Extending the Model of Interoperability

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1 Introduction

The work of the FIG-OOI (Focussed Interest Group on Ontology Of Interoperability) group in the INTEROP-NoE [1] focuses on establishing a general, domain-independent model of interoperability with a pragmatic, problem solving view. The interoperability model discussed in this group is based on the work of Rosener et al. [4,5] which was driven their proposal for the definition of the interoperability problem: *"The interoperability problem appears when two or more heterogeneous resources are put together"* [5]. In [4,5] interoperability problem is modelled by utilising three different meta-models, namely resource composition, systemic and decisional meta-models. The resource composition and systemic meta-models are used to describe how resources, systems composed of resources, and models describing the properties of resources and systems, are related with each other through resource interfaces and relations [5].

The decisional meta-model describes the relationships between interoperability problems, their solutions, and their corresponding dependencies on contextual conditions. Interoperability problems can be solved by solutions which again may induce more interoperability problems. The decisional meta-model defines two kinds of solutions, namely *a priori* and *a posteriori* solutions with respect to the appearance of the problem [5]. Two subclasses for conditions are identified, namely application conditions and existence conditions. Interoperability solutions are dependent of the application conditions (for example the cost of the solution) while problems are related with corresponding existence conditions, such as resource heterogeneity.

This paper contributes extensions to the FIG-OOI model of interoperability, putting more emphasis on the dynamic and social aspects of interoperability. The decisional meta-model described in [5] is extended with the concepts of indicators and environmental conditions and provided with the corresponding top-level class-hierarchies. In the extended model the existence of a solvable interoperability problem necessitates appropriate indicators for focusing the designer concerns on relevant issues, while environmental conditions represent a priori knowledge of the domain and inherent properties of the operational environment.

The extensions proposed in this paper are based on the work conducted in the area of interoperable and collaborative computing research at the Department of Computer Science at the University of Helsinki. While the extensions are initially driven by the requirements stemming from software engineering and autonomic computing areas, we believe that they are general enough to preserve the generosity and domain indepence of the proposed top ontology, which is considered as one of the primary criteria for the FIG-OOI interoperability model.

2 Extending the decisional meta-model with dynamic aspects

Our proposal extends the decisional meta-model with concepts and relationships which explicitly take into consideration the dynamic aspects of interoperability. By dynamic aspects we here refer to relational and environmental aspects of the interoperable system. For example, autonomy of the participating agents or changes in the environmental properties, such as usage policies over the resources, are considered as dynamic aspects of interoperability since they introduce effects that cannot be dealt appropriately with or within static system models.

We extend the conditions with a subclass of environmental conditions and relate interoperability problems to existence conditions only through an appropriate indicator. In the original decisional meta-model [5] the problem was directly associated with a corresponding existence condition. The resulting extended decisional meta-model is illustrated as a simplified UML class-diagram in Figure 1.

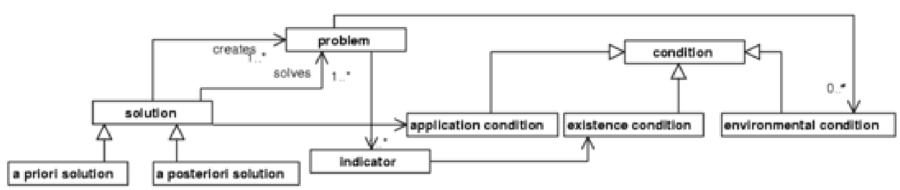

Fig. 1. The extended decisional meta-model.

The environmental conditions provide a holder for properties which are inherent for the operation environment but not part of the system itself. For example in the domain of open distributed computing, autonomy and dynamism of the participating agents and services are environmental properties that must be considered. These kind of properties cannot usually be modelled in the systemic models but instead their existence must be identified and dealt with appropriate anticipatory solution methods and techniques.

We extend the decisional meta-model with explicit interoperability problem indicators. A problem indicator represents a mechanism for identifying and detecting interoperability problems in the system. The existence conditions are linked to interoperability problems only through a corresponding indicator; without a well-defined problem indicator the interoperability problems cannot be detected. The use of an indicator as a mediator between the problem and its existence condition also provides a mechanism for distinguishing potential problems from actual problems: interoperability problems become actual and can be reacted to only when the corresponding indicator has been identified in the system.

A top-level class-hierarchy for interoperability problem indicators is given in Figure 2. The concepts of anti-patterns and conformance points are introduced as specific classes of problem indicators. Anti-patterns provide models which describe domain specific knowledge of bad solutions or habits. Anti-patterns have been used especially in the area of software-engineering for increasing software quality. Automated tools can be used for recognising architectural and design anti-patterns such as Common Coupling from architecture descriptions [3]. The notion of anti-patterns can be applied also to social contexts to identify for example organisational incompatibilities. Conformance points are observable locations or situations in the system which are used for testing the correspondence between the expected behaviour and actual operation of the system. Each conformance point consists of a location information and conformance rules. The notion of conformance point is similar to the notion used for example in the ODP enterprise language [2].

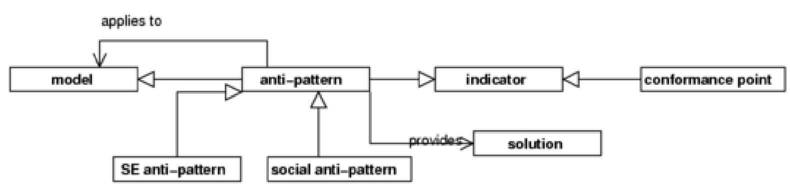

Fig. 2. The top-level class-hierarchy for problem indicators.

Solutions in the decisional meta-model are classified into namely *a priori* and *a posteriori* solutions as proposed in [5]. Homogenisation of resources was introduced in [5] as the primary *a priori* solution method while bridging of heterogeneous resources provided an *a posteriori* solution method; these methods are appropriate for statically establishing interoperability in systems. To address the dynamic aspects of interoperability, we extend the model with negotiations and compensations. The resulting class-hierarchy for solutions is illustrated in the Figure 3.

Negotiations are used to jointly decide about properties of a forthcoming collaboration and give possibilities for the participants to express their autonomic intentions, such as their willingness to collaborate. The autonomy aspect of interoperation can be addressed using negotiations between the resource holders before the actual operation. For negotiations to be successful, the participants

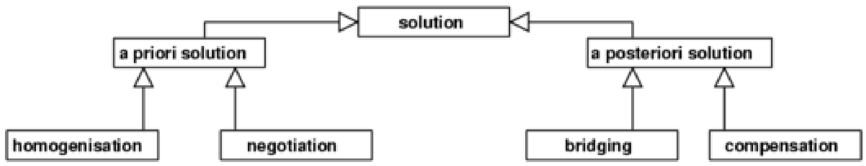

Fig. 3. The top-level class-hierarchy for interoperability solutions.

must share a common model (or meta-model) of the domain. Compensation is "*something (such as money) given or received as payment or reparation (as for a service or loss or injury)*" [6]. Compensations provide mechanisms that can be used to deal with wide range of unforeseeable interoperability problems stemming from the dynamic nature of the operational environment. Compensations can be provided for both specific problems and as a generic solution for perceived interoperation problems. The compensation mechanisms can be a part of the systemic model or can be negotiated before collaboration.

3 Conclusions

The contribution of Rosener et al. [4, 5] identified important concepts and relationships related to interoperability problems. In this paper we proposed extensions to the model for addressing the dynamic aspects of interoperability. We hope that the good work started in [4, 5] and continued in the FIG-OOI group would provide generic concepts, methods and tools for addressing the interoperability problems especially in the area of service-oriented software engineering.

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