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ENGINEERING DESIGN IN INTEGRATED PRODUCT DEVELOPMENT
Design Methods that Work

INTERNET-BASED ENGINEERING PROJECTS' MANAGEMENT

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Abstract: *Scope of this elaboration are conceptual presumptions and work of Internet application that supports the design- engineering works process in the dispersed team. This system allows to collect, store and access the data concerning technical projects by means of Internet connection. Owing to that circumstances projects' participants can cooperate with each other, while performing their parts of task in a different time and place.*

1. INTRODUCTION

With the beginning of 80-ies the common chance of using the computers to support engineer works become a sober fact. Together with first applications for designers the new notions, such as CAD, CAM and CAE, came into use. Nowadays there is a huge number of constantly- evolving computer programs beyond the shortcut CAx. Probably the most important change concerns the way of presenting the modeled artifacts. In the first stage of CAD, first applications were used to create (in deed it was time-consuming sectors, bows and lines composing) two-dimensional drawings' documents; nowadays the base of applications' work is three-dimensional, solid figured record of the structure. Information this kind of model contains can be used to create almost automatically the technical documents (drawings, lists of parts), calculations (e.g.: MES) and generating NC codes.
Changes mentioned above in most cases concern only individual design [1] process, that means: work of the single engineer in a separate (computer) work plot, on a separate design task. To be quite truthful modern CAD programs allow cooperation of the team via net, but it is LAN in most cases. Besides CAx type programs support only part of design-engineering process– e.g. they concern only designer tasks that are apart of the structure shaping process. Strong diversification and individualization of the CAD, CAM, and CAE programs' group still can be seen in data exchange between systems as well as from an organization (integration) of the design-engineering process point of view, communication in the design- engineering team, etc.
It is worth to be mentioned that there is a group of documents' management dedicated programs, based on the Internet browser. It is for e.g. Microsoft Project 2000 with Internet extension: Microsoft Project Central. This application is dedicated to the wide group of users; it concerns the projects' management problem in general way, that's why it becomes very difficult to tailor it to the design- engineering process' needs. Authors' self-experience (year 2000-2001) shows the number of imperfections of this software. They can be seen especially when updating database by both, administrator and user of the system. When there is no efficient technical support available (this also refers to the period of 2000-2001) it must be considered as the problem that questions the idea of using the mentioned system.
Obviously, the complex systems, that integrate works in large companies, such as (I-DEAS, CATIA) exist for quite a long time. Nevertheless, authors pay attention to needs of small and middle-sized companies. But, as Wróbel [3] stresses, despite of relatively high abilities concerning costs, for

small and middle-sized companies those systems are too expensive.
However, development of telecommunication technique, computer nets and, particularly, Internet and connected with it client- server applications allows to create proper information canals between workers engaged in the project's task [1] so it becomes possible to create computer systems which are able to supply the needs of design- engineering process in a complex way, for small and medium enterprises.
Present elaboration is the description of the computer program that helps to go through the defined stages of the design- engineering process in dispersed work team [1]. The main scope of this work are information flows in each stage of the design process: structural (modeling the structure, selection of the structure's features) and execution process (preparing technical and technological documents) [2].
One allowed himself to precise the classic meaning of the "team" notion [1] with adjective: "dispersed", to stress lack of limits concerning distance between design- engineering process team members and differences in time of their work.
System which is the subject of this article were prepared by workers of Faculty of Mechanical Engineering at University of Technology and Agriculture in Bydgoszcz..

2. PRESUMPTIONS CONCERNING PROGRAM'S FUNCTIONS

It was assumed that systems described in this elaboration, called Projects' Central Station needs to fulfil following functions and has following features:
1. It supports information (concerning the project) flow in the dispersed group of workers engaged in the process, so it allows to: collect, store and access the information .
2. It presents information about the project in hierarchic way- as a tree that is the visualization of project's structure.
3. It treats design- engineering process as time-evolving event. In practice it means that e.g. it: allows to edit (change) the project's structure, remembers the history of the project, that is to say it administrates versions of the documents and generates log (event register).
4. Scope of it's work are design and execution phases, in other words it has the power to transform different kind of documents and files.
5. It supports team work that is to say e.g.: it protects the documents from deleting (e.g. overwriting) information by other members of the working group.
6. It notifies about events important for the user, what shortens the time of reaction and rationalize cooperation.

System with features mentioned above has been based on the client- server architecture. It makes hardware and software basic layer, and is the matter uner discussion in the chapter 4. The solutions of the database architecture for keeping those information are presented in the chapter 5. The work of the system and it's utility is presented in the chapters 6 and 7. In those chapters authors present the way the system collects and allows to access the data..

3. CLIENT-SERVER ARCHITECTURE

To make collecting, storage and access to the information concerning process possible from any work post and in any time, one proposed the computer system based on client-server structure. Server is connected to the Internet constantly. On user's side the Internet connection (it can be temporary, for e.g. by means of modem) and WWW browser is required.
Storage of data concerning project on a server is possible through database server and properly designed structure of database. Storage and access of those information is possible through WWW server, which is the element that joins database server with user's computer, by means of active-built HTML

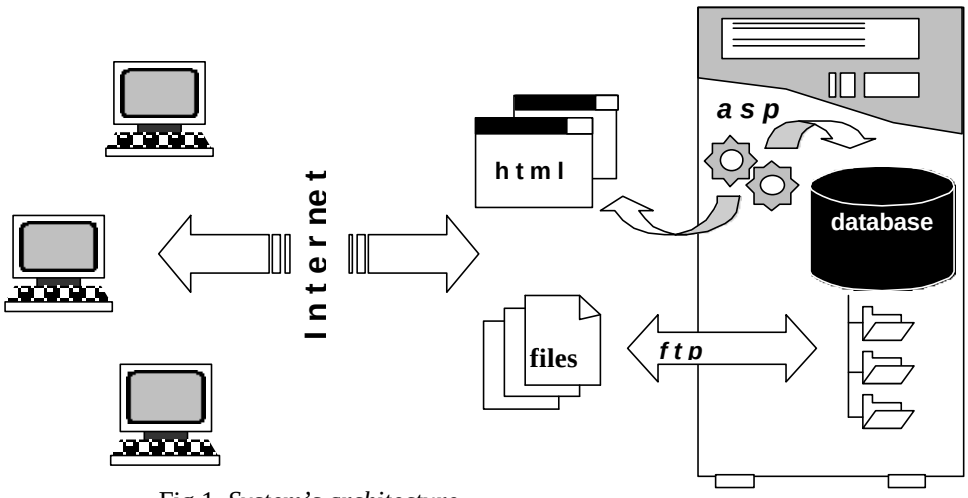

Fig.1. *System's architecture*

pages (ASP). On the one side server WWW transforms data stored in the database into HTML sites that are send to the client's browser, on the other side, from HTML forms send form user it collects data and saves them in the database.
Storage of files' data is executed in server's folders of a suitable structure. Files' transport to and from server is assured by FTP protocol..

4. MEANS OF STORAGE AND PRESENTATION OF INFORMATION CONCERNING THE PROJECT

Project is understood by system as the collection of elements linked to each other. Elements are linked to one another in a special way, because each element has to contain (except project data) information about place it takes in the tree-structure of the project.

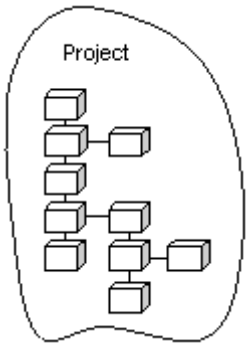

Fig.2. *Project as the collection of linked elements*

It is presumed that the structure of the project's elements is the picture of the functional structure of the designed product (functions the products consists of) and that it will has mounting nature[2]. That's why the element of the project can be only a part or combination of parts. Combination of parts is interpreted as a group of parts or other combinations of parts. (drawing 3.). Each element stores only information concerning superior element. It means that the part becomes a combination of parts, if there is the subordinate (for this element) element in the database of the project.

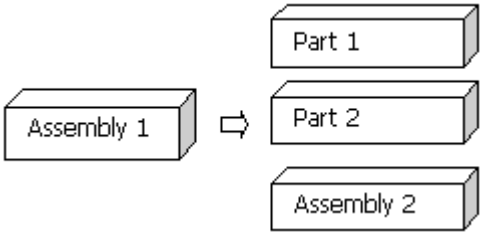

Fig.3. *Structure of the combination of parts*

Part is interpreted as last, non-dividable element of the structure [2]. In this system part can be interpreted as container (folder) that stores elements linked to this part. Each document, except document's file, stores in the database additional, descriptive information, such as: author, date, material, standard, etc.
Each element (part or combination of parts) remembers all versions of it's documents. Present (active) is always the last version of the specified kind of the document.

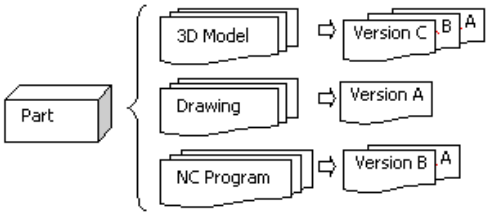

Fig.4. *Part's structure*

It is obvious that each element can have different collection of documents' types. E.g. documents of the combination of parts differs from documents of part by means that it doesn't store a certain kind of documents – in this case CNC programs (drawing 5).

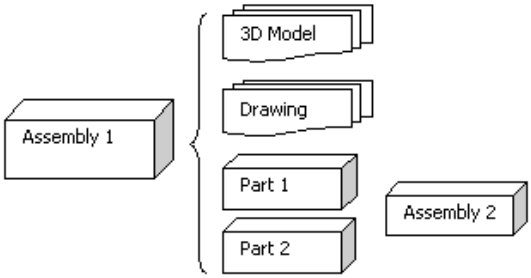

Fig.5. *Structure of the combination of parts*

Elements defined in one project can appear in many other projects (drawing 6.). it is possible to use other parts or combination of parts taken from the other projects. In this case in the tree- structure of the project the distinguished element- that is link to the original element- appears.

Elements can be also copied in the same project. They can appear many times in one project. Also in this case such an element is link to the original element.

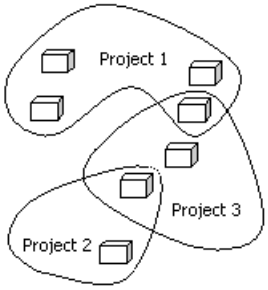

Fig.6. *Common parts of the projects*

The example of use of this multi-utilize elements mechanism is using library's elements. Library is a group of ready elements, common and equal for other projects.

5. STRUCTURE OF DATABASE

Main element of database is two-dimension table, which specific structure allows to record complicated tree-structure of the project. The difficulty of recording this tree-structure comes out of this, that each project's element can have "infinite" number of elements directly or indirectly subordinate to it. Directly subordinate elements are all elements of the project that in specified part of the structure appear as the original of the element. Indirectly subordinate elements are the elements which are copies of the elements existing in other parts of the tree-structure.

Each element of the project (combination of parts, part, document, etc.) is recorded in one record of the table, where each record has it's own unique index. Index is an information that identifies each element explicitly. Additionally each record in the table has a field with index of the superior element. If element is link to any complete part of the tree-structure (combination of parts, part, etc.) except of index of the superior element it has also index of original element in the separate field.

ID	Superior-ID dne	Name
1	0	AT_0010
2	1	AT_0011
3	0	AT_0012
4	0	AT_0013
5	4	AT_0014
6	4	AT_0015
7	4	AT_0016
8	6	AT_0017

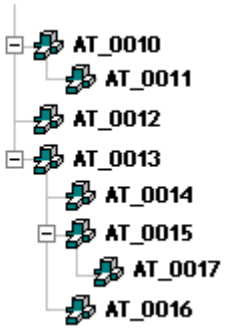

Fig.7a. *Tree-structure records in the table* *Fig. 7b. Tree-structure shape*

This kind of structure of the main table assures simple and plain structure and relatively less-complicated algorithm of registration of the data, mainly because of the fact, that elements are recorded as the records of the identical structure (number and kind of fields). Registration of the new element on the optional level of the structure comes to specifying the index of the superior element.

Flexibility of this solution is conductive to free modifying: moving single elements or all parts of the tree-structure, adding new elements etc. E.g. moving of a part of a tree-structure can be made by changing the index of the superior index into new one in elements on the first level- the inner rest of the part of the structure is still subordinate to the same elements.

But to get data and generate the tree-structure it is necessary to use complicated algorithms that use recurrent functions.

Recurrent functions choose the data from the same two-dimension table in the following way: the single element's data record (of the specified index) is being read, than the set of records with superior index equal with element's index is being taken. Subsequently for each of those elements next sets of records with equal superior indexes are being taken etc. That's how the loop of the algorithm that takes data from one record (that responds one element) is being made necessary (unidentified) number of times, that depends on the number of elements and structure of the tree.

6. ENTERING INFORMATION INTO THE SYSTEM

The main role while designing 'entering information to the system' function was to guarantee the fastest possible run of the process. The most important principle to achieve this goal was corroboration that states that information prepared once cannot be prepared once again in any other part of the system. One has tried to point such a sources of information in computer aid design- engineering process, which are certain, that means that e.g.: always exist, are always up-to-date. Two sources have been pointed out:

a) Drawing documents file's name.

b) Information in drawing files memory.

To successfully (automatically) use information from the files name some principles concerning file name's format have been assumed. Documents symbol should consist of classifying and identifying parts, of following syntax and contents:

a) Classifying part contains two information divided with underline: various number of signs pointing out the project and a letter that informs about the type of the document, Project'sName_A

b) Identifying part of the file's name consist of part's identity and it's version Identity is discretional, unique 4-digit number. Document's version is defined by the alphabet letter. 0123B

Format of the file's name appears as follows: Project'sName _A0123B

Owing to formalization of files' names program, while copying file to the Projects' Central Station, automatically finds right place in the tree-structure of the project and puts the file there. If the program won't find the suitable place, it will create one, based on the information from the file name.

Copying of the files to the Projects' Central Station has many additional tools and conveniences. E.g.:

a) User is notified about the danger of overwriting the file, if the file of name like this already exist.

b) During copying user can make new version of this document or make new version of the other document, linked to this one.

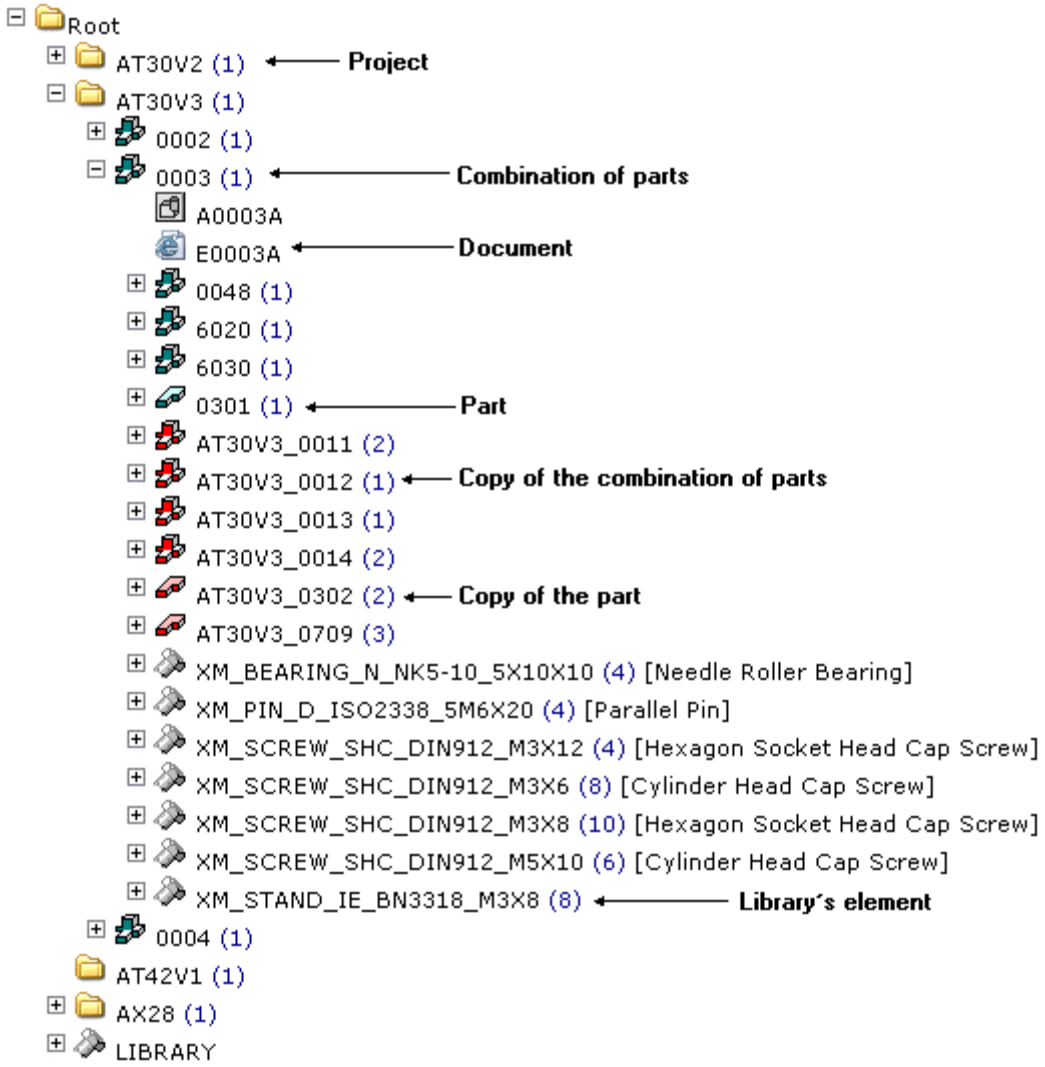

Fig.8. *Project's tree-structure example*

First situation described above can take place when the file with drawing of the part , contains solid model, and the designer wants the sketcher to prepare next version of this file, with execution drawing. The example of the situation when new version can be needed is when solid model of the element is changing and one had to made somebody to prepare new version of the CNC program, corresponding with the new model.

System assumes also utilization of the information from the drawing documents' files. In those files optional, defined by user data can be recorded e.g.: author, date, material, standard signature etc. 'Combination of parts' files additionally have also information about files the combination is made of i.e.: the list of files' names and other data that are saved in a single element's file. Creators of CAD programs give the opportunity to export from optional drawing file all those information to external file. Projects' Central Station takes those files and, according to the information in the file's name, in the automatic way:

a) Updates fields connected with the documents.

b) Changes the tree-structure of the project.

As the project gets more advanced, there is more information, which is specified up-to-date, the project's tree-structure can easily get new branches with automatically- growing "fruits"- documents.

Obviously there is also possibility of self (non-automatic) edition of fields- elements of the tree. It is useful especially for those files, which are not a drawing files of the project, that means those that doesn't contain required information e.g.: bitmaps or CNC programs.

7. ACCESS TO DATA

First source of information about the project for application's user is, obviously, the tree-structure of the project itself. Hierarchic structure of a project is a background for the symbols of elements such as:, parts, documents, copies of combinations of parts and parts, library's elements. Element's name, element's count in the combination of elements and description appear directly in the project tree-structure.

In addition, after pointing out the optional element full information concerning this element appears in the dialog window. Besides text information, if there is previewing file available, also file contents is being displayed.

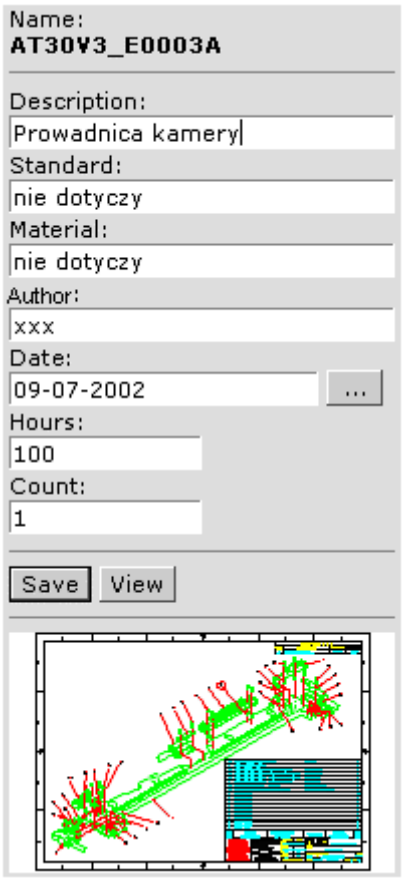

Fig.9. *Dialog window*

To get full information about the project the advanced reports are needed. Projects' Central Station is equipped with creator of reports. User is able to create various reports, lists, comparisons . Question asked by user is being transformed into SQL language (language of database) and saved as a report's form.

To use the report one have to choose the report form (kind) and point out optional part of the tree-structure of the project. Various lists are being generated for all the branches and all the elements fitted on them, starting from the marked point, automatically e.g.: count of the pieces in the combination of parts, structural lists, material lists, report concerning project's stage of advance the, report concerning working hours for members of the designers' team i.e.

Basing on the lists of elements listed in the reports it is possible to mark files that are meant to be to copied to a user's computer. Program collects files from projects that it found links to, and from library of elements. Program prepared in this way can be run on a user's computer. Furthermore, user (while downloading the file) has a possibility to inform other users that the file is in the edition mode at the time. This information is being displayed as a graphic sign in a project tree-structure and in all reports in which this file appears.

8. SUMMARY

System presented in this elaboration follows most requirements of documents management system for small and middle-business listed by Wróbel [4]. System has most functions of basic modules of standard system: basic module (e.g. central database station, documents' versions management, possibility of modeling the hierarchic structure of project), CAD-serve module (e.g. linking drawings' elements to data from database) and information's transfer management module (e.g. visualization of information's transfer).

Central Project Station has been created as the response for the users (designers' dispersed work team) needs and at present time the application is being brought into practice. It seems that this program, together with support of the computer technique's newest achievements, if still developed can become extremely useful tool in designer's work.

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