Northumbria University NEWCASTLE

Panel Discussion: Enterprise Modeling in the Digital Age

Dirk van der Linden[a], Jolita Ralyté[b], Kurt Sandkuhl[c], and Jelena Zdravkovic[d]

[a] *Northumbria University, Department of Computer and Information Sciences, Newcastle upon Tyne, UK*
[b] *University of Geneva, Geneva, Institute of Information Service Science, Geneva, Switzerland*
[c] *University of Rostock, Business information systems, Rostock, Germany*
[d] *Stockholm University, Department of Computer and Systems Sciences, Kista, Sweden*

Abstract

This paper reports the discussion of the "Enterprise Modelling in Digital Age" plenary panel held at the PoEM2020 conference. The panel was concerned with the interplay between emergent digitalization, big data, high complexity, needs for competencies and collaboration, in the scope of enterprise modelling methods and enterprise architecture frameworks. Both in terms how these global organisations related phenomena provide new challenges to be included in enterprise modelling, as well as of how they can benefit from the modeling.

Keywords

Enterprise Modeling, Enterprise Architecture, Digitalisation, Big Data, Capability

1. Introduction

Enterprise Modeling (EM) has been established as an approach for the development of IT solutions congruent with the business of their organizations [1]. By a compound modeling of business goals, services, processes, resources, actors, IS capabilities and requirements, EM describes a desired state of the organization integrating business and technology perspectives [2]. The notion closely relates to Enterprise Architecture (EA), which applies various architecture principles through model-based frameworks for guiding organizations towards business and technology changes necessary to execute their strategies.

Ongoing digital transformation, technological disruptions, and business agility require enterprise modeling to evolve to keep up with the pace of change, but moreover - to predict, facilitate, and leverage that change to the advantage of the business. Today's actual concerns in IS engineering relate to high needs for business integration, setting demands to efficient deployment, connectivity, interoperability, and management of supporting digital components that are of diverse structure, size and dynamics. EM and EA frameworks are increasingly moving the modeling focus from traditional company oriented towards ecosystems orchestrated on digital platforms [3]. Today's business environments entail cooperation. Because the pace of activities across business sectors accelerates, constellations are becoming more complex. This means that, to survive and grow, business organizations need to reshape the methods and models for their IS design to consider both internal and external relationships, as well as to by digital means accurately plan, analyze, simulate and integrate desired capabilities; and to facilitate their resilient evolution [4].

The aim of this panel discussion was to explore the challenges and opportunities that massive digitalization of business data and functions brings to the field of EM&EA:

- *How modeling frameworks need to change and extend their concepts to meet the needs for modeling networked organizations in terms of digital business ecosystems?*
- *How existing modeling methods need to be extended to involve and automate acquisition of massive and diverse digital data and functionalities?*

PoEM'20 Forum: 13th IFIP WG 8.1 Working Conference on the Practice of Enterprise Modelling, Forum, November 25–27, 2020, Riga, Latvia
EMAIL: djt.vanderlinden@gmail.com (D. van der Linden); jolita.ralyte@unige.ch (J. Ralyté); kurt.sandkuhl@uni-rostock.de (K. Sandkuhl); jelenaz@dsv.su.se (J. Zdravkovic)
ORCID: 0000-0002-8597-3156 (D. van der Linden); 0000-0001-8561-3567 (J. Ralyté); 0000-0002-7431-8412 (K. Sandkuhl); 0000-0002-0870-0330 (J. Zdravkovic)

- *How can we increase the efficiency of enterprise modeling, given the current and future business dynamics and interorganizational scopes, to facilitate timely deployment of IS solutions?*

The panel involved Dirk van der Linden, Jolita Ralyté, and Kurt Sandkuhl as the panelists, while Jelena Zdravkovic was the session chair. The remainder of the paper provides the views of the panelists regarding the three main questions described above: section 1 focuses on the ability of modeling frameworks for supporting objectivity, with a focus on social and cultural perspectives; section 2 discusses possible means for enterprise modeling methods to systematically cope with context-awareness and big data; and section 3 takes the focus to discussing the challenge of efficiency of enterprise modeling in respect to business complexity, dynamics, and needed humans' modeling competencies and collaboration. The conclusion reflects the positions presented in the previous session, as well as it summarizes the outcome of the panel discussion.

2. Modeling frameworks need to stop treating all model entities as neutral

There is a plethora of modeling languages to capture everything possibly relevant to an enterprise. The major modeling languages and frameworks, like, e.g., ArchiMate, similarly, have access to numerous extensions to further build out what they can capture and integrate. Yet, a key thing still seems to elude our grasp, even though it has become increasingly critical in this age of data-driven interactions and ever-faster spread of information. It is something seemingly trivial, that might even be done by simple annotations: ensuring that key concepts which business processes rely upon are not treated as if they are some neutral entities avoid of inherent bias. In particular, "resources" in models (whether physical things like servers, or non-physical things like datasets and algorithms) should be explicitly handled as inherently biased entities. This is vital because systems (whether it be some piece of hardware, software, a business model, or indeed an entire enterprise), and the way we design them, reinforce the biases and viewpoints of its designers [5], and if left unchecked, can reinforce systemic oppression and deepen social inequity [6]. Yet, resources often seem to be seen as neutral black-boxes, devoid of principle or value, and positively contributing to capabilities and agency, rather than potentially also taking away from it.

Consider, a simple example. An enterprise is looking to optimize access procedures to its premises and, wanting to do away with human porters, opts to automate matters. They chose to use facial recognition technology. This can be integrated into an enterprise model fairly trivially by considering the different kinds of resources needed for the similar "check employee is authorized" functionality that already exists. That would likely involve the physical technologies (e.g., cameras, network infrastructure, and so on), and the needed application resources (e.g., facial recognition software). But the datasets this software are trained on have been shown to have significant bias [7] and lead to high accuracy for white men. Anything else, and accuracy drops. Practically, while white male employees might easily pass this new access procedure, everyone else would suffer. This could have been trivially caught if only we systematically ensured that resources in our models have to make explicit their assumptions and biases—here that the resource was trained only on a specific ethnic group.

Consider another example. An AgriTech company develops a piece of sensor-driven hardware that works perfectly in the context of their professional culture, and, through a careful balance of human behaviors and expectancies of the sector in that country, come together to mitigate, indeed nearly nullify, the impact of the most prevalent cyber threats [8]. That mitigation is not borne out of the technology itself, but relies on the complex, situated nature in which it exists. Yet, in reality, such technology rapidly diffuses across borders, and is adopted and integrated in new enterprises, blissfully unaware of how dangerous it might be to them given their situated particularities. Again, this could have been trivially caught if only we systematically ensured that resources in our models have to make explicit their assumptions and biases—here that the technology is assumed to operate safely only in a specific cultural situated context.

One might argue that little extension of modeling languages or frameworks is needed per se. Rather, we can rely on our Enterprise Architecture principles, or the use of explicit goal models and other requirements specifications that tell us *not to make biased decisions*, or even simply *not to use biased resources.* But therein lies the crux—Enterprise Modelers will need to know when a model, or even just an entity within it, violate those principles, or goals, or requirements. And to get to that point, whether manually or automated, we ought to make sure the way we model forces ourselves to ensure we do not treat key concepts as being neutral. Even if that only means annotating their biases and assumptions for now. Given the growing trend of using large-scale datasets and automated reasoning to inform enterprise decision-making, it is ever more imperative to give, nay, tell, modelers to model explicitly the bias inherent in our models and stop treating them as neutral.

3. What is needed to manage diverse digital data and functionalities?

One of the most obvious features of the digital age probably is the massive and increasing use of digital data. Increased availability of computing power at low costs, growing digitalization of most industrial and service domains and new data-intensive business models are further increasing this trend. Although enterprise modeling methods and languages in general are well prepared or even explicitly designed for analyzing, capturing or designing data and information processing solutions, there are some aspects of the growing data intensity that deserve discussion with respect to potential implications on EM. Smart connected products and context-aware business services are among the areas that require high volumes of data and can serve as examples to discuss implications on EM.

Smart connected products basically are physical products enhanced by built-in sensors and actuators, embedded software modules and connectivity components connecting them via the Internet to their owners or producers [9]. This allows for monitoring and control of the product but also for new kinds of services, such as performance tuning, energy optimization or integration of third-party applications. Examples are smart cargo boxes, connected cars or intelligent household devices. Every device creates a substantial amount of data by reporting relevant events to its owner, operator or producer (e.g. activities, error situation, configuration changes, etc.). As long as all possible event types are known or can be designed during a modeling project, EM can be done with existing methods and languages. But new kinds of event types or changing ones caused by integration of smart connected products into business models that emerge during use requires dealing with incompleteness of the modeling domains or uncertainty what events to handle and how to handle them. Established EM languages and methods are in general not prepared for this challenge.

Context-based services are designed to adapt to changes in their application environment, which requires continuous evaluation of indicators that in turn are usually based on data streams from sensors, filtering of transaction data or analysis of profiles and behavior. Examples are compliance monitoring applications in different regulative contexts or assistive systems for individual users requiring situation recognition and adaptation. Here, the challenge for EM lies in high complexity mutual dependency of indicators and high variability of the overall system. Using EM techniques to model such context-based systems is possible (as shown, for example, in capability-as-a-service project [10]), but adaptation often is expensive in terms of modeling effort. Modeling the adaptation mechanisms might reach the same limits of incompleteness and dealing with uncertainty as mentioned for the smart connected products.

The impact of data-intensive applications areas on EM depends on the purpose of modeling. In EM projects aiming for analysis of the current situation in an enterprise, preparation of decision making for new business models or the design of organizational change, modelling the specifics of event types or context settings is not required with all technical details. The focus is more on business processes, organizational structures or product/service structures, which is possible with established EM methods and languages. However, when EM is applied as an activity in a software system engineering process, specification of input and output data, information models and information flow as complete and exact as possible would be required to allow for model-based engineering scenarios. In this case, we should investigate "plug-in" concepts for EM meta-models, dynamic extensions of modeling languages or generation of models from event or data streams. Here, not only organizational change has to be addressed but also the possibility to define policies, frame conditions or business rules as manifestations of the desired business logic.

Data-intensive application areas also raise the question if enterprise models should continue to be primarily design time constructs or rather be developed towards runtime artefacts. "Design-time" construct means that most enterprise models only capture the design of (organizational) solutions, but are not executable or enactable. Such models either serve as blueprint or documentation of the "to-be" situation and are used by human actors or they have to be transformed into executable formats including operational semantics. "Runtime-artefact" would mean that an enterprise model could even be the basis for execution, which not only requires more formal specification but also would allow to actually handle the required extensions mentioned above.

4. Towards efficient enterprise modeling

Enterprise modeling takes time and effort. But, once produced, models have a very limited lifespan as they are mare blueprints of a time-stamped situation, current (as-is) or desired (to-e) one. This situation does not last. Digital transformation takes us to a society in which things are increasingly dynamic. Organizations are constantly undergoing change that has an impact at all levels of EA: business structure and processes, services and products, information systems and technology. A model that is valid today may already be obsolete tomorrow. Does it then still make sense to build the models? Can we really measure the return on investment in EM? Probably not, if we stay with "traditional" modeling way and frameworks.

So, what would be the characteristics of efficient EM? We argue here that a multi-criteria approach is needed to assess EM efficiency. First, it depends on the quality of the method and its components, then the process of building and using models, including required expertise and responsibilities, has to be considered, and, last but not least, tool support is vital for EM efficiency.

Khademhosseinieh and Seigerroth [11] propose a method, taking form of a set of criteria and evaluation questions, for assessing the efficiency of EM methods. The criteria concern the quality of the method product part (modeling perspective, components, concepts and their notation) and its process part (framework, procedures, cooperation forms) but omit to evaluate the tool support. Also, it is not possible to judge the effectiveness of the way of using the method.

Enterprise modeling, while certainly done using modeling tools and frameworks, remains a manual task. It requires human resources having modeling skills and taking responsibility of building and updating models. Therefore, the efficiency of EM heavily depends on the availability of modelers and their expertise. In [12] Persson and Stirna stress that "much of the success of projects using EM depends on how the EM process is organized and on the competence level of the expert responsible for the EM approach". They define a set of core EM competences classified in two categories: those related to modeling itself (ability to model, to facilitate modeling sessions) and those related to setting up and managing EM projects.

However, having one or two EM experts, especially if they are not necessarily aware of all organizational changes, may not be enough. Given current business dynamics and interorganizational scopes, cross-organizational and even inter-organizational collaboration in EM becomes vital. Collaborative modeling itself is not a new topic, many works have been published (e.g. [13, 14]). They highlight challenges, analyze related problems and propose solutions to collaborative modeling sessions. Though, the motivation and responsibility issues, which are critical in EM, are not discussed.

Beyond the need of collaboration in EM, we should also consider the need of contribution from various business actors as we are aiming to model increasingly complex business ecosystems. Competencies in modeling does not necessary include domain expertise, but, both are necessary to build consistent and precise enterprise models. Therefore, we advocate the need for a contributory EM approach involving various stakeholders as co-creators of enterprise models, especially the "to-be" ones. Involving stakeholders in EM is of course a challenge, but it is worth of considering. The inspiration for building such an approach could be taken from [15] where a contributory approach is proposed to the co-creation of transdisciplinary information service.

To be efficient, enterprise models need to be dynamic, i.e. to evolve on-the-fly. The "as-is" models should always reflect the situation of the day not that of yesterday, which means they need to evolve at any change in the organization. This is a real challenge as the current modeling frameworks and tools do not support dynamic evolution of models. Quite often there is a lag between the evolution the organization and its information systems and the updating of related enterprise models. Also, enterprise models should help to simulate enterprise evolution – to get the picture of the "to-be" enterprise. But, that requires going beyond the classic EM and its current tools. A framework for IS evolution steering proposed in [16] goes towards this direction. It provides a kernel model and guidance for developing an Informational Steering Information System (ISIS). ISIS is a meta-IS to drive organizational and IS changes in an interdependent manner and thus guarantee their consistency. Even if this approach does not support modeling in its traditional way, as no graphical representations are used, however, it allows to simulate IS evolution and so enterprise evolution. The next step, would be to extend ISIS with features allowing to generate enterprise models and thus facilitate timely deployment of IS solutions.

5. Conclusions

In this section, we summarize the key findings from the panel discussion as it was presented in sections 2-4.

Modeling frameworks need to ensure objectivity. The concepts of EM and EA frameworks, such as goals, capabilities, services, processes, resources, with their underlying infrastructure - technologies and hardware are, from the social perspective, fundamentally neutral; however, they may become inherently biased based on the way we design and use them. Bias can emerge from improper sized or structured data that instantiate these concepts, or for example from different policies of use of a technical infrastructure in different business, demographic, or other types of contexts; some illustrative examples are given in section 2. This relevant threat cannot be left unchecked, i.e. the modeling frameworks need to reinforce systemic mechanisms for ensuring resilience of the objectivity of instances of modeled entities. The mechanisms could be different - explicit requiring some modeling extensions of the current frameworks; or rather implicit by enforcing additional constraints or quality requirements in the modeling process of the key concepts.

Models need to be situational and embracing data. Enterprise modeling methods and languages are, in general, designed for explicitly capturing and modeling data, as well as for development of information processing solutions. However, increasingly emerging smart connected products and context-aware business services are some examples that use huge bulks of data, and as such, they pose the challenges for managing this data within the frameworks, as discussed in section 3. Beyond the high volume and dynamics of the data, additional challenges relate to the complexity of the products' and services' indicators due to their amounts and mutual dependency. A known mechanism of EM techniques for handling context-awareness and variability in systems is adaptation – yet it is often expensive in terms of modeling effort. When EM is applied in the situations where information flow should be considered as complete and exact as possible, extending the frameworks by "plug-in" meta-modeling components, dynamic extensions of modeling languages, or generation of models from event or data streams, may be a right solution.

Modeling need to be efficient. Enterprise modeling is an overarching and effort activity; yet, once produced, the models have a limited lifespan as they are the blueprints of a time-stamped situation. Digital transformation even more increases this challenge owing to its high dynamic nature. This leads to the questions for how to assess efficiency of EM. One logical answer leads to the multi-criteria approach - the quality of the modeling method and its components, the process of building and using models, as well as with a reliable tool support. In addition, enterprise modeling remains a human task – it requires human resources having modeling competencies and taking responsibilities for building and updating models, as well as those related to setting up and managing EM projects. Furthermore, interorganizational scopes, make collaboration in EM to become vital, and where the motivation and responsibility issues are of the essential importance. When modeling complex business ecosystems, the needed competencies go beyond domain expertise; they require contributory EM approach involving various stakeholders as co-creators of models.

Enterprise models need to be dynamic and right, i.e. to evolve on-the-fly in the correct direction. The "as-is" models should always reflect the situation of the day not that of yesterday, which means they need to evolve at any change in the organization. This raises the challenge for enterprise models to continue being design time constructs and even more than today target runtime artefacts.

6. References

[1] WMP van der Aalst, J. Becker, M. Bichler, HU Buhl, J. Dibbern, U. Frank, U. Hasenkamp, A. Heinzl, O. Hinz, K-L Hui, M. Jarke, D. Karagiannis, N. Kliewer, W. König, J. Mendling, P.

Mertens, M. Rossi, S. Voss, C. Weinhardt, R. Winter, J. Zdravkovic. Views on the Past, Present, and Future of Business and Information Systems Engineering. Bus Inf Syst Eng 60 (6):443-477 60 (6):443-477 (2018)

[2] K. Sandkuhl, J. Stirna, A. Persson, M. Wißotzki, Enterprise modeling. Springer, Berlin, Heidelberg (2014)

[3] C. H. Tsai, J. Zdravkovic, J. Stirna, Capability Management of Digital Business Ecosystems – A Case of Resilience Modeling in the Healthcare Domain. In: Proceedings of the 32nd. International Conference on Advanced Information Systems Engineering, volume 386 of CAiSE2020, LNBIP Springer, Cham, pp. 126–137 (2020)

[4] F. Björck, M. Henkel, J. Stirna, J. Zdravkovic. Cyber Resilience – Fundamentals for a Definition. In: Proceedings of the conf. New Contributions in Information Systems and Technologies. Advances in Intelligent Systems and Computing, vol 353. Springer, Cham (2015)

[5] C. Breslin. Bias Creeps into Technology—We can't avoid bringing our own perspective to the products we build. Towards data science. [online] 2020 Available at: https://towardsdatascience.com/bias-creeps-into-technology-e221dd7eae76

[6] R. Benjamin, R. Race after technology: Abolitionist tools for the new Jim code. Cambridge: Polity, 285 pp. (2019)

[7] J. Buolamwini, T. Gebru. Gender shades: Intersectional accuracy disparities in commercial gender classification. In Proceedings of the 1st Conference on Fairness, Accountability and Transparency, PMLR 81:77-91 (2018)

[8] D. van der Linden, O.A. Michalec, A. Zamansky. Cybersecurity for smart farming: socio-cultural context matters. IEEE Technology and Society Magazine (2020)

[9] M. Porter, J Heppelmann. How smart, connected products are transforming competition. Harvard Business Review, 92(11), 64-88 (2014)

[10] S. Bērziša, G. Bravos, T. Cardona Gonzalez, U. Czubayko, S. España, J. Grabis, M. Henkel, L. Jokste, J. Kampars, H. Koç, J-C Kuhr, C. Llorca, P. Loucopoulos, R. J. Pascual, O. Pastor, K. Sandkuhl, H. Simic, J. Stirna, F. G. Valverde, J. Zdravkovic. Capability driven development: an approach to designing digital enterprises. Business & Information Systems Engineering, 57(1), 15-25 (2015)

[11] B. Khademhosseinieh, U. Seigerroth. Towards Evaluating Efficiency of Enterprise Modeling Methods. In: Skersys T., Butleris R., Butkiene R. (eds) Information and Software Technologies. ICIST 2012. Communications in Computer and Information Science, vol 319. Springer, Berlin, Heidelberg (2012)

[12] A. Persson, J. Stirna. Towards Defining a Competence Profile for the Enterprise Modeling Practitioner. In: Proceedings of the Work. Conf. Practice of Enterprise Modeling, PoEM 2010, LNBIP 68, pp. 232–245 (2010)

[13] P. Rittgen. Collaborative Modelling – A Design Science Approach. Proceedings of the 42nd Hawaii International Conference on Systems Science, 2009, pp. 1– 10 (2009)

[14] P. Rittgen. Success Factors of e-Collaboration in Business Process Modeling. Proceedings of CAiSE 2010, Springer LNCS 6051, pp.24–37 (2010)

[15] J. Ralyté, J., M. Léonard. Tiers-Lieu for Services: An Exploratory Approach to Societal Progression. In: Proc. of the Conference Exploring Service Science. IESS 2020, LNBIP 377, Springer, pp. 289-303 (2020)

[16] W. Opprecht, J. Ralyté, J., M. Léonard. Towards a Framework for Enterprise Information System Evolution Steering. In: Proc. of The Practice of Enterprise Modeling, 7th IFIP WG 8.1 Working Conference PoEM2014, LNBIP 197, pp. 118-132, Springer, Berlin, Heidelberg (2014)