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

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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-

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work of Pohl also pointed to the need for agreement between the stakeholders of the model.

These extensions, in addition to a specific focus on requirements specification models resulted in the framework presented in (Krogstie, Lindland, & Sindre, 1995). At the same time Shanks and Moody (Moody & Shanks, 1994) started their work on quality of data models. Becker, Rosemann and Schütte (1995) focused on the quality of process models. Later a number of other researchers, e.g. (Nelson, Poels, Genero, & Piattini, 2011) have worked within this area.

In hindsight the work done on SEQUAL can be framed as design science research (Hevner et al., 2004), with the quality framework as the core artifact. Whereas the early validation was primarily analytical, later work e.g. together with Moody (Moody, Sindre, Brasethvik, & Sølvberg, 2002) has also included empirical evaluations. The framework has been developed through a number of iterations, and have also in some cases been established as part of the knowledge base e.g. in the development of a framework for quality of maps (Nossum & Krogstie, 2009). The current version of the framework is described in (Krogstie, 2012a) where also newer work on language quality (including Moody (2009)) is included. The framework has been used for evaluation of modeling and modeling languages of a large number of perspectives, including data models (Krogstie, 2013a), process models (Krogstie, 2012b; Recker, Rosemann, & Krogstie, 2007), interactive models (Krogstie & Jørgensen, 2002), enterprise models (Krogstie & Arnesen, 2004), requirements models (Krogstie, 1999; Krogstie, 2001) and models (Krogstie, 2008). It has been used both for models on the type level and instance level (i.e. data quality (Krogstie, 2013b)).

To summarize, SEQUAL has three unique properties compared to the early work on quality of models:

- It distinguishes between quality characteristics (goals) and means to potentially achieve these goals by separating what you are trying to achieve from how to achieve it.
- It is based on a constructivistic world-view, recognising that significant models are usually created as part of a dialogue between the many stakeholders involved in modelling, whose knowledge of the modelling domain changes as modelling takes place.
- It is closely linked to linguistic and semiotic concepts. In particular, the core of the framework including the discussion on syntax, semantics, and pragmatics is parallel to the use of these terms in the semiotic theory of Morris. Also the work in FRISCO on the semiotic ladder took the work of Morris as an outset, but has extended this with physical, empirical, and social aspects which we have adapted.

FRAMEWORK FOR QUALITY OF MODELS

The current framework is illustrated in Figure 1. Quality has been defined referring to the correspondence between statements belonging to the following sets (the sets depicted as boxes):

- **G:** The set of goals of the modeling task.
- **L:** The language extension, i.e., the set of all statements that are possible to make according to the rules of the modeling languages used.
- **D:** The domain, i.e., the set of all statements that can be stated about the situation.
- **M:** The externalized model itself.
- **K:** The explicit knowledge relevant to the domain of the audience.
- **I:** The social actor interpretation, i.e., the set of all statements that the audience interprets that an externalized model consists of.
- **T:** The technical actor interpretation, i.e., the statements in the model as 'interpreted' by modeling tools.

The main quality types as illustrated as relationships in Figure 1 are:

1. Physical quality is the basic quality goal is that the externalized model *M* exists physically and is available to the relevant actors.
2. Empirical quality deals with comprehension when a visual model *M* is read by different social actors. Before evaluating empirical quality, physical quality should be addressed.

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