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A WEB BASED FRAMEWORK SUPPORTING COLLABORATION IN THE MANUFACTURING PROCESS

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ABSTRACT

Despite the rapid evolution of technology and more specifically of the web and the services provided, the weakness of an immediate transformation of data exchange in the manufacturing world still exists. The need of promoting the collaboration between designing and manufacturing systems is driving towards the need of independent and reliable systems. This paper presents a framework based on the usage of Web Services technology along with the eXtensible Markup Language (XML), the SOAP protocol and the UDDI registries in an attempt to facilitate the communication between designers of prismatic parts and manufacturing companies. This electronic interaction is independent of any specific CAD/CAM software and provides an easy, fast and more economical way of manufacturing a workpiece.

1. Introduction

The process planning depicts the procedure of deciding which manufacturing operations and machines to be used in order to produce a component from its original designing features. Many researches have been carried out in the past years in order to provide a qualitative procedure independent from the format of data. Many Computer Aided Process Planning (CAPP) systems have been introduced in the field such as the generic Petri Net Model [1], the COMPLAN, FCAPP/SM and TAMCAM systems [2] along with many researches focusing on the selection of the data base that will be the most appropriate in the manufacturing procedure [3] for storing and controlling the data as well as frameworks for a web based environment supporting a general and concise CAPP system [4]. However, in order for a proper, thorough and complete CAPP procedure to take place, the manufacturing industry has placed a heavy lift on the type of the data that describe the prismatic parts and therefore the way that these data are going to be transferred through the web is now of outmost importance.

This system describes the communication between two endpoints, the designing and the manufacturing companies which have to collaborate safely, reliably and fast through the network. Each designer has the ability to upload his designing file on the particular system and gain economical offers for its production. The files are being stored in the systems database and from there are forwarded to the interested and registered manufacturers who examine the data and raise offers. Through this System

different designers can have access to manufacturing companies, without a time consuming process and without the need for direct access to any of them.

2. Specifications of the Proposed System

The proposed framework is based for its development on Web Services, a new emerging technology that delivers software as a service accessible to anyone, anywhere, at anytime. It therefore abolishes the need for installing any specific software either on the designer's or on the manufacturer's side. The only required components for a Web Service to be established are a standard messaging format for requests and responses, a service description language and a Web Services Discovery Language/ mechanism. As a result, the only necessary thing for both sides of the communication is to be compatible with the Web Services technology meaning being able to process the xml files and perform any tasks or applications in order to use the system.

The system is comprised of three main entities, the designers, the manufacturer and the Data Base. The first step for every designer, manufacturer and simple visitor of the environment is to sign in to the system by filling out an on-line form of personal data. The visitors of the web site can get informed of the capabilities, advantages and safety regulations offered by the site by browsing into particular pages that provide the necessary information. In case they want to take part in this communication process the above form of personal data is available and obligatory in order to provide the visitors with the necessary username and password they will need to sign in and out of the system.

After the process of signing-in to the web site and of visitors being registered, each user depending on his attribute (manufacturer or designer), follows the procedure stated below:

- Each designer has the possibility to upload a particular file in .xml format in order to gain economical offers for its production. The system must provide a safe mechanism for the uploading as well as for the management and storage of the data in the Data Base.
- Each designing file is being forwarded by the System to all the registered manufacturers.
- When the manufacturers receive the offers, they have a specific period of time to examine the data and decide whether or not to raise an offer. In case they want to proceed with the manufacture of a prismatic part, they upload their offer to the System.
- Then, the System stores the offers in the Data Base and sends them back to the designer.
- Thereafter, the designer can choose the manufacturing company that suits him best and has the capability, provided by the system, to communicate with the selected manufacturer for the arrangement of the cost, of the delivery date and even for certain changes that may need to be made for a more precise production of the workpiece.
- The system has to provide an appropriate environment for the reliable transaction of the designing data and of the personal information of each user along with the trustworthy management of the received offers.

The main characteristic of the above environment is the use of the XML language and of the SOAP protocol. More specifically the designing files are necessary to be uploaded in the .xml format for releasing both endpoint systems from the need of using specific software as well as for rendering this platform independent from any CAD/CAM systems [5]. By this way the problem of incompatibility of data no longer exists making the collaboration of the involved parts easier, more reliable and independent. The organization of the data and the transfer of the messages are being performed with the use of the SOAP protocol [6], [7]. The messaging format is based on SOAP messages that encrypt in their body the xml files that contain the description of the mechanical parts, the offers that the manufacturers raise as well as the requests from the users of their personal data and of the history of their orders.

The above specifications and the involved parts of this web based environment are presented in Figure 1.

This system is based as stated above, on the use of Web Services, on the technology that provides interoperability between incompatible systems and permits the transport of any type of digital data, which allows the transformation of any data into XML format. New technologies are based on the Web Services expanding its use and application. These are the SOAP

protocol (the necessary format for the requests and responses), the WSDL files (the description language) and the UDDI registries (the mechanism for their discovery) [8], [9], [10] as appears in Figure 2 which will be explained below.

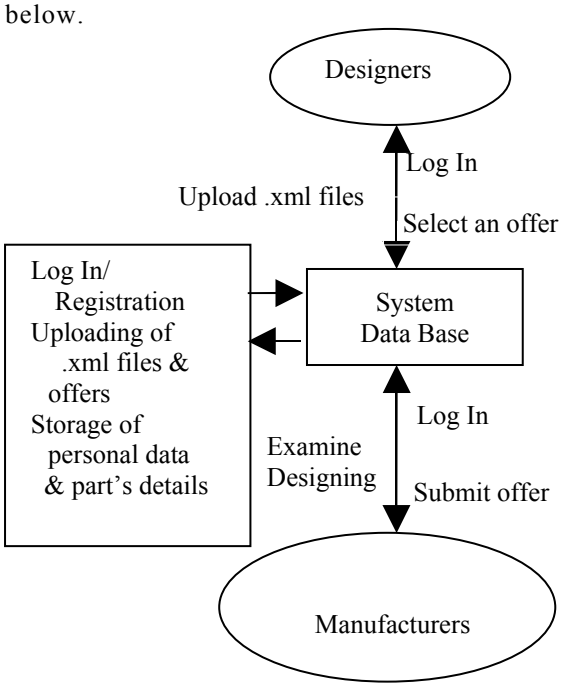

Figure 1: Basic Entities of the System and their Operational Specifications

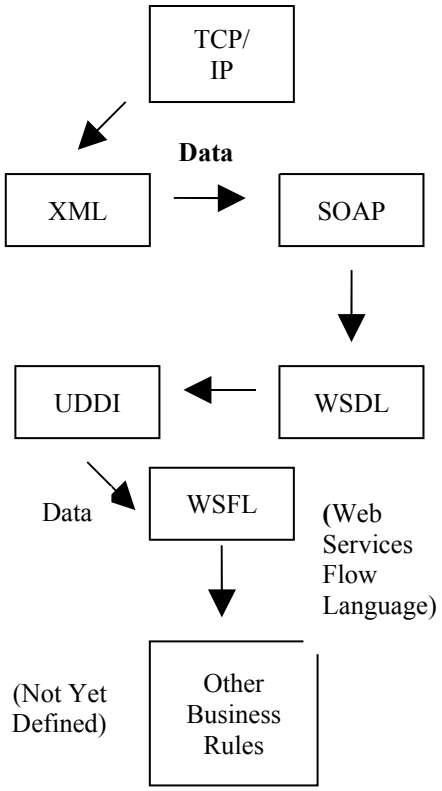

Figure 2: Main Technologies of the Web Services

3. Technologies Based on Web Services and XML

3.1. The SOAP Protocol

The Simple Object Access Protocol is a simple and light-weight protocol which provides a way for different applications and programs to exchange data that run on different systems and that are encoded in different programming languages. It runs on HTTP, on SMTP etc and eliminates the firewall barriers. Each SOAP message consists of three elements, the envelope, the header and the body. Each element carries significant information about the protocols specifications, namespaces and its reliability issues [12]. More precisely:

- The *envelope* element defines the beginning and the end of each message and may include one or more header elements. It solves the problem concerning the end of a messages' transfer and receive time as well as the time that a message begins to be processed.
- The *header* element consists of one or more header blocks which contain information about the services provided, its attributes, about security tokens, transaction identifiers etc. Moreover, it includes information about the reliability and safety of the transferred data and the addresses of the sender and the receiver. The header controls and processes the message until it arrives to its ultimate receiver.

All the necessary information concerning the data that are meant to be delivered is included in the *body* element whether the data is a document or personal information.

In case a message with large size of data is meant to be transferred, this protocol supports the attribute of an attachment inside the body of the message. These attachment messages have the same structure with the rest of the messages with the exception that inside the body element the attachment is stated as a link and a content ID that exists, informs the SOAP processor that the link is an attachment to a MIME envelope. In general, attachments can be used inside an envelope as long as there is a MIME envelope to support its use. This characteristic of the SOAP protocol enables the system to transfer the message without a limit to their size thus eliminating any barriers concerning the size of the designing files that the designers will upload.

3.2. The Web Services Description Language

A WSDL document is a set of a services' specification concerning the data that the service is receiving, the results it sends back and the sort of protocols and transformation it uses. This document is used in combination with an XML Schema and thus enables the transportation of the data through the web by clarifying the content of the data to the receiver and the sender of the message. It also contains information about the description of the way that this document is going to be processed as well as for the actions that will be performed on its content. These documents are transferred with the use of the SOAP protocol by using a SOAP binding with a specific web service providing descriptions of on-line services for electronic business.

For the establishment of a communication both parts must have access to the same WSDL file and to the same XML schema. This mutual understanding of the file enables two different operating systems and different environments to comprehend each other and therefore collaborate. This practically means that the sender of a message will transform and encode a particular message in a way that the receiver will know how to decrypt and use.

Therefore, in a Web Services the involved parts can exchange messages by using different technologies, such as Corba, Com, Erp Systems etc and by sharing the same data encoding specified by the WSDL file. The designers and manufacturers of the proposed system can interact without the need of understanding or remembering all the information that specify the access to the particular service.

The connection of the SOAP protocol with the WSDL files, the UDDI registries, that are presented below, and with the main entities of the system appear in Figure 3.

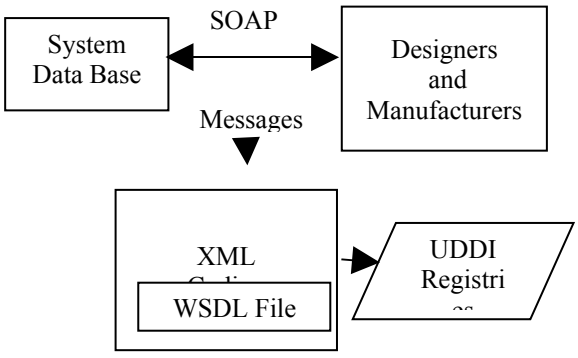

Figure 3: The related Framework

3.3. Universal Description Discovery Integration

The UDDI are registries that gather all the information that describe a business or company and the services it perform on-line searches. They merely focus on the offers providing a set of directories that enable users to description and discovery of businesses and service providers, on the services that these companies provide and on the technical specifications used for gaining access to these services. The registries are based on HTTP, XML, XML Schema and SOAP thus providing an interoperable, open and foundational infrastructure for a web services environment that offers publicly and internally exposed services [11].

Regarding the information that the UDDI registries offer, they are organized into three broader categories the white, the yellow and the green pages. Through the white pages basic contact information about a company are presented such as the name, the address and the telephone numbers it uses. The yellow pages organize the businesses and the services they offer according to the kind of services it offers, its products and its location based on different industry taxonomies. Last, the green pages gather details concerning the technical information of a company, its behavior and the function that it supports. This is the place where the WSDL file is being placed and processed.

In this system, the UDDI technology can be used in an actually twofold way. First of all, the Data Base behind the System stores information about the designing files, the offers and the personal data of the registered users. Alternatively, the Data Base can pull this information out of a UDDI registry where the designers and manufacturers that want to collaborate through this web based environment have to be registered. This literally means that the system will accept users, designers and manufacturers, which are registered in the UDDI directories. On the other hand, the systems' reliability and discovery of services can be broaden by registering the environment in the UDDIs allowing a wider range of businesses to get informed about and thereafter gain access to the system. The choice of materializing either of these registries depends on the expandability of the provided system, on the reliability and on the authentication features needed to restrict access to trusted applications and users.

4. Case Study

In order for the above framework to be properly understood, in this case study a part of the Data Base's design will be presented with the necessary tables of its construction. The Data Base consists of the following five tables:

1. "Designers_Data": all the information that concerns the designers' personal data is being stored here. In particular, information about his name, his address, telephone number etc as well as his username and password with which he will be able to sign-in to the system.
2. "Manufacturers_Data": as before manufacturers' personal data are being stored in order for the System to be reliable when forwarding all the designing files.
3. "Part": in this table are gathered all the designing files that have been uploaded to the System. This table is separated into as many fields as the characteristics of the parts geometrical and topological features. It also contains the identifiers of the part and of the designer who owns the particular design.
4. "Offers": it contains all the offers that have been proposed by the interested manufacturers during the communication through the System. Along with the offers' information, such as price and delivery date, it also contains the identifiers of the manufacturer who raised that offer and of the specific part that is going to be produced.
5. "Final_Entrusting": all the final entrusting of the offers that are going to be materialised are gathered in this table with the identifiers of the Offer, of the Part, of the Designer and of the Manufacturer. These identifiers are provided by the system throughout the whole procedure.

A part of the mentioned tables is being presented in the figures 4,5,6,7 and 8.

ID_Des	Username	Password	FirstName	LastName	Address	….
D_1	pdarras	30672	Paul	Darras	Dafnhs 12	….

Figure 4: "Designers_Data" Table Structure

ID_Man	Username	Password	FirstName	LastName	Address	….
M_4	iliappis	271145	Ion	Liappis	Skra 2	….

Figure 5: "Manufacturers_Data" Table Structure

ID_Part	ID_Des	Angle	cuttingEdges	Cylinder
14	D_1	…..	….	….

Figure 6: "Part" Table Structure

ID_Offer	ID_Man	Price	DeliveryDate	PartChanges
Offer_32	M_9	….	….	CubeChanges.xml

Figure 7: "Offers" Table Structure

ID_Offer	ID_Part	ID_Des	ID_Man
Offer_32	14	D_1	M_4

Figure 8: "Final_Entrusting" Table Structure

```
<?xml version="1.0"?>
 <soap:Envelope
      xmlns:soap="http://www.w3.org/2001/12/soap-envelope"
      soap:encodingStyle="http://www.w3.org/2001/12/soap-encoding">
     <env: Header>
            <m: Trans
               xmlns: m="http://www.w3schools.com/transaction/"
               soap:mustUnderstand="1"> 234
          </m: Trans>
     </env: Header>
     < env: Body>
          <m: File_D12
                xmlns: m="http://www.w3schools.com/Identifications">
                <m: Designer>D_2345</m: Designer >                    6.
              <m: ID>Circle_12</m: ID>                                7.
                <m: XmlFile>Circle.xml</m: XmlFile >                  8.
          </m: File_D12>
     </ env: Body>
 </soap: Envelope>
```

Figure 9: A typical SOAP message for the specified Web based environment

Based on these tables the System has a well constructed Data Base which offers the requested transparency and expendability meaning the possibility of adding new data and features records without confronting any problems concerning characteristics' confliction.

All the data are in .xml format and transferred between the communications' parts with the aid of the SOAP protocol.

A typical form of a SOAP message is consisted of three parts the envelope, the header and the body as is presented in the Figure 9.

In this example the designer with the identifier "D_2354" (line 6) wants to send the designing file with the ID Circle_12 (line 7). These data form the Circle.xml (line 8) file which contains a design of a circle, as shown in Figure 10 that is going to be transferred through the system, with the Web Services technology.

5. Future Work

In an attempt to exceed possible problems that may occur in this system, regarding the uploading of the .xml file, a future research can be carried out by examining the possibility of the existence of an on-line form. This form will provide a thoroughly organised way of describing the designing features of a mechanical part by filling out fields in the form concerning all the geometrical and topological features of a part along with information such as holdings of the workpiece, the process plan that will be executed and many others [5]. These data will be automatically transformed into an xml format and thus will be compatible with the systems specifications. Moreover, a wider range of designers will be able to take part in this communication procedure, for this form will facilitate the way in which a user can access the system and gain offers.

What's more, the environment will become more functional and reliable when the ability to create from the designing features of the part a 2D or 3D on-line model will be granted. With this new model, designers and manufacturers will have a better view of the part that is going to be manufactured and moreover will be able to make the necessary changes to the part for its proper and economical production. This attachment to the system will open the way towards a more immediate and accurate collaboration between the designers and the manufacturers.

Lastly, the communication for the arrangement of the changes that may be necessary to be made for the manufacture of a particular product can advance through an on-line conversation between the designer and the manufacturer that cooperate. This capability will provide flexibility to the System along with a reduction of the time and of the number

of messages needed to be transferred between the involved parts.

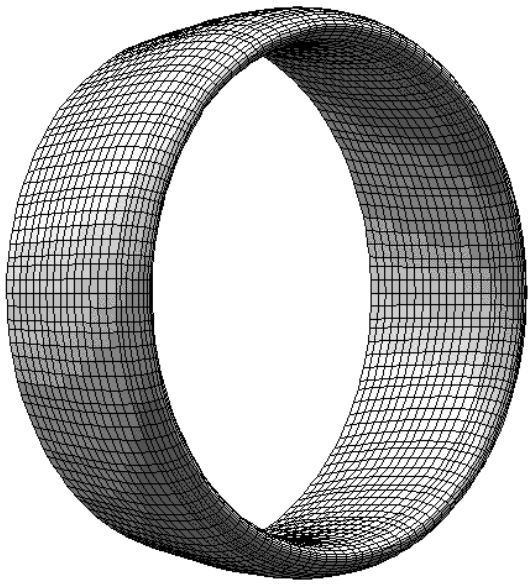

Figure 10: An application example

6. Conclusions

The proposed framework is based on the technology of Web Services and the XML language to provide a secure and fast environment for the transportation of the necessary messages in order for the designers to communicate and arrange a deal with manufacturing companies. It generally succeeds in organizing a complete electronic transaction abolishing the need of a direct contact between the involved parts of the communication. It ensures the necessary reliability and safety with the use of the above technologies while constitutes an innovation in the manufacturing world because it exceeds the obstacles of incompatibility of data that exist among different designing, CAD and manufacturing, CAM systems, opening the way towards an easier and independent computer aided process planning.

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