# Chapter XII
# Rules Verification and Validation

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## ABSTRACT

*In this chapter an introduction to verification of rules is presented. Logical models of rules, knowledge representation languages and inference rules are introduced in brief. Required characteristics of rule-based systems are analyzed and issues of formal verification techniques for rules are presented in details. The aim is to show how the quality of rules can be improved or kept at a relatively high level, even in environments with numerous active rules. This involves verification methods for rules discussing the expressive power issues of different rule representation logical languages. Moreover, verification checks for rules incorporating consistency, redundancy, completeness and minimal form are presented.*

## INTRODUCTION AND MOTIVATION

A Knowledge-Based System (KBS) for Business Intelligence (BI) applications can be composed of several heterogeneous components, such as database, fact base, text base, domain ontology specification, multimedia components, etc. However, the core component with respect to efficient knowledge processing is the Inference Engine (IE) operating on Business Rule-Base (BRB). Both the rule-base and the inference mechanism are responsible for *efficient* production of *complete* and *correct* output, fitting the current needs and generated in the right time.

A rule is a basic component of each operational Knowledge Base (KB); in principle, a rule is a statement of the generic form:

**IF** <conditions> **THEN** <conclusion>.

The **IF** part defines the preconditions, i.e. conditions under which the rule can be fired. The **THEN** part defined conclusions, decision, actions or jus a new fact deduced from the knowledge base. A set of particular inference rules is referred to as a Rule-Base (RB) or – when equipped with inference control mechanism (the so called *inference engine*) – a Rule-Based System (RBS).

A Business Rule (BR) is *a compact statement about an aspect of business* (Morgan, 2002). In fact, a business rule is an instance of a rule oriented towards business domain application. Typically, such a rule covers a chunk of knowledge of certain organization. Initially, such statements are expressed in (restricted) natural language. Contemporary BI applications can contain hundreds and thousands of rules (Morgan, 2002) which constitute mainly man-designed and hand-encoded input to the system. As such, they are prone to different types of errors. Before applying and during evolution of the system such rule bases should undergo several stages of analysis and improvement; this includes:

- **Refinement** – a transformation from abstract, general, usually expressed in natural language form into a formal statement of rules in some knowledge-representation language of appropriate expressive power, syntax and semantics,
- **Verification** – proving correctness of the set of rules in terms of some verifiable characteristics; in fact features such as consistency, completeness, and various features of correctness are checked with formal methods. Most of the knowledge engineering papers summarize this as answering the question: „Are we building the product right?"
- **Validation** – checking if the set of rules provides correct answers to specific inputs. In other words, validation consists in assuring that the system is sound and fits the user requirements. Most of the knowledge engineering papers summarize this as answering the question: „Are we building the right product?"
- **Testing** – means to undergo the system a number of runs on specially prepared data and comparing the obtained results with the correct (expected) ones. It is empirical investigation oriented towards evaluation of the rule set quality and discovering bugs.
- **Correction** – is a process of localizing and removing bugs from the set of rules; rules can be modified or replaced by other rules. Certain unnecessary rules can be eliminated, and new rules can be added. Rules can be split to more detailed, specific rules and joined (glued) to form more general rules if necessary.
- **Improvement** – even a correct rule base can be improved. This can be performed by various means: adding new rules, reduction of the rule set, tuning of rules, etc. The goal is to obtain better – in terms of specific quality measures – performance indicators.

In order to be incorporated in information systems business rules must be expressed in some formal language, with well defined syntax and semantics. The refinement of initial set of rules leads to some computer-oriented representation, usually expressed in some general or domain-specific knowledge representation language. On the other hand, disregarding syntactic sugar, the expressive power depends on the logical (and operational) level of the language, and typically spans from simple propositional languages to first (or even higher) order logic. This stage is normally performed by hand, possibly with support of some visual editors and graphical knowledge modeling languages (Ligęza, 2006).

Once formal representation is obtained, formal analysis methods can be applied to check if required characteristics are satisfied. This stage consists in *formal verification* of the knowledge base. It can be performed on-line, incrementally, during the design process. Some formal criteria to