Report from Dagstuhl Seminar 18471

Next Generation Domain Specific Conceptual Modeling: Principles and Methods

Edited by

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Abstract

This report documents the program and the outcomes of Dagstuhl Seminar 18471 "Next Generation Domain Specific Conceptual Modeling: Principles and Methods". It summarizes the resultsof the seminar and shows in which direction (Domain Specific) Conceptual Modeling shoulddevelop in the opinion of the participants. In addition, the report contains abstracts of thenumerous talks presented during the seminar as well as a summary of the discussions held inworking groups during the seminar. In particular, some open questions will be touched upon,which will be dealt with before a follow-up seminar.

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1 Executive Summary

Heinrich C. Mayr (Alpen-Adria-Universität Klagenfurt, AT)

Joint work of The seminar participants and organizers

Models are the basic human tools for managing complexity and understanding and therefore play a key role in all scientific and engineering disciplines as well as in everyday life. Many modeling paradigms have evolved over time into a wide variety of modeling languages, methods and tools that have come and gone. This is particularly true for Informatics, which is a modeling discipline in itself.

Since the 1970s, special attention has been paid to conceptual modeling. This approach essentially uses a formal language whose concepts are linked to a semantic interpretation (e.g. by the grounding in an ontology) and a more or less transparent graphic or textual representation (which supports efficient linguistic perception). Normally, such a language is embedded in a model/meta model hierarchy. The dimensions of conceptual modeling languages are structure, dynamics (behavior) and functionality.

Despite all efforts, however, there is still no comprehensive and consistent use of conceptual modeling in practice. Often conceptual models are only used as prescriptive documents, which – e.g. in the area of software development or business process management – are rarely synchronized with the developed artifact, so that reality and model diverge step by step. This observation motivated us to promote and conduct this seminar by focusing on domain-specific conceptual modeling, as this promises a methodology that is more tailored to the needs of each user group.

In view of the highly committed discussions during the seminar, the intensive discussions in the working groups and the very positive results of the participant survey, we can say without exaggeration that the seminar was a complete success. Almost all participants wished for a continuation, which we will probably apply for in 2021, when the already decided projects (cooperation and publications of subgroups) are on their way.

Since, with one exception, every participant wanted to present their ideas in a talk, the programme was tightly packed: 36 talks and 2 full evening sessions in working groups, the results of which were reported on the next morning, made the seminar week a very intensive but also highly inspiring experience.

First results are already tangible:
- The workshop "Conceptual Modeling for Multi-Agent Problem Solving" at the IJCAJ 2019 in Macao: The idea was born during the seminar and implemented afterwards: http://austria.omilab.org/psm/content/cmmaps19/info.
- A working group is currently writing a summary paper on the results of the working groups on which agreement was reached in the plenary discussions.
- Questions that were discussed during the seminar will be included in contributions to the Summer School "Next Generation Enterprise Modelling in the Digital Transformation" in Vienna (July 15-26, Vienna).
- The seminar organizers are currently writing a somewhat more popular scientific column to be submitted to CACM.

A number of open questions and "grand challenges" that also could be topics of future relevant conferences have been identified, among others:
- Business Transformations in the age of digitalization as "Models are driving the Digital Transformation"
- Social Aspects of Conceptual Modeling
- Explanatory Models for Neural Networks and Big Data
- Conceptual Modeling for validation purposes in simulation
- Modeling of Ultra Large Scale Architectures
- Privacy Modeling
- Modeling of Behavior Goals for Assistive Systems and Emotions
- Better integration into teaching at universities of applied sciences and universities
- Tools and Technical Infrastructures for Conceptual Modeling, in particular for "multi-metamodeling frameworks"
- Involvement of researchers and practitioners from other fields: "go beyond the obvious".

The biggest challenge for a follow-up seminar will be to encourage more practitioners to participate. For this purpose, we will propose to dedicate two consecutive seminar days to this and the discussion with them, as practitioners usually cannot spend more time.

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3 Overview of Talks

3.1 Multi-Level (Domain-Specific) Conceptual Modeling

João Paulo Almeida (Federal University of Espírito Santo – Vitória, BR)

Conceptual models are often built with techniques which propose a strict stratification of entities into two classification levels: a level of types (or classes) and a level of instances. Despite that, there are several situations in which domains of inquiry transcend the conventional two-level stratification and domain experts use types of types (or categories of categories) to articulate their conceptualizations. For instance, in a project we are currently involved in–concerning integration of water quality data in the Rio Doce river basin [1]–the ontology-based conceptual models we are defining must cover both particular water quality measurements (observations set in a particular time and location) as well as the types of measurement they instantiate ("water sampling", "soil sampling", "specimen sighting", "specimen collection"); types of aquatic animals ("native species", "invasive species", the various types of fish according to biological taxonomy and systematics: "pimelodid catfish", "red piranha") as well as specific specimens (e.g., a specific catfish collected for analysis).

In these settings, types are instances of other types and multiple levels of classification can be identified (individuals, classes, metaclasses, metametaclasses, and so on), characterizing what is now called "multi-level modeling" [2].

In my talk, I have discussed how multi-level conceptual models are relevant not only in the conceptual modeling of specific domains (as illustrated earlier), but also in the definition of the real-world semantics of (domain-specific) modeling languages. In this process, it is key to identify that we are addressing two tasks during modeling language engineering: the design of a language's abstract syntax (often approached by defining a metamodel and associated syntactic constraints) and the definition of the language's semantics in terms of a reference ontology [3].

Acknowledgments. This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001.

References

1 Patrícia M. Campos, Cássio C. Reginato, João Paulo A. Almeida et al., *Building an Ontology-Based Infrastructure to Support Environmental Quality Research: First Steps*, Proc. XI Seminar on Ontology Research in Brazil, São Paulo, Brazil, 2018, pp. 227–232.
2 João Paulo A. Almeida, Ulrich Frank and Thomas Kühne, *Multi-Level Modelling (Dagstuhl Seminar 17492)*. Dagstuhl Reports, vol. 7, 2018, pp. 18–49.
3 Victorio A. Carvalho, João Paulo A. Almeida, G. Guizzardi, *Using Reference Domain Ontologies to Define the Real-World Semantics of Domain-Specific Languages*, Proc. 26th International CAiSE Conference, 2014, pp. 488–502.

3.2 On the Quality of Requirements Goal Models

João Araújo (New University of Lisbon, PT)

Joint work of Catarina Gralha, João Araújo, Miguel Goulão, Mafalda Santos, Ana Moreira
Main reference Catarina Gralha, João Araújo, Miguel Goulão: "Metrics for measuring complexity and completeness for social goal models", Inf. Syst., Vol. 53, pp. 346–362, 2015.
URL https://doi.org/10.1016/j.is.2015.03.006

Requirements models have been developed for the requirements engineers and stakeholders work, providing abstraction mechanisms to, for example, facilitate the communication among them by providing better structuring of requirements, thus helping with their analysis. Nevertheless, the extent to which requirements modelling languages are adequate for communication purposes has been somewhat limited. Several quality aspects have contributed to that, ranging from lack of abstraction mechanisms to address model's complexity, to the impact of layout of models or the actual notation adopted. For example, in large-scale systems, building requirements models may end in complex and/or incomplete models, which are harder to understand and modify, leading to an increase in costs of product development and evolution. Consequently, for large-scale systems, the effective management of complexity and completeness of requirements models is vital. Moreover, it is undeniable that the communication potential of requirements modeling languages is not entirely explored, as their cognitive effectiveness is often not boosted. For example, choosing an ad-equate layout for requirements models may be a relevant issue, as a bad layout may compromise the adequacy of the models. Also, although visual notations are often adopted (as they are perceived as more effective for conveying information to nontechnical stakeholders than text), their careful design is often not considered. Not taking all this into account, in the long run, may result in poorly understood requirements, leading to problems in artifacts produced in later stages of software development. So, in this talk, I will discuss in detail these issues based on the results of experiments where metrics were collected to evaluate and discuss some quality aspects of requirements models, in particular requirements goal models (increasingly popular in the requirements community), such as complexity, completeness, understandability and semantic transparency.

3.3 Conceptual Modeling Issues in Knowledge-intensive Processes

Fernanda Baião (PUC – Rio de Janeiro, BR)

Main reference Juliana Baptista dos Santos França, Joanne Manhães Netto, Juliana do E. Santo Carvalho, Flávia Maria Santoro, Fernanda Araujo Baião, Mariano Gomes Pimentel: "KIPO: the knowledge-intensive process ontology", Software and System Modeling, Vol. 14(3), pp. 1127–1157, 2015.
URL https://doi.org/10.1007/s10270-014-0397-1
Main reference Tiago Prince Sales, Fernanda Araujo Baião, Giancarlo Guizzardi, João Paulo A. Almeida, Nicola Guarino, John Mylopoulos: "The Common Ontology of Value and Risk", in Proc. of the Conceptual Modeling – 37th International Conference, ER 2018, Xi'an, China, October 22-25, 2018, Proceedings, Lecture Notes in Computer Science, Vol. 11157, pp. 121–135, Springer, 2018.
URL https://doi.org/10.1007/978-3-030-00847-5_11
Main reference Bedilia Estrada-Torres, Pedro Henrique Piccoli Richetti, Adela del-Río-Ortega, Fernanda Araujo Baião, Manuel Resinas, Flávia Maria Santoro, Antonio Ruiz-Cortés: "Measuring Performance in Knowledge-intensive Processes", ACM Trans. Internet Techn., Vol. 19(1), pp. 15:1–15:26, 2019.
URL https://dl.acm.org/citation.cfm?id=3289180

Knowledge-intensive Processes, simply put, are a composition of prospective activities (events) whose execution contributes to fulfilling a goal and whose control-flow, at the instance level, typically presents a high degree of variability. KiPs are acknowledged as the most valuable assets in current organizations; nevertheless, there are several elements which, apparently, impact their behaviour in an unpredictable way, posing risks that are difficult to be managed. Therefore, KiPs pose several challenges with regard to an ontology-based definition of what they essentially "are", a corresponding metamodel that is able to constrain the set of possible KiP models that may be generated, adequate modeling languages to represent them in such a way to provide adequate understanding, assessment and management by process stakeholders, and a technological infrastructure that is able to keep track of observed instances from the real-world.

In this talk, I point to a set of initiatives that were/are being conducted in our research group to address each of this challenges. These initiatives are organized in a framework called KiPaIS (Knowledge-intensive Process-aware Information System), which comprises: (i) CognitiveKiP, a cognitive-based ontology for KiPs; (ii) KiPO, a metamodel for KiP modeling that applies Multi-Level modelling and combines declarative and imperative modelling approaches; (ii) KiPN, a graphical modeling language for the domain of KiPs, and (iv) KiPOwl, a codification of KiPO in OWL, stored in a NoSQL database, to enable instantiation of KiP instances from several sources, such as documents, declarative modeling tools, event and message logs from transactional systems.

3.4 Value-driven Approach for BI Application Design

Ladjel Bellatreche (ENSMA – Chasseneuil, FR)

In a very short time, the data warehouse (DW) technology has gone through all the phases of a technological product's life: the introduction on the market, growth, maturity, and decline. Maturity means there is a clearly identified design life cycle plus a race and competition between companies to increase their decision-making power. The decline was signaled by the appearance of Big Data. It is therefore essential to find other challenges that will contribute to the revival of DW while taking advantage of the V's of Big Data. The arrival of Linked Open Data (LOD) era is an excellent opportunity for both the DW academia and industry communities. LOD may bring an additional Value that the sources feeding a DW typically do not usually succeed to yield. Offering the added value of a DW is related to a high Variety of sources. In this talk, first, we show the role of conceptualization to deal with the variety of internal and external sources and study its impact on the ETL phase to ease the value capturing. Secondly, three scenarios related to added value for integrating LOD in the DW are given. Finally, experiments are conducted to show the effectiveness of our approach

3.5 Specification Techniques for Conceptual Modeling Methods

Dominik Bork (Universität Wien, AT)

Joint work of Dominik Bork, Dimitris Karagiannis, Benedikt Pittl
Main reference Dominik Bork, Dimitris Karagiannis, Benedikt Pittl: "How are Metamodels Specified in Practice? Empirical Insights and Recommendations", in Proc. of the 24th Americas Conference on Information Systems, AMCIS 2018, New Orleans, LA, USA, August 16-18, 2018, Association for Information Systems, 2018.
URL https://aisel.aisnet.org/amcis2018/AnalysisDesign/Presentations/1

Conceptual modeling languages such as BPMN and UML are widely used in industry and academia. Such modeling languages are usually introduced in overarching specification documents maintained by standardization institutions. Being the primary – often even the single – source of information, such specifications are vital for modelers, researchers, and tool vendors. However, how to derive a coherent and comprehensive specification was never systematically analyzed. This presentation reports on the analysis of 11 current modeling language specifications with a focus on how their abstract and concrete syntax are specified. Identified specification techniques are discussed and their sample usage is illustrated. Thereby, individual strengths and weaknesses of each technique are discussed. The contribution of this presentation is a foundation for increasing the consistency and expressive power of modeling language specifications, ultimately leading to an improved understanding and better utilization of those languages.

3.6 Conceptual Modeling of Prosopographical Databases

Isabelle Comyn-Wattiau (ESSEC Business School – Cergy Pontoise, FR)

Main reference Jacky Akoka, Isabelle Comyn-Wattiau, Cedric du Mouza, Stéphane Lamassé: "Modeling Historical Social Networks Databases", in Proc. of the 52nd Hawaii International Conference on System Sciences, HICSS 2019, Grand Wailea, Maui, USA, January 8-11, 2019, pp. 151–161, 2019.
URL http://hdl.handle.net/10125/59714

Prosopographical researchers share many concepts: persons, sources of information, locations/place, time, uncertainty. There is a need to build a common conceptual model putting together these concepts. On such a basis, we could develop more powerful and evolutive databases, available for all historians. In terms of conceptual modeling, there are at least three main challenges: 1) genericity, 2) modeling uncertainty, 3) granularity of factoids/events. I first define prosopography and its differences with connected fields such as onomastics or genealogy. Then I explain why prosopographical researchers need databases and why current databases do not meet all their requirements. In particular, I claim that, except the factoid model, there is no past effort of conceptual modeling for prosopography.

3.7 Attribute based communication for Collective Adaptive Systems

Rocco De Nicola (IMT – Lucca, IT)

Joint work of Rocco De Nicola, Michele Loreti, Yehia Abd Alrahman

I presented the approach I have been following in the past twenty years for developing applications following specific programming paradigms such as: Network Aware Programming, Service Oriented Computing, Autonomic Computing and Collective Adaptive Systems that have brought us to introduce the languages KLAIM, COWS and SCC, SCEL and more recently AbC. I explained what I meant by domain specific formalisms and outlined our approach based on three basic steps (i) introducing a specification language equipped with a formal semantics, (ii) implementing supporting a programming frameworks with its associated runtime environment, (iii) providing verification techniques and tools. After this I concentrated on the Autonomic Computing and Collective Adaptive Systems paradigm and on some of their key notions and advocated the use of a novel communication paradigm that is based on selecting communication partners according to their run time properties expressed as attributes.

3.8 Experience in Stochastic Model-Based Dependability Analysis: Modeling and Analysis of Cyber-Physical Systems

Felicita Di Giandomenico (CNR – Pisa, IT)

The talk addresses stochastic model-based analysis of critical CPS from the point of view of dependability and energy saving perspective. The goal of the analysis is mainly to assess the impact of faults/attacks (and their propagation) on the ability of the system to provide correct service. A general overview of the conceptual model is first presented, based on the concepts of generality, modularity and compositionality. Then, two application domains are considered: Smart Grids and Railway transportation. Challenges, modeling approaches, property of interests as well as examples of analysis results are briefly discussed. Some general observations on the role of the analysis purpose (e.g., the impact of failures on resilience/QoS related indicators) and the application domain of the system under analysis (e.g., the Smart Grids) in guiding choices leading to conceptual models and model implementations, as well as directions for further research investigations, are drawn at the end.

Dependability of critical infrastructures, such as electric power systems and transportation systems, is paramount, since they provide services our everyday life strongly depends on. Stochastic model-based analysis is a popular approach to assess dependability properties, especially at early stages of system development. However, these infrastructures are Cyber Physical Systems, characterised by a variety of challenging aspects from the modelling point of view, such as: continuos and discrete state variables, failure propagation through interdependencies, heterogeneity and dynamicity of components structure and behaviour, topology-dependent criticality, large size of interconnected components. Based on the principles of generality, modularity and compositionality, a conceptual model can be built, guided by the purpose of the analysis (e.g., the impact of failures on resilience/QoS related indicators) and by the specific application domain of the system under analysis (e.g., the Smart Grids). However, building such a model is still an art and strongly dependent on the skill and experience of the modeler. A sound approach to assist the model developer in carrying on her/his task in a more rigorous way would be highly desirable. This is identified as a research direction where further investigations are still needed.

References

1 S. Chiaradonna, F. Di Giandomenico, P. Lollini, Definition, Implementation and Application of a Model-Based Framework for Analyzing Interdependencies in Electric Power Systems, International Journal on Critical Infrastructure Protection, N. 4 (2011), pp. 24–40.
2 Silvano Chiaradonna, Felicita Di Giandomenico, Giulio Masetti A stochastic modelling framework to analyze smart grids control strategies. In: SEGE 2016 – 4th IEEE International Conference on Smart Energy Grid Engineering (Oshawa, Canada, 21-24 August 2016). Proceedings, pp. 123–130. IEEE, 2016.
3 Giulio Masetti, Silvano Chiaradonna, Felicita Di Giandomenico: A Stochastic Modeling Approach for an Efficient Dependability Evaluation of Large Systems with Non-anonymous Interconnected Components. Proceedings 28th IEEE International Symposium on Software Reliability Engineering ISSRE 2017, pp: 46–55
4 Davide Basile, Silvano Chiaradonna, Felicita Di Giandomenico, Stefania Gnesi A stochastic model-based approach to analyze reliable energy-saving rail road switch heating systems. In: Journal of Rail Transport Planning and Management, vol. 6 (2) pp. 163–181. Elsevier, 2016.

3.9 The Role of Visualization in Conceptual Modeling

Hans-Georg Fill (University of Fribourg, CH)

Main reference Hans-Georg Fill: "Visualisation for Semantic Information Systems", Gabler, 2009.
URL https://doi.org/10.1007/978-3-8349-9514-8

In many conceptual modeling approaches, the use of visualization techniques is inherent. The used graphical notations are often intuitive and easy to understand, despite the sometimes formal foundation of the modeling languages they are attached to. Visualization thus contributes to the communication of model information and the processing of complex information by humans. Despite existing guidelines that have been proposed for designing graphical notations of modeling languages, this task still requires considerable experience and a good understanding of graphical design and its technical implementation, especially in the case of dynamic notations. The challenge thus persists to provide adequate guidance on designing and choosing good visual representations for models and for simplifying their implementation on metamodeling platforms. Furthermore, when such visualizations are coupled with data-based approaches as found in the area of information visualization, with virtual or augmented reality environments or device-less interaction, a lot of technical know how is required. It should therefore be researched in the future for example, how existing modeling approaches can be transitioned to VR and AR environments and how interaction can take place in such settings.

References

1 Sandkuhl, Kurt, Fill, Hans-Georg, Hoppenbrouwers, Stijn, Krogstie, John, Leue, Andreas, Matthes, Florian, Opdahl, Andreas, Schwabe, Gerhard, Uludag, Omer, Winter, Robert

(2018): From Expert Discipline to Common Practice: A Vision and Research Agenda for Extending the Reach of Enterprise Modelling, Business and Information Systems Engineering, Volume 60, Issue 1, pp 69-80, Springer.
2 Fill, Hans-Georg (2009): Visualisation for Semantic Information Systems, Gabler.
3 Bork, Domenik, Fill, Hans-Georg (2014): Formal Aspects of Enterprise Modeling Methods: A Comparison Framework, Proceedings of the 2014 47th International Conference on System Sciences, IEEE.
4 Fill, Hans-Georg, Höfferer, Peter (2006): Visual Enhancements of Enterprise Models, in: Lehner, F., Nösekabel, H., Kleinschmidt, P. (2006): Multikonferenz Wirtschaftsinformatik 2006, GITO Verlag, 541-550.

3.10 Supporting and Assisting the Execution of LooseLy Framed and Knowledge-intensive Processes

Frederik Gailly (Ghent University, BE)

Modeling loosely framed and knowledge-intensive business processes with the currently available process modeling languages is very challenging. Some lack the flexibility to model this type of processes, while others are missing one or more perspectives needed to add the necessary level of detail to the models. In this project we have composed a list of requirements that a modeling language should fulfil in order to adequately support the modeling of this type of processes. Based on these requirements, a metamodel for a new modeling language was developed that satisfies them all. The new language, called DeciClare, incorporates parts of several existing modeling languages, integrating them with new solutions to requirements that had not yet been met. Deciclare is a declarative modeling language at its core, and therefore, can inherently deal with the flexibility required to model loosely framed processes. The complementary resource and data perspectives add the capability to reason about, respectively, resources and data values. The latter makes it possible to encapsulate the knowledge that governs the process flow by offering support for decision modeling. The abstract syntax of DeciClare has been implemented in the form of an Ecore model. In order to also make it possible to automatically discover a DeciClare model we also developed DeciClare Miner. Currently both the language and the miner are evaluated in an Emergency Department of a Belgian Hospital.

3.11 Achieving resilience and robustness in strategic models

Aditya K. Ghose (University of Wollongong, AU)

The need to future-proof businesses is widely acknowledged as one of the hardest challenges facing business decision makers. Businesses need to anticipate market movements, price movements, regulatory/legislative changes and the likely behaviour of competitors. Much of what happens in the business environment (the effects of moves by these actors) is *adversarial* in nature. *Strategic resilience* requires that businesses make decisions that are most resilient to adversarial moves by players in the business environment. We cast the strategic resilience problem in the context of organizational goal models. Specifically, we address the problem of selecting the most resilient alternative means of realizing a goal/strategy. We offer a novel means of supporting this decision by using game tree search. We offer a novel data structure that leverages the notion of state update drawn from the literature on reasoning about action, over which we apply game tree search. We show that MINIMAX search and Monte Carlo Tree Search can both underpin a machinery that scales and that makes solving problems of sizes commonly encountered in real-life decision-making feasible.

In this talk, I will also argue that very similar intuitions can underpin flexible business process execution.

I will also provide a brief preview of my Friday talk.

3.12 Liberating Modelers from the Tyranny of a Strict Modeling Language

Martin Glinz (Universität Zürich, CH)

Joint work of Dustin Wüest, Norbert Seyff, Martin Glinz
Main reference Dustin Wüest, Norbert Seyff, Martin Glinz: "FlexiSketch: a lightweight sketching and metamodeling approach for end-users", in Software and Systems Modeling, pp. 1–29, Springer, 2017.
URL https://doi.org/10.1007/s10270-017-0623-8

Classic modeling tools do not work well in situations where modelers want to sketch ideas, without being constrained by the syntax of a modeling language. This is, for example, the case in creative requirements elicitation and design sessions. On the other hand, whiteboards or paper provide the required flexility of using any kind of notations, but the resulting diagram sketches are just uninterpreted drawings which do not have any syntactic or semantic information associated with the drawn elements. So there is nothing that could be exploited for interpreting the sketches or evolving them into models that could be further processed in a classic modeling tool.

What would be needed is a lightweight modeling approach that supports freeform sketching, but also lets the modeler assign meanings to the drawn elements, thus enabling (a) stepwise transformation from sketches into semi-formal models, and (b) the co-evolution of models and their metamodels.

FlexiSketch, which has been developed in the Requirements Engineering Research Group at the Department of Informatics of the University of Zurich, is a tool providing exactly these capabilities. It is a mobile tool for model-based sketching of free-form diagrams that allows the definition and re-use of diagramming notations on the fly. FlexiSketch lets users draw any node-and-edge diagram they want and recognizes the drawn elements as individual entities and relationships between them. When users assign types and further meta-information to the drawn elements, FlexiSketch generates a lightweight metamodel in the background. FlexiSketch thus supports the co-evolution of models and metamodels. Both models and metamodels can be exported as XML files and then be used for further processing in other tools.

The latest version of the tool, called FlexiSketch TEAM, also supports collaboration with multiple tablets and an electronic whiteboard, such that several users can work simultaneously on the same model sketch.

More information about FlexiSketch is available at http://www.flexisketch.org.

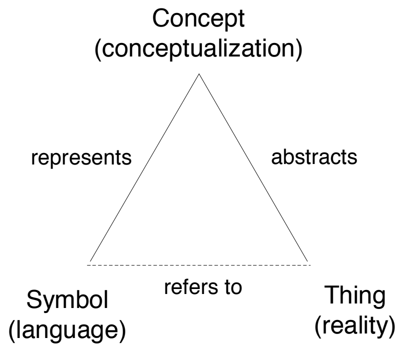


Figure 1 The Semiotic Triangle.

3.13 Yet the Same Look at Models

Giancarlo Guizzardi (Free University of Bozen-Bolzano, IT)

In his 1967 classic paper "Another Look at Data" [1], Mealy brought, perhaps for the first time to the attention of this community, the Semiotic Triangle connecting Reality, Conceptualizations and Symbolic Representations (see Figure 1). As he reminds us there, the latter are representations of Conceptualizations. In other words, the relation between Representations and Reality is always mediated by a Conceptualization. Moreover, Mealy reminds us that "data are fragments of a theory of the real-world" and that this is an issue of "Ontology, or the question of what exists". In line with this view, the first point I defend in this talk is that concepts are a prerequisite for the existence of facts, i.e., facts are not in reality but are carved out of reality according to a Reference Conceptualization. In other words, without fixing an a priori conceptualization, there are no determinate Facts! (and, hence, also no Counterfacts).

This view can be depicted in Figure 2, which can be seen as an extension of (one of the sides of) the Semiotic Triangle. As the figure shows, models are representations of abstractions that are carved out of reality according to a certain conceptualization. Moreover, models are grammatically valid constructions built in a modeling language. A language delimits the set of grammatically valid expressions that can be built in that language, in a manner that is analogous to how a conceptualization delimits a set of abstractions (of reality) that it deems acceptable. So, a second point I illustrate in this talk is that the quality of a language to model a set of phenomena in reality can be evaluated and (re)designed by systematically comparing language and conceptualization in these two levels of the Figure 2. To put it simply, a language should contain exactly those modeling primitives that represent the conceptual distinctions put forth by a conceptualization, and it should contain (semantically motivated) syntactical constraints that delimit its set of grammatical models to exactly those that are deemed acceptable by the conceptualization [2, 3]. Finally, as discussed in depth in [3], I defend that systematically analyzing and engineering conceptualizations as in these figures is indeed an issue of "Ontology, or the question of what exists".

References

1 Mealy, G. H., Another Look at Data, AFIPS Conference Proceedings, Volume 31, Washington, DC: Thompson Books, London: Academic Press, 525–534, 1967.

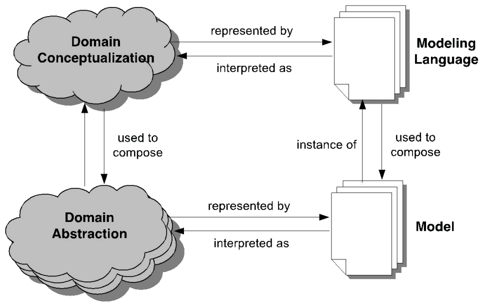


Figure 2 Conceptualizations and their Abstractions, Modeling Languages and their Models [2, 3].

2 Guizzardi, G., On Ontology, ontologies, Conceptualizations, Modeling Languages, and (Meta)Models, Frontiers in Artificial Intelligence and Applications, Databases and Information Systems IV, Olegas Vasilecas, Johan Edler, Albertas Caplinskas (Editors), ISBN 978-1-58603-640-8, IOS Press, Amsterdam, 2007.
3 Guizzardi, G.: Ontology-Based Evaluation and Design of Visual Conceptual Modeling Languages, Research Directions in Domain Engineering, Iris Reinhartz-Berger, Arnon Sturm, Tony Clark, Jorn Bettin, Sholom Cohen (Editors), Springer-Verlag, 2013.

3.14 Meta Aspects of Operational Conceptual Modeling for Complex Evolving Requirements

Kamalakar Karlapalem (IIIT – Hyderabad, IN)

The key idea is to question what does the model do? If it is only an understanding artifact then how to apply the understanding and where. This, we explore the interplay between comprehensible and non-formal expressive conceptual models along with the enactment of the software solution underneath. We present examples from e-contracts and smart solutions to extrapolate on this interplay.

References

1 Himanshu Jain, P. Radha Krishna, and Kamalakar Karlapalem. e-contract enactment system for effective e-governance. In *7th International Conference on Theory and Practice of Electronic Governance, ICEGOV '13, Seoul, Republic of Korea, October 22-25, 2013*, pages 344–345, 2013. doi:10.1145/2591888.2591951.
2 Himanshu Jain, P. Radha Krishna, and Kamalakar Karlapalem. Context-aware workflow execution engine for e-contract enactment. In *Conceptual Modeling – 35th International Conference, ER 2016, Gifu, Japan, November 14-17, 2016, Proceedings*, pages 293–301, 2016. doi:10.1007/978-3-319-46397-1_23.
3 Anushree Khandekar, P. Radha Krishna, and Kamalakar Karlapalem. A methodology and toolkit for deploying contract documents as e-contracts. In *Challenges in Conceptual Modelling. Tutorials, posters, panels and industrial contributions at the 26th International Conference on Conceptual Modeling – ER 2007. Auckland, New Zealand, November 5-9, 2007. Proceedings*, pages 91–96, 2007.

4 P. Radha Krishna and Kamalakar Karlapalem. Active meta modeling support for evolving e-contracts. In *Challenges in Conceptual Modelling. Tutorials, posters, panels and industrial contributions at the 26th International Conference on Conceptual Modeling – ER 2007. Auckland, New Zealand, November 5-9, 2007. Proceedings*, pages 103–108, 2007.
5 P. Radha Krishna and Kamalakar Karlapalem. Electronic contracts. *IEEE Internet Computing*, 12(4):60–68, 2008. doi:10.1109/MIC.2008.77.
6 P. Radha Krishna and Kamalakar Karlapalem. Data, control, and process flow modeling for iot driven smart solutions. In *Conceptual Modeling – 36th International Conference, ER 2017, Valencia, Spain, November 6-9, 2017, Proceedings*, pages 419–433, 2017. doi:10.1007/978-3-319-69904-2_32.
7 P. Radha Krishna and Kamalakar Karlapalem. Event-context-feedback control through bridge workflows for smart solutions. In *Conceptual Modeling – 37th International Conference, ER 2018, Xi'an, China, October 22-25, 2018, Proceedings*, pages 626–634, 2018. doi:10.1007/978-3-030-00847-5_46.
8 P. Radha Krishna, Kamalakar Karlapalem, and Dickson K. W. Chiu. An er^{ec} framework for e-contract modeling, enactment and monitoring. *Data Knowl. Eng.*, 51(1):31–58, 2004. doi:10.1016/j.datak.2004.03.006.
9 P. Radha Krishna, Kamalakar Karlapalem, and Ajay R. Dani. From contracts to e-contracts: Modeling and enactment. *Information Technology and Management*, 6(4):363–387, 2005. doi:10.1007/s10799-005-3901-z.
10 P. Radha Krishna, Anushree Khandekar, and Kamalakar Karlapalem. Modeling dynamic relationship types for subsets of entity type instances and across entity types. *Inf. Syst.*, 60:114–126, 2016. doi:10.1016/j.is.2016.03.010.
11 Nishtha Madaan, P. Radha Krishna, and Kamalakar Karlapalem. Consistency detection in e-contract documents. In *Proceedings of the 8th International Conference on Theory and Practice of Electronic Governance, ICEGOV 2014, Guimaraes, Portugal, October 27-30, 2014*, pages 267–274, 2014. doi:10.1145/2691195.2691249.
12 Pabitra Mohapatra, P. Radha Krishna, and Kamalakar Karlapalem. E-contract enactment using meta execution workflow. In *On the Move to Meaningful Internet Systems: OTM 2013 Workshops – Confederated International Workshops: OTM Academy, OTM Industry Case Studies Program, ACM, EI2N, ISDE, META4eS, ORM, SeDeS, SINCOM, SMS, and SOMOCO 2013, Graz, Austria, September 9 – 13, 2013, Proceedings*, pages 714–717, 2013. doi:10.1007/978-3-642-41033-8_91.

3.15 Challenges in Improving Collaboration in Conceptual Modeling

Julio Cesar Leite (PUC – Rio de Janeiro, BR)

Main reference Julio Cesar Sampaio do Prado Leite: "The Prevalence of code Over Models: Turning it Around with Transparency", in Proc. of the 8th IEEE International Model-Driven Requirements Engineering Workshop, MoDRE@RE 2018, Banff, AB, Canada, August 20, 2018, pp. 56–57, IEEE Computer Society, 2018.
URL https://doi.org/10.1109/MoDRE.2018.00013

Open source software has been very successful since it relies on massive collaboration.

Massive collaboration involves a very large number of programmers working on the same project in different locations in an asynchronous way. However, to achieve this type of collaboration, programmers use a proper infrastructure to support the basic issues of collaboration, which heavy relies on configuration management.

An example of such infrastructure is GitHub[1], with millions of repositories and millions of users. We [2] and others[3] believe that massive collaboration is possible because GitHub helps transparency, thus allowing for this kind of social interaction among programmers.

As modeling is fundamental in software construction/evolution, we posit[4] that we need to tackle the issue of how to bring massive collaboration towards the process of building/evolving conceptual models. Several obstacles do exist. In particular, we believe that three of them are paramount:

a) Reuse,
b) Transparency, and
c) Collaboration mechanisms.

A possible path to Reuse is by means of domain-oriented models/patterns. As for Transparency, the understanding of GitHub mechanics and their application on modeling infrastructures seems a way to proceed. Collaboration mechanisms for conceptual modeling do exist and are being used/studied on site (same location in a synchronous mode), so we should research the adaptation/extension of these mechanisms to modeling infrastructures.

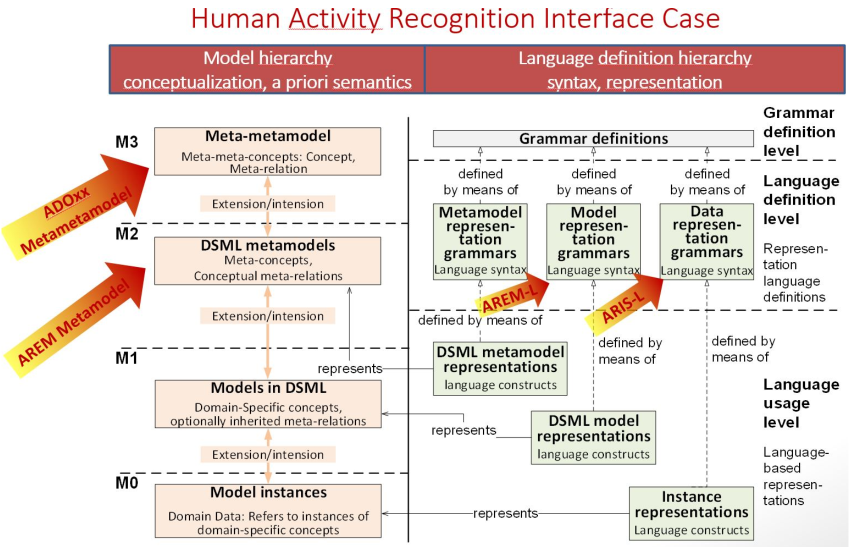
References

1 https://github.com/
2 J.C.S.P. Leite, C. Cappelli, *Software Transparency*, Bus Inf Syst Eng, vol. 2, pp. 127, 2010.
3 Laura Dabbish, et al. *Social coding in GitHub: transparency and collaboration in an open software repository.* In Proceedings of the CSCW '12. ACM, (2012),1277–1286.
4 Leite, J.C.S.P., *The Prevalence of code Over Models: Turning it Around with Transparency.* MoDRE@RE 2018: 56–57

3.16 Extraction and validation of Structural Models by using AI/ML

Wolfgang Maaß (Universität des Saarlandes, DE)

Automatic validation of structural models interferes with the deductive research method in information systems research. Nonetheless it is tempting to use a statistical learning method for assessing meaningful relations between structural variables given the underlying measurement model. In this talk, we discuss the epistemological background for this method and describe its general structure. Thereafter this method is applied in a mode of inductive confirmation to an existing data set that has been used for evaluating a deductively derived structural model. In this study, a range of machine learning model classes is used for statistical learning and results are compared with the original model.



3.17 The Paradigm of Model Centered Architecture (MCA)

Heinrich C. Mayr (Alpen-Adria-Universität Klagenfurt, AT)

Joint work of Heinrich C. Mayr, Judith Michael, Suneth Ranasinghe, Vladimir A. Shekhovtsov, Claudia Steinberger
Main reference Heinrich C. Mayr, Judith Michael, Suneth Ranasinghe, Vladimir A. Shekhovtsov, Claudia Steinberger: "Model Centered Architecture", in Proc. of the Conceptual Modeling Perspectives., pp. 85–104, Springer, 2017.
URL https://doi.org/10.1007/978-3-319-67271-7_7

The MCA paradigm is based on the obvious fact that any type of data managed and/or processed within a digital ecosystem, as well as the processes themselves, are instances of explicitly specified or implicitly underlying models and are thus models again. We therefore see each software and system component as a construct consisting of model handlers (consumers and/or producers). MCA can be seen as a generalization of Model Driven Architecture (MDA), Model Driven Software Development (MDSD) and models@runtime. Like multi-level modeling, MCA advocates the use of (possibly recursive) hierarchies of domain-specific modeling languages (DSML) for any system aspect, each embedded in a suitable methodological framework. Thus, all system interfaces are also defined via models using a corresponding DSML. This means that MCA concentrates on several meta-models and models in each development step up to the running system. The semantic concepts defined by the model hierarchies are to be represented by suitable representation languages, which again form a hierarchy. In the lecture, the MCA paradigm was illustrated with an example from the field of assistive systems: It was shown how arbitrary human activity detection systems can be docked to a support system via a meta-model-based interface specification. In addition, a number of interesting open questions were raised, such as the extension of meta-model frameworks to multi-metamodel environments, the alignment with agile software development process models like SCRUM or the need of mechanisms for meta-model reuse.

References

1 E. Ströckl and H.C. Mayr. *Multi-Modal Human-System Interaction based on MCA* . Proc. 2nd International Conference on Intelligent Human Systems Integration: Integrating People and Intelligent Systems, Feb. 2019, San Diego, California.

2 V. Shekhovtsov, S. Ranasinghe, H.C. Mayr and J. Michael. *Domain Specific Models as System Links*. Advances in Conceptual Modeling, LNCS 11158, Springer Int., 2018.
3 H.C. Mayr, J. Michael, V. Shekhovtsov, S. Ranasinghe and C. Steinberger. *A Model Centered Perspective on Software-Intensive Systems*. Proc. 9th Int. Workshop on Enterprise Modeling and Information Systems Architectures, Rostock Germany, CEUR-WS.org Vol 2097, pp 58–64.

3.18 Conceptual Modeling and MDSE – Two worlds on one planet

Judith Michael (RWTH Aachen, DE)

URL https://materials.dagstuhl.de/files/18/18471/18471.JudithMichael.Slides.pdf

Every researcher has a certain definition of the main scientific terms in mind. These definitions are based on our socialization, e.g., the research group we made our PhD in, the scientific community where we attend most conferences, the researchers we work and communicate with, the application domains we work on. In communication, we use these terms with respect to our own definitions in mind and our counterpart with his own definitions. Since these backgrounds can vary greatly, discussions on the same topic often run in different directions. For the conceptual modeling community this aspect is even more important as there is not only one main community all researchers belong to: they are e.g., related to databases, software engineering, ontologies, formal methods, petri nets, business processes. These communities even have a variety of main conferences. The exchange between these conferences is low and researchers stay in their filter bubbles. Because of these different backgrounds the understanding of e.g. a project on the semantic difference of models, can be either understood as a project using computational linguistics and ontologies to solve this challenge or on using denotational semantics and mathematical calculations. Thus, terms such as semantics, models, conceptual models, domain or domain specific (modeling) language are interpreted in different ways. To make an improvement of the current situation, we plan to publish our own work on User-Centered and Privacy-Driven System Design, as well as the research in the MaCoCo (Management Cockpit for Chair Controlling and Science Management) and SemanticDiff Projects not only in one community but to show it to different ones. In order to bring the conceptual modeling community closer together it is important to (1) make the different understandings explicit to be able to talk more conscious, (2) establish a platform or institution for regular exchange and (3) very concretely: to know the literature of the different communities and conferences and to publish the own research more widely. These aspects will be discussed even more intensively during this Dagstuhl Seminar.

3.19 Using High-level Petri Nets in Domain Specific Language Design

Daniel Moldt (Universität Hamburg, DE)

Creating DSLs for a domain or project is complex if you need a tool to draw models in addition to language. If models are run with the tool for simulation or animation purposes, the challenges become even greater. General solutions are currently not available.

Equipped with our Renew tool (http://www.renew.de) and our RMT framework (Renew Meta Modeling and Transformation), we address all kinds of dynamic models. States, state changes / transitions, events, processes and related terms (firing, activation, conflict resolution, synchronization etc.) can be covered with RMT in the development of DSLs. Thus, we offer transformative semantics to provide an underlying Petri net design for such DSLs.

This contribution focuses on the provision of simulation and animation feedback for models of such DSLs. For such DSLs, all common concepts of Petri nets are provided. In this way, we can highlight the desired properties for graphical elements in a model as desired by DSL model users. Activation, triggering, synchronization, conflicts, concurrency etc. can be covered.

Based on an abstract syntax, a concrete syntax and a tool configuration, meta-modeling offers the possibility to feed the RMT framework in such a way that a tool is generated. As stated already, the DSL tool supports the modeling of DSL models and their simulation and visualization.

The entire approach is illustrated by some examples from the area of Business Process Model and Notation (BPMN).

3.20 Conceptual modeling for Social networks and Crowdsourcing to support emergency management

Barbara Pernici (Polytechnic University of Milan, IT)

Developing complex information systems for specific domains is becoming more and more frequent and the stakeholders require a good understanding of the domain. For conceptual modelers it is difficult to move from one domain to another, so a possible way is to become a conceptual modeler expert in a given domain. Even in this case, it will always be needed to evolve models as new requirements arise. In this paper we present the approach developed in the European H2020 E2mC project on Evolution of Emergency Management Services in Copernicus and we discuss how data and services have been modeled. Some emerging concepts for new conceptual modeling methods are discussed in the presentation, in the direction of making the models closer to the users' and their data. An initial proposal in the direction of providing support to domain experts for designing and revising their own models in their own terms is discussed.

3.21 Contextual Aspects in Situational Method Engineering

Jolita Ralyté (University of Geneva, CH)

Joint work of Jolita Ralyté, Xavier Franch
Main reference Jolita Ralyté, Xavier Franch: "Using Contextual Goal Models for Constructing Situational Methods", in Proc. of the Conceptual Modeling – 37th International Conference, ER 2018, Xi'an, China, October 22-25, 2018, Proceedings, Lecture Notes in Computer Science, Vol. 11157, pp. 440–448, Springer, 2018.
URL https://doi.org/10.1007/978-3-030-00847-5_31

Situational method engineering (SME) has emerged as a result of the common recognition that one-size-fits-all methods can never be totally successful in a constantly changing information systems development (ISD) environment. The mission of SME consists in providing concepts and guidance for situation-specific (i.e., situational) method construction and adaptation by reusing various types of method chunks. Many approaches have been proposed by now, but the contextual aspects of SME are still a subject for investigation and formalization. Indeed, situation and intention are two fundamental notions in SME. They are used to assess the situation of an ISD project and to specify method requirements in this situation. They also allow defining the goals of the method chunks and the conditions under which they can be applied. In this way, the selection and assembly of method chunks for a particular ISD project is driven by matching situational method requirements to method chunks' goals and context descriptions. In our current work we propose to use contextual goal models for dealing with intentional and contextual aspects in SME, and even supporting all SME steps. Our approach is based on iStar2.0 modeling language that we extend with contextual annotations.

3.22 The quest for a general framework for composition and compositionality of conceptual models

Wolfgang Reisig (HU Berlin, DE)

Main reference Wolfgang Reisig: "Associative composition of components with double-sided interfaces", Acta Inf., Vol. 56(3), pp. 229–253, 2019.
URL https://doi.org/10.1007/s00236-018-0328-7

Informatics is nowadays about large systems that consist of heterogeneous components, including not only software packages, but also people, things, services, etc. Composition of such components is an essential issue. A general, fundamental, theory driven, formal basis to systematically compose components, would decisively improve systematic design of nowadays large informatics systems. This talk presents a number of requirements at such a formal basis, and suggests a formal framework that fits these requirements. The essential idea is to be liberal on the description of the inner behavior of components, but to be strict on the technicalities of composition. In particular, associativity of composition must be guaranteed. It is shown that the suggested framework adequately covers various different examples and case studies.

3.23 Traceability Engineering: A research agenda

Marcela Ruiz Carmona (Utrecht University, NL)

The larger the software or systems development project, the more engineers and engineering artefacts – and thereby traceability links – are involved. Large-scale software or systems development can involve many thousands artefacts from heterogeneous systems like source code, test cases, requirements, crowd-sourced feedback, and elicited data. In the context of governmental, healthcare, and financial institutions, the role of traceability is highly appreciated but not exploited.

In the context of this Dagstuhl seminar, I share my research agenda for Traceability Engineering. My six-year research goal is to establish the Traceability Engineering Lab. I see great potential on combining current Big Data and IoT technologies for the management and exploitation of traceability in large-scale software and information systems development projects. The three pillars of the lab are presented, which motivated the attendees to provide valuable feedback in terms of quantitative metrics, visualisation challenges, the opportunities to bring conceptual modelling for agile software development, and the need for formal definitions.

3.24 Engineering Software Languages

Bernhard Rumpe (RWTH Aachen, DE)

We discuss about the "Engineering" aspect in the engineeering of software languages. In particular, composition of models, refinement and a good notion of modularity are important.

Heterogeneous languages, such as SysML, however, lift the notion of model composition also to the notion of language composition, which needs to be understood in detail to be able to use models for describing different abstractions and aspects of a system (or a "world").

Many more aspects are related to SLE:
http://www.se-rwth.de/topics/Language-Engineering.php

3.25 Conceptual modelling of real-time and real-space aspects for cyber-physical systems and processes

Heinz W. Schmidt (RMIT University – Melbourne, AU)

My talk summarises some lessons and challenges from a few past research projects in conceptual and architectural modelling of cyberphysical systems (CPS) and software. These projects were focused on extra-functional properties, model-based verification and testing, but also on collaboration platform architecture for widely distributed multi-disciplinary design and development teams.

The term internet of people, things and services (IoPTS) was coined to stress the ultra-large scale character of such systems including (for some vendors) extremely large numbers of human actors, devices and services. Modeling, analysis and architectural design are not limited to software and data in these systems of systems, but include organisational, human and artificially intelligent actors, as well as very large and very small physical systems and processes.

Fur our industry collaborators, the physical aspects related to robotics automation, remote management of plants or computational and physical science experiments. Many challenges remain. Not the least of these is that CPS cross boundaries of professions and expertise, for example mechatronics engineers, software engineers, business analysts, computer scientists, industrial designers and others. Each have significantly different foundations, standards and practices in modelling, analysis and design.

Consequently architectural notations (typically based on formalising annotations on top of 'boxes and lines' drawings) remain of great interest to us. For, architectural language is the lingua franca connecting the different disciplines. While much progress has been made in modeling architecture over the past couple of decades, the composition of different formal and informal domain-specific models associated with elements in the shared architecture however remains elusive.

3.26 Analytical Patterns: Domain-independent and domain-specific cores of analytical queries

Michael Schrefl (Johannes Kepler Universität Linz, AT)

Analytical query patterns capture the reusable core of analytical queries. They are in business analytics the counterpart to design patterns in software engineering.

An analytical pattern is defined by (1) a set of pattern elements, (2) a set of constraints over pattern elements, (3) an a pattern expression with pattern elements embedded in some analytical query language such as SQL. Each pattern element is a named placeholder of one or a list of element(s) of the dimensional-fact-model (DFM) of a data warehouse, such as dimension, level, fact, or measure. Pattern elements may be input-parameters, result-parameters, or local pattern elements. Analytical patterns are best exploited by using an enriched the DFM-model that comes with ontologies of predicates (over facts or dimensions) and of calculated measures that can also constitute elements of an analytical pattern.

An analytical pattern is practically/fully instantiated by binding some/each formal input parameter element either to the name for a DFM-element (to be bound later during application) or to the identity, e.g., URI, of a DFM-element (static binding). A fully instantiated analytical pattern is applied to a specific data warehouse (DWH) by identifying the data warehouse context and by dynamically binding the name of actual pattern elements to the identity of a DFM-element in the indicated DWH-context. A pattern application is valid if the bindings of the pattern elements satisfy the pattern constraints.

We present a set of domain-independent analytical patterns identified by generalizing similar analytical queries frequently accounted in various domains (such as medicine, farming, and production). We present selected domain-independent analytical patterns that are defined by partially instantiating domain-independent patterns with facts, dimensions, levels, predicates, and calculated measure of the domain ontology, whereby bound input elements become local elements.

3.27 Recitals by computer scientists

Sibylle Schupp (TU Hamburg, DE)

The General Data Protection Regulation (GDPR) defines "Privacy by Design" as "data protection through technology design." Other privacy laws or regulations have a similar view so that it is common for legal texts in this domain to contain several references to "technology" or "the state of the (technological) art." Formal methods are suited to transform legal wordings into "echnology." Unless one is an expert in formal methods, however, it is not always obvious which legal terms are subject to a formal specification, and in what way, nor, conversely, which legal terms are underspecified and cannot be formalized without additional assumptions. For questions on legal interpretations, one can resort to recitals, which are associated with particular articles and provide additional explanations. What could be the counterpart for open issues concerning the formalization of a privacy regulation?

3.28 Realizing Digital Ecosystems in MCA

Vladimir Shekhovtsov (CICERO Consulting GmbH – Klagenfurt, AT)

Joint work of Heinrich C. Mayr, Judith Michael, Suneth Ranasinghe, Vladimir A. Shekhovtsov, Claudia Steinberger

I presented the realization of digital ecosystems in Model Centered Architecture (MCA) on an example of Ambient Assistance system. This example is based on the Human Behavior Monitoring System (HBMS) project which goal is to preserve the individual episodic memory of a person by building cognitive model of his/her behavior, and to exploit this model for support (ambient assistance) in case of cognitive impairments. The language architecture of the HBMS system features four different modeling languages on M1 level, and some more M0 representation languages, this architecture can be exemplified by the metamodel-based Human Cognition Modeling Language (HCM-L) which is used to describe the models of human behavior and the necessary contexts, to be stored and exploited by the system according to the MCA paradigm. The HBMS system architecture is built as an instance of MCA; it includes the following components: (1) the modeling tool implemented by means of ADOxx metamodeling framework, (2) the system kernel (3) the model transfer interface connecting (1) and (2), (4) the model storage, (5) the interface to external Human Activity Recognition (HAR) systems implemented as a set of MCA links. The user's behavior is captured by HAR systems by means of sensors, then the recognized structures are transferred to the kernel, where they are matched against the structure of stored behavioral models of the supported person to find possible inconsistencies, made predictions, and provide support. The support is provided by means of multimodal user support interface featuring audio and visual output. The system kernel also provides the monitoring interface which uses the graphical representation of the models to provide information about current position of the user within the behavioral scenario, and the simulator for sensor output. The HBMS system was validated by implementing it as a part of the sensor lab, which was then used to test its functionality to support human participants.

3.29 Model-based analysis of runtime business process behavior

Pnina Soffer (Haifa University, IL)

Joint work of Pnina Soffer, Yotam Evron, Arava Tsoury, Anna Zamansky, Iris Reinhartz-Berger

Conceptual process models are typically considered as design-time artifacts, aimed at establishing an understanding of a business process, redesigning it, or communicating about it. The talk presented three approaches which use process models as a basis for analyzing aspects of process runtime behavior. First, an analysis approach of potential data quality problems that may occur at runtime. The approach is based on an ontology-based view of a process, and a formal notion of Data-Inaccuracy-Awareness (DIA), which indicates that at a given state in a process, it is known whether data values accurately reflect real world values. An algorithm was developed for automatically analyzing a process model and identifying where data is used by the process at non-DIA states. With this analysis it is possible to add controls to the process (at design time) and avoid data inaccuracy consequences during execution. Second, a notion of cross-instance data impacts, which relates to variables / data items that are shared by different process instances (e.g., resource capacity). Events and changes in such variables, that take place in one process instance, might affect the state of other process instances. However, such effects are apparent in process models, which typically depict a single process instance. The proposed approach analyzes the cross-instance impacts of unexpected changes in values of variables and identifies where responses are needed. Last, we propose a notion of conditional conformance checking, which extends existing conformance checking techniques between an actual (executed) business process and the (prescribed) process model. Once an unexpected deviation from the model takes place, it is expected that some responses and compensations will take place rather than that the process would continue as if nothing happened. Our conditional conformance takes this into account. Upon an unexpected deviation, the expected response is automatically calculated (based on the model). The conformance measurement relates to the "normative" process model as well as to the expected compensating actions that should follow a deviation.

3.30 Lessons learnt from the design and development of a method and domain-specific language for security-risk assessment – The CORAS experience

Ketil Stølen (SINTEF – Oslo, NO)

This talk presents lessons learnt from the design and development of the CORAS approach for security risk assessment. The work on CORAS was initiated in 2001 and reached a major milestone in 2015 with the publication of the CORAS book. The talk starts by giving a brief overview of CORAS with particular focus on threat modelling. We then go on to present our experiences and what we learnt. Finally, we try to align our work with the overall Dagstuhl-theme of languages for conceptual modeling.

3.31 Deep and Normal Models

Bernhard Thalheim (Universität Kiel, DE)

Joint work of the Kiel model-to_model-modelling MMM team
Main reference Bernhard Thalheim: "Normal Models and Their Modelling Matrix", in Proc. of the Models: Concepts, Theory, Logic, Reasoning and Semantics – Essays Dedicated to Klaus-Dieter Schewe on the Occasion of his 60th Birthday, pp. 44–74, College Publications, 2018.

There are many notions of the (conceptual) model. One of them is the following general one. The problem is, however, whether all facets of this notion are essential within the given application and utilisation scenario, for the given community of practice, within the given context, for the current scope and focus of interest, and the profile of the model. In most case, we may restrict ourselves to some of them an thus develop "normal" models. The rest of the model is inherited from the "deep" model that is shuffled into the normal model and thus form the foundation of the normal model.

A model is a well-formed, adequate, and dependable instrument that represents origins and functions in some utilisation scenario. A model is a representation of some origins and may consist of many expressions such as sentences. Adequacy is based on satisfaction of the purpose or function or goal, analogy to the origins it represents and the focus under which the model is used. Dependability is based on a justification for its usage as a model and on a quality certificate. Models can be evaluated by one of the evaluation frameworks.

A model is functional if methods for its development and for its deployment are given. A model is effective if it can be deployed according to its portfolio, i.e. according to the tasks assigned to the model. Deployment is often using some deployment macro-model, e.g. for explanation, exploration, construction, documentation, description and prescription.

Models function as instruments or tools. Typically, instruments come in a variety of forms and fulfill many different functions. Instruments are partially independent or autonomous of the thing they operate on.

3.32 Automatic Experiment Generation for Supporting the Analysis of Domain Specific Simulation Models

Pia Wilsdorf (Universität Rostock, DE)

Joint work of Pia Wilsdorf, Andreas Ruscheinski, Kai Budde, Tom Warnke, Bjarne Christian Hiller, Marcus Dombrowsky, Adelinde M. Uhrmacher

Domain-specific modeling approaches, such as ML-Rules [1], play an important role in modeling biological systems since they are able to capture the complex dynamics between multiple levels of organization. The development and analysis of such models involves a wide variety of simulation experiments. In recent years, domain-specific languages (e.g., SESSL [2]) have also been applied for expressing experiment specifications, thereby making this part of a simulation study explicit and easier to replicate. However, writing such specifications can be challenging even if a specification language exists, as questions about models and the experiments necessary to answer them are becoming more complex and diverse. Therefore, to facilitate the specification of simulation experiments we create templates for certain experiment types, such as sensitivity analysis, or statistical model checking, which can then be adapted to the concrete simulation model and study based on information provided in the model's documentation [3]. We propose an automatic extraction procedure, however, the lack of (semi-) formal documentations hinders a fully-automatic extraction. Furthermore, the lack of an explicit conceptualization for simulation experiments and their constituents makes a context-dependent inference of information difficult.

References

1 Maus, Carsten and Rybacki, Stefan and Uhrmacher, Adelinde M. (2011) Rule-based multi-level modeling of cell biological systems. BMC Systems Biology, 5(1), p.166.

2 Warnke, Tom and Helms, Tobias and Uhrmacher, Adelinde M. (2018) Reproducible and flexible simulation experiments with ML-Rules and SESSL. Bioinformatics, 34 (8), pp. 1424–1427

3 Ruscheinski, Andreas and Budde, Kai and Warnke, Tom and Wilsdorf, Pia and Hiller, Bjarne Christian and Dombrowsky, Marcus and Uhrmacher, Adelinde M. (2018) Generating Simulation Experiments Based on Model Documentations and Templates. In: Winter Simulation Conference (WSC 2018), 09-12 Dec 2018, Gothenburg, Sweden.

3.33 Modeling for Industry 4.0

Manuel Wimmer (TU Wien, AT)

Joint work of Luca Berardinelli, Stefan Biffl, Emanuel Mätzler, Tanja Mayerhofer
Main reference Luca Berardinelli, Stefan Biffl, Emanuel Mätzler, Tanja Mayerhofer, Manuel Wimmer: "Model-based co-evolution of production systems and their libraries with AutomationML", in Proc. of the 20th IEEE Conference on Emerging Technologies & Factory Automation, ETFA 2015, Luxembourg, September 8-11, 2015, pp. 1–8, IEEE, 2015.
URL https://doi.org/10.1109/ETFA.2015.7301483

Production systems are becoming more and more software-intensive, thus turning into cyber-physical production systems (CPPS). This is also highlighted and reflected by Industry 4.0, which is seen as the next industrial revolution. As with the previous industrial revolutions, new demands have to be satisfied, e.g., virtually exploring variants, finding optimal solutions, and making dynamic runtime decisions, to allow companies to be more competitive. As a consequence, however, the complexity of CPPS is increasing. To deal with this increased complexity, modeling is considered as a promising approach which is explored in several academic and industrial efforts.

In my talk, I will introduce one of the most prominent family of modelling languages in the context of Industry 4.0, namely AutomationML (www.automationml.org). In particular, I will present some lessons learned from past and ongoing projects dealing with AutomationML and outline challenges and opportunities in this realm for the conceptual modelling research community. To sum up, the main open research question is how to best reach engineers in different engineering disciplines?

4 Working groups

4.1 Working group on Grand Challenges in Conceptual Modeling

João Paulo Almeida (Federal University of Espírito Santo – Vitória, BR),João Araújo (New University of Lisbon, PT), Fernanda Baião (PUC – Rio de Janeiro, BR), Giancarlo Guizzardi (Free University of Bozen-Bolzano, IT), and Pnina Soffer (Haifa University, IL)

Here we report on working group discussions that were driven by five questions posed by the seminar organizers. The members of this break-out group were João Paulo A. Almeida (responsible for these notes), João Araújo, Fernanda Baião, Giancarlo Guizzardi and Pnina Soffer.

1. *Your university plans to establish an Institute of Modeling; one research group including a full professorship of that institute is planned for conceptual modeling research and teaching. What should the job posting look like?*
   Capable of leading high-quality research on theories, methods and tools for producing cognitively-effective conceptual models that convey real-world semantics. Experience with specific high-impact application domains a plus.
2. *Suppose a donator gives you 5 million dollars for research in conceptual modeling: what would you be researching?*
   We have identified two options:
   a. Establish a Network-of-Excellence on Conceptual Modeling, or;
   b. Run a Research Project on Foundations and Applications, which would emphasize interdisciplinarity and would have an exploratory character. It would entail:
      i. Investigating foundations;
      ii. Identifying high priority domains, and;
      iii. Selecting complex (high-impact) problems for conceptual modeling for experimentation.
3. *How can we make 1 and 2 happen?*
   Frame (or disguise `:-)`) the work as a machine learning project. Joke aside, we have identified that there is wide potential for research into the synergy between conceptual modeling and machine learning. Given the momentum for the latter, there could be funding opportunities in this unexplored intersection.
4. *Which are the most important findings in the CM discipline within the last 10 years?*
   We discussed a number of high-impact results in the last 10 years, but could not identify "major breakthroughs". We concluded we should look back further, and identified the work of Nicola Guarino in the 90s, Ron Weber and Yair Wand in the late 80s, and also Bill Kent in the late 70s.
5. *What do you expect from a conference on Conceptual Modeling in General?*
   Address grand challenges. Accept vision-oriented papers.

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