D

SEQUAL as a Framework for Understanding and Assessing Quality of Models and Modeling Languages

John Krogstie
IDI, NTNU, Trondheim Norway

INTRODUCTION

An essential challenge in information technology is to effectively represent and transfer *knowledge*. An important reason why humans have excelled as species is our ability to represent, reuse and transfer knowledge across time and space. Whereas in most areas of human conduct, one-dimensional natural language texts are used to express and share knowledge, we see the need for and use of two and many-dimensional representational forms to be on the rise. A form of representation which plays an increasingly important role in information systems and enterprise development is *conceptual models* (Krogstie, Opdahl, & Brinkkemper, 2007), which are diagrams expressed in some (semi-) formal visual language (e.g., boxes interconnected with arrows), describing some area of interest. Examples could be organization charts, business process models, or models of the information to be contained in a database. Such models can be descriptive (about a current state of affairs) or prescriptive (of a wanted future situation, for instance an information system to be built). The *quality* of a conceptual model will strongly affect decisions based on the model, and can therefore be of vital importance to the stakeholders.

Whereas modeling techniques traditionally have been used to create intermediate artifacts in systems analysis and design, modern modeling methodologies take a more active approach. For instance in Business Process Management (BPM) (Havey, 2005), Model Driven Architecture (MDA) and Model-driven Software Engineering (Brambilla, Cabot & Wimmer, 2012), Domain specific modeling (DSM) (Kelly & Tolvanen, 2008), Enterprise Architecture (EA) (Lankhorst, 2005), Enterprise modeling (EM) (Vernadat, 1996), Interactive Models (Krogstie & Jørgensen, 2004) and Active Knowledge Modelling (AKM) (Lillehagen & Krogstie, 2002; Lillehagen & Krogstie, 2008), the models are used directly as part of the information system of the organization. At the same time, similar modeling techniques are also used for sense-making and communication, model simulation, quality assurance, and requirements specification in connection to more traditional forms of information systems and enterprise development (Krogstie, Dalberg, & Jensen, 2008).

Since modeling techniques are used in such a large variety of tasks with different goals, it is hard to assess whether a model is sufficiently *good* to achieve the goals. To provide guidance in this process, a framework for understanding quality of models and modeling languages will be presented in this article.

BACKGROUND

Since the early 90ties, many researchers have worked on quality of models. Work in our group on this topic can be traced back to at least 1993 (Lindland, 1993). Sindre and Lindland in particular collaborated on the next step, which ended up in a widely cited article (Lindland, Sindre & Sølvberg, 1994). Although a very elegant framework which was easily applicable for understanding important aspects of quality of models, several other works pointed to the need for extending the framework. Important inspirations in this regard was the work on 3 dimensions of requirements engineering (Pohl, 1993) work related to the semiotic ladder presented in early versions of the IFIP 8.1 FRISCO framework (Lindgren, 1990) and work on social construction of 'reality' and models thereof of the domain, which is typically not as ideal and objectively given in practice that as the original framework worked with (Berger & Luckmann, 1966). Specifically the frame-

DOI: 10.4018/978-1-4666-5888-2.ch154

Cheetah (Pinggera et al., 2012) that can track detailed modeling activities. From literature (Krogstie, 2012a; Pinggera et al., 2012) starting hypothesis for this setting exist, thus we will first have an objective-centered initiation. When tools and methods are developed to support this modeling-setting, studies having a design and development centered initiation can be performed.

- Group experiments, investigating how groups of modelers with different expertise jointly develop models on open problem areas. Participatory modeling (Gjersvik et al., 2004) can be done with a main modeler as in socio-technical walkthrough (Prilla & Jahnke, 2012) using a traditional individual tool (like Cheetah), or with parallel input from all the participants (Stirna, Persson, & Sandkuhl, 2007), in which collaborative tools like ModLab or TeleBoard is appropriate. We are currently experimenting with these types of tools, but will need to start out with a problem-centered initiation of the research, and move to the right in Figure 3 as the work progresses.
- Longitudinal case-studies of modeling in practice, studying the modeling process of collaborators already applying the core SEQUAL framework (e.g. Statoil (Wesenberg, 2011)). The first phase of this will have a problem-centered initiation, whereas we in the end hope to have research being initiated by external clients, evaluating the results.

CONCLUSION

More active approaches to the use of models in IT and organizational development are increasing. In enterprise modeling and requirements engineering in particular one aim at representing knowledge in a format available for a wide variety of stakeholders. These techniques are being taken into use to an increasing degree in areas such as health care, public administration, the oil and gas industry, the building industry, defense, and higher education to make it possible to be able to manage the increased usage and dependency on ICT. One striking aspect is that the number and variety of stakeholders that will need to relate to models increase. Given the increased educational level in most countries, with an increasing group of people with master degrees, it is not unlikely that also more people will be able to relate to these types of abstractions, given that one of the things that you are exposed to in a master study of most types, is how to deal with abstractions. Visual modeling must become as easy for e.g. designers and engineers as scribbling in order for them to express their knowledge while performing work, reflecting on this for learning and excelling in their roles. This will also enable users to capture contextual dependencies between roles, tasks, information elements and the views required for performing work without having to go through traditional systems developers to have enhanced support for their work. The importance on supporting judgment on quality of these models will thus increase, and also the usefulness of frameworks for quality of models and modeling languages such as SEQUAL

REFERENCES

Becker, J., Rosemann, M., & Schütte, R. (1995). Guidelines of Modelling (GoM). [in German]. *Wirtschaftsinformatik*, *37*(5), 435–445.

Berger, P., & Luckmann, T. (1966). *The Social Construction of Reality: A Treatise in the Sociology of Knowledge*. Penguin.

Brambilla, M., Cabot, J., & Wimmer, M. (2012). *Model-driven Software Engineering in practice*. Moregan Claypool publishers.

Gjersvik, R., Krogstie, J., & Følstad, A. (2004). Participatory Development of Enterprise Process Models. In J. Krogstie, K. Siau, & T. Halpin (Eds.), *Information Modeling Methods and Methodologies*. Idea Group Publishers. doi:10.4018/978-1-59140-375-3.ch010

Gopalakrishnan, S., Krogstie, J., & Sindre, G. (2012). Capturing Location in Process Models: Comparing Small Adaptations of Mainstream Notation. *International Journal of Information System Modeling and Design*, *3*(3), 24–45. doi:10.4018/jismd.2012070102

Havey, M. (2005). *Essential Business Process Modelling*. O'Reilly.

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design Science in Information Systems Research. *Management Information Systems Quarterly*, *28*, 75–105.

Kelly, S., & Tolvanen, J.-P. (2008). *Domain-Specific Modelling: Enabling Full Code Generation*. New Jersey: John Wiley & Sons. doi:10.1002/9780470249260

Krogstie, J. (1999). Using Quality Function Deployment in Software Requirements Specification. Paper presented at the *Fifth International Workshop on Requirements Engineering: Foundations for Software Quality (REFSQ'99*).

Krogstie, J. (2001). A Semiotic Approach to Quality in Requirements Specification In *Proceedings of IFIP 8.1. Working Conference on Organizational Semiotics*, Montreal, Canada.

Krogstie, J. (2008). Integrated Goal, Data and Process modeling: From TEMPORA to Model-Generated Work-Places. In P. Johannesson, & E. Søderstrøm (Eds.), *Information Systems Engineering From Data Analysis to Process Networks* (pp. 43–65). Hershey, PA: IGI Global. doi:10.4018/978-1-59904-567-2.ch003

Krogstie, J. (2012a). *Model-based Development and Evolution of Information Systems: A Quality Approach*. Springer. doi:10.1007/978-1-4471-2936-3

Krogstie, J. (2012b). Quality of Business Process Models. In *Proceedings PoEM'2012*, Lecture Notes in Business Information Processing, 134, (76-90).

Krogstie, J. (2013a). Quality of Conceptual Data Models. *Proceedings 14th ICISO*, Stockholm Sweden, April.

Krogstie, J. (2013b). A Semiotic Framework for Data Quality. In *Proceedings EMMSAD 2013*. Valencia, Spain.

Krogstie, J., & Arnesen, S. (2004). Assessing Enterprise Modeling Languages using a Generic Quality Framework. In J. Krogstie, K. Siau, & T. Halpin (Eds.), *Information Modeling Methods and Methodologies*. Idea Group Publishing. doi:10.4018/978-1-59140-375-3.ch004

Krogstie, J., Dalberg, V., & Jensen, S. (2005). Using a Model Quality Framework for Requirements Specification of an Enterprise Modeling Languages. In K. Siau (Ed.), *Advanced Topics in Database Research, 4*. Idea Group Publishing. doi:10.4018/978-1-59140-471-2.ch006

Krogstie, J., Dalberg, V., & Jensen, S. M. (2008). Process modeling value framework. In Y. Manolopoulos, J. Filipe, P. Constantopoulos & J. Cordeiro (Eds.), *Selected papers from 8th International Conference, ICEIS 2006,* 3, (pp. 309-321). Paphos, Cyprus: Springer.

Krogstie, J., & Jørgensen, H. (2004). Interactive Models for Supporting Networked Organisations. In *Proceedings of 16th Conference on advanced Information Systems Engineering (CAiSE 2004)*.

Krogstie, J., & Jørgensen, H. D. (2002). Quality of Interactive Models. *Prooceedings of First International Workshop on Conceptual Modelling Quality* (IWCMQ'02).

Krogstie, J., Lindland, O. I., & Sindre, G. (1995). Defining Quality Aspects for Conceptual Models. In *Proceedings of IFIP8.1 working conference on Information Systems Concepts (ISCO3): Towards a Consolidation of Views*.

Krogstie, J., Opdahl, A., & Brinkkemper, S. (2007). *Conceptual Modelling in Information Systems Engineering*. Springer Verlag. doi:10.1007/978-3-540-72677-7

Lankhorst, M. et al. (2005). *Enterprise Architecture at Work - Modelling, Communication and Analysis*. Berlin: Springer-Verlag.

Lillehagen, F., & Krogstie, J. (2002). Active Knowledge Models and Enterprise Knowledge Management. In *Proceedings of International Conference on Enterprise Integration and Modelling Technology (ICEIMT'02*).

Lillehagen, F., & Krogstie, J. (2008). *Active Knowledge Modelling of Enterprises*. Springer. doi:10.1007/978-3-540-79416-5

Lindgren, P. (1990). A framework for information systems concepts. Interrim report FRISCO.

Lindland, O. I. (1993). *A Prototyping Approach to Validation of Conceptual Models in Information Systems Engineering*. Unpublished doctoral dissertation, IDT, NTH.

Lindland, O. I., Sindre, G., & Sølvberg, A. (1994). Understanding Quality in Conceptual Modeling. *IEEE Software*. doi:10.1109/52.268955

Moody, D. L. (2009). The "Physics" of Notations: Toward a Scientific Basis for Constructing Visual Notations in Software Engineering. *IEEE Transactions on Software Engineering*, *35*(6), 756–779. doi:10.1109/TSE.2009.67

Moody, D. L., & Shanks, G. G. (1994). What Makes a Good Data Model? Evaluating the Quality of Entity Relationship Models. In *Proceedings of the 13th International Conference on the Entity-Relationship Approach (ER'94)* (pp. 94-111), Manchester, England.

Moody, D. L., Sindre, G., Brasethvik, T., & Sølvberg, A. (2002). Evaluating the Quality of Process Models: Empirical Testing of a Quality Framework. In S. Spaccapietra, S.T. March, and Y. Kambayashi (Eds.), *Proceedings ER 2002*, LNCS 2503 (pp. 214-231).

Nelson, H. J., Poels, G., Genero, M., & Piattini, M. (2011). A conceptual modeling quality framework. *Software Quality Journal*.

Nguyen, L., & Swatman, P. A. (2001) Managing the Requirements Engineering Process. In *Proceedings REFSQ 2001*. Interlaken, Switzerland.

Nossum, A., & Krogstie, J. (2009). Integrated Quality of Models and Quality of Maps. *Proceedings EMMSAD 2009*. Springer.

Peffers, K., Tuunanen, T., Gengler, C. E., Rossi, M., Hui, W., Virtanen, V., & Bragge, J. (2006) The Design Science research process. In *Proc. of DESRIST* (pp. 83-106).

Persson, A., & Stirna, J. (2010). Towards Defining a Competence Profile for the Enterprise Modelling Practitioner *Proceedings PoEM 2010.* Springer.

Pinggera, J., Zugal, S., Weidlich, M., Fahland, D., Weber, B., Mendling, J., & Reijers, H. (2012). Tracing the Process of Process Modeling with Modeling Phase Diagrams. In *Proceedings ER-BPM'11* (pp. 370–382).

Pohl, K. (1993). The Three Dimensions of Requirements Engineering. In *Proceedings of CAiSE'93*. Springer.

Prilla, M., & Jahnke, I. (2012). The Socio-Technical Walkthrough for Participatory Process Design. In T. Böhmann, W. Burr, T. Herrmann, H. Krcmar, (Eds.), Implementing International Services. Springer.

Recker, J., Rosemann, M., & Krogstie, J. (2007). Ontology- versus pattern-based evaluation of process modeling language: A comparison. CAIS 20,774-799.

Reijers, H., Mendling, J., & Recker, J. (2010) Business Process Quality Management in J. vom Brocke and M. Rosemann (eds.) Handbook on Business Process Management I. Springer.

Sindre, G., & Krogstie, J. (1995). Process heuristics to achieve requirements specification of feasible quality. In *Proceedings Second International Workshop on Requirements Engineering: Foundations for Software Quality (REFSQ'95*).

Stirna, J., Persson, A., & Sandkuhl, K. (2007). Participative Enterprise Modeling: Experiences and Recommendations. *Proceedings CAiSE 2007*, Springer.

Vernadat, F. B. (1996). *Enterprise Modelling and Integration: Principles and Applications*. Chapman & Hall.

Wand, Y., & Weber, R. (1993). On the Ontological Expressiveness of Information Systems Analysis and Design Grammars. *Journal of Information Systems*, *3*(4), 217–237. doi:10.1111/j.1365-2575.1993.tb00127.x

Wesenberg, H. (2011). Enterprise Modeling in an Agile World. In *Proceedings of the 4th conference on Practice of Enterprise Modeling*, Oslo, Norway, November 2-3.

ADDITIONAL READING

Aguilera, D., Gómez, C., & Olivé, A. (2013). Enforcement of Conceptual Schema Quality Issues in Current Integrated Development Environments In Camille Salinesi, Moira C. Norrie, Oscar Pastor (Eds.), *Proceedings Advanced Information Systems Engineering - 25th International Conference, CAiSE 2013* (pp. 626-640). Valencia, Spain, June 17-21, 2013.

Batini, C., Cappiello, C., Francalanci, C., & Maurino, A. (2009). Methodologies for data quality assessment and improvement. *ACM Computing Surveys*, *41*(3). doi:10.1145/1541880.1541883

Gao, S., & Krogstie, J. (2012). Capturing Process Knowledge for Multi-Channel Information Systems: A Case Study. [IJISMD]. *International Journal of Information System Modeling and Design*, *3*(1), 78–98. doi:10.4018/jismd.2012010104

Genero, M., Fernández-Saez, A. M., Nelson, H. J., Poels, G., & Piattini, M. (2011). Research Review: A Systematic Literature Review on the Quality of UML Models. [JDM]. *Journal of Database Management*, *22*(3), 46–70. doi:10.4018/jdm.2011070103

Gopalakrishnan, S., Krogstie, J., & Sindre, G. (2012). Capturing Location in Process Models: Comparing Small Adaptations of Mainstream Notation. [IJISMD]. *International Journal of Information System Modeling and Design*, *3*(3), 24–45. doi:10.4018/jismd.2012070102

Houy, C., Fettke, P., & Loos, P. (2012). Understanding Understandability of Conceptual Models – What Are We Actually Talking about? In Proceedings Conceptual Modeling ER 2012 Lecture Notes in Computer Science (Vol. 7532, pp. 64-77).

Jiang, L., Barone, D., Borgida, A., & Mylopoulos, J. (2009). Measuring and Comparing Effectiveness of Data Quality Techniques. In *Proceedings CAiSE 2009* (pp. 171-185).

Mendling, J., Reijers, H. A., & Recker, J. (2010). Activity labeling in process modeling: Empirical insights and recommendations. *Information Systems*, *35*(4), 467–482. doi:10.1016/j.is.2009.03.009

Mendling, J., Reijers, H. A., & van der Aalst, W. M. P. (2010). Seven Process Modeling Guidelines (7PMG). [IST]. *Information and Software Technology*, *52*(2), 127–136. doi:10.1016/j.infsof.2009.08.004

Moody, D. (2005). Theoretical and Practical Issues in Evaluating the Quality of Conceptual Models. *Data & Knowledge Engineering*, *55*(3), 243–276. doi:10.1016/j.datak.2004.12.005

Moody, D., Heymans, P., & Matulevičius, R. (2010). Visual syntax does; matter: improving the cognitive effectiveness of the i* visual notation. In *Proceedings RE,* 15(2), 141-175. Springer.

Moody, D. L., & Shanks, G. (2003). Improving the quality of data models: empirical validation of a quality management framework. *Information Systems*, *28*(6), 619–650. doi:10.1016/S0306-4379(02)00043-1

Price, R., & Shanks, G. (2005). A semiotic information quality framework: Development and comparative analysis. *Journal of Information Technology*, *20*(2), 88–102. doi:10.1057/palgrave.jit.2000038

Siau, K., & Rossi, M. (2011). Evaluation techniques for systems analysis and design modelling methods – a review and comparative analysis. *Information Systems Journal*, *21*, 249–268. doi:10.1111/j.1365-2575.2007.00255.x

KEY TERMS AND DEFINITIONS

Analysis Model: A model developed to learn all aspects of a problem domain to determine the best way to solve a specific set of user needs.

Conceptual Model: Models in some (semi-) formal visual modeling language describing some area of interest.

Design Model: A model developed to represent the optimal technical solution of a specified user need (as represented in a requirements model).

Enterprise Model: A model with similar abstraction level as an analysis model meant to capture the totally of relevant aspects for enterprise development.

Model: An abstraction represented in a modeling language.

Modeling Language: A language (i.e. a set of symbols, and rules for how to combine these symbols) to represent knowledge.

Requirements Model: A model to represent the external requirement to a system without taking into account how the system looks inside.

Visual Modeling Language: A diagrammatic modeling language, i.e. where the models made in the language are 2-dimensional diagrams.