5th International Conference on Experiments/Process/System Modeling/Simulation/Optimization
5th IC-EpsMsO
Athens, 3-6 July, 2013

DEVELOPMENT OF WEB BASED OPTIMIZATION SERVICE FOR DISTRIBUTED HETEROGENEOUS FRAMEWORKS

Moussas V.C.[1,2], Tsahalis J. [1], and Tsahalis H.-T.[1]

[1] Paragon S.A.
Protopapadaki 19, Galatsi, GR-11147, Athens, Greece
e-mail: jtsahalis@paragon.gr, web page: http://www.paragon.gr

[2] School of Technological Applications, Tech. Educ. Inst. (TEI) of Athens,
Ag. Spyridonos Str., Egaleo 12210, Athens, Greece
e-mail: vmouss@teiath.gr, web page: http://users.teiath.gr/vmouss/

Keywords: Optimization methods; web services; distributed tools; heterogeneous network; scheduling

Abstract. *The increased interest on processing large scale & heterogeneous problems in distributed environments creates the need for more flexible and easily accessed software tools. In this paper we present the development of a web based optimization tool that can support remotely the solution of specific optimization problems. By using web services, the optimizer can publish its function to the rest of the world and to different operating systems using the XML & SOAP technologies. The first prototype was successfully tested using typical optimization problems and optimization tools developed in MatLab®. The final implementation of the service will be developed under the iProd framework to handle simulation workflow optimization in the manufacturing domain, in a distributed and heterogeneous network of collaborating tools.*

1 INTRODUCTION

The increasing need for cross-enterprise business interaction that happens quickly without human intervention, led to an accelerated creation and availability of web services, which is today's major Web trend. Instead of the traditional flow models requiring dedicated networks between companies with high cost and reduced scalability and reusability, web services are platform-independent, loosely-coupled software components, which enable interoperability between heterogeneous distributed components [1][2]. Web services are services that are made available from a business' Web server for Web users or other Web-connected programs (figure 1). The web services are self-describing and discoverable. The Extensible Markup Language (XML) is the foundation for a series of standards such as WSDL, UDDI, SOAP, etc., that are used to support the activities of web services such as Description, Discovery and Invocation [3].

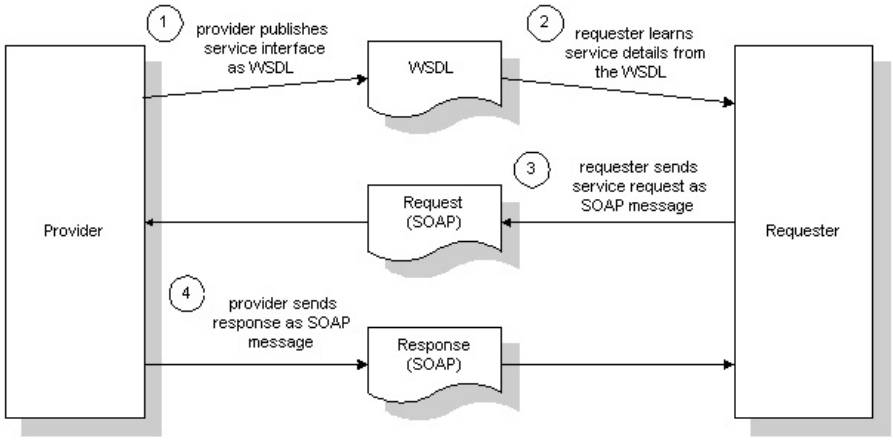


Figure 1. Interaction between a web service provider and a web service consumer.

Another trend in today's business and factories is the wide application of optimization techniques on various aspects of business processes and manufacturing. The recent advances in computer hardware enabled the

practical application of the more advanced but resource consuming optimization techniques. These methods can now be used by e.g., a manufacturing plant to achieve an optimal functionality, not only in terms of time and cost, but also by taking into account environmental and social impacts, sustainability, etc. These combined problems are very complex, with multiple & contradictory objectives and they require powerful and/or specially designed optimization tools [4]. In addition, due to the distributed nature of today's enterprises, these tools must have an easy way to connect, communicate and interact.

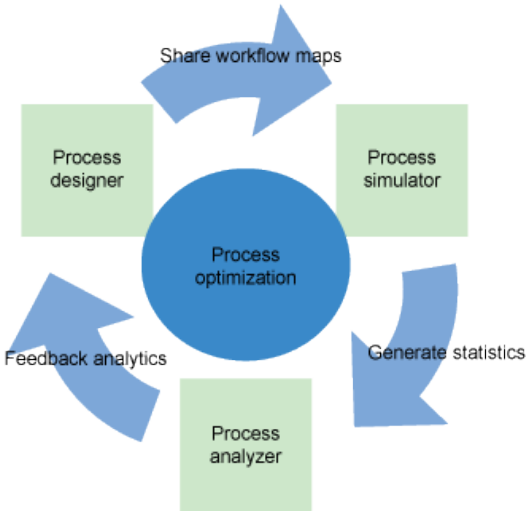


Figure 2. The process optimization loop

A typical optimization scenario implements the process optimization loop shown in figure 2. Especially in a product development process (PDP) there are several stages that can be improved by optimization. Design optimization is a very important stage as it reduces remanufacturing costs and subsequent delays. Sustainability is another optimization task that reduces the environmental impact to the product. Product testing and verification procedures also require optimization techniques in order to achieve the most efficient schedule of both simulated and physical tests required.

In an attempt to improve a distributed PDP, this work focuses on the use of web services for implementing an optimization method, in a distributed and heterogeneous network of collaborating systems and tools. The aim is to present a flexible web service that will able to wrap and promote an existing optimization method, make it available through the internet to a remote application or another service and thus support a wider automated collaboration between heterogeneous design and simulation tools.

2 WEB SERVICE FOR OPTIMIZATION

There is a variety of optimization tools available, running on proprietary or open software and general or specific hardware, and they all use different I/O and invoking procedures. Here we will use an example optimization tool developed in MatLab by the user, to demonstrate the procedure to implement it as a web service.

This work has two main steps:

- The optimization tool must be wrapped and published by a web service
- The problem solver must find the web service and call the optimization tool

If the web service calling stage is omitted, the data exchange between problem and tool should be equivalent to the one when they were parts of the same program or system. The problem solver must collect the right data, variables, parameters, restrictions, etc, formulate them and submit them to the optimization tool. What was done internally using functions and arguments, in the distributed world will be done through the XML and SOAP protocols.

There are two main differences between the local and the remote call of the tool:

- The data exchange format must be known and followed correctly by the caller
- The delays in the process due to communication setup and the remote tool execution start-up must be taken into account (e.g. these delays may favor batch execution, as they are repeated in iterative mode).

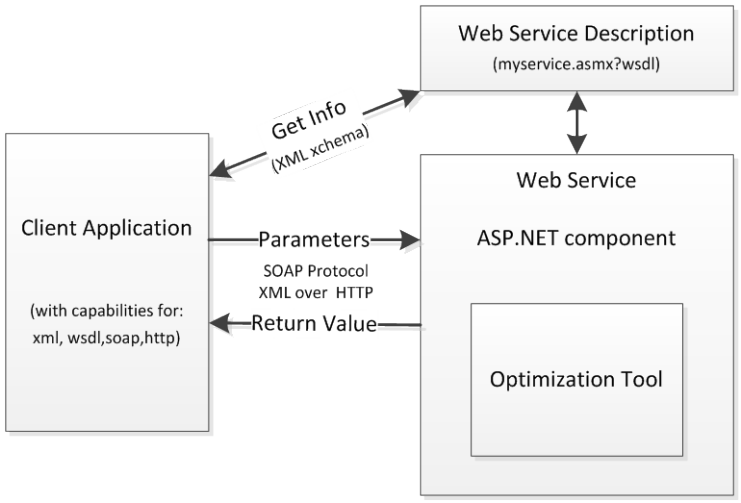


Figure 3. Connection of a remote client application to a web service offering a tool.

3 DEVELOPMENT REQUIREMENTS

To publish and consume a Web Service a set of tools and the corresponding infrastructure are needed. In a Windows environment an IIS web server and the Visual Studio development tool are needed to build a .NET web service in C# or vb.net (figure 4)

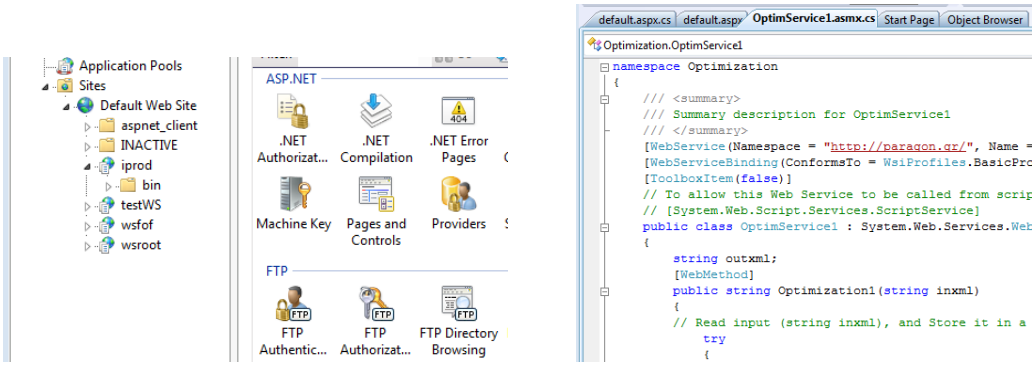


Figure 4. A web server (IIS) and a development tool (Visual Studio) to implement the WS.

The optimization tool must be in a standalone executable form. If it is developed in MatLab, then the Matlab Compiler Runtime (MCR) is required to be installed in the hosting server

Figure 5. The Matlab Compiler Runtime (MCR) is required to run the optimizer at the server after building it as standalone program.

As shown in the example below, data can be passed as parameters to the WS. On the other hand, as each optimization method has its own set of I/O requirements, in order to create a more flexible service the data

exchange between client applications and the web service could be done by submitting and retrieving XML files containing all required I/O in a pre-specified format.

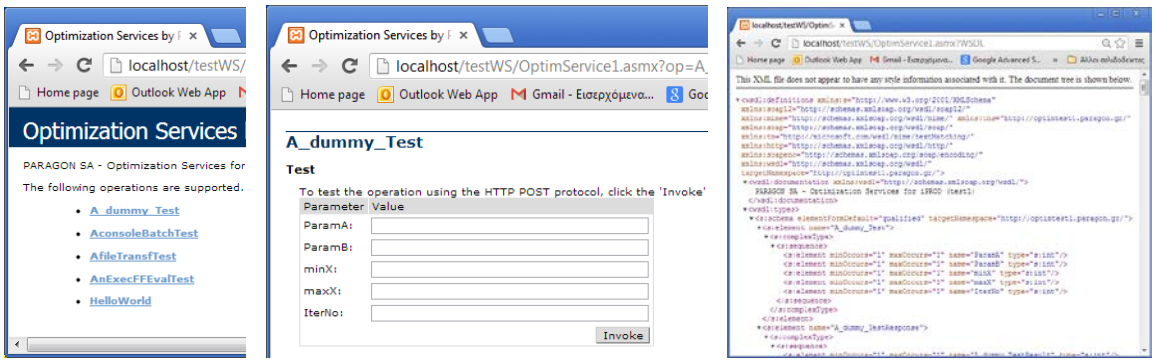
In order to add such capability to the optimization program already developed in Matlab, an extra I/O section is required implementing some special functions such as: xmlread, xmlwrite, etc.

4 IMPLEMENTING THE WEB SERVICE

Starting from the optimization tool there are two possible implementations, the simpler one as a function exchanging arguments, and the more general as a program exchanging .xml files.

Each case will be accompanied by the corresponding vb.net or c# code that implements the WS.
Some of the required modules for wrapping and publishing the optimization tool are:

- The WS interface presenting one or more of the developed Optimization services,
- The function(s) receiving all input parameters and/or XML file(s) and preparing them for the optimization tool,
- The function calling the optimization tool or a batch file that invokes the tool, also controlling correct execution,
- The function(s) returning the output XML file with the optimization results,
- Other auxiliary functions for status, log, backup, temporary files, etc.



(a) (b) (c)

Figure 6. a) The automatic Web Service interface with a list of test examples. b) The sample optimization tool called and its list of input parameters. c) The .wsdl file of the WS.

The web service can be consumed in two ways either manually via an HTML interface or automatically via the wsdl info and a web service aware program. If it is necessary to call the web service manually then an HTML Consumer is provided, i.e. an auxiliary Web Page(s) that invokes/calls the service similar to the automatically generated one shown in figure 6b. To call the web service automatically from within a program a consumer in c#, vb or matlab is created that discovers the web service, reads the .wsdl information (figure 6c) and calls the optimizer. If the WS consumer is written in matlab it will make use of the special functions like 'callsoapservice', etc. (figure 7).

Figure 7. MatLab special functions to consume a web service and handle xml files

An example optimization tool was created to test the above described environment. A typical genetic algorithm optimizes a fitness function based on some user defined data (figure 8).

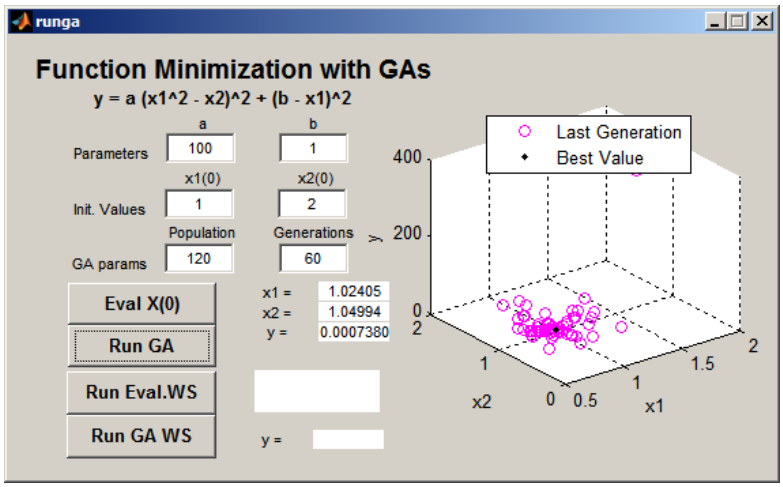


Figure 8. The example case GUI for calling the optimization either locally or via WS.

When calling the tool locally, the application uses the following command to invoke the function:

fval = ff1(popSize, genNo, a, b, nVar, X0)

In order to call the same tool via the web service, the above command must be substituted by:

service = OptimizationServices;
fval = ff1Optim(service,popSize,genNo,a,b,nVar,X0);

provided that the following command has been submitted earlier to read the .wsdl file and create the appropriate class (figure 9):

createClassFromWsdl('http://localhost/wsroot/optimservice1.asmx?WSDL')

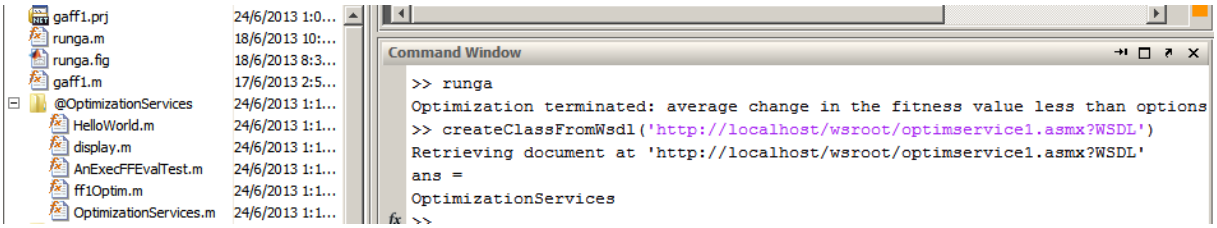


Figure 9. Snapshot of the MatLab command window when reading the wsdl info and creating the classes found in the optimization web services (@OptimizationServices).

Further development of the optimization web service follows with the aim to implement the service under the iProd framework and use it for the 'simulation workflow optimization' problems encountered in the manufacturing domain and in a distributed and heterogeneous environment**.** A sample of the HTML based interface that will invoke the Simulation workflow optimization service follows in figure 10.

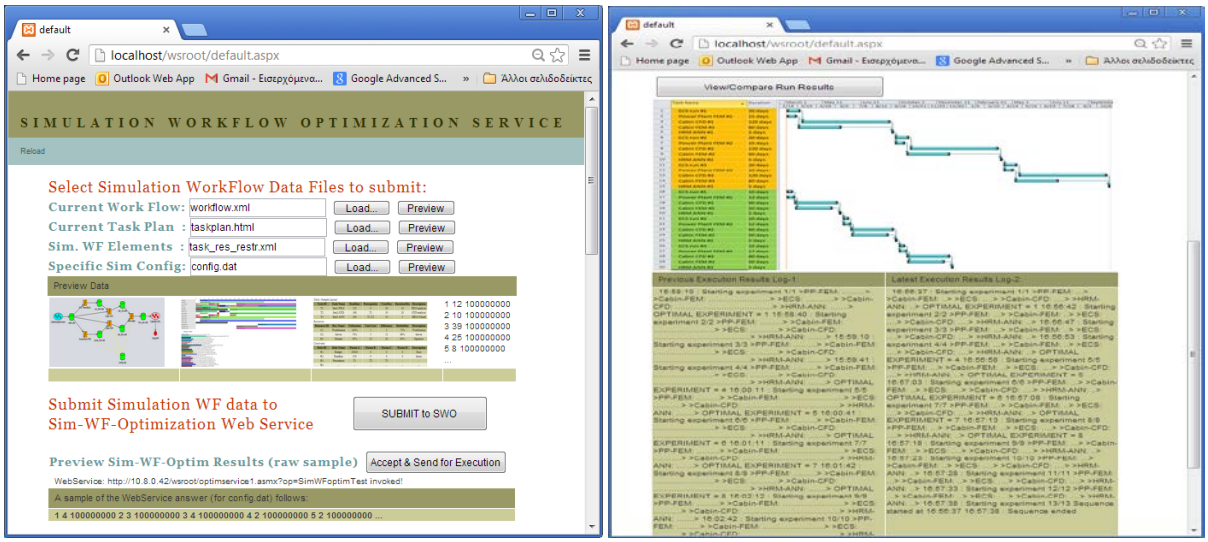


Figure 10. Sample html page invoking and receiving the results of the simulation workflow optimization service under development.

5 CONCLUSIONS

In this paper the development of a web based optimization tool that can support remotely the solution of specific optimization problems was presented. By using web services, an optimizer developed in MatLab publishes its function to the rest of the world and different operating systems using the XML & SOAP technologies. The first prototype was tested using a typical optimization problem, while the final implementation of the service developed under the iProd framework will handle simulation workflow optimization problems of the manufacturing domain, in a distributed and heterogeneous network of collaborating tools.

6 ACKNOWLEDGMENTS

The work presented in this paper has been partially funded by the European Commission and was performed under the framework of the FP7 ICT project “Integrated Management of Product Heterogeneous Data” (iProd), contract number FP7-ICT-2009-5-257657.

REFERENCES

[1] Cerami, E. and S. Laurent (2002). *Web services essentials*, O'Reilly & Associates, Inc. Sebastopol, CA, USA.
[2] Papazoglou, M. (2003). "Web services and business transactions." *World Wide Web* 6(1): 49-91.
[3] Lau, R. (2007). "Towards a web services and intelligent agents-based negotiation system for B2B eCommerce." Electronic Commerce Research and Applications 6(3): 260-273.
[4] Lee H. and Kim S.-S. (2001), “Integration of Process Planning and Scheduling Using Simulation Based Genetic Algorithms”. Int J Adv Manuf Technol 18:586–590, 2001.
[5] iProd project: Integrated management of product heterogeneous data, http://www.iprod-project.eu