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Integrated Enterprise Modeling Lectures for Master Classes

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Abstract: This paper presents the structure and contents of an integrated curriculum on teaching enterprise modeling for master students at a large German university. The module is composed of two main master classes (Business Engineering and Enterprise Modeling) and supplemented by an additional seminar and the final master thesis. The major classes respectively consist of twelve lectures and a large practical exercise part, in which the students have to solve given modeling tasks from two realistic case studies. The curriculum is organized and arranged according to an enterprise architecture framework in order to provide an integrated view on enterprise modeling and respective learning contents. It covers business-related and IT-related perspectives and their consequences for applicable modeling languages.

Keywords: Business Engineering, Enterprise Modeling, Modeling Lectures, Master Studies

1 Introduction and Context

Enterprises are multifarious, heterogeneous socio-technical information systems, whose components are interrelated within a complex system of interdependencies on various abstraction levels [Ve03]. The research discipline of Enterprise Modeling (EM) aims to conceptualize, abstract and represent parts and aspects of enterprises by creating conceptual models in order to foster communication between involved stakeholders and enable an integration of static, procedural and functional dimensions [La09, Fr13, Fr14a]. In the light of the growing number of interdependencies and dynamics between information systems, EM serves as capable and auspicious approach for managing present-day business complexity. EM is especially relevant for the crucial integration between different stakeholder groups (e.g. business and IT experts), EM fosters inter-organizational communication and it provides specific means for operative support on different levels of automation (e.g. [Ma13, BF14]). It is therefore imperative to provide appropriate educational programs and trainings in master classes at university level.

This paper therefore encourages the issue of educating EM by presenting the structure and contents of two integrated master classes from the curriculum of a large German university. The classes are respectively designed according to the consideration of different groups of students, i.e. business students, students of Information Systems (IS) and industrial engineers.

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The remainder of this paper is organized as follows. Section 2 presents the structure of the master courses, outlines the general architecture and its underlying didactic motivation. Section 3 introduces the first master class *Business Engineering* aiming to motivate and elaborate the general idea of conceptual modeling and its various applications. Section 4 then presents the structure of the subsequent master class *Enterprise Modeling*, which focusses particular modeling methods. Section 5 finally discusses several aspects from current classes and outlines further improvement cycles.

2 Architecture of the Master Modules

2.1 Conceptual Scope

As stated in Section 1, the learning contents of the entire master classes are structured in accordance to the *Dresden Architecture Framework (DAF)* [EW08, AE07] in order to provide an integrated orientation framework for aligning different topics and hence facilitating the student's understanding of rather abstract issues. DAF was explicitly designed for model-based enterprise management, which proclaims the consequent and methodically guided usage of models for solving different types of business-related problems [EW08, p. 14]. DAF intends to emphasize the strengths of existing enterprise frameworks [AE07, p. 7] and aims to structure and consistently integrate different model types within a central model repository [EW08, p. 14]. Thereby, DAF provides a framework for considering and aligning modeling approaches from the business domain, the IS domain as well as from the IT domain.

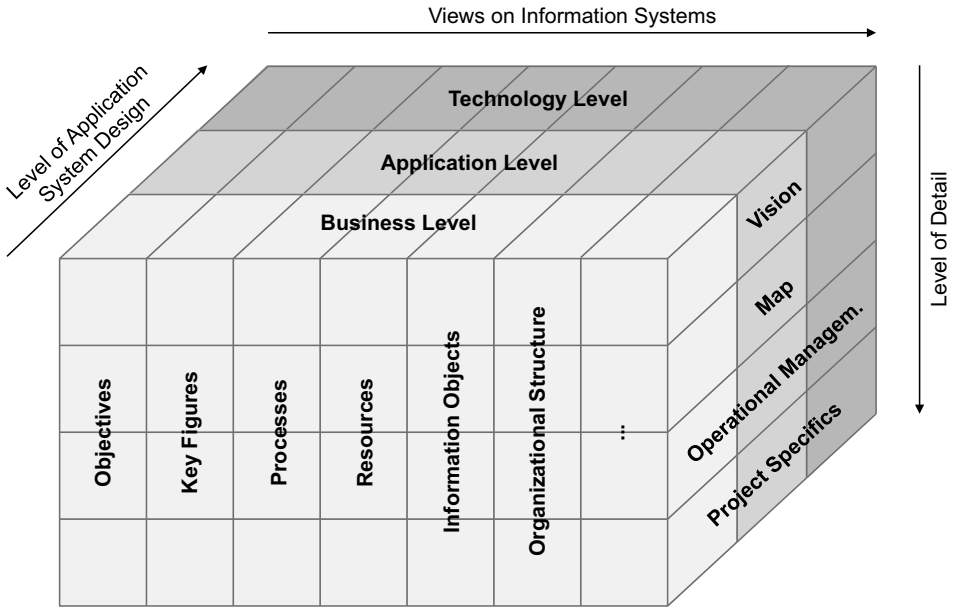

Figure 1: The *Dresden Architecture Framework (DAF)* serves as framework for the class contents.

Fig. 1 presents the DAF architecture, which is composed of three dimensions: *Views on Information Systems*, *Level of Detail* and the *Level of Application System Design* [AE07, p. 20]. The first dimension provides classical enterprise framework views like the process view or the resources view on the one hand. On the other hand, it provides further views for the definition of objectives and key figures, which are required for governance and management [AE07, EW08]. The second dimension aims to provide different levels of granularity and the third dimension should support the integrated derivation of appropriate application systems in order to support the software and hardware environment of an enterprise [AE07, p. 21].

The *Business Level* serves as starting point for several topics by addressing stakeholder-specific and rather business-oriented issues (e.g. by using the *Balanced Scorecard* approach) and by proposing respective modeling approaches (e.g. BPMN). We thereby intend to make the research field of EM explicitly available and accessible for different stakeholders (e.g. students of business administration or engineering economics). These issues are subject of the class *Business Engineering*, while the subsequent *Enterprise Modeling* class focusses specific modeling languages as well as layer-across topics like model-driven engineering (cf. Section 4).

Consequently, two main learning objectives are pursued. Firstly, it is intended to facilitate an integrated and holistic understanding of enterprises as complex socio-technical systems, which have multiple facets, abstraction layers and perspectives. Secondly, we propose the constant application of model-based approaches in order to structure and analyze enterprises and support respective transformation processes.

2.2 Organizational Structure

The organizational structure of the curriculum in master studies is depicted in Fig. 2. The *Business Engineering* class takes place in the winter semester and serves as business-driven motivation for the entire topic of EM and model-based management in order to elaborate the benefits of conceptual models for IS management. The class is scored by a written exam and the assessment of case study solutions (cf. Section 3.2).

Subsequently, the *Enterprise Modeling* class in the summer semester intensifies several topics, especially in regard of method engineering, meta modeling and selected Enterprise Modeling Languages (EMLs). This embodies a focus shift from the overall business view to the rather detailed and fine-grained level of conceptual modeling, method engineering and meta modeling. Consequently, those aspects cause the consideration of numerous model-driven techniques like multi-level modeling, reference modeling and model-driven architectures. Further, students are encouraged to learn and train several EMLs in detail (e.g. BPMN). The class is also scored by a written exam and the assessment of case study solutions (cf. Section 4.2).

Further, the seminar *Current Topics of Enterprise Engineering* is provided in parallel with the stated main courses. The seminar requires a detailed consideration of current topics within the EM domain by analyzing and discussing those topics based on a limited set

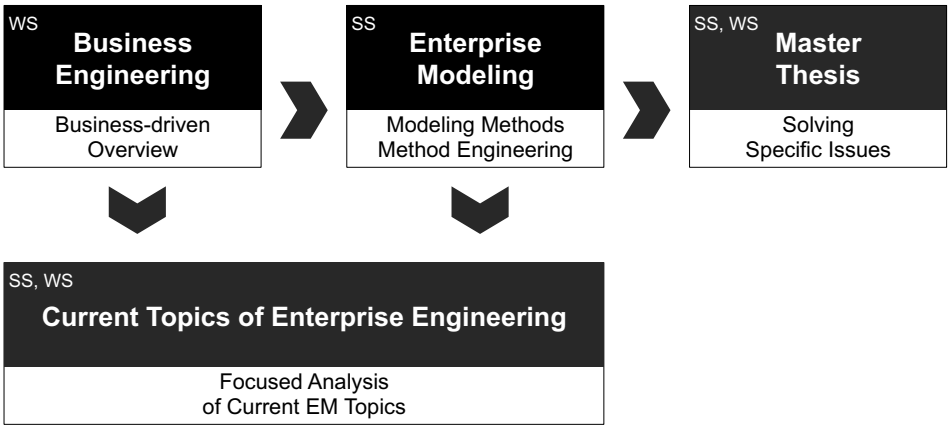

Figure 2: Curriculum of the classes (SS = summer semester, WS = winter semester).

of reputable journal papers. This should encourage master students to become acquainted with current EM research, critically reflect the work and assess alternative approaches. This serves as convenient preparation phase of the final master thesis and can also facilitate respective topic selection. Current topics in this class are, for instance, the Unified Enterprise Modeling Language (UEML) [An10, Op11], Natural Modeling [Za14], multi-level modeling approaches [Fr14b, AGF15] or research on ontological analysis [SAG13].

Finally, the *Master Thesis* is intended to work on specific EM problems from the area of the previously introduced topics.

The stated courses and contents contribute to the development of professional expertise of the students. Expertise is developed by the transmission of knowledge and the training of skills [AK11]. Corresponding to the master level, the lectures contribute to the attainment of a comprehensive, detailed knowledge concerning the mentioned learning objectives. The case studies contribute to the development of specialized technical and conceptual skills to solve business-related problems.

3 Business Engineering

3.1 Contents

The class *Business Engineering* aims to introduce into the field of modeling and EM by motiving several business-related scenarios and issues in order to emphasize the appropriateness of conceptual models for solving both business problems and IT-related issues. As stated in Section 2, the idea behind is an integrated model-based management approach that is consistently taught and flanked by essential topics like semiotics, general model theory and systems theory. Further, basics on method engineering, meta modeling and language engineering are addressed in order to theoretically support the understanding of introduced modeling languages in the case study.

After the stated introduction into several fundamental topics, the class covers several aspects of EM in accordance to the DAF: Firstly, the topic of goal modeling is addressed in order to stress the pragmatic means end relation behind model-driven management. Afterwards, the large field of process modeling is discussed and particular workflow patterns are introduced, for instance. Thirdly, the organizational structure of enterprises and respective techniques for its modeling are taught. Fourthly, different types of resources are discussed and finally the issue of modeling data and information objects is elaborated. At the beginning of each lecture, the current topic is located within the mentioned DAF in order to support an integrated understanding of EM and its interdependencies.

Each of the stated themes is further illustrated by several modeling techniques according to different modeling purposes. The level of detail is thereby limited to a certain pragmatic degree and the entire vocabulary of some modeling languages (e.g. BPMN) is introduced and applied in an extensive manner within the *Enterprise Modeling* class.

3.2 Case Study

The case study intends the application of the lecture's content in a simplified real world scenario. Therefore, the case study is built around a fictitious young company, which is faced by multiple challenges. The described company is a manufacturer of shoulder bags and is called *Saturday Inc*. The company started few years ago as a small start up and grew fast without having a reasonable strategy on how to respond to this growth. Main problems of the company are the undirected growth, not adaptable organizational structures and a small proportion of high margin direct sales due to a non-functional online shop and a missing IT strategy.

The case study is structured into five parts which correspond to the structure of the lecture: Business objectives, processes, organizational structure, resources and information objects. The overall task for the students is to put themselves into the position of an internal consultant of the company in order to asses its current situation and plan the required transformation of the company. This is realized by different tasks for each part of the case study. All of these tasks are solved in groups of five students and final results have to be documented in short papers (3-5 pages). For each task, one group is selected for presenting their results and encouraging a discussion of alternative solutions.

The *first part* of the case study provides an overview of the company's history and its current situation. The task for the students in this part is to identify problems and responsible complexity drivers, discuss appropriate strategies and explicate company goals in a Balanced Scorecard. The *second part* describes a selection of procurement and production processes, which have to be modeled with Petri Nets and EPCs. Additionally, a given BPMN process model has to be examined concerning its shortcomings and redesigned by reasonable improvements.

In the *third part* the students receive a brief history of the development of the organizational structure and a summary of problems it is causing. The students have to assess the situation in an organizational chart, elaborate respective strategies and improve the struc-

ture. Concerning the resources in the *fourth part* of the case study the students have to identify used resources in a given process, classify them and discuss required language extensions to integrate them within BPMN. The *fifth part* of the case study deals with the data and information objects. Therefore, the students have to analyze a given research article within the topic of data modeling. They have to present this excerpt and discuss interlinks with the lecture at all. Furthermore, the students have to build an Entity Relationship Diagram following the partial description of Saturday's data-related structures.

4 Enterprise Modeling

4.1 Contents

While the *Business Engineering* class primarily considers EM from a user perspective and discusses several fundamental themes, the *Enterprise Modeling* class has a rather technical focus and aims to intensify working on and working with enterprise models. The class therefore especially considers several issues in the context of meta modeling and language engineering. At the beginning, different principles and paradigms of meta modeling are presented in detail. This includes the introduction and comparison of existing meta modeling languages like MOF [OM14], MEMO MML [Fr11] and E3 [Gr04] as well as respective meta modeling tools like *MetaEdit+*[2], *ADOxx*[3], the *Eclipse Modeling Framework*[4] or *Cubetto*[5].

Within the *Enterprise Modeling* class single aspects are considered in detail. For instance, the role of cognition in the context of the concrete syntax and respective implementation capabilities in meta modeling languages [Mo09, SE12]. Also the topic of language extensibility and adaptability is addressed separately due to the increasing need for flexible modeling languages [BE14]. Besides syntactical topics, also the role of material and formal semantics as well their concern with pragmatic modeling purposes is taught and discussed (e.g. [BPS14, PG05]). This includes the consideration of the ontological analysis approach [RGI04] and the role of enterprise ontologies [An10].

The class further addresses the features and characteristics of Domain-Specific Modeling Languages (DSMLs), General Purpose Modeling Languages (GPMLs) and possible hybrid types. For instance, MEMO is discussed as framework for DSMLs [Fr11], UML for GPMLs and BPMN as hybrid form for the purpose of process modeling. This part aims to sharpen the understanding for different language types and their application consequences. The last part of the class is then used for covering several special issues like multi-level modeling [AGF15, Fr14b], reference modeling [BD07] or model-driven engineering [AK03]. Hence, the final derivation of IT-related models and artifacts is addressed.

[2] http://www.metacase.com
[3] https://www.adoxx.org
[4] https://eclipse.org/modeling/emf
[5] http://cubetto.semture.de/de

4.2 Case Study

Similar to the *Business Engineering* class, students have to accomplish multiple tasks in regard of a realistic case study that describes the structure and features of a large pharmaceutical company. Students are expected to elaborate multiple issues and modeling tasks in the context of this company by applying BPMN, UML and ARIS. The stated modeling languages should thereby be investigated in detail, which means that the entire vocabulary of a language has to be examined in regard of an appropriate modeling application. This explicitly covers the consideration of rather unknown modeling concepts or diagram types in order to encourage students to become familiar with the entire modeling language instead of just get to know the most common elements.

This should strengthen the modeling expertise on the one hand and should also provoke a critical reflection of existing approaches and alternative modeling approaches on the other hand. Therefore, students have to assess and discuss the modeling results of other students in order to sensitize the awareness of finding the most appropriate modeling solution. Despite pure modeling within the case study, students also have to extend modeling languages like BPMN in order to adapt them for particular purposes. This should foster the understanding and application of fundamental meta modeling capabilities.

5 Conclusion and Outlook

This paper presents the structure and contents of two major master classes for teaching EM at a large German university. The curriculum is organized by conducting an enterprise architecture framework for an integrated and consistent view on the entire topic of EM, its facets, perspectives, aspects and theoretical fundamentals. Each of the classes is supplemented by a mandatory case study practice aiming to apply several modeling languages indeed and in detail. Those exercises should also foster the critical reflection of used languages and their adaptation in view of respectively differing modeling purposes.

Feedback from industry is largely missing so far, since the entire course structure was revised and introduced in the last year. However, several students reported that especially their process modeling skills were appreciated in businesses during internships, for instance. The feedback from master students themselves is overwhelmingly positive, especially regarding to the complex case studies, as they provide an opportunity to apply and understand the *"rather abstract topics from the lectures"*. However, some students criticized the weighting of lecture contents and case study exercises in the final mark, as solving particular case study tasks was perceived as very time-intensive.

It remains generally challenging to strike a good balance between the sophisticated study of theoretical foundations (e.g. model theory and language engineering) and industry-oriented practical application (e.g. process modeling with BPMN). Both directions are subject of ongoing revision. For instance, it is planned to extend the class contents in regard of modeling semantics and pragmatics in order to tackle the still perceivable gap between industrial requirements and modeling capabilities [BPS14, DKM15]. It is also planned

to revise and extend the already existing case studies in order to provide more modeling opportunities and perhaps even apply novel modeling techniques like multi-level modeling [Fr14b, AGF15]. Finally, the repository of relevant modeling approaches is extended incrementally, which corresponds to the long-term objective of publishing a textbook on modeling languages from a business-driven perspective.

References

[AE07] Adam, Silke; Esswein, Werner: Untersuchung von Architektur-Frameworks zur Strukturierung von Unternehmensmodellen. Dresdener Beiträge zur Wirtschaftsinformatik 50. Technische Universität Dresden, 2007.

[AGF15] Atkinson, Colin; Gerbig, Ralph; Fritzsche, Mathias: A multi-level approach to modeling language extension in the Enterprise Systems Domain. Information Systems, 2015.

[AK03] Atkinson, Colin; Kuhne, Thomas: Model-driven development: a metamodeling foundation. IEEE Software, 20(5):36–41, 2003.

[AK11] AK, DQR: Deutscher Qualifikationsrahmen für lebenslanges Lernen. Arbeitskreis Deutscher Qualifikationsrahmen, 2011.

[An10] Anaya, Victor; Berio, Giuseppe; Harzallah, Mounira; Heymans, Patrick; Matulevičius, Raimundas; Opdahl, Andreas L; Panetto, Hervé; Verdecho, Maria Jose: The unified enterprise modelling language – overview and further work. Computers in Industry, 61(2):99–111, 2010.

[BD07] Becker, Jörg; Delfmann, Patrick: Reference Modeling. Springer, 2007.

[BE14] Braun, Richard; Esswein, Werner: Classification of Domain-Specific BPMN Extensions. In: The Practice of Enterprise Modeling. volume 147 of LNBIP, pp. 42–57, 2014.

[BF14] Bork, Domenik; Fill, Hans-Georg: Formal Aspects of Enterprise Modeling Methods: A Comparison Framework. In: Proceedings of the 47th HICSS. pp. 3400–3409, 2014.

[BPS14] Bjekovic, Marija; Proper, Henderik A; Sottet, Jean-Sébastien: Embracing pragmatics. In: Conceptual Modeling. volume 8824 of LNCS, pp. 431–444, 2014.

[DKM15] De Kinderen, Sybren; Ma, Qin: Requirements Engineering for the Design of Conceptual Modeling Languages - A Goal-and Value-oriented Approach. Applied Ontology, 2015.

[EW08] Esswein, Werner; Weller, Jens: Unternehmensarchitekturen – Grundlagen, Verwendung und Frameworks. HMD Praxis der Wirtschaftsinformatik, 45(4):6–18, 2008.

[Fr11] Frank, Ulrich: The MEMO meta modelling language (MML) and language architecture. Technical report, ICB Research Report, 2011.

[Fr13] Frank, Ulrich: Domain-specific modeling languages: requirements analysis and design guidelines. In: Domain Engineering, pp. 133–157. Springer, 2013.

[Fr14a] Frank, Ulrich: Enterprise Modelling: The Next Steps. Enterprise Modelling and Information Systems Architectures, 9(1):22–37, 2014.

[Fr14b] Frank, Ulrich: Multilevel modeling. Business & Information Systems Engineering, 6(6):319–337, 2014.

[Gr04] Greiffenberg, Steffen: Method Engineering in Business and Administration (Methodenentwicklung in Wirtschaft und Verwaltung). Kovač, 2004.

[La09] Lankhorst, Marc: Enterprise Architecture at Work: Modelling, Communication and Analysis. 2009.

[Ma13] Malavolta, Ivano; Lago, Patricia; Muccini, Henry; Pelliccione, Patrizio; Tang, Anthony: What industry needs from architectural languages: A survey. IEEE Transactions on Software Engineering, 39(6):869–891, 2013.

[Mo09] Moody, Daniel L: The "physics" of notations: toward a scientific basis for constructing visual notations in software engineering. IEEE Transactions on Software Engineering, 35(6):756–779, 2009.

[OM14] OMG: Meta Object Facility (MOF) Core Specification, Version 2.4.2. 2014.

[Op11] Opdahl, Andreas L: Anatomy of the unified enterprise modelling ontology. In: Enterprise Interoperability, pp. 163–176. Springer, 2011.

[PG05] Pfeiffer, Daniel; Gehlert, Andreas: A framework for comparing conceptual models. In: Proceedings EMISA. pp. 108–122, 2005.

[RGI04] Rosemann, Michael; Green, Peter; Indulska, Marta: A reference methodology for conducting ontological analyses. In: Conceptual Modeling, pp. 110–121. Springer, 2004.

[SAG13] Santos, Paulo Sérgio; Almeida, João Paulo A; Guizzardi, Giancarlo: An ontology-based analysis and semantics for organizational structure modeling in the ARIS method. Information Systems, 38(5):690–708, 2013.

[SE12] Stark, Jeannette; Esswein, Werner: Rules from cognition for conceptual modelling. In: Conceptual Modeling, pp. 78–87. Springer, 2012.

[Ve03] Vernadat, François B: Enterprise modelling and integration. Springer, 2003.

[Za14] Zarwin, Zoe; Bjekovic, M; Favre, Jean-Marie; Sottet, Jean-Sébastien; Proper, H: Natural modelling. Journal of Object Technology, 13(3):1–36, 2014.