METAMODELING AS A FOUNDATION FOR FORMALIZING LAW

Hans-Georg Fill

Abstract: The formalization of law is a fundamental prerequisite to enable its processing and interpretation by machines as discussed today in the context of legal tech. Many different kinds of formalization approaches have been designed, implemented, and applied for this purpose. In the paper at hand, we discuss the technique of metamodeling and its abilities for supporting such formalizations. Metamodeling characterizes the engineering of modeling methods whose language is based on a schema containing a set of concepts. Such modeling methods have been used for many purposes, especially in the domains of business and software engineering. Also, for the domain of law, various types of such modeling methods have recently been designed. Their major benefit lies in supporting human communication and interpretation through intuitive visual notations and machine processability through underlying formal or semi-formal representations.

Table of contents

A. INTRODUCTION

The processing of information using techniques from the field of artificial intelligence where machines are able to interpret information and autonomously derive according actions is today widely discussed. This finding applies equally to the field of law where several attempts in this direction are currently being made under the trend-label «legal technology» or «legal tech».[1] Many of the approaches found in legal tech focus on supporting the automated processing of large amounts of textual data. This direction has been studied early in the scientific literature on natural language processing in the domain of law[2] and is thus being re-visited today.

However, there exists a large body of academic research on more advanced techniques in artificial intelligence for interpreting and processing legal information, e.g. for using logics for describing and reasoning over contracts[3] or advanced machine learning techniques for classifying legal norms.[4] A notable recent example for such an approach has been presented by VAN DOESBURG ET AL., where the domain-specific language FLINT (Formal Language for the Interpretation of Normative Theories) is provided for formalizing legal norms and simulating legal cases.[5]

---

1 BETTINA MIELKE/CHRISTIAN WOLFF, E-Justice, Justiz 3.0 und Legal Tech – eine Analyse, in: Jusletter IT 18. Mai 2017.

2 Cf. ERICH SCHWEIGHOFER, Rechtsinformation und Wissensrepräsentation, Automatische Textanalyse im Völker- und Europarecht, Springer, Wien 1999; WERNER WINIWARTER/ERICH SCHWEIGHOFER, Legal Expert System KONTERM – Automatic Representation of Document Structure and Contents, in: Vladimir Marik/Jiri Lazansky/Roland Wagner (eds.), 4th International Conference on Database and Expert Systems Applications, Springer, Berlin Heidelberg 1993, 486–497.

3 GUIDO GOVERNATORI, Representing Business Contracts in RuleML, International Journal of Cooperative Information Systems 2005, Vol. 14, Issue 2–3, 181–216.

4 BERNHARD WALTL/JOHANNES MUHR/INGO GLASER/GEORG BONCZEK/ELENA SCEPANKOVA/FLORIAN MATTHES, Classifying Legal Norms with Active Machine Learning, in: Adam Wyner/Giovanni Casini (eds.), Legal Knowledge and Information Systems, IOS Press, Amsterdam 2017, 11–20.

5 ROBERT VAN DOESBURG/TIJS VAN DER STORM/TOM VAN ENGERS, CALCULEMUS: Towards a Formal Language for the Interpretation of Normative Systems, in: Gal A. Kaminka/Maria Fox/Paolo Bouquet/Eyke Hüllermeier/Virginia Dignum/Frank Dignum/Frank van Harmelen (eds.), Workshop Artificial Intelligence for Justice, 22nd European Conference on Artificial Intelligence, IOS Press, Amsterdam 2016.

One fundamental prerequisite for any type of machine processing of legal information is the understanding of the context where the processing shall take place by the designers of the according machine solution. Due to the complexity of law and its corresponding legal scenarios, such an understanding can only be achieved by people who are well-trained in the legal domain, i.e. legal experts who not only possess knowledge about legal norms but also about their application in practice. Just considering the information contained in legislation such as bills and operational policy documents as well as textual case decisions would not suffice for understanding legal relationships in practice. The knowledge of these legal experts thus first needs to be elicited and provided in a way that is more easily accessible to the designers of legal information systems and legal technology. Ideally, this elicited knowledge can already be represented in a way that bridges the gap to machine-interpretable formats. Then, algorithms can be designed to further process this knowledge and use it as additional input for legal technologies.

In the following, it will be described how such a bridge between the knowledge available from legal experts and machine-adequate representations can be provided by using the approach of metamodeling. For this purpose, at first some foundations on conceptual modeling and metamodeling will be provided. Thereafter, recent examples for applying metamodeling in the domain of law will be described. The paper will end with a conclusion and an outlook on opportunities for further research in this area.

B. FOUNDATIONS

In order to familiarize the reader with some fundamental concepts in the areas of conceptual modeling and metamodeling, the following two subsections are devoted to a brief introduction in these two areas.

I. Conceptual Modeling

The technique of conceptual modeling has a long tradition in computer science and applied computer science. Its main goal is to formally describe aspects of the world or

a system under study for the purpose of human communication and understanding.[6] This is in contrast to other modeling approaches that target primarily the processing by machines, e.g. formal specification languages in software engineering.[7] Conceptual modeling has been used extensively in the field of requirements engineering and data modeling where the elicitation of requirements plays a major role for conceptualizing information systems.

The view that we will take on conceptual modeling in this paper is visual language-based. This implies the following assumptions: a. models that abstract from an arbitrary universe of discourse can only be created using a visual modeling language; b. the models have a mapping relation to the universe of discourse; and c. algorithms may be added based on the constructs in the visual modeling language and subsequently applied to the models. These relations are depicted in Figure 1 below.

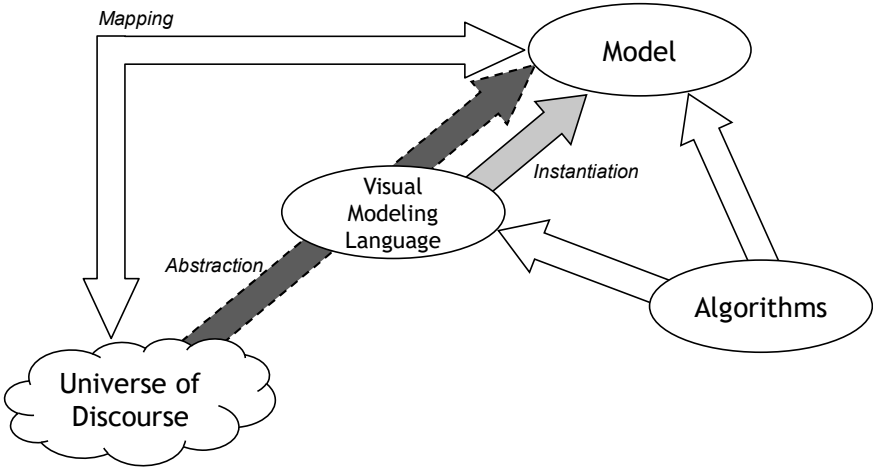

Figure 1: Main Entities in Conceptual Modeling

6 JOHN MYLOPOULOS, Conceptual Modeling and Telos, in: Pericles Loucopoulos/Roberto Zicari (eds.), Conceptual Modelling, Databases and CASE: An Integrated View of Information Systems Development, Wiley, Hoboken 1992, 49–68.

7 Cf. MARTIN FRASER/KULDEEP KUMAR/VIJAY VAISHNAVI, Strategies for Incorporating Formal Specifications in Software Development, Communications of the ACM 1994, Vol. 37, No. 10, 74–86.

The use of a visual modeling language further implies that the models are represented in visual form and that at least the syntax of the language is formally specified. The semantics may be given in natural language or may also be formally described. If algorithms are used for processing the model contents, they may also act as formal specifications for the operational semantics of the language.

II. Metamodeling

The term metamodeling needs to be defined as its usage differs substantially across different domains and sometimes even within a domain. In the context of this contribution, metamodeling is understood as the process of *conceptualizing an IT-based modeling method*. This further includes the steps of creation, design, formalization, development, and deployment.[8] In addition to the modeling language and corresponding algorithms as described in the previous subsection, a modeling method adds the usage aspect of the modeling language. This means that it is expressed, how the modeling language and the algorithms are applied for creating models and for processing the information contained in models. Again, this usage may be formally specified or may be given in natural language.[9]

[8] DAVID GÖTZINGER/ELENA-THEODORA MIRON/FRANZ STAFFEL, OMiLAB: An Open Collaborative Environment for Modeling Method Engineering, in: Dimitris Karagiannis/Heinrich C. Mayr/John Mylopoulos (eds.), Domain-Specific Conceptual Modeling, Springer, Cham 2016, 55–76.

[9] DOMENIK BORK/HANS-GEORG FILL, Formal Aspects of Enterprise Modeling Methods: A Comparison Framework, in: Ralph H. Sprague Jr. (ed)., Proceedings of the 47th International Conference on System Sciences 2014, IEEE Computer Society, Washington 2014.

When engaging in metamodeling, not only the representation of knowledge needs to be taken into account. It also needs to be considered how the interaction of the users with the resulting tool will be accomplished and how the information stored in the models can be optimally executed in particular execution environments. All these dimensions together – i.e. knowledge representation and analysis capabilities of the modeling language, user interaction, and execution – determine how the IT-based conceptual modeling method needs to be designed and realized. By using state-of-the-art software platforms for metamodeling such as ADOxx, these methods can be easily implemented.[10] These relationships are visually depicted in Figure 2 below.

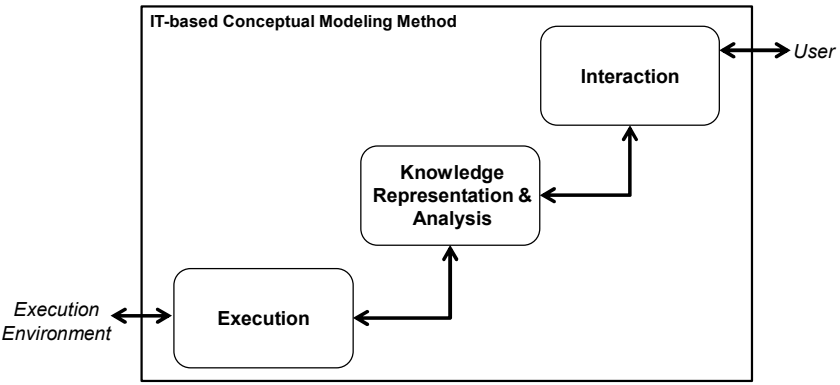

Figure 2: Conceptualization Dimensions for IT-based Conceptual Modeling Methods

C. EXAMPLES IN THE DOMAIN OF LAW

For illustrating how metamodeling can act as a foundation for formalizing law, some recent examples will be discussed in the following. The examples that will be shown take a bottom-up research perspective. Thereby it is understood that the modeling approaches are developed by investigating the activities of legal experts in their real, professional environment and by then deriving according technical solutions. This is in contrast to approaches that follow a top-down research perspective where new

10 HANS-GEORG FILL/DIMITIS KARAGIANNIS, On the Conceptualisation of Modelling Methods Using the ADOxx Meta Modelling Platform, Enterprise Modelling and Information Systems Architectures – An International Journal 2013, Vol. 8, Issue 1, 4–25.

technical solutions are derived from theoretical considerations, e.g. for formalizing legal norms, that are subsequently applied in real environments.

The first approach is described by NABIZAI and FILL.[11] It targets the representation of laws as visual models. The advantage of this particular model-based representation is that the elements of a norm can be referenced down to the level of sentences. In addition, the visual representation makes it easy to get an overview of the structure of a norm. This can serve as input for people concerned with the design of laws and guide them towards less complex structures. The approach – as shown in Figure 3 – has been implemented on the ADOxx metamodeling platform. This enables a coupling of the visual modeling language with algorithms for automatically generating the models from laws in textual format. For this purpose, it is reverted to a set of patterns for automatically segmenting sentences, which are then represented as separate model elements. These elements, together with the other elements for representing paragraphs, sections, etc. can then be referenced, e.g. to formally express a reference from one sentence to another sentence in another law. In this way, the approach contributes to the automated processing of legal information.

11 ARZO NABIZAI/HANS-GEORG FILL, Eine Modellierungsmethode zur Visualisierung und Analyse von Gesetzestexten, in: Erich Schweighofer/Franz Kummer/Walter Hötzendorfer/Christoph Sorge (eds.), Trends and Communities of Legal Informatics – Conference Proceedings of the 20th International Legal Informatics Symposium IRIS 2017, OCG, Wien 2017, 403–410.

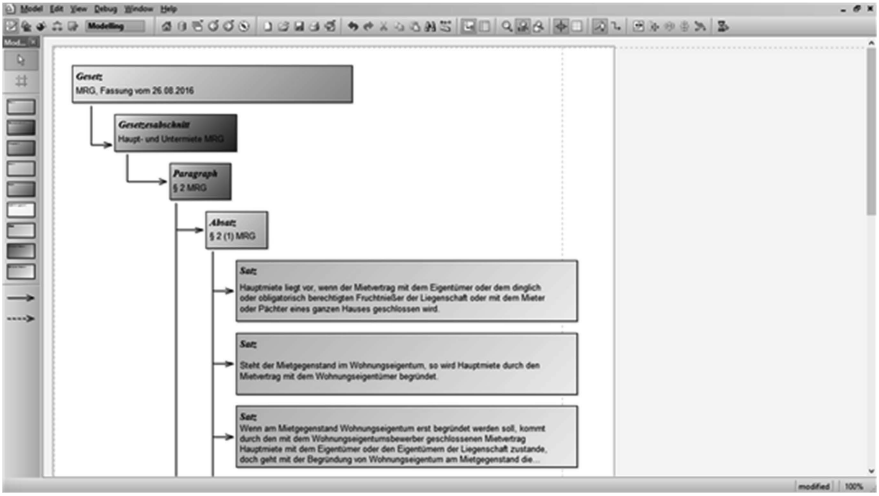

Figure 3: Visual Model of an Excerpt of an Austrian Law (Source: NABIZAI/FILL, 2017)

The second approach that is shown in Figure 4 below, is described by FILL and GRIEB.[12] It presents a visual modeling method that has been elaborated in a cooperation with a judge in civil law. The purpose of this method is to elicit the way how judges as legal experts solve cases.

12 HANS-GEORG FILL/ANDREAS GRIEB, Visuelle Modellierung des Rechts: Vorgehensweise und praktische Umsetzung für Rechtsexperten, in: Erich Schweighofer/Franz Kummer/Walter Hötzendorfer/Christoph Sorge (eds.), Trends and Communities of Legal Informatics – Conference Proceedings of the 20th International Legal Informatics Symposium IRIS 2017, OCG, Wien 2017, 387–394.

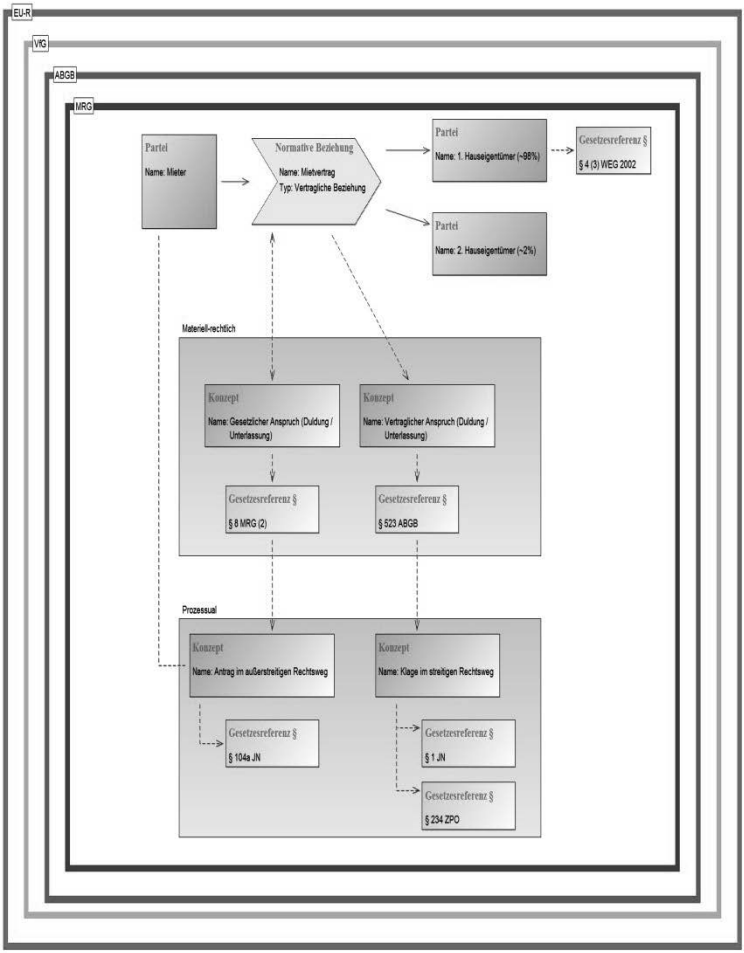

Figure 4: Excerpt of the Modeling Method (FILL/GRIEB, 2017)

It provides constructs for representing legal concepts and their relationships as well as references to the above-mentioned visual models of legal norms. Thereby it can be documented how a legal expert refers to various legal concepts that are based on concrete legal norms and then uses these concepts to apply them to a concrete case. Although the approach has so far only been used for a small part of Austrian civil law, it could be extended for further legal areas where legal experts need to document their

knowledge. Based on this documentation, requirements for possible automation mechanisms could then be derived that are able to interpret the legal concepts and their relationships automatically.

D. OPPORTUNITIES FOR FUTURE RESEARCH

The presented examples give a first idea how metamodeling can be used to formalize aspects of law and legal norms as they are viewed by legal experts. From the numerous opportunities for further research endeavors, three areas shall be listed in particular: The first area concerns further research on modeling methods that are adequate to document legal knowledge. Thereby, it should not only be focused on full machine interpretability. Rather, it should be investigated how the knowledge of legal domain experts can be represented and how they apply their knowledge in legal scenarios. This would provide further insights into the actual working of legal reasoning, which would be beneficial for designing future legal AI systems. Second, the visual representation of legal norms and legal scenarios could offer ways to explain law to legal laypersons. Although the representations developed so far target experts in law, alternative representations for other stakeholders could be designed on top. The area of legal visualization has developed several interesting approaches in this direction. By using metamodeling, these approaches could be described more formally and linked to the models for legal experts. The third area concerns the further exploration of using visual models of law as an interface to technical systems in artificial intelligence. Due to the formal description used for the modeling languages, artificial intelligence systems could automatically explore the represented knowledge and use it as input for approaches such as machine learning or computational reasoning. As a bridge, the approach of semantic annotations of visual models could be used that enables the linkage of conceptual models to ontologies as formal, machine-interpretable knowledge bases.[13]

[13] HANS-GEORG FILL, SeMFIS: A Flexible Engineering Platform for Semantic Annotations of Conceptual Models, in: Semantic Web 2017, Vol. 8, Issue 5, 747–763; HANS-GEORG FILL, Semantic Annotations of Enterprise Models for Supporting the Evolution of Model-Driven Organizations, in: Enterprise Modelling and Information Systems Architectures 2018, Vol. 13 (https://doi.org/10.18417/emisa.13.5.).