Information management of mechatronic systems materials

R. Ben Mosbah, S. Dourlens, A. Ramdane-Cherif, N. Levy, F. Losavio

Abstract: *This paper presents a platform that allows information management in mechatronics systems development process. The main problem focused is the material selection for a spare part of a mechatronic complex system. Within the O2M mechatronics project, a database and its access platform has been developed. This platform aims at understanding the process in which different specialists provide the designer with all the analyses, test and simulations required in order to select the best material. The paper focuses on the search capabilities of the platform.*
Key words: *Mechatronics systems, information management, Material database.*

INTRODUCTION

Scientists always wanted to share information and tools. But they are faced with problems of lack of common vocabulary to communicate, different interests or goals, and heterogeneous tools that must interoperate. Three main research axes appear as a solution to the above problems: Information sharing, integration frameworks and global methodologies to design mechatronic systems. Information sharing appears to be essential to face these challenges [1]. Integration frameworks or platforms offer tools interoperability [2]. These solutions are data oriented, i.e. the important things to share are the data and the process is data oriented. But when scientific cooperate; the followed process is as important as the data. Other approaches consider the stakeholders view and process oriented approaches, using for example SysML [3] or [4], integration framework using an agent-based architecture and a global process model expressed in SysML. Other works offer a methodology with support tools such as ontology [5], [6].

In the context of the O2M project, different specialists cooperate to provide an automotive mechatronic systems designer with all the analyses, test and simulations required in order to select a material for such a system. Our objective was to provide our O2M partners with a database allowing them to share their knowledge on systems. To do so, we started modelling the existing process integrating all stakeholders' interactions and terminology. From this process we derived the structure of the database that received a general agreement among the teams because they recognize their work in the process and the data they needed in the database.

This paper presents the platform developed that allows information management in mechatronics systems development process. Mechatronics has this special feature to bring specialists from different fields to cooperate to complete a project. Mechanical engineers, electronic engineers, controls engineers computer engineers have to join their expertises to create new mechatronic products. However, inefficient communication between the engineers becomes one of the main problems [7]. Interactions among stakeholders become more complex. Managing this complexity can prove challenging to engineering teams who define requirements, find new solutions, test and implement their ideas. This is one of the objectives of the O2M mechatronics project.

In the context of the O2M project, we had to define a way to help a designer to choose the material for a mechatronic system in the automotive domain. Such an engineer uses results of many tests and simulations in order to reinforce his decision. Specialists of different fields make these tests and simulations. The designer must be sure of the behaviour of the chosen material under the conditions it will be used: temperature, vibrations,… Properties concern its hardness, its conductivity, etc…

The important thing is to be able to capitalize experiences, which is very difficult in general. In the special case of mechatronics, it is even more difficult, because the experiences come from different fields and the designer must be able to synthesize all of them. In order to provide the designer with some help, the idea has been to define a common database where every specialist would be able to store his knowledge.

This paper describes the four steps of the communication platform development process:

1. Understand the process in which different specialists cooperate to provide the designer with all the analyses he requires
2. Develop the database itself using PostgreSQL[1] [8]
3. Make it usable so users can feel comfortable with it, use it, and fill it!
4. Propose querying procedures adequate for all users: those who know what they are looking for and those who don't know

The last step, not done yet, will be to deduce from the data stored in the database new solutions, using data mining techniques; however this requires first to have many information to deduce from.

In this paper we will describe the above four steps. The multidisciplinary process is described in section 2. Section 3 presents the database called BaDoI. The defined platform and its search engine are described in section 4. Finally, section 5 presents the conclusion and perspectives.

A multidisciplinary process

The designer models spare parts; he needs many test results and simulations to be able to choose the adequate materials; the local material database is used to check properties of raw materials. Tests are performed on tubes taken from a manufactured spare part. It is important to use exactly the same material as the one in the spare parts, because when manufacturing it the material is wrought, extruded, casted, annealed, machined, etc., and its properties change. It can also be mixed with other materials. The test engineer also needs classical information on materials and may consult his own database. The specimens are subjected to harsh tests: stretched, heated, crushed, etc. The results are then both used by the designer and by the simulation engineer. This engineer needs to identify the behavioural law parameters before being able to perform any simulation; behavioural laws are also in a separate database. Simulation results will be given to the designer who will validate his material choice. The process ends when the designer gives the validated spare part model to the project manager (figure 1).

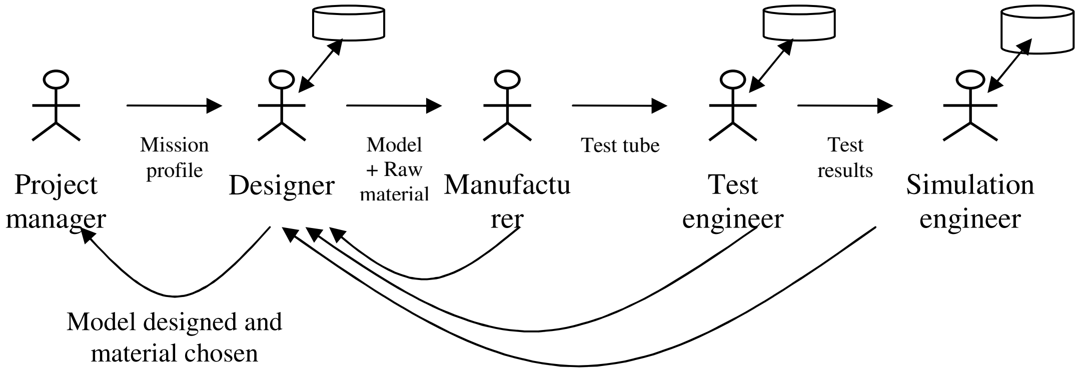

Figure 1: Material selection process with local databases

[1] http://www.postgresql.org/

BaDoI: the developed Data Base

To facilitate the above process of material selection for manufacturing spare parts, the BaDoI database is structured in four main parts, according to the multidisciplinary work teams involved: Materials, Spare parts, Tests and Behavioural laws. All the results obtained by the different stakeholders are now stored in the BaDoI database and can be retrieved accordingly (figure 3). They can be easily updated and reused via exchangeable CSV files, becoming software assets for the mechatronic domain.

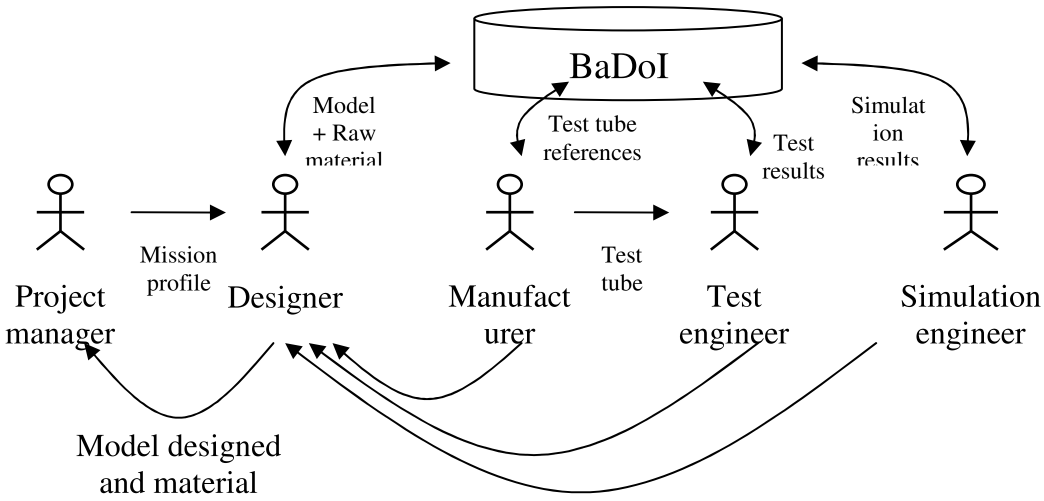

Figure 2: Material selection process with BaDoI

BaDoI: A friendly platform with a search engine

We choose 3-tier SOA architecture for our platform. The Web Server part contains the Website client. This web server is connected to a web service to ask the database server using soap secured protocol and a user/password authentication (figure 3).

This platform provides a uniform query interface to data concerning several specialities, thereby freeing the user from the tedious task of looking manually for the necessary data from the individual sources. The platform then executes the queries and combines the data returned from the database, to produce the desired answers to the user.

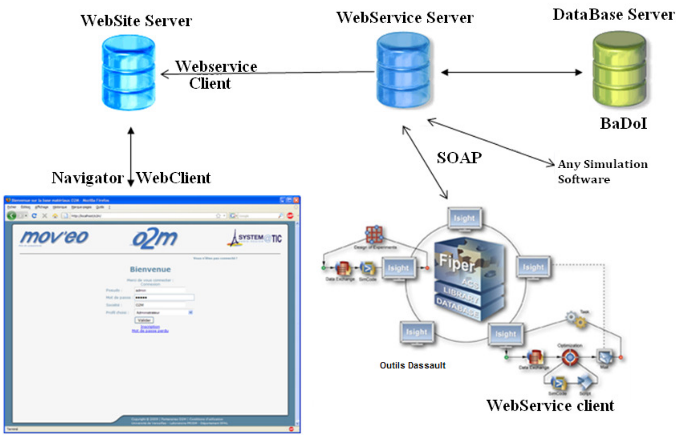

Figure 3: the platform architecture

Looking for information knowing it is in the data base: the guided search

If the user is a specialist and knows what he is looking for, a guided search is proposed in the form of 12 predefined results tables. The menu on the left of the screenshot in figure 4 shows these different possibilities. The search is based on an indexation table.

Figure 4: Result table example of the guided search

Looking for information without knowing exactly: the keywords search

If the user has no experience, he can use a Google style search by keywords (figure 5).

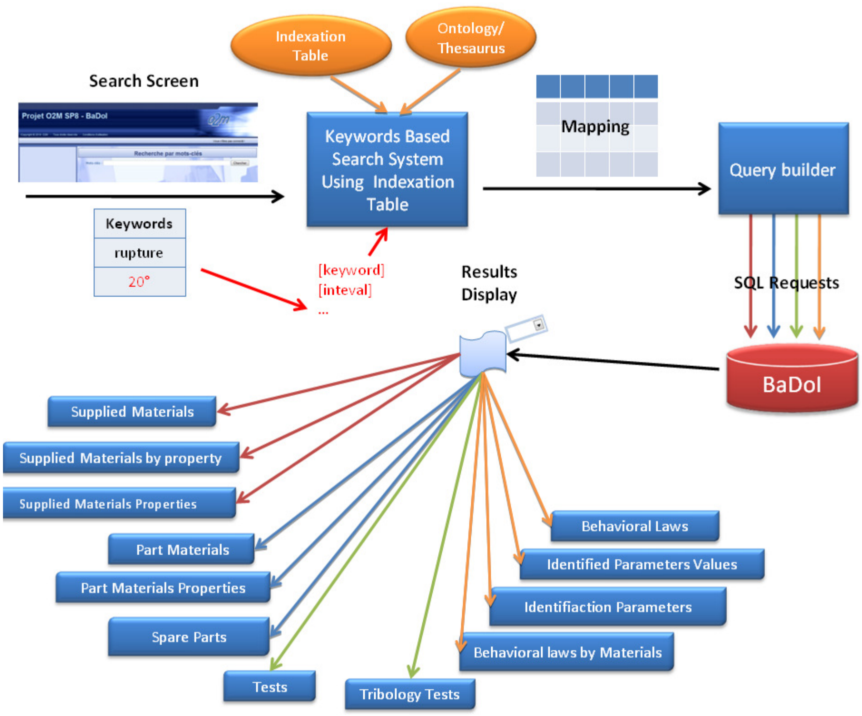

Figure 5: The keywords search process

We distinguished two types of keywords search, direct and approximative.

1. The **direct search** consists in searching the keyword in the indexation table prebuilt in the indexation phase. Indexation aims at constructing a reference table that contains the mapping between the different values, tables, fields and indexes of the

BaDoI data base. It allows also to make a link between those values and their suitable PostgreSQL stored procedures which engenders the 12 result tables. The direct search gives results only if the keyword(s) is a value or a substring of a value in the indexation table.

2. The **approximative search** offers a second chance to the user to get a satisfying result if the keyword(s) he's looking for is/are not in the indexation table. The causes may be :
   a. The user knows the word phonetically or approximatively; in this case, we have a **fuzzy search**. Technically, we use postgreSQL functions from the *fuzzystrmatch* package. The "difference" function converts two strings to their soundex code (a 4-characters code for phonetic representation) and returns the number of matching code positions. This number varies from 0 (no similarities) to 4 (perfect match). The "levenshtein" function measures the similarities between two strings. This measure is defined as the minimum number of edits needed to transform one string into the other, with the allowable edit operations being insertion, deletion, or substitution of a single character. This number varies from the difference of the sizes of the two strings to the length of the longer string, zero means that the strings are identical.
   b. The user knows the word by one of its synonyms or by its semantic root; in this case we have **full text search.** We used a thesaurus for the synonyms and added a field in the indexation table to map the values and their synonyms. We also added a field with the semantic roots of all values with their synonyms.

The results undertaken from the fuzzy and the full text search (list of values in Indexation) will be the inputs of the direct search, i.e. they will be considered as the new keywords.

CONCLUSIONS AND FUTURE WORK

In this paper we presented the search part of our solution for the O2M multidisciplinary project. After building the centralized shared database, filling it, validating its data, we proposed a solution to retrieve the mechatronics knowledge. First, we developed a guided search interface reserved for the people who know exactly what they are looking for. Second, we developed a google-like interface for keywords search. In this part, we treated the cases whether the keyword exists in the database or not. In this last case, we used functions that treat issues like when the user makes typos, knows the keyword phonetically, approximatively, by one of its synonyms or its semantic root. The system we presented if fully functional and used by our partners in the project.As a future work, we plan to develop a higher layer to extract knowledge from the raw data. In this purpose, we'll use data mining algorithms to analyse the database content to deduce how material will react based on properties of another one for example. Furthermore, we'll develop a recommendation system based on semantic rules.

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