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Comparison of Expert System Building Tools:

A Case Study of OPM and OpenRules Dialog

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***Abstract*—**For designing an expert medicinal prescription system, rule base generation is required for storing the knowledge and implementing it for appropriate decision making. Such a rule base system can prove to be of significant help as ready reckoner to the medical practitioners' community to make the correct diagnosis. There are several tools available for building Rule Base knowledge system. In this paper, medical prescription system is designed by using two expert system building tools. The selection of the tools and their comparison is made by using certain criteria, so that it will facilitate the choice of the appropriate system.

Keywords-*Expert Medicinal Prescription System; Expert System; RuleBase System; Expert System Building Tools; Artificial Intelligence.*

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I. INTRODUCTION

Nowadays, Medical diagnosis and prescribing medicine is one of the area where the knowledge base generation is necessary for storing and manipulating the knowledge gathered from experts. To build such a Rule based ES, several ES building tools are available. We are comparing two ES building tools based on ten parameters.

1.1 Building blocks of Expert System-

Generally, an Expert System requires: GUI to interact with users, Knowledge Base to store the and Inference Engine to make decision, based on user input and knowledge stored in Knowledge Base.

D Figure 1.1 shows that, to design the prescription expert system, the knowledge engineer should gather the related domain knowledge from experts, in this case experts are physicians. The knowledge acquired from the expert is used to develop the GUI as well as Rule base knowledge.

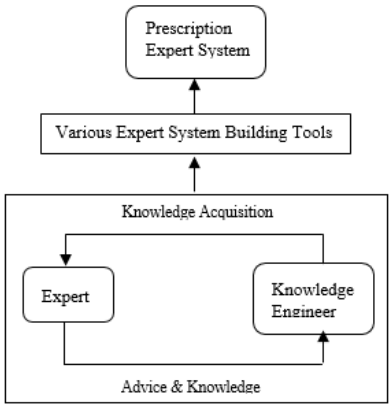

Fig. 1.1 Building blocks of Expert System

Now, to build any Expert System, one will try to find out the building tool which is suitable for designing. Though the users of the system are medical practitioners, medical researchers, investigators, patients and so on. The focus of designing the ES and selection of ES building tool is done from the medical practitioner's perception.

Some selection criteria for choosing ES tool are: user friendly GUI, knowledge base building, Exhaustive data storage, Case specific advice, good report generation. Based on these selection criteria, the comparison criteria used are: Knowledge Acquisition, Knowledge Representation Scheme, Interface, Knowledge Base Repository, Rules Representation, Rule Engine, Rules Optimization, Support, Simplicity for comparing two ES building tools Oracle Policy Modelling (OPM) and Open Rules Dialogs.

This paper is organized in following order: Section II includes the literature survey, Section III mentions about tools that are considered for comparison, Section IV discusses different comparison criteria, Section V shows implementation of example cases, and Section VI concludes the paper.

II. LITERATURE REVIEW

A. Different types of Expert System Building Tools

To support the study of tools, the researcher reviewed, various resources available on web. There are several Expert System building tools are available on web, they are mainly classified in Six groups: Free, Commercial, Free for non-commercial use, Commercial - Open Source, Free - Open Source and Earlier existing systems but currently withdrawn.

B. Type Level Classification

In Table 2.1, researcher tried to classify 45 different expert system building tools into six above mentioned classes. Here, near about 10 tools are either merged, converted into enhanced version or they are removed from the web.

Table 2.1 Type Level Classification

Type	Free	Commercial	Free for non-commercial use	Commercial & Open Source	Free & Open Source	Existing systems But currently withdrawn
Count	6	11	6	1	10	10

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C. *RBS & BRMS Level Classification*

Given a real-life situation Rule Base System(RBS) is used to make a decision based on the knowledge stored in knowledgebase and Business Rule Management System(BRMS) is used to make decision within the organization. With the help of BRMS, one can create, deploy, test execute and maintain the decision support application.

In RBS rules are written in more technical, where as in BRMS, rules are English-like statements written in such way that the upper level management (nonprogrammers) can also understand the formation of the rules [4].

Table 2.2 gives a classification of expert system tools as RBS and BRMS depending upon the rule formation methods.

TABLE 2.2 RBS & BRMS LEVEL CLASSIFICATION

Tools	RBS	BRMS
Acquire Software	√	
CLIPS	√	
Corticom	√	
drools	√	
Fair-Isaac Blaze Advisor		√
ILOG Rules and Jrules		√
Infosapient	√	
Jboss		√
JEOPS	√	
Jess	√	
JLisa	√	
MindBox		√
OFBiz	√	
OpenRules		√
OPSJ	√	
Rule Core	√	
TyRuBa	√	
XpertRule	√	

D. *Programming Level Classification*

Table 2.3 describes the classification based on language support used for the expert system building tools as per the six groups mentioned in 2.1. This analysis shows that maximum expert system building tools are written in JAVA.

TABLE 2.3 PROGRAMMING LEVEL CLASSIFICATION

Language Classes	Source/Vendor	Tools	C	C++	.NET	JAVA	OWL	php	Python	Cyc	Java Script	AJAX
Free	ghg.net	CLIPS	√									
	jboss.org	Drools				√						
	agfa.com	Eulee				√						
	eXpertise2Go.com	eXpertise2Go				√						
	info-sapient	Infosapient				√						
	sm.tdpe.fr	JEOPS				√						
Commercial	Acquire Intelligence	Acquire	√	√	√	√						
	Corticon	Corticon Decision Mgmt Software				√						
	EXITS	Convil				√						
	Fair-Isaac	Blaze Advisor			√	√						
	Gensym	G2	√	√								
	Haley Enterprise	CIA	√	√		√						
	ILOG	Rules and Jrules	√	√	√	√						
	GAIA- Group	jCOLIBri				√						
	coreologic.com	MindBox			√							
	Rule Core Systems	RuleCore							√			
	XpertRule	XpertRule			√						√	√
Free for non-commercial use	IBoss	Jboss				√						
	Sandia Labs	Jess				√						
	Oracle Policy Au	OPM				√						
	Production Systems Technologies	CLIPS/R2		√	√							
		OPS/R2	√	√								
		OPSJ			√							
Commercial & Open Source	OpenRules.com	OpenRules				√						
Free & Open Source	dfweb.de	dfWeb				√						
	let.rp.si	JDEN				√						
	jlogic	JLog				√						
	jlisa	JLisa				√						
	ofbiz.apache.org	OFBiz				√						
	Cycorp	OpenCyc				√				√		
	OpenExpert.org	OpenExpert							√			
	opent-tablets.org	OpenL Tablets				√						
	SemWebCentral	Smart Rules				√						
	tyruba	TyRuBa				√						
Earlier existing systems But currently withdrawn	Computer Associates	Aion	√		√							
	drools.com	DTRules				√						
	jena.apache.org	Jena2				√						
	Stanford Univ.	JTP				√						
	mandarax.source forge.net	Mandarax				√						
	Pega Systems	PegaRules				√						
	Link Removed	Pellet					√					
	pyke.sourceforge.net	PyKE							√			
	mcrcm.cs.cmu.edu	ROWL					√					
	CDAC.in	Vidwan				√						

III. DESCRIPTION OF EXAMPLE EXPERT SYSTEM BUILDING TOOLS

A. *About the tools*

Following two tools are taken as the representatives of the class of generation tools of Expert System for Medicinal Prescription. The selection is made using the criteria that they belong to two different classification groups: free for non – commercial use and open source but for commercial use.

B. *Oracle Policy Modeling (OPM)*

Oracle Policy Modeling is a freeware desktop application that is used to develop interactive web based interviews, online forms, complex policies and legislation. To generate these rules the statements that are written in simple English, Chinese and Japanese language in Microsoft Word or Excel are required. To write rules, a person should have little knowledge of rules writing.

Policy Automation Hub showed in figure 3.1 describes that OPM is the one of the component of it, and channelized with other Oracle Policy Automation components. With the help of Policy Modelling user can design interview by designing screens, to design screen user need to first write rules either in Microsoft Word or in Excel.

Fig 3.1 Architecture of Policy Automation Hub
[Source adapted from [2]]

After, the interview generation is over, it can be deployed on the Hub, by running Java application server, Tomcat in background.

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C. *OpenRules Dialog (ORD)*

OpenRules Dialog (ORD) is developed by OpenRules, Inc. It is an open source software product that is built on Business Rules Management System "OpenRules". It allows a layman to develop a web-based questionnaire that is also called as Dialog. There is no need of having knowledge of different web programming techniques, the little knowledge of Excel is enough to develop Dialogs. These Dialogs can be developed by using layouts of pages, sections, questions in a very simplified way in Excel tables [3].

The architecture of OpenRules-based web applications shows lots of components incorporated in it, but the example case which is explained in Section 4 used Rule Forms type of Web applications, which is also known as business and presentation logic. Where in user need not be expert in different Web development techniques. By simply using Excel interface, user can define his/her own business logic in the form of Excel-based business rules. Then, user can define his presentation logic using Excel-based web forms. Once this presentation oriented Web application is deployed, then this Web application will invoke the related rule service whenever it is required [3].

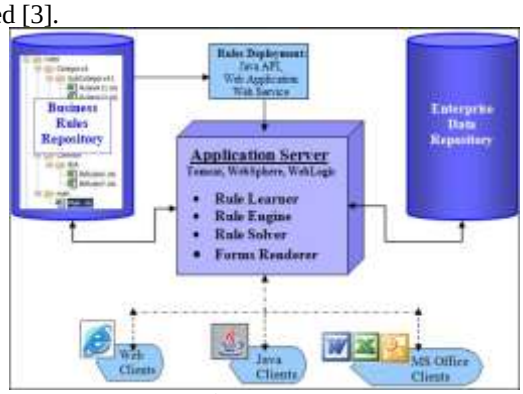

Fig. 3.2 Architecture of OpenRules-based web applications
[Source adapted from [3]]

User can define complex relationships between fields that are mentioned within web pages as well as between different web pages. User can also change the content of the form and the sequence of presentation dynamically. Here, also Java application server Tomcat is used for deployment of Web applications [3].

IV. PARAMETERS FOR THE ASSESSMENT OF TOOLS

A. *Knowledge Acquisition*

To capture the knowledge from human experts, the Tools for building ES uses some frame work.

Here, Tool1 [OPM] used	Whereas Tool2 [Open Rules] used
• Word Document – for writing Rules • Excel Sheets- For Writing Rule tables	• Excel sheets –To generate Layouts of pages and complex relationships between them using Excel Tables

B. *Knowledge Representation Scheme*

Here, Tool1 [OPM] used	Whereas Tool2 [Open Rules] used
• To develop Web based Questionnaire.	• Rules Dialog – To create Web Based Questionnaire • Stand Alone Applications - To create applications also.

C. *Interface*

Here, we need to write Rule first then Data type is generated and then we can use them to create questionnaire.	Whereas Tool2 [Open Rules] uses separate Excel sheet for maintaining hierarchy of Page layout. i.e. Page, Section and then questions.

D. *Knowledge Base Repository*

A KB Repository is nothing but DB Repository

Tool1 stores the knowledge in intermediate XML file formats and DB.	Whereas Tool2 [Open Rules] physically stores all knowledge in Excel sheet or XML files.

E. *Rules Representation*

In Tool1 user needs to write Rule, Like : Treatment is M1 if The Symptom is S1 and The Symptom is S2 and The patient is child	Whereas Tool2 [Open Rules] user need not write rules but he has to provide layout and complex relationships between them, the inference engine will itself interpret.

F. *Rule Engine*

In Tool1 rule engine is based on Patented linear inferencing algorithm. Which is faster than Rete algorithm	Whereas Tool2 [Open Rules] rule engine is based on Rete Algorithm.

G. *Rules Optimization*

Tool1 tells bout Shortcut Rules.	Whereas Tool2 [Open Rules's] one of the best optimization service is Rule Compression.

H. *Programming Techniques*

Both are Java Based.

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I. Support

TOOL1 GIVES:	***TOOL2 GIVES:***
• ***ORACLE PREMIER SUPPORT*** • My Oracle Support • Oracle Advanced Customer Support	• ***EMAIL SUPPORT*** • ***ANNUAL SUPPORT*** • ***LIVE ASSIST - FAST SUPPORT SERVICE***

J. Simplicity

In Tool1 user must have the knowledge of writing Rules.	Whereas Tool2 [Open Rules] A lay man can develop and maintain web-based questionnaires (dialogs) using only Excel.

V. FEATURES REQUIRED BY MEDICINAL PRESCRIPTION ES

To design a Medicinal Prescription ES (MPS), essential features of ES are studied in detail and using design and creation research methodology the appropriate expert system building tools are identified.

Characteristics of the Expert Systems are, it should exhibit the intelligent behaviour, explain the reasoning, draw the conclusions from the relationships that are very complex in the nature, provide the much-needed portable knowledge, deal with certainty and predict the results.

A. Attainable characteristics of a Medicinal Prescription System

The attainable characteristics are achieved through well-defined relationships between the interfaces as per sequence /order of their requirement. The built-in features clearly explain why a particular WHO Staging is assigned or why a particular medicine is prescribed. Besides, it also prescribes proper medication, store patient wise records, assign & define proper confidence variable, and provide advice.

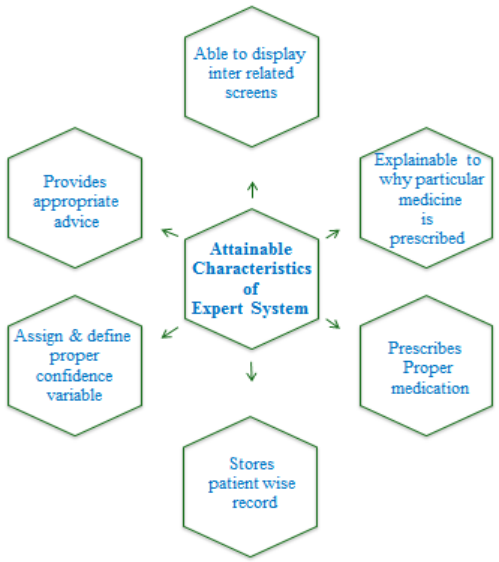

Fig. 5.1 Attainable Characteristics of MPS

B. Mapping between known characteristics and Attainable characteristics of ES

A detailed study of working and flow of different ES building tools, the one to one correspondence between the standard characteristics of any ES and attainable characteristics of MPS is determined as presented in fig 5.2

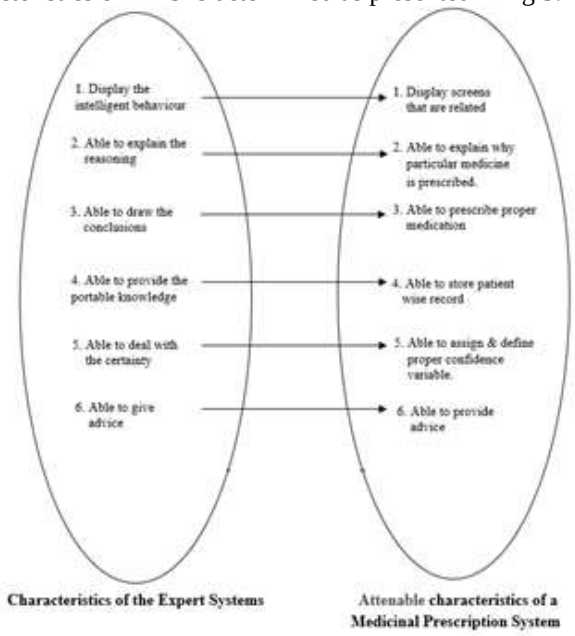

Fig. 5.2 Mapping b/w characteristics of ES & attainable characteristics

C. Attainable characteristics satisfied by two tools

Following table 5.1 describes that which are the attainable characteristics are satisfied by OPM and ORD ES building tools.

Table 5.1. Attainable characteristics satisfied by two different ES building tools

S.No.	Attainable Characteristics	OPM	ORD
1	Able to Display screens that are related	✓	✓
2	Able to explain why particular medicine is prescribed	✓	✘
3	Able to prescribe proper medication	✓	✘
4	Able to store patient wise record	✘	✓
5	Able to assign & define proper confidence variable	✘	✘
6	Able to provide advice	✓	✘

According to above table 5.1 OPM satisfies 4/6 characteristics, whereas ORD satisfies only 2/6 characteristics. So, the choice of OPM is more beneficial then ORD.

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VI. EXAMPLE CASES AND THEIR OUT COMES

A. *Rules written in Oracle Policy Modeling (OPM)*

1) Simple Rules: Following figure shows that the patient is suffering from Symptom1 and Symptom4:

Fig. 6.1 User Input Screen1

Rules that are running behind this screen are:

The Treatment is Tr1 if
Symptom1
The Treatment is Tr2 if
Symptom2
The Treatment is Tr3 if
Symptom3
The Treatment is Tr4 if
Symptom4
The Treatment is Tr5 if
Symptom5
The Treatment is Tr6 if
Symptom6

Based on these rules, OPM will generate following (figure 6.2) screen:

Fig. 6.2 Prescription according to the symptom1 & 4

2) Complex Rules Type1: Once, the patient clicks on "Next" button of figure 5.1, following screen will be displayed (figure 5.3), where in patient can select the symptoms, that falls under cases, mentioned in Case1 and Case2

.

Fig. 6.3 User Input Screen2

After clicking "Next" button, the system will show:

Fig. 6.4 Prescription according to the symptom1 & 3

Case 1: For some symptoms medicines are common

So, system must not show the same medicine again, and again- While choosing S1 and S3 sys is not showing M8 twice.

Rule:
Treatment is M8 if
The Symptom is S1 and
The Symptom is S3

Since the medicine is same then system must show higher dosage- While choosing S1 and S3 system is showing higher dosage.

Rule:
Dosage is 2t3 if
Treatment is M8 and
The Symptom is S3

3) Complex Rules Type2: Now, in Stage 2, if patient is suffering from symptom S1 and S2 then system screen will be:

Fig. 6.5 User Input Screen2

After clicking "Next" button, the system will show:

Fig. 6.6 Prescription according to the symptom1 & 2

Rules behind, this screen (Fig. 6.6) is of Case2:

Case2: For one symptom, there can be multiple medicines-

While choosing S1 and S2 system is showing M7, M9 & M10, since all three medicines are required for symptom S2

Rule:
Treatment is M9 if
Symptom is S2 or
The Symptom is S3 or
The Symptom is S4

Rule:
Treatment is M10 if
The Symptom is S2 or
The Symptom is S4

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For S1 & S2 Medicine M7 is common

Rule:

Treatment is M7 if

The Symptom is S2 and

The Symptom is S1

Rule:

Treatment is M71 if

The Symptom is S2 or

The Symptom is S1

Since the medicine is same then system must show higher dosage- While choosing S1 and S2 system is showing higher dosage.

Rule:

Dosage is 1g3 if

Treatment is M7 or

The symptom is S2

B. Rules written in OpenRules Dialog

OpenRules doesn't give any flexibility to write complex rules. If the logic mentioned in section V complex rules Type1 and complex rules Type2 is applied in OpenRules, It makes the inferencing logic complex. That is the reason the researcher has mentioned " If a particular medicine is prescribed for two or more symptoms, then take Higher dosage as well as continue it for Longer Period. [Among 250mg, 2-0-2, 2-2-2 is the Highest Dosage]" at the bottom of the "Medicinal Advice" screen.

Therefore, there is no segregation for simple and complex rules, output shown in figure 6.7 and figure 6.8 respectively.

Fig. 6.7 Oputput for simple rules

Fig. 6.8 Oputput for complex rules

Since, OpenRules not liberate to apply complex logic, the researcher made basic changes while taking input from patients, figure 6.9 shows input screen for simple rules whereas figure 6.10 shows for complex rules.

Fig. 6.9 Input for simple rules

Fig. 6.10 Input for complex rules

To generate the prescription or medicinal advice, researcher has prepared different Excel sheets in one Excel book, out of those four mainly required sheets are shown. For taking input from user Questions sheet (figure 6.11) is prepared.

Fig. 6.11 Question Sheet

To generate the output screens, developer needs to create Section sheet (figure 6.12) that will hold questions in a proper format.

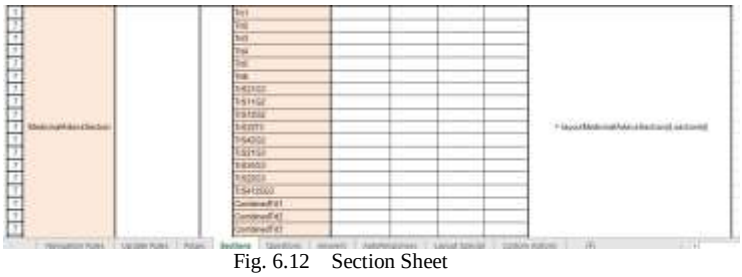

Fig. 6.12 Section Sheet

Now, these sections are aligned in Page Sheet (Figure 6.13)

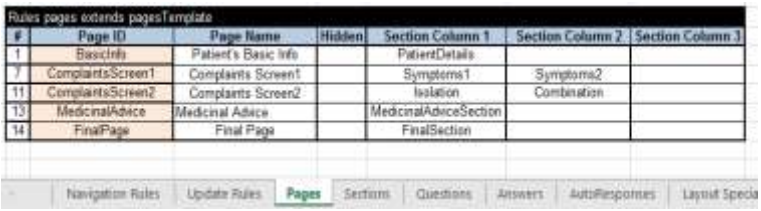

Fig. 6.13 Update Rules Sheet

Finally, to display the Medicines according to the symptoms Update Rules Sheet (figure 6.14) is prepared.

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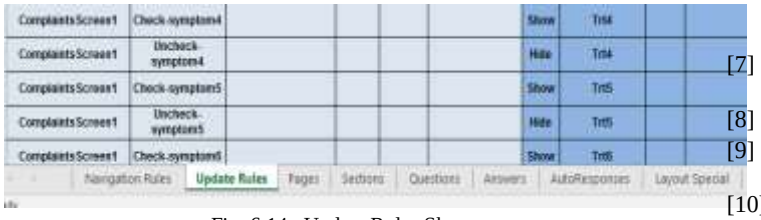

Fig. 6.14 Update Rules Sheet

VII. FINDINGS AND CONCLUSION

On Comparison, the following observations are made:

Table 7.1 Findings based on comparison

Sno	Criteria	OPM	OpenRules
1.	Classification Group	Free for non-commercial use	Open source but commercial
2.	Language Support	JAVA	JAVA
3.	Interface	Easy but requires little knowledge of specialized way of formulating the rules.	Easy but user must have the knowledge of Excel.
4.	Generation of rules	Easy to write	Easy to write
5.	Simple Rules writing & handling	Easy to write	Easy to write
6.	Complex Rules writing & handling	Easy to write	Difficult to write
7.	Facilities provided	Controls (text fields & buttons) can be drawn using drag & drop facility	Controls are drawn based on specifications given in Excel sheet.

This paper can act as guide to choose the correct Expert System building tool. The developers, who are planning to design their expert system in any domain, by looking at example classifications and comparisons made in this paper.

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