

# Pharmaceutical Validation of Medication Orders Using an OWL Ontology and Business Rules

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**Abstract.** Ontologies are description of domains encoded in a formal language while Business Rules are description of business policies encoded in a natural controlled language. In this paper we present an application of pharmaceutical validation of medication order based on an OWL ontology and business rules or more specifically clinical decision rules. This application has been developed based on a prototype that enables business users to author, in a controlled natural language, execute and manage their Business Rules over OWL Ontologies.

**Keywords:** OWL Ontology, Business Rule, Clinical Decision Rule, Pharmaceutical Validation.

## 1 Introduction

Ontologies are more and more used to model the business knowledge which is due to their power of expressiveness and to their flexibility. On the other hand, many business applications are nowadays built based on Business Rules especially after the emergence of the BRMS (Business Rules Management System). Business Rules are a description of a business policy, encoded in a natural controlled language. They define or specify constraints of some aspect of the business<sup>7</sup> and enable automating business decisions. An example of a business rule is given in the following :

*IF the presentation name of the drug is "GLUCOPHAGE 850MG TAB"  
and the dosage unit of the dosage regimen phase is "TABLET"  
THEN the prescription is not valid;*

In this paper, we present an application of pharmaceutical validation that enable to automate the decision of validation of medication orders. It is based on

<sup>7</sup> <http://www.businessrulesgroup.org>

an OWL ontology and business rules, or more specifically clinical decision rules. The OWL <sup>8</sup> (Web Ontology Language) ontology models the most pertinent entities (concepts and properties) of pharmaceutical validation activity used in the Hôpital Européen Georges-Pompidou (HEGP) (Georges Pompidou European Hospital) <sup>9</sup>. The rules, test on the values given to the entities described in the ontology and assert if a medication order is valid or not [2].

The fact of using business rules enables the business user (*i.e.* pharmacist, physician) to be involved in the implementation of the application as he/she can author the rules in a natural controlled language.

Business rules and ontology have already been combined to support clinical decision [6] [7]. However, end user involvement in the design and the implementation of the application is a neglected aspect. In this study we propose to involve the end user (pharmacists, physicians, nurses) in the implementation of the application and to experiment the business rules designed as a clinical decision rules.

To develop this application, we first implement a prototype <sup>10</sup>, *OWL plug-in for WODM*, that enable authoring and executing business rules over OWL ontologies [3]. For this, we based on the infrastructure offered by the Business Rule Management System (BRMS) WebSphere Operational Decision Management (WODM) <sup>11</sup> and added as input OWL ontologies.

This paper is organized as follows; Section 2 present the *OWL plug-in for WODM*. Then Section 3 describes the application of pharmaceutical validation of medication order. Finally Section 4 concludes and presents our perspectives.

## 2 Proposed Approach

WODM offers an infrastructure that enables business users to author, - in a controlled natural language -, execute and manage business rules in a collaborative way. As the majority of BRMS, it uses an object oriented models to formalize the domain knowledge. In WODM, this object oriented model is called BOM (Business Object Model). The BOM represents the entities of a given business (*i.e. patient, age*). It is generated over the XOM (eXecutable Object Model) then verbalized. The XOM is the model enabling the execution of rules. It references the application objects and data, and is the base implementation of the BOM. The XOM can be built from compiled Java classes (Java execution object model) or XML Schema (dynamic execution object model). The verbalization of the BOM consists of generating a controlled natural language vocabulary (VOC) which enables authoring the business rules (*i.e. the patient, the age of the patient*).

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<sup>8</sup> <http://www.w3.org/2004/OWL/>

<sup>9</sup> <http://www.aphp.fr>

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<sup>11</sup> <http://www-01.ibm.com/software/decision-management/operational-decision-management/websphere-operational-decision-management/>

## 2.1 Authoring Business Rules over OWL Ontologies

To enable business users to author business rules, in a natural controlled language, we developed the WODM OWL plug-in. This plug-in exploits infrastructure offered by WODM to import OWL ontologies within it. The main component for authoring rules in WODM is the BOM. For this, we performed a mapping of OWL concepts (TBox) into the BOM. Thus, when we import an OWL ontology within WODM, the BOM is automatically generated and the functionalities offered by the BRMS can be used. The general idea of the mapping is: ontology concepts are mapped into BOM classes and the properties are mapped into attributes of the classes. Nevertheless, due to the difference of the power of expressiveness between OWL ontology and the BOM, there are some OWL construct that could not map into the BOM [3].

## 2.2 Executing Business Rules over OWL ontologies

The process of executing business rules in WODM consists of several steps. Business rules, authored in a controlled natural language are translated into executable rules, which are written in a formal technical rule language IRL (ILOG Rule Language). During this translation, the references to the BOM's classes and properties are translated to references into the XOM. When the input provided to WODM is a Java object model, the XOM is built from this model. But in our case, the input provided to WODM is an OWL model.

To execute business rules authored over ontologies, we perform a second mapping of OWL/BOM entities to a XOM using Jena. Jena is a Java framework, including an ontology API for handling OWL ontologies, which allows generating Java objects from the entities of the ontology. These Java objects then constitute the XOM. The use of Jena provides an execution layer for the OWL ontologies. This execution layer provides inference mechanisms on this model and the mapping of OWL concepts, properties, and individuals to a Java object model.

## 3 Experimentation

The method described above enables to author and execute business rules over OWL ontology. This method can be used in different business domain. In our case, to experiment our work, we used a pharmaceutical validation use case to implement clinical decision rules for pharmaceutical validation of medication orders.

To illustrate our work, we present a business scenario that stages three personas representing business users involved in the design and the implementation of a set of clinical decision rules for pharmaceutical validation of medication orders (see Figure 1).

Marc is the business analyst. His mission is to formalize the business knowledge and to make sure that the business model (i.e. ontology) is correct, complete

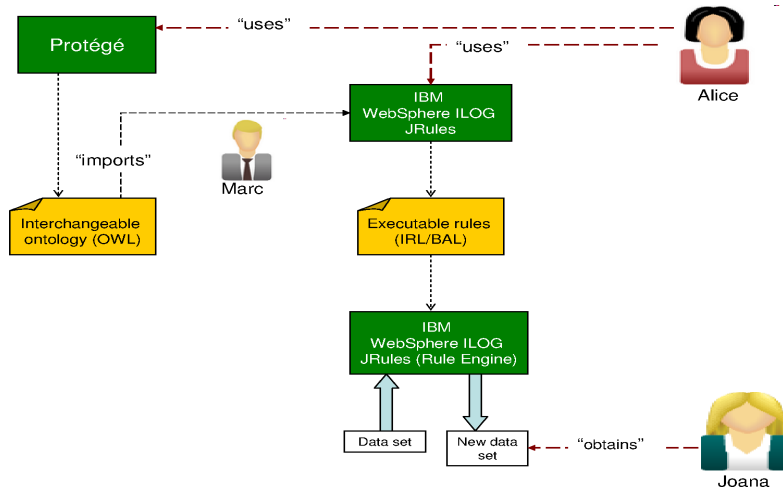


Fig. 1. Business scenario.

and valid. Alice is the domain expert. In this business scenario two domain experts interact which are a pharmacist and a physician. They understand the formalization of the rules and uses business rules tools. They are in charge of editing the clinical decision rules in the business application. Joana is the operational user who is the pharmacist. She uses the application to verify if a given prescription is valid or not.

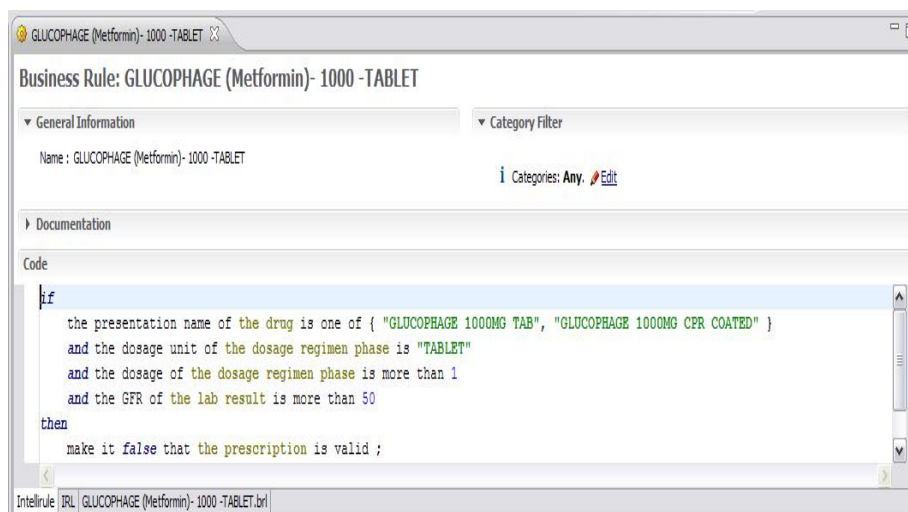
The ontology used to build this business application and the authored business rules that we will show in the following have been built based on the work presented in [2]. This work has been made in collaboration with pharmacists and physicians from the Georges Pompidou University Hospital [4]. The ontology is composed of 17 concepts and 25 properties. We will focus on 5 concepts and their properties used to author the rules we present in this paper. The ontology contains a concept **Patient** which has **LabResult** and is concerned by a **Prescription** that has a **DosageRegimenPhase**. The rules authored over this ontology test on the *presentation name* of a **Drug**, the *dosage unit* and the *dosage* of the **DosageRegimenPhase** of a **Prescription** and on the *GFR* (Glomerular Filtration Rate) of the **LabResult** of a **Patient**. Depending on the values given to these properties, they assign if a **Prescription** is *valid* or not.

When Marc finish the edition of the ontology using an ontology editor (i.e. Protégé), he imports it into WODM which automatically generate the BOM. Once the BOM is generated, the domain experts (pharmacists and physicians) author the clinical decision rules in natural controlled language. Two examples of authored rules are presented in the following (see Figure 2 & 3).

The rule in Figure 2 tests if :

- the presentation name of a drug is “GLUCOPHAGE 1000MG TAB” or “GLUCOPHAGE 1000MG CPR COATED”
- the dosage unit of the dosage regimen phase is “TABLET”
- the dosage of the dosage regimen phase is more than 1
- the GFR of the lab result of a patient is more than 50

Then it sets that the prescription is not valid.



**Fig. 2.** GLUCOPHAGE (Metformin)-1000.

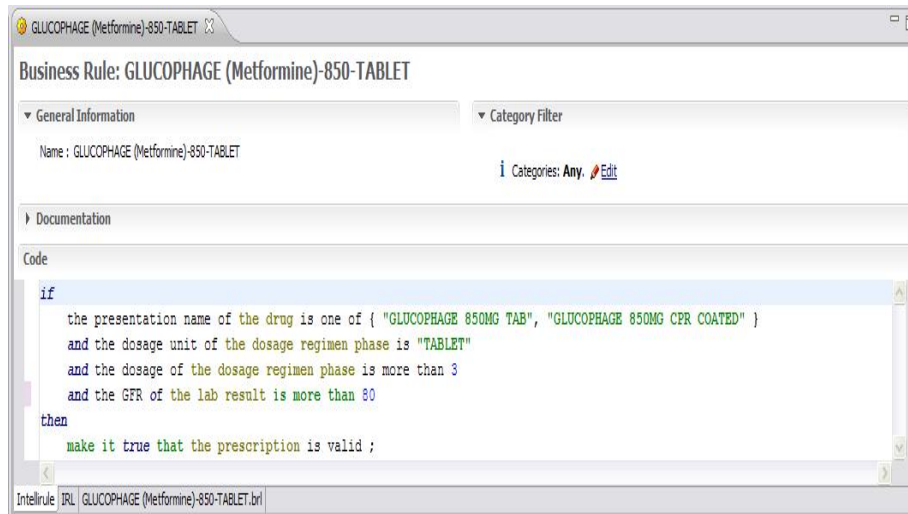
The rule in Figure 3 tests if:

- the presentation name of a drug is “GLUCOPHAGE 850MG TAB” or “GLUCOPHAGE 850MG CPR COATED”
- the dosage unit of the dosage regimen phase is “TABLET”
- the dosage of the dosage regimen phase is more than 3
- the GFR of the lab result of a patient is more than 80

Then it sets that the prescription is valid.

The pharmacist enters the data concerning a prescription and launches the execution of the rules which will determine if the prescription is valid or not. For example, Joana enters data concerning two prescriptions given to two different patients (see Table 1).

Prescription 1 for patient 1 who has the GFR of his lab result equals to 90. The dosage unit of the dosage regimen phase of the prescription is TABLET and its dosage is 2. The prescription contains a drug called GLUCOPHAGE 1000MG TAB. In this case the rule called GLUCOPHAGE - 1000 TABLET Rule (see Figure 2) will be launched and set the validation of the prescription to false.



**Fig. 3.** GLUCOPHAGE (Metformin)- 850.

Prescription 2 for patient 2 who has the GFR of his lab result equals to 95. The dosage unit of the dosage regimen phase of this prescription is TABLET and its dosage is 4. The prescription contains a drug called GLUCOPHAGE 850 MG TAB. In this case the rule called GLUCOPHAGE (Metformin) 850 (see Figure 3) will be launched and the validation of the prescription will be set to true.

Table 1. Prescriptions of the pharmacist

	Presentation name	Dosage unit	Dosage	GFR
P1	GLUCOPHAGE 1000MG TAB	TABLET	2	90
P2	GLUCOPHAGE 850 MG TAB	TABLET	4	95

## 4 Conclusion

In this paper, we present an application of pharmaceutical validation of medication orders that implement clinical decision rules, in a natural controlled language, over an OWL ontology. In order to develop this application we use the prototype described in Section 2 that enables authoring and executing business rules. The clinical decision rules designed in this study will be integrated with the HEGP clinical information system as an alert system for more assessment.

In perspective, we propose to improve the rule presented in this work in order to have recommendations that enable to revise the invalid prescription. Such recommendations, considered as alerts, inform the pharmacist about the cause of the invalidity of a prescription.

One particularity of ontologies is that they evolve over time. Ontology evolutions consist of changes that could impact an ontology. The business rules depend on the entities of the ontology and its evolution may have an impact on them and causes inconsistencies. This is an issue on which we focus and for which we developed the  $\mathcal{MDR}$  approach (Model-Detect-Repair) [5]. This approach enables to track ontology changes, detects the rule inconsistencies that could be caused by a change and then proposes solution, called repair, to repair the inconsistencies.

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