Intentional Models based on Measurement Theory

Andre Rifaut[1]

[1] Public Research Centre Henri Tudor, 29, av. J. F.Kennedy,
L-1855 Luxembourg-Kirchberg, Luxembourg
andre.rifaut@tudor.lu

Abstract. Metrics and measures have always been the subject of quite a lot of research works in the Requirements Engineering (RE) community, including about intentional models of Goal-Oriented RE (GORE) such as those of ***i****. However, using recent developments of the Measurement Theory, in this paper we show that the concept of Measurement Framework (MF) for soft-systems is useful for the analysis of business service systems that need long-term service agreements based on consistent measurements at all stages of their life-cycle (from inception to operation). We show that with two kinds of goals and softgoals based on MF, it is possible to improve (a) the elicitation of functional and non- functional requirements, (b) the structure of the ***i**** models, and (c) the consistency between run-time measurements and the model-based assessments of business services at early stages of RE.

Keywords: goal-oriented requirements engineering, measurement theory, measurement framework, business service, service level management.

1 Introduction

IT based business systems are enablers to create business opportunities across business entities boundaries that belong to complex business constellations. Being able to analyze those opportunities contributed to the successful application of the requirements engineering activities based on ***i****, in particular with the use of the concepts and analysis techniques based on the Strategic Dependency Diagrams and the Strategic Rationale Diagrams. However, for the business services, which are means often used in those business constellations, agreements between the service stakeholders (e.g. the service provider and the service client) must be faithful to what actually happens during the service performance. This is why those agreements, often called service-level agreements, must be based on *empirically valid measurements*. If not, some party will assess negatively its business collaborations and can find other business services offered on the market. Progress of our current research projects is reported with an example of a case study followed in the Construction Sector [4].

Section 2 motivates the objectives of the research in the context of GORE, before presenting in Section 3 our method based on measurement frameworks (MF). We conclude and explain future works in Section 4.

Note that this paper uses some terminology of Measurement Theory that may conflict with GORE terminology (e.g. about model-based evaluations).

2 Objectives of the research

As explained in the introduction, it is necessary to have consistent assessments of the business services at the different stages of their life-cycle, from requirements engineering to operation. Empirically valid measurements should be the basis of all assessments used thorough the life-cycle of the business services.

Recent developments in Measurement Theory for soft-systems can be used to support the development of RE techniques in ***i**** that focus on those empirically valid measurements provided at run-time. Our aim is to provide RE support for *complex measurements having an empirical validity* in the context of GORE for business services. This aim has come up from needs identified during more than 6 years of research in related contexts: RE for risk management [12, 10], RE for regulated business [3] and RE for business service management systems [6]. In all three aforementioned research contexts there is a negotiation process occurring between stakeholders (business managers, IT service providers, auditors, regulators) and based on empirically valid measurements of attributes of IT based business systems.

3 Scientific contributions

3.1 Measurement Theory

Since long Measurement Theory [13] has formalized measurement concepts in the context of the measurement of physical phenomena, such as the length of an object. In short, *measurement systems* are composed of procedures and artifacts (e.g. a wood yardstick) that can *assign* a *measurement result,* i.e. a time-varying or time-independent *profile,* (e.g. 11") to an *attribute* (e.g. the length) of the target *empirical phenomena* (e.g. a sheet of paper). The measurement process is a faithful operationalization of the *measurement model* of the attributes. All this, called *measurement framework* (MF), becomes more complex for the measurement of "soft-systems" [5] (to contrast with physical systems), such as organizational processes (e.g. a set of business processes). In that context what is a measurement? Actually, it is mainly the same: an *empirically valid assignment* of a *value* to an *attribute* of the *target system* (e.g. a set of business process).

The recent developments have pointed out three important characteristics of measurements (see Fig. 1): measurements must be *empirical*, *objective*, and *inter-subjective*. Briefly, "empirical" means that the (empirical) attribute must be clearly identified; "objective" indicates that the measurement model must respect all (empirical) properties of the attribute (e.g. measured length must respect the size ordering); and "inter-subjective" expresses the fact that the measurement model (and scales) is a belief shared by everybody using (or referring to) the MF. All three characteristics make a distinction between *measures*, *evaluations*, and *preferences* (see Fig. 1). Measures and evaluations must be empirically validated. During RE elicitation processes sometimes we have to model attributes of systems that are not

yet scientifically well understood. For instance, the usability attribute of IT applications: do we have a precise definition of what "usability" is? Research is still needed for validating empirical and objective measurements of usability. According to the Fig. 1, if neither empirical, nor objective, a wide place for (implicit) preferences is left in those models.

	Empirical		Objective		Inter-subjective	
	yes	no	yes	no	yes	limited
Measure	√		√		√	
Evaluation	√			√		agree on common references
Preference		√		√		shared personal viewpoint

Fig. 1. Characteristics of measurements (using terminology of Measurement Theory)

This motivates us to define specific types of softgoals and goals: *when their description is complete, those types of goal and softgoals can be specified on the basis of measurement frameworks*. For those two specific types of goals and softgoals, a distinction can be made between them: the fulfillment of a goal is *measured*, whereas the fulfillment of a softgoal is *evaluated*. (For now on in this paper, we consider only goals and softgoals of these types.)

3.2 Practical uses of those measurement characteristics.

Our research works present two methods: one [9] for extracting and structuring compliance (textual) requirements from regulation through the use of a MF and another [11] for translating those requirements into rigorous requirements modeled in ***i**** also with the help of a MF. Two other works ([6, 4]) show how to derive requirements when using MF.

A partial view on the case study in the Construction Sector [4] is shown in Fig. 2. At the top, is the model of a *generic* MF, ISO/IEC 15504 [8] defining the measurement of assurance management of any business process in terms of its purpose and outcomes (15504 terminology distinguishing softgoals from goals; 15504 indicators are not explained). Then, the middle part shows this generic MF that is instantiated into a specific MF ([2]) for assurance management of business services.

Finally, at the bottom, both MF are instantiated to the specificities of the collaborative work needed in construction projects, in this case, the sharing of documents and expertise. The three horizontal lanes at the bottom separate the high-level strategic diagram, the MF resulting from the instantiation of the two preceding MF and one "solution" (at the very bottom). The actors and their dependencies are not shown. The solution describes functional requirements that are derived from the measurement. The evaluation procedure imposed by the MF rigorously structures the arguments of the model-based assessments: see the shaded area on the evidences showing that the goal "reactions time are monitored" of the MF (i.e. an outcome) will be fulfilled.

Using goals and softgoals based on MF has practical consequences for RE activities and requirements models. First, the measurement model of the MF provides *constructive insights to derive functional and non-functional requirements* (see the top and middle models). Second, our specific kind of goals and softgoals basically

imposes an expected measurement profile to the result of a MF that can be applied to detailed requirements of alternatives solutions. This increases the structure of large ***i**** models *respecting the separation of concerns* of the different MF. This is sketched at the bottom of the Fig. 2. The separation of concerns can be expressed with (a) the attributes (and their MF); (b) the measurement profiles; (c) the solution (as measurement target). Third, the MF provides a complete specification of a measurement system that can be implemented and used at runtime for an objective measurement of the fulfillment of goals and softgoals. (Those measurement systems can also be used during operational tests.)

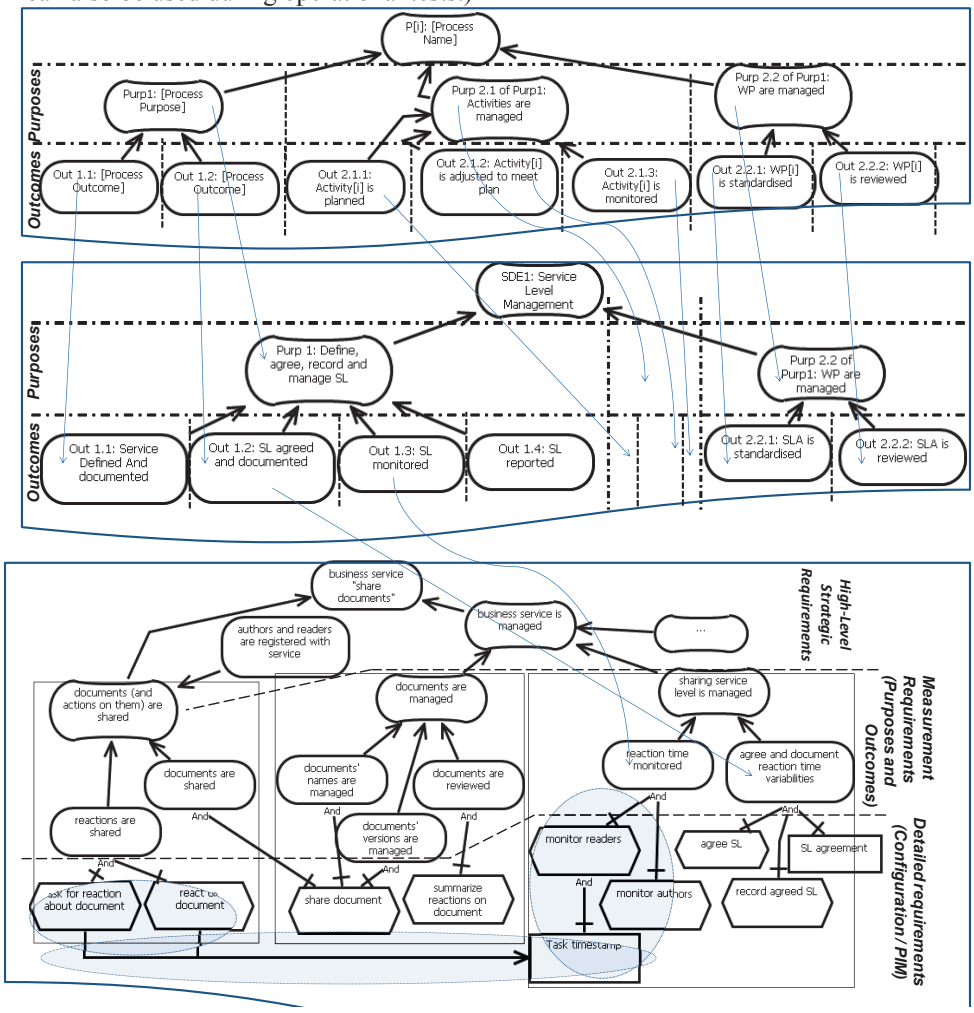

Fig. 2. Generic, Specific and Instantiated Measurement Framework Model.

Fourth, the same measurement specifications can be used for creating the arguments of model-based assessments of the fulfillment of goals and softgoals as explained in Sec. 3.1. (Measurements are made at run-time, whereas model-based

assessments provide expected measurement results.) However, when carefully made the results of the assessments will be consistent with the results of the measurements. (Those model-based assessments can also be used for model-based simulations.)

As seen in the example, the design method is based on the insertion of soft-system measurements between the strategic goals and the solutions. This creates a valid relationship between the (elicited) measurement profiles and alternatives of functional (and also non-functional) requirements. For a bottom-up design process it is possible to collect arguments and evidences from the analyzed solution and derive the measurement results of the model-based evaluation defined by the MF. For a top-down elicitation, measurement results of model-based evaluations can be imposed in order to derive the requirements on the basis of refinement patterns (cfr. KAOS by A. van Lamsweerde) or strategies (cfr. MAP by C.Rolland) that generate alternative solutions (not shown). For instance, concerning monitoring activities (outcome 2.1.3), in the selected measurement profile the monitored activities can include the sharing of documents and exclude the sharing of expertise. The advantage of this design method is to benefit from the constructive insights given by the MF of the soft-systems.

3.3 Discussion.

In recent overviews [1, 7] of the model-based techniques for assessing GORE models, nothing is said about the empiricity and objectivity of the measurements used. Those three aspects are independent of any category of statements used in RE (functional/ non-functional; requirement/assumption; belief/desire/intention; "precise"/"vague" statements, etc.). For each statement of the requirements model, the importance level of each three aspects depends on its use during the life-cycle of the "system to-be": indeed, those aspects must be compatible with the measurements methods used in analyses or assessments needed from early requirements activities to system operation. For instance, what is the level of the three aspects in the annotations of models elements with qualitative/quantitative values and their propagation/aggregation? Soft-systems measurements [5] are built on top of indicators linked to goals/softgoals with the aim to strengthen the validity of the same links found in software engineering or business process improvement methods, or in RE models ([1, 7]).

Using the same MF for requirements analysis and for defining the specifications of the measurement system and method, and for performing the actual measurements during system operation, this provides a greater consistency between the argument structure used in the requirements model, and the argument structure used at run-time.

4 Conclusions, Ongoing and future work

In this paper we have shown that the recent developments of Measurement Theory adapted to GORE methods, in particular ***i****, gives a sound basis for an interesting type of goals and softgoals to guide the elicitation and analysis of functional and non-functional requirements of business services. To benefit from the scientific knowledge of a number of MF defined, improved and validated by the scientific community

(often using social sciences research techniques), the efficiency of the proposed methods should be improved by providing tools supporting (a) the import of measurements frameworks into a knowledge base, (b) the definition of refinement patterns and strategies needed by the elicitation activities, (c) the assessment of the requirements models [1] on the basis of the measurements frameworks. (This last issue is similar to other engineering domains.) Ontology-based Software Engineering and Multi-Criteria Decision Theory provide techniques that depart from searching solutions to hard problems (e.g. searching inconsistent scenarios or plans), but aim at classifying and characterizing solutions of under-constrained problems that often occur in very early requirements engineering (see e.g DDP by M.S. Feather).

Acknowledgments. This work is supported by the project MOTIVATE of the National Research Fund, Luxembourg.

References

1. Amyot, D., Ghanavati, S., Horkoff, J., Mussbacher, G., Peyton, L., Yu, E..: Evaluating Goal Models within the Goal-Oriented Requirement Language, International Journal of Intelligent Systems, Vol. 25, pp. 841-877 (2010)
2. Barafort et al.: ITSM Process Assessment Supporting ITIL (TIPA), van Haren Publishing, Zaltbommel, The Netherland, 2009.
3. Di Renzo B., Hillairet M., Picard M., Rifaut A., Bernard C., Hagen D., Reinard D.: Operational risk management in financial institutions - Process assessment in concordance with Basel II. Software Process: Improvement and Practice 12(4): 321-330 (2007)
4. Dubois E., Kubicki S., Ramel S., and Rifaut A.:Capturing and Aligning Assurance Requirements for Business Services Systems, International Workshop on Business System Management and Engineering. June 28, (2010). Málaga (Spain).
5. Finkelstein, L.: Widely, strongly and weakly defined measurement, Measurement 34 (2003), Elsevier, pp. 39–48
6. Grandry E., Dubois E., Picard M., Rifaut A.: Managing the Alignment between Business and Software Services Requirements from a Capability Model Perspective. ServiceWave (2008): 171-182
7. Horkoff, J., Yu, E., Analysing goal models: different approaches and how to choose among them, SAC 2011; 675-682
8. ISO, ISO/IEC 15504: Information Technology – Process Assessment: Part1 to 5, 2003.
9. Rifaut, A.: Goal-Driven Requirements Engineering for Supporting the ISO 15504 Assessment Process, LNCS 3792, Proc. Int. Conf. EUROSPI, Budapest, Hungary. (2005)
10. Rifaut A., Picard M., Di Renzo B.: ISO/IEC 15504 Process Improvement to Support Basel II Compliance of Operational Risk Management in Financial Institutions. In: Proc. Conf. SPICE 2006, Luxembourg (2006).
11. Rifaut A and Dubois E.: Using Goal-Oriented Requirements Engineering for Improving the Quality of ISO/IEC 15504 based Compliance Assessment Frameworks: In Proc. IEEE Intl. Conf. On Requirements Engineering, Barcelona, IEEE Press (2008).
12. Rifaut A., Di Renzo B., Picard M.: ISO/IEC 15504, a Basis for Generally Accepted Sound Process Models in Financial Institutions: A Case Study about Venture Capital Fund Management. In: Proc. Conf. SPICE 2008, Nuremberg, (2008).
13. Rossi, G.: On some key concepts and terms in measurement having a cross-disciplinary impact, 12th IMEKO TC1 & TC7 Joint Symposium on Man Science & Measurement, September, 3-5, 2008, Annecy, France