Specifying the Rule Metalogic on the Web

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Metalogic studies properties of logics, e.g. comparing the syntax of their formulas as well as their model-theoretic and proof-theoretic semantics. This is obviously needed for fields using different logics, e.g. for AI and the Semantic Web (http://www.w3.org/2001/sw), which are built on various (computational) logics such as Horn logic and description logics; hence much of their work (e.g., on knowledge interchange and efficient reasoners) is also in the realm of metalogic. Similarly, since contemporary philosophers make heavy use of logics, including modal logics, to formulate, and reason in, philosophical theories, metalogic is also highly relevant to philosophy (cf. http://tedsider.org/books/lfp.html). A combined effort of bringing a metalogic to the Web will support the sharing and analysis of data, knowledge and theories on a ubiquitous scale. We discuss here the Web specification of the Rule Metalogic (RuleML), which evolved from the investigation of Horn rule systems to the study of increasingly general logics.

RuleML has started as an open Rule Markup Language for expressing Semantic Web and business logics by extending an object-oriented Datalog to Horn logic etc., up to a First Order Logic (FOL) allowing Negation as failure (Naf) (http://ruleml.org/modularization). RuleML has since evolved to a Rule Modeling Language for a large family of rule systems, including higher-order and modal deliberation rules as well as reaction rules (http://cs.unb.ca/~boley/papers/RuleML-Overarching.pdf). It has employed an XML-RDF-unified data model (http://www.dfki.uni-kl.de/~boley/xmlrdf.html) using a normalizer to bridge between XML-like ('stripe-skipped') relational/positional and RDF-like ('fully striped') object-oriented/slotted syntax (http://ruleml.org/1.0/#XSLT-Based%20Normalizer). RuleML has used URIs and later IRIs as object identifiers (which can also occur as slot fillers), slot keys, type identifiers, and document identifiers for rulebases (modules). It has permitted the use of principal and variant semantics via semantic attributes, e.g. for the semantics of Naf. RuleML 1.0 is a de facto standard.

Beyond that, RuleML is currently being specified as a Rule MetaLogic on the Web.

Syntax: RuleML had initially employed the Document Type Definition (DTD) metasyntax, which was transited to XML Schema Definition Language (XSD) schemas in RuleML 0.85. XSD is now being transited to the Relax NG metasyntax (http://wiki.ruleml.org/index.php/MYNG), where RuleML 1.0 acts as the bi-metasyntactic "Rosetta Stone" release. The increased expressivity of Relax NG has allowed incorporating semantic constraints, finer-grained modularization into sublanguages, and higher automation (e.g., generation of documentation and XSD co-releases). RuleML's data model and most of its syntactic vocabulary have been adopted by W3C RIF (http://www.w3.org/2005/rules/wiki/RIF_Working_Group). Since ISO Common Logic's (http://common-logic.org) current XCL 1 serialization is not wide-spread and is quite different from RuleML/XML, a preliminary RuleML study was done (http://philebus.tamu.edu/pipermail/cl/2010-October/002179.html). This led to a project on XCL 2 / CL RuleML, which is developing XCL to coincide with RuleML syntax.

Semantics: The metalogic approach allows for different semantics in different branches of the family, enabling the study of their interoperation and ultimate convergence. For example, RuleML aims at bridging between Common Logic and W3C RIF. In particular, the semantics of Common Logic shall be retained in the new CL RuleML family of RuleML (modulo changes suggested independent of the CL RuleML project and approved by the Common Logic committee). Semantics-preserving translators between compatible subsets of Common Logic and FOL RuleML (http://www.w3.org/Submission/FOL-RuleML) will be built, and composed with semantics-preserving translators between compatible subsets of FOL RuleML and RIF-FLD (http://www.w3.org/TR/rif-fld). Experience with this interoperation between subsets could then lead to a better understanding (e.g., of how these subsets might be augmented), to revised standards, and, ultimately, to full convergence.

The Rule Metalogic specification is kept open for accommodating needed extensions, including the following ones.

RuleML has been extended for Defeasible Reasoning, in the system DR-DEVICE (http://lpis.csd.auth.gr/systems/dr-device.html), to efficiently handle incomplete and inconsistent (Web) information. This can be used, for example, to model opposing technical, business, or philosophical arguments, based on the argumentation semantics of defeasible reasoning. The same group has also developed a RuleML-based system for visualizing rulebases and proof explanations on the Semantic Web, which can, e.g., support 'negotations' between opposing views in the EMERALD multi-agent system (http://lpis.csd.auth.gr/systems/emerald/emerald.html).

In the current RuleML approach to modal logics, modal operators are generically viewed as special relations at least one of whose arguments is a proposition represented as an atom with an uninterpreted relation (http://ruleml.org/talks/RuleML-Family-PPSWR06-talk-up.pdf). In an extension to DR-DEVICE, non-iterated modalities are regarded as extra simple arguments of the non-modalized literal. We are currently studying the application of the Rule Metalogic to a unified framework for multi-modal logic based on

Kripke-style possible-worlds semantics (http://philog.ruc.dk/phiconf1.html). The incorporation of modalities will benefit the new OASIS effort on LegalRuleML (http://lists.oasis-open.org/archives/legalxml-courtfiling/201110/msg00000.html).

Various approaches to modules and contexts have been explored in the Rule Metalogic, including embedded rulebases, IRI references to external rulebases, and modal operators applied to sentences. The CL RuleML project has recently focused on modules and contexts in a novel XML-based Common Logic eXtension, called XCLX, inspired by Interoperable Knowledge representation Language (IKL), IKRIS Context Language (ICL), and Geography Markup Language (GML). The chosen method will also help to formalize the modularization of knowledge over distributed agents in the RuleML-based multi-agent systems EMERALD and Rule Responder (http://ruleml.org/RuleResponder).

By applying the Rule Metalogic to different specific logics over various knowledge domains, RuleML's generality and neutrality will be furthered, spanning from logics for philosophy to business rules (http://www.businessrulesgroup.org/brmanifesto.htm) to Social Semantic Web ontologies and rules (http://ruleml.org/WellnessRules).