

Hues of Satisfaction: Many-valued Institutions for Constraint Specification

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Service-Oriented Computing (SOC) is a recent paradigm focusing on the development of software applications based on dynamically changing networks of systems. In short, SOC builds upon a need-fulfilment mechanism through which software applications (requesters) connect to external suppliers (providers) every time a need for services appears. The requester first needs to discover the system components that guarantee, through an interface, the fulfilment of its conditions, and then selects and binds to a provider. The interfaces express properties that are independent of the actual implementation of the services (such as functional properties of their input-output behaviour) and are usually defined using algebraic specifications of abstract data types or temporal specifications. Besides functional properties, one could also specify constraints that express preferences meant to be used for the selection of a best provider in terms of the maximisation of their satisfaction degrees (see [6]). In this context, constraint systems have already been successfully employed in dealing with such non-functional requirements of orchestrations of service-oriented architectures [9] or in supporting the negotiation of service-level agreements [3].

The two main approaches to soft constraint satisfaction problems, SCSP [2] and VCSP [10], generalise the classical crisp variant of CSP by evaluating constraints over c-semirings and valuation structures, respectively. Aiming to employ soft constraint specification for the selection of a supplier in the context of service discovery and binding, we advance a general technique for enriching logical systems formalised as institutions [8] with soft constraints, generalising the preliminary results from [7] on the extension of algebraic specifications of interfaces. We obtain soft constraint specifications by adding constraints (regarded as sentences of a specialised logic) to theory presentations over an arbitrary institution.

To this end, we first extend the traditional notion of institution along the lines of [5] by replacing the boolean space of truth values with a given object of a concrete category, and we present the many-valued logic of soft constraints as a construction parameterised by an institution and a truth structure. Our work makes use of residuated lattices [1], which offer a unifying truth structure for both idempotent c-semirings and valuation structures. This allows us to base our methodology for selecting the most promising provider on the concept of graded semantic consequence introduced in [5], and thus to quantify the compatibility of two constraint specifications as a value of a residuated lattice.

We then take into account the dynamicity of preferences during the development of a system (all of its components had hitherto the same immutable underlying truth structure), and consider the circumstances under which such changes can occur. Motivated by the heterogeneity of complex systems inspired from social interactions, we investigate the situation in which different constraint specifications are based on different truth spaces. Drawing inspiration from Borgo and Goguen's work [4], we propose as a case study the formalisation of collective Free Jazz performances as complex systems in the context of SOC, and we present the performance "Hues of Melanin" of the Sam Rivers trio discussed in [4] as a non-mereological composition of service modules.



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In order to facilitate an implementation of our model-theoretical approach to choosing a best supplier, we intend to further examine sound and complete proof systems defined in terms of many-valued rules as in [5]. These could be used in the development of an operational semantics for the execution of service-oriented applications (i.e. of a model for dynamic reconfiguration of systems in the style of [6]) that accounts for the evolution of the applications' underlying truth structures. Towards that end, the logic-programming semantics of services recently proposed in [12] provides a starting point. Besides the obvious need to adapt the theory presented therein to our many-valued setting (which means replacing linear temporal sentences with soft constraint specifications), the main open question is how to generalise the orchestrations of client applications and service modules in order to capture the way in which the satisfaction of constraint sentences changes upon iterations of the processes of service discovery, selection and binding. The generalisation that we aim to develop has to consider the effect of past computations on the choice of the best provider at a given time: in the context of free jazz this corresponds to the dependency of the next musical phase on the music that has already been played. We also consider worthwhile investigating how a graded variant of institution-independent logic programming, which generalises service-oriented logic programming, can be defined in relation to the developments presented in [11]. This would necessitate adapting the institution-independent abstractions of the concepts of Herbrand model, unification, resolution and computed answer (with a given degree of confidence) to the many-valued nature of our setting.

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