INTEGRATING DEXI EVALUATION MODELS INTO DECISION DECK d2 SOFTWARE

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ABSTRACT

DEXi is an educational Multi Criteria Decision Aid (MCDA) computer program aimed at interactive development of qualitative multi-criteria and hierarchical decision models and the evaluation of options. The Decision Desktop software, or d2 for short, is one of the software modules being developed in the Decision Deck project. It is a desktop, client/server application which has integrated several MCDA methods in order to improve the interaction and compatibility between different MCDA methods. In this paper we present our proposal to integrate qualitative DEXi decision models into d2 as a plugin.

1 INTRODUCTION

Multi-criteria (or multi-attribute) decision aiding (MCDA), also termed multi-criteria decision analysis and multi-criteria decision making (MCDM), is a discipline which aims at supporting decision makers who are faced with making numerous and conflicting evaluations [1]. Many different MCDA methods have been developed and implemented [2], but these software programs were developed in an uncoordinated way: they have very different operational requirements, they use different and incompatible representations of data and decision models, and are, consequently, very difficult to integrate.

Decision Deck is an initiative to implement functionalities of a large range of MCDA methods within a common Open Source platform [4]. In particular, it provides a component, called d2, which facilitates a unified implementation of different MCDA methods. d2 is a desktop, client/server application, meaning that it is designed to be installed locally (it is not a web application), and uses a database to store application data, thereby enabling multiple users.

DEXi [3] is a stand-alone computer program for multi-attribute decision making. It facilitates interactive development of qualitative multi-attribute and hierarchical decision models, and the evaluation of options. DEXi has been used in many real-life decision problems in the areas such as selection and evaluation of computer hardware and software, evaluation of companies and business partners, personnel management, project evaluation, land-use planning, risk assessment in medicine and health-care.

DEXi falls in a broad category of MCDA methods and is therefore a good candidate for the integration in the Decision Deck platform. In this paper we propose a way to integrate DEXi into d2 and present the current implementation.

The structure of this article is as follows. In section 2, we first present the tools we used: DEXi, Decision Deck and d2. In section 3, which is the main part of the paper, we present the methods of integrating DEXi models into d2. Section 4 illustrates the current implementation of the DEXi plugin through an example of car evaluation. Section 5 concludes the paper and suggests further work on DEXi integration into Decision Deck.

2 MCDA METHODS AND TOOLS

In this section, we introduce the multi-criteria decision making methods which were used in this work: (1) DEXi as a method that is being integrated into Decision Deck, (2) Decision Deck platform in general, and specifically (3) its d2 component.

2.1 DEXi

DEXi [3] is a MCDA computer program which differs from most conventional MCDA tools in that it uses qualitative (symbolic) attributes instead of quantitative (numeric) ones. Also, aggregation (utility) functions in DEXi are defined by ‘if-then’ decision rules rather numerically by weights or some other kind of formula. Consequently, a DEXi model includes the following four components:

- attributes: qualitative variables that represent decision sub-problems;
- scales: ordered or unordered sets of symbolic values that can be assigned to attributes;
- tree of attributes: a hierarchical structure representing the decomposition of the decision problem;
- utility functions: rules that define the aggregation of attributes from bottom to the top of the tree of attributes.

Bellow is an example of a simple DEXi multi-attribute model for the evaluation of cars taken from DEXi user’s

manual [3]. Figure 1 shows the hierarchical attribute tree, Figure 2 shows the scales of all the attributes, and Figure 3 shows the utility function of attribute CAR in this model.

Attribute	Description
CAR	Quality of a car
├**PRICE**	Price of a car
│ ├BUY.PRICE	Buying price
│ └MAINT.PRICE	Maintenance price
└**TECH.CHAR.**	Technical characteristics
├**COMFORT**	Comfort
│ ├#PERS	Maximum number of passengers
│ ├#DOORS	Number of doors
│ └LUGGAGE	Size of the luggage boot
└SAFETY	Car's safety

Figure 1: *Hierarchical attribute tree of car evaluation.*

Attribute	Scale
CAR	unacc; acc; good; *exc*
├**PRICE**	high; medium; *low*
│ ├BUY.PRICE	high; medium; *low*
│ └MAINT.PRICE	high; medium; *low*
└**TECH.CHAR.**	bad; acc; good; *exc*
├**COMFORT**	small; medium; *high*
│ ├#PERS	to_2; 3-4; *more*
│ ├#DOORS	2; 3; 4; *more*
│ └LUGGAGE	small; medium; *big*
└SAFETY	small; medium; *high*

Figure 2: *Attribute scales in the car evaluation model.*

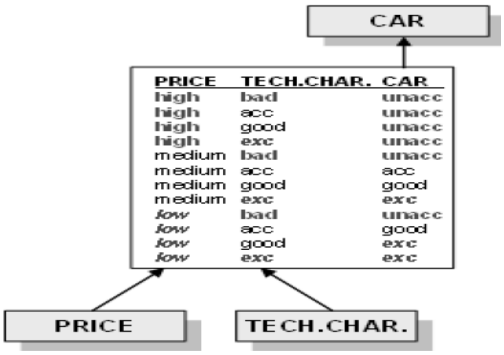

Figure 3: *Utility function of attribute car.*

In the stage of evaluation and analysis of decision options, DEXi facilitates [3]: description of options, evaluation of options, analysis of options and reporting. The analysis of options includes 'what-if' analysis, 'plus-minus-1' analysis, selective explanation and comparison of options.
DEXi models, which are created and/or edited in DEXi, are stored in DEXi ('.dxi') files. The basic format of '.dxi' files is XML (eXtensible Markup Language) [6].

2.2 Decision Deck

Decision Deck [4] is a platform for implementing various MCDA methods. Decision Deck provides several software modules (d2, d3, Diviz, XMDCA), which offer a common framework for MCDA methods. The emphasis is on developing multiple software resources that are able to interact. Consequently, several complementary efforts focusing on different aspects contribute to Decision Decks various goals [4]:

- d2: a rich open source Java software containing several MCDA methods;
- d3: an open source rich internet application for XMCDA web services management;
- diviz: an open source Java client and server for designing, executing and sharing MCDA methods, via the composition of XMCDA web services;
- XMCDA: a standardised XML recommendation to represent objects and data structures issued from the field of MCDA. Its main objective is to allow different MCDA algorithms to interact and be easily callable;
- XMCDA web services: distributed open source computational MCDA resources, using the XMCDA standard.

2.3 d2

d2 [4] was the first software to be developed in the Decision Deck project. It is rich open source Java software containing several MCDA methods as plugins, e.g. Iris, Rubis, Vip, and Weighted Sum. However, all of them are quantitative MCDA methods, dealing only with linear utility aggregation. Figure 4 shows a screenshot of d2 which includes two methods Iris and Weighted Sum. In the left column, there is a Navigation for different MCDA methods. Under the menu Global Settings, users can assign the Alternatives and Criteria, and under the Evaluations menu, users can enter specific values of each Alternative for the corresponding criterion. The right part of the figure shows the results of scoring of some decision alternatives (a1–a7 and P1–P3) using the method Weighted Sum.

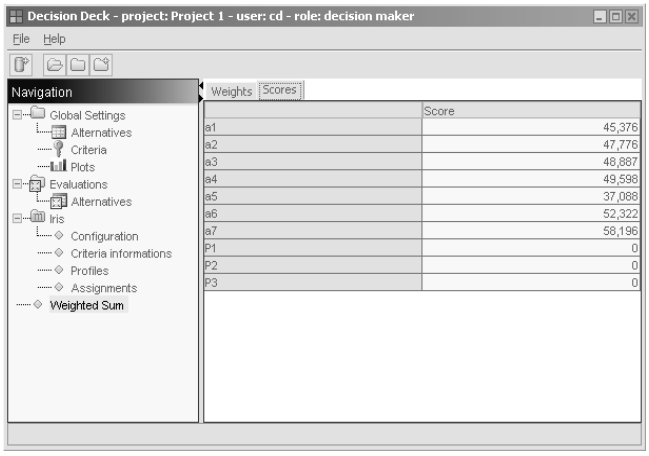

Figure 4: *Screenshot of d2.*

3 DEVELOPING DEXi PLUGIN

In this section, we present our implementation of the DEXi plugin in d2 software. First we introduce the mechanism of the d2 plugin; then we explain the methods we used when developing the plugin; finally, we demonstrate and discuss the results of our work.

3.1 OSGI

A d2 plugin is nothing more than an OSGI bundle [4]. An OSGI bundle is a package that encapsulates classes, resources, native files, etc. It can do nothing alone and is intended to be deployed inside an OSGI environment. It is a framework that enables service oriented platforms. It provides a number of infrastructure services (it takes care of bundle isolation, integrates bundle versioning, deals with security concerns, etc.) and allows to dynamically plug and unplug services (e.g., a MCDA computation service).
A typical d2 plugin usually contributes to the user interface (UI) and refines the common model provided by d2. It is usually composed of the following layers :

- model layer;
- data access layer;
- service layer;
- UI layer.

3.2 Methods

d2 is known to work against these versions of software: Eclipse 3.3.1.1, Java 5+ and MySQL 5. For developing the DEXi plugin in d2, we employed the following methods:

- Technology framework: Swing + Hibernate. Java Swing has been used to design the interface, Hibernate and MySQL have been used to handle with data;
- MVC: Model, View and Controller three layers have been developed to carry out the basic DEXi functionalities in d2 by using Java.

3.3 DEXi Plugin

So far the d2 software focused on dealing with linear MCDA methods rather than hierarchical models. DEXi, on the other hand, is based on hierarchical models, and the current version of d2 was not powerful enough to handle DEXi tree-structured models. Therefore, during the process of DEXi plugin designing, we designed the model, data access, service and UI layers only for the DEXi plugin, rather than modeling through the Alternatives and Criteria functions under Global Settings in d2. This to some extent reduces the interactivity and compatibility between the DEXi plugin and the other MCDA methods, but appears to be the only solution in the current d2 framework.
Figure 5 shows the DEXi plugin in d2. In the left column, there is a navigation menu of different MCDA methods which have been integrated into d2, here we added the DEXi icon together with three sub-menus: Model, Options and Evaluation, which implement the basic functionalities of DEXi:

- *Model*: When the Model sub-menu is selected, the main plugin window (Figure 5, center) displays the current hierarchical DEXi model. The user can edit the model. In the rightmost column, the user can edit attribute scales (Scale) and decision rules (Utility Function) that corresponds to the currently selected attribute from the model.
- *Options*: When the Options sub-menu is selected, the corresponding right window shows a table where the user can define and edit different decision options (see section 4.2 for an example).
- *Evaluation*: Here, the right part of the pulgin window displays evaluation result of the options (section 4.3).

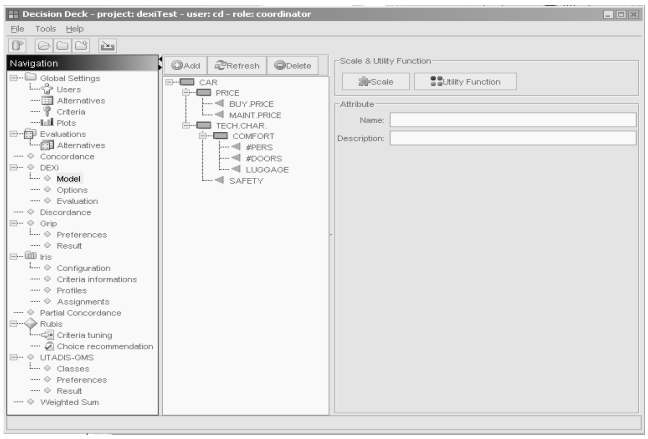

Figure 5: *DEXi plugin in d2.*

3.4 Data Storage

d2 uses MySQL to store the data of MCDA models. This is different from DEXi, which uses an XML format. Therefore, the DEXi plugin could only construct one model at the same time. Figure 6 shows the database VM where data of all d2 methods stored by MySQL. For DEXi plugin, we created 4 tables: dexi_option, dexi_rule, dexi_scale and dexi_treenode to handle with the car evaluation model. Importing the existing models and exporting models are not implemented at the moment. This is somehow a shortcoming of our work, we are planning to solve when the d2 version is upgraded.

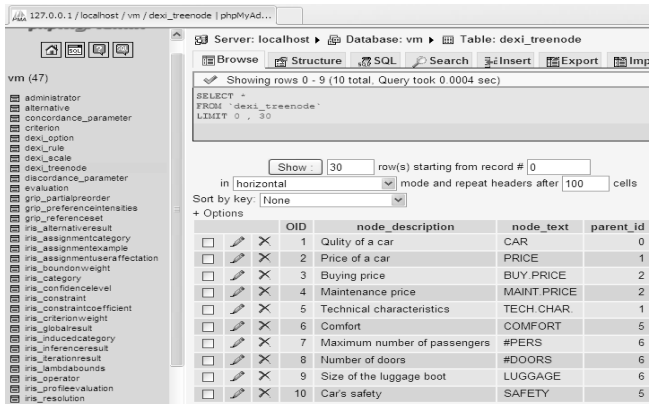

Figure 6: *Data storage in d2.*

4 AN EXAMPLE OF CAR EVALUATION

In order to test the DEXi, we use an example of car evaluation model, introduced in section 2.

4.1 Car Evaluation Model

Figure 7 shows the model of car evaluation, which we used to test the DEXi plugin and illustrate its capabilities. When we click the PRICE attribute, the plugin shows the details of this attribute on the right. By clicking the Scale and Utility Function buttons, the user can edit the scale and utility function of this attribute, respectively.

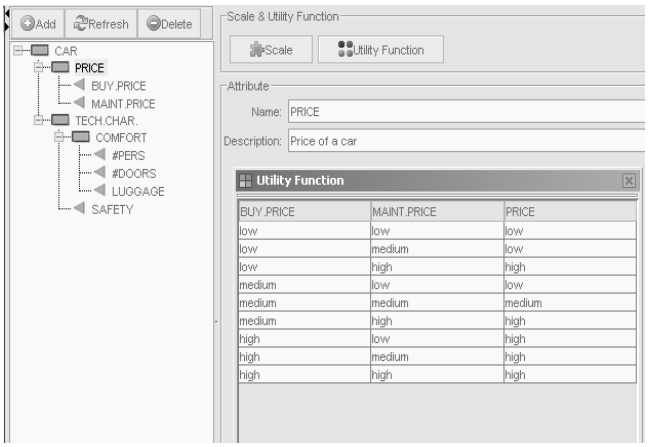

Figure 7: *Model of car evaluation.*

4.2 Options of Car Evaluation Model

Figure 8 shows seven different cars (decision options), represented with different values of attributes. These values were entered by the user under the Options sub-menu.

Option	BUY.PRICE	MAINT.PRICE	#PERS	#DOORS	LUGGAGE	SAFETY
Car1	medium	low	more	4	big	high
Car2	medium	medium	more	4	big	medium
Car3	low	medium	to_2	4	medium	high
Car4	high	medium	more	more	big	medium
Car5	medium	low	more	more	medium	high
Car6	low	medium	more	more	big	high
Car7	medium	medium	3_4	3	medium	medium

Figure 8: *Options of car evaluation model.*

4.3 Evaluation of Car Evaluation Model

In figure 9, the field CAR shows the evaluation results of seven cars. For example, “Car1” is evaluated as “exc” (excellent), because of its “PRICE” is “low”, and “COMFORT” is high; “Car3” is evaluated as “unacc” (unacceptable), because its “PRICE” is “low”, but its “COMFORT” is “small”. These values are determined according to the utility functions defined by the user.

Option	CAR	PRICE	BUY.PRICE	MAINT.PRICE	TECH.CHAR.	COMFORT	#PERS	#DOORS	LUGGAGE	SAFETY
Car1	exc	low	medium	low	exc	high	more	4	big	high
Car2	good	medium	medium	medium	good	high	more	4	big	medium
Car3	unacc	low	low	medium	bad	small	to_2	4	medium	high
Car4	unacc	high	high	medium	good	high	more	more	big	medium
Car5	exc	low	medium	low	exc	high	more	more	medium	high
Car6	exc	low	low	medium	exc	high	more	more	big	high
Car7	acc	medium	medium	medium	acc	medium	3_4	3	medium	medium

Figure 9: *Evaluation of cars.*

5 CONCLUSION

We integrated DEXi qualitative MCDA program into the Decision Desktop platform as a d2 plugin, supporting the basic functionalities. This is the first hierarchical MCDA method that has been integrated into d2. This has shown that the Decision Deck platform, in addition to ‘flat’ quantitative models, can support a qualitative decision making method which deals with the hierarchically structured data. We believe that both d2 and DEXi have benefited from this integration: d2 by being extended by a first hierarchical qualitative MCDA methodology, and DEXi by becoming a member of a widely recognized open source decision-support software platform.

The current implementation of DEXi plugin has some shortcomings. As the current version of d2 focuses on linear MCDA methods, the platform does not provide framework to implement hierarchical methods. We had to develop our own framework for the DEXi plugin; this reduces the interaction and compatibility with the other MCDA methods to some extent.

d2 uses MySQL to store the data rather than XML files which DEXi uses, therefore our DEXi plugin could only construct one evaluation model at the same time, meanwhile it could not import and export models. This will be overcome with the upgrading of d2 platform and our subsequent work.

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