitated modeling and reflection activities. Modeling in the interactive modeling approach is mainly on the *instance* level, which should be manageable by most knowledge workers, given that they have an appropriate working environment (e.g. a model-generated workplace [15]) .There are still large challenges for such an approach, especially on the interoperability of modeling infrastructures that need to be tackled. This paper has reported on one approach based on the use of the tools from Planview Troux to support such a process. Some early experience from parts of this process is reported in [2]. The full approach is currently investigated in practice in industrial case studies, which we hope to be able to report from in the future.

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