Web Service Platform for Engineering Design Optimization of a Mechatronic Multi-parts Component

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Abstract: *This paper presents a new platform integrating expert knowledge and different software products in an optimization loop, to optimize the design of mechatronic components in the project lifecycle management (PLM). These components are part of an automotive product and they contain different parts constituted by different materials. All providers of the automotive market use these components. The O2M two-years project involving different partners developed the platform, which has been tested in an industrial environment and now available on line. The platform allows to store, retrieve and share all the information about the design process of mechatronic components and optimize the PLM.*
Keywords: *Technologies, Webservice, Mechatronic platform, Engineering Design Optimization.*

INTRODUCTION

These last years, the production of the global car fleet changed as a response to the problems of reduction of the pollution and the increase in the oil price. This produced upheavals on several levels: technological, scientific and in the management of the trades of the company. To be increasingly more competitive in the race with the electric car, the small and large companies of the car market must pay attention to all these challenges and changes. This article presents the optimization process to build valuable components for cars and how suppliers can manage to satisfy the car manufacturers. Different kinds of business are involved: software editors, engineers of optimal calculation, graphic simulation and material engineers. Optimization is ~~a~~ part of operation research domain and can be done on various 1D or 3D models, according to multiple functional and non-functional criteria (size, cost, performance, security, main material in the component, noise of vibrations) and in various physics (mechanics, electric, electromagnetic, acoustic, and so on). Some calculus may take several days. All these points arise serious problems, in particular experts do not speak the same language, do not use the same words, must exchange data of different software and measurements. Engineering Design Optimization (EDO) [1,2,3,4,5] platforms exist but they are website or they are domain specific (scientific, mathematic calculus, material or methods) [6,7]. Our platform has been designed in a new and unified way. This paper presents a web service platform permitting to:

- Store, retrieve and share goals, references to car component parts, full models and models of parts, mission profiles, results of calculus, optimization criteria and objective functions;

- Manage the complete optimization process loop from problem definition to quality and reliability analysis of results.

Next sections will present our optimization loop on a concrete case study from the O2M project (Research and Development Project Lifecycle Management, R&D PLM) and its implementation in our website and web service platform.

EDO DEFINITION

We have taken an example where a car manufacturer builds a new car and needs a mechatronic component to insert into the car. It gives the specifications to the designers who draw 1D and 3D models of parts of the desired component. Based on his experience, the designer chooses size and material of each part thinking to resistance of material, noise due to acoustic vibrations, size to fit the required space and so on. Our example concerns a little motor (electric part) with two reducers inserted into a back door actuator of a car: gears moving in a tube (mechanic parts) and the door shape. Figure 1 presents parts of the mechatronic component and the optimization problem to solve "open/close the back door". Electronics is on a PCB card, thermal dissipation has been studied (thermic part).

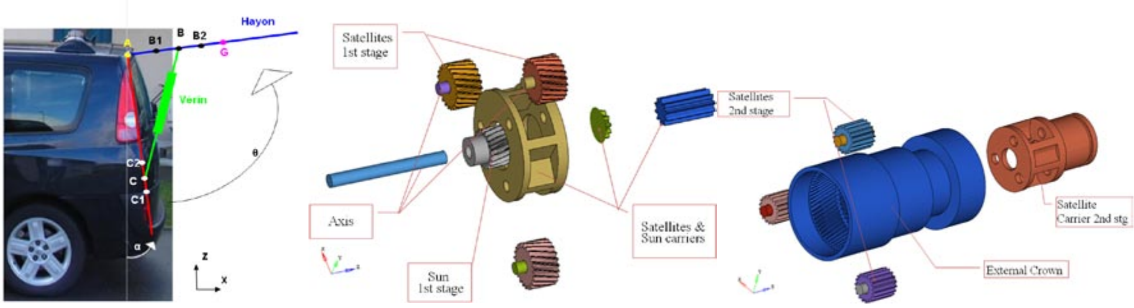

Figure 1 – Mechatronic Multi-parts Component

A second scenario, not complete for this paper, is the electric car engine. The two scenarios are very close in a mechatronic multi-disciplinary domains point of view. The global optimization objectives are to find the best fitting parameters: position of the system, size of the system, noise for human ears, energy consumption and thermal study of component deformation. Our platform must manage people, demands, components, parts of components, models of parts (each part has different material), mission and optimization parameters, results of robust calculus and analysis. Final choices are made by designers using the platform.

EDO LOOP

All requirements are given by manufacturer. EDO loop can now begin. All models are designed by specialists of various scientific and technical domains using their own tools (See figure 2).

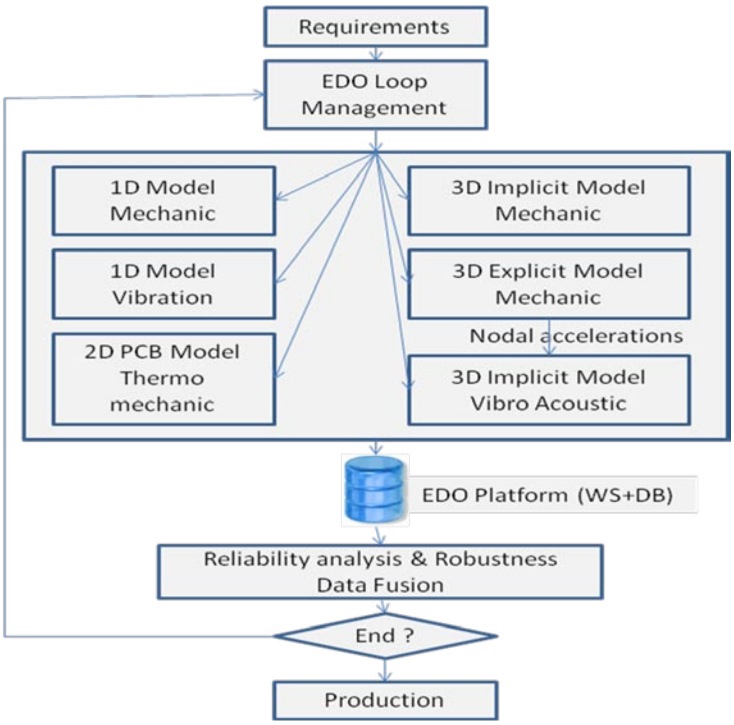

Figure 2 – EDO Loop

All models of components (1D and 3D) are designed with specific software in each field. Some experts may need other results like in the case of building a vibro-acoustic model, the reuse of mechanical model to get nodal accelerations as an example. Once models are finalized and checked, experts in charge of multi-criteria and multiphysics optimization can deploy their optimization algorithms to manage the main loop and adapt parameters. It's a synchronous work because some computation may be very long. When all optimization results are stored in the EDO database using EDO platform, robustness calculus and reliability analysis are realized.

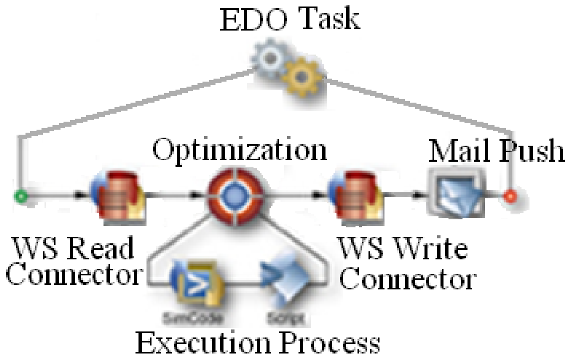

Figure 3 – EDO Loop in an I-Sight workflow

We have also implemented this loop in Dassault I-Sight workflow (Figure 3). I-Sight is a software (FIPER is the server running I-Sight) making it possible to conceive data flows on one or more loops with various levels of overlap of the modules of code: external code, read/write in an Excel file, read/write in a Matlab file, read/write in a database, sending of e-mails or a module intern I-Sight (DOE, optimization,…). We created an I-Sight external module named "WebService Connector" which carries out connection to the database via our web service.

EDO PLATFORM

Figure 4 shows our web service platform designed for EDO. It's a fully open platform with 3 main objectives: data security, software interoperability and respect of standards.

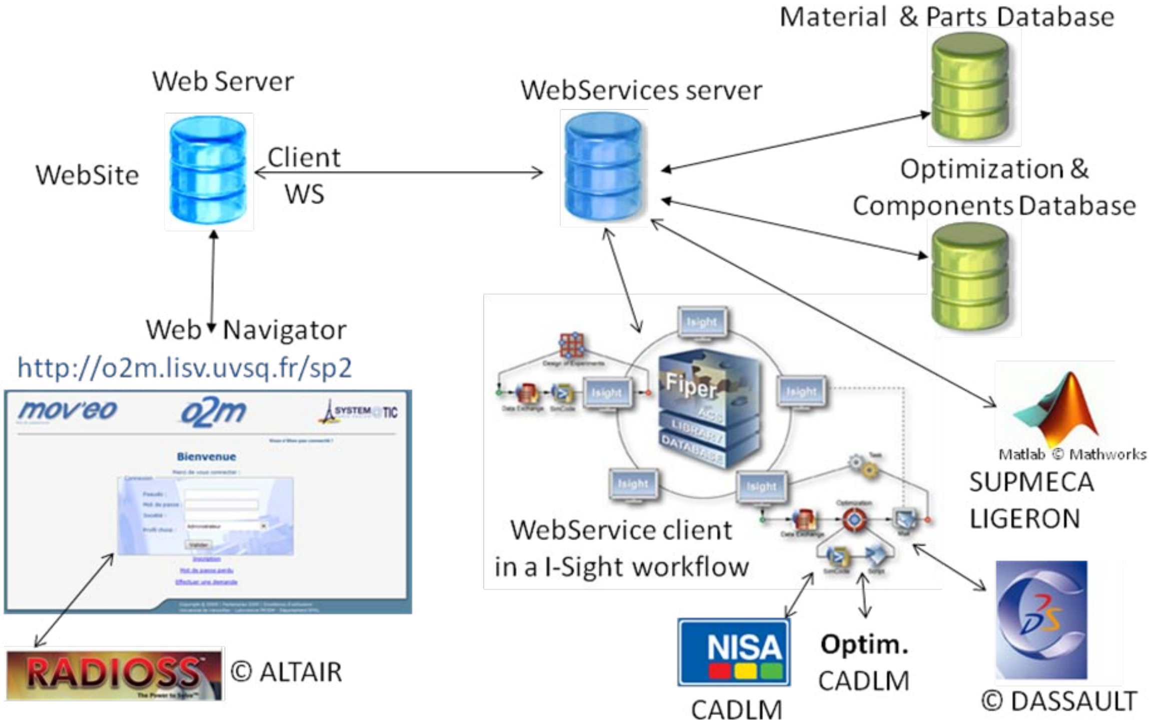

Figure 4 – EDO platform

This architecture permits a direct access to data (post and get information, files of models or files of results) by using a basic website or a web service. Material and Parts Database and Optimization and Components Database (figure 5) are not directly accessible. In figure 4, we added various clients using website or directly connected to our web service. Our web service has been developed respecting W3C recommendation and SOAP [8] protocol included in PHP Scripts and Apache Server running on any operating systems.

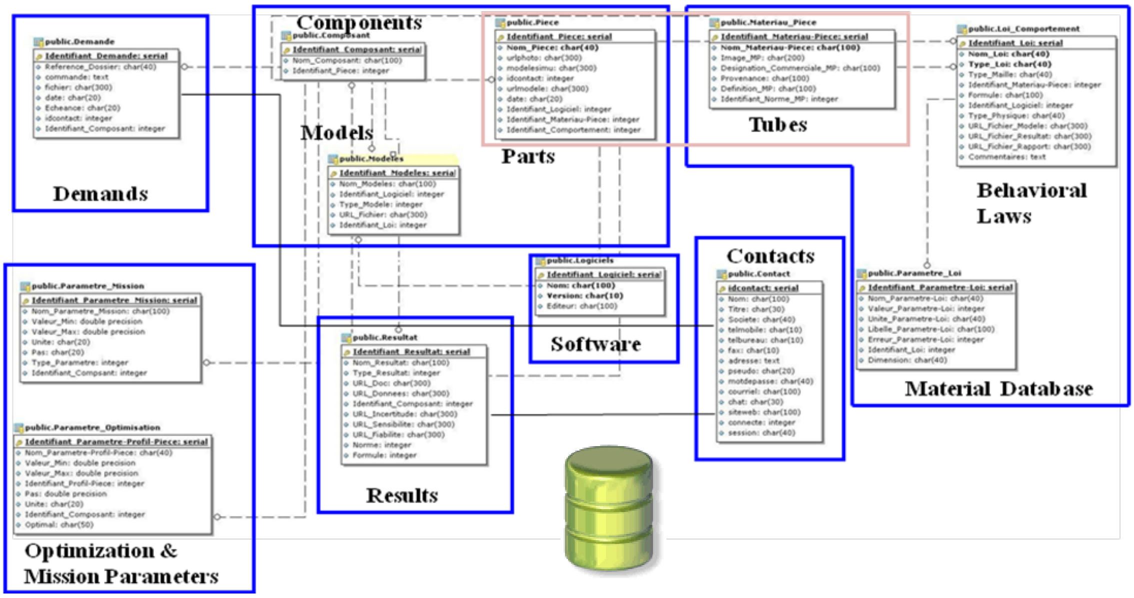

Figure 5 – EDO Database Schema

Web service brings interoperability. Two web service connectors have been implemented: an I-Sight one and a universal one. Universal one is a connection script based on PHP_SOAP module for PHP executable and it can be easily launched by any software used by designers or suppliers. Two main functions are offered by our web service: a *connect()* function to authenticate users and a *executerequest()* function to execute a given request to query or store information in the database.

Data and Security management is managed by the database engine and user profiles. Lots of models and data results are very large so they are kept into files directly stored on our server, or we store URL of external files or private files into the database. The requirement of current standards has also been respected.

Our website and database permit to manage contacts, demands, components, models, parts of components, software, optimization and component's mission parameters and results.

EDO PROCESS RESULTS

Returning to our scenario introduced in the EDO Definition, we present in this section the results of the EDO process. Technical experts use our platform to get and store results. When the main loop can't be fully automatic, i.e. not fully integrated in an I-Sight type of optimization loop, a system of push e-mail notifies them that a result is finished and ready in the base to be exploited. Figures 6 to 9 show results of simulations and calculus applied to our redactor component in multi-disciplinary fields: mechanic, thermo-mechanic, vibro-acoustic, Robustness and Reliability Analysis. We added screenshots of our website for manual management of results under the form of data, files and URL. The screens and database of our platform is a result of two years of discussion with lots of professional experts and educational scientists. All results and processes have been tested during this period and the implementation of a web service client for different software has been integrated in other parts of the whole mechatronic component project lifecycle.

Figure 6 – Static and Dynamic mechanics Simulation

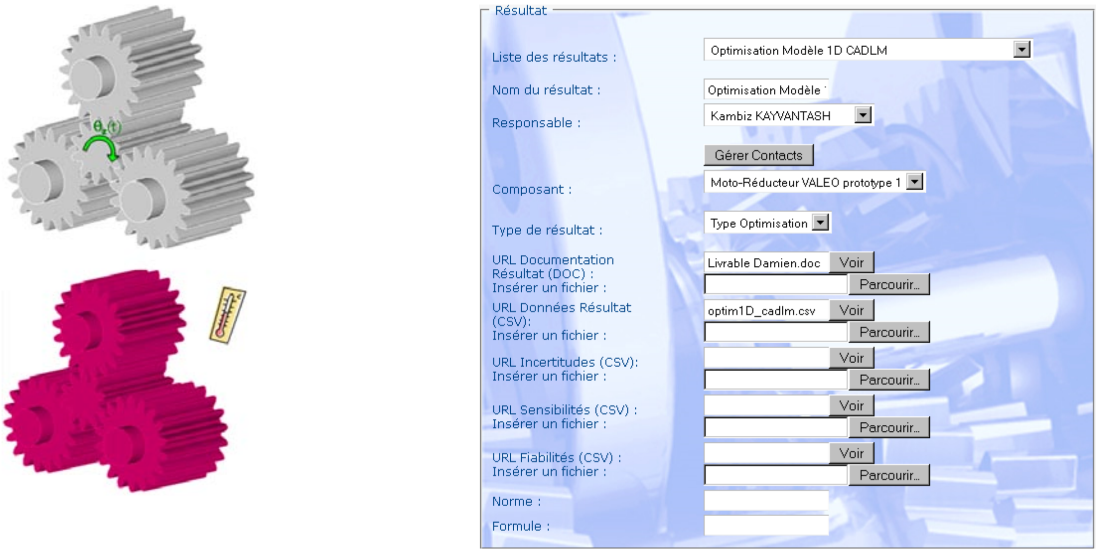

Figure 7 – Thermo mechanic Simulation

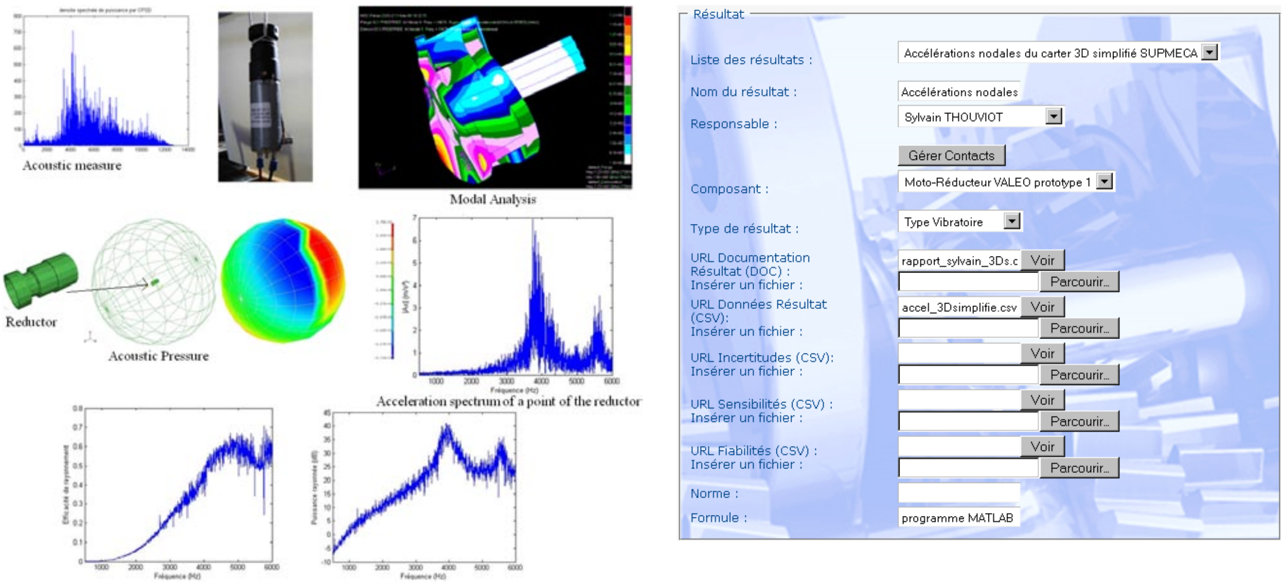

Figure 8 – Vibro-acoustic Simulation

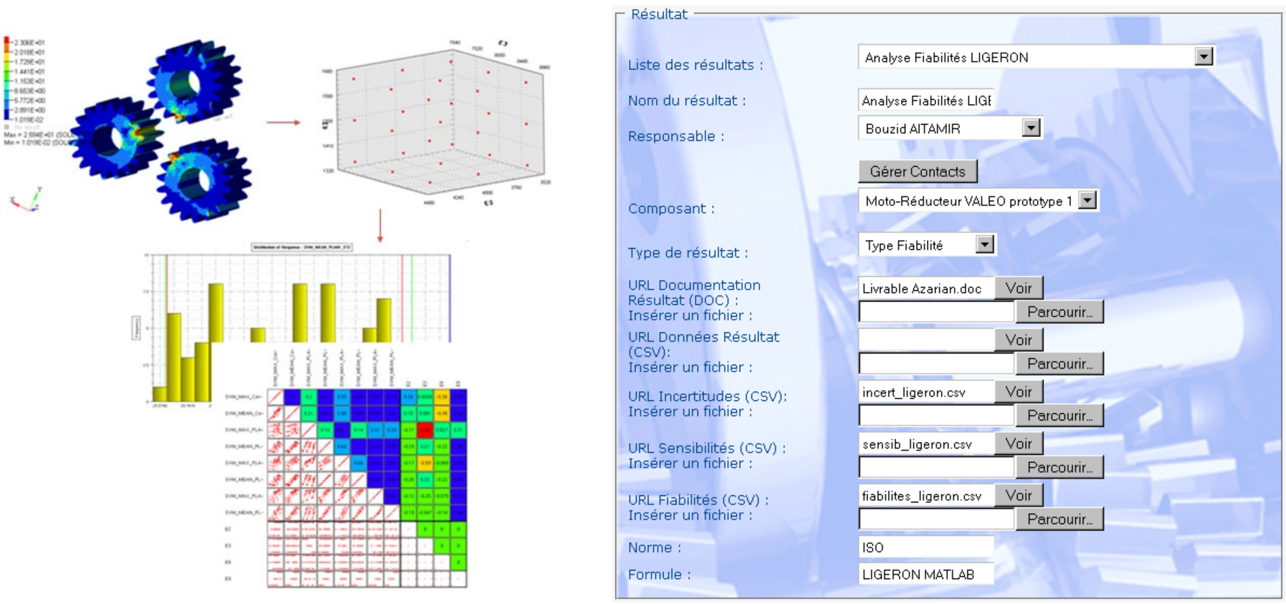

Figure 9 – Robustness and Reliability Analysis

CONCLUSIONS AND FUTURE WORK

We have presented in this paper a new and fully operational web service platform for engineering design optimization of a mechatronic multi-parts component. We designed this platform to insure interoperability and respect a common language for people coming from different disciplines to work together on a complex component with lots of constraints, to be always more competing in a fast growing and changing automotive market. Our EDO platform respect new standards and will be certainly improved by using multi domain ontologies and more web service clients to link to PLM software. A complete case study has shown our platform very useful and efficient for engineers . Another strong point of this knowledge management platform is its ability to keep a trace of the optimization process that has given such results, in terms of quality certification.

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