Customized CAD/CAM Data Management System for an Aircraft Development Programme

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Abstract

Managing information and their retrieval are often made difficult by storing it at multiple locations and in different formats. Thus a prime function of an efficient data base management system is to provide timely, reliable and scalable accessibility of the data or information stored. Additionally, handling of legacy data in various formats makes the task of developing a customized database management system a challenging task. This means that there is minimum control over data updates or its sharing until the product is released and the data is post facto uploaded into the database system. This paper aims to address these problems through a customized CAD/CAM Database Management System (CDMS) for Computer Aided Design and Manufacturing (CAD/CAM) data related to a typical aircraft development project. The scalable CDMS with multiple visual cues manages and retrieves the engineering data in their native digital formats with a flexible and powerful multi user database.

Keyword: AJAX, Apache Tomcat, CAD/CAM, Engineering Data, Network Attached Storage, Numerical Master Geometry, Visual Salience.

1. Introduction

Aircraft design and development is a multi disciplinary and data intensive programme. The various stages in aircraft development projects viz., design, development, manufacture of prototypes and flight testing leading to operational clearance of aircraft are associated with specific design and data requirements. This is where the Engineering Data Management comes into picture wherein recalling information of generic type or by keyword search is required in areas such as manufacturing, methods, analysis, project management etc. The CAD/CAM group undertakes activities involving solid modeling, assembly modeling, Computer Numerical Control (CNC) programming, manufacturing, generation of Loft and Numerical Master Geometry (NMG) drawings which refer to sectional information of surfaces which are used for manufacturing of forming tools for sheet metal components, which here after will be called NMG drawings for sheet metal components in an aircraft development programme. These activities involve extensive interaction with different design groups and various external agencies. The multitude of tasks handled in an aircraft project involving multiple configurations such as prototypes, structural testing specimens, fatigue testing specimens, production standard aircraft etc, demands the development of a dedicated manufacturing database system, which establishes digital interaction and real time status updates among the group members. Commercially available systems require extensive customization and thus tend to be expensive and beyond the reach of small and medium size enterprises [1] [2]. Therefore, development of an automated CAD/CAM Database Management System (CDMS) which can effectively manage large number of drawings and the related documentation and additionally help in interacting with multiple divisions / organizations was taken up. This system effectively assists the CAD/CAM group in managing voluminous design data generated and also keep track not only of the hierarchy of the drawings but also of change control necessitated by design modifications not uncommon in a development project.

2. Assumption, Dependencies and Challenges

For usefulness of an engineering data management system, it is essential that the users should input the right data at the right time; the data in our particular case include drawings, solid models, CNC programs, CNC program simulation/verification data, manufacturing process and setup data, part inspection data and snag sheets to name a few. Sufficient checks are introduced in the software to ensure its correctness by controlling the naming sequence and forcing naming exclusivity, espouse drawing number nomenclature and also adopting "on screen selection" methodologies. All such files pertaining to every drawing/part are uploaded to a Network Attached Storage (NAS) in real time and authenticated.

2.1 Design and Implementation Constraints

In the development of any engineering data base management software, it is important to note that the data are generated by different CAD/CAM/CAE software. It is normal to expect a large number of legacy data which need to be updated and converted to a

readable format so as to establish a common uniform operational system. This may sometime necessitate manual data entry, particularly during the initial implementation stage of the software. However, working discipline is essential for sustainability after successful implementation wherein the prescribed standard formats and procedures are to be strictly adhered to.

2.2. Description and Scope of the Project

The primary users of this system are:

1. Group Leader and Team members (TM) of CAD/CAM group.
2. Project Management Group.
3. Work Centre Coordinators.

Every activity assigned to the Team members by the Group Leader details the nature of work to be carried out and a date of completion for each activity. The CDMS captures the outsourcing details, purchase order details, material specification, quantity required per aircraft, the CAD weight and the manufactured weight comparison informing the increase or decrease in final weight, which is of enormous importance during the development phase of any project. The software also explicitly captures the category and the group to which the component belongs to and designated aircraft configuration that the part is being manufactured for and thereafter assembled. Further the software clearly depicts the status of the work at any point of time defining it as *Work in Progress*, *Not Assigned*, and *Complete*. This management tool not only helps in monitoring the various stages of the work in CAD/CAM Group, but also helps in online retrieval of critical information on the status of the project.

3. Design of the Proposed System

Complex product design is distinctly different from mass customization products and their peculiarity makes data management extremely difficult [3].

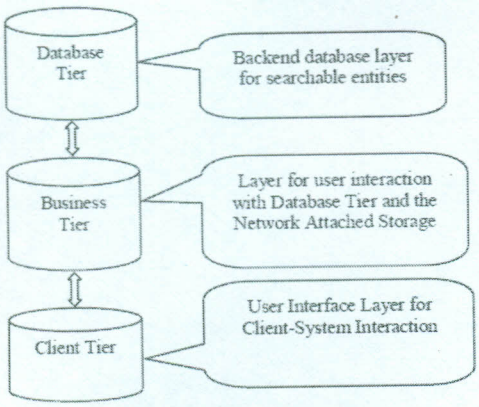


Fig. 1 Operational structure of CDMS.

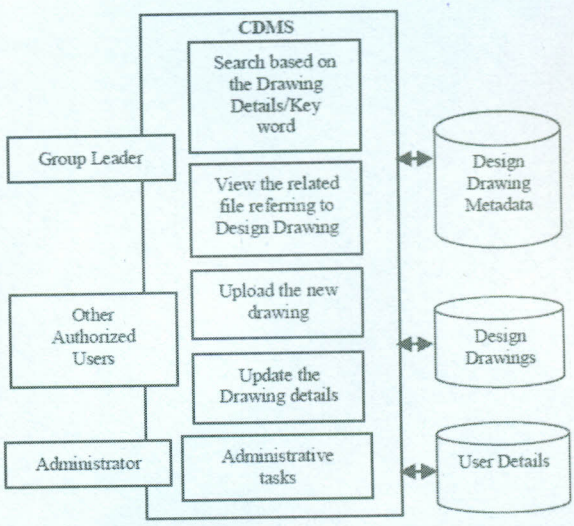


Fig. 2 High Level Component Design.

The design of CDMS is structured on a three tier management of data, viz., database tier, business tier and client tier. The database tier functions as a backend data base to store all the data base search entities. The business tier effectively supports the user interaction with the database tier and the actual data residing on NAS. The NAS device is used to store, access, modify the drawing related files viz., AutoCAD files, CAD Drawings developed on CATIA software including CATProcess, CATModel, CAT Drawings, Vericut files and MS Word Documents with the specific nomenclature. The client tier acts as a user interface layer wherein the users interact with the system. Fig.1. and Fig. 2 explain the proposed operational structure and design features of the software respectively.

4. Implementation and Experience

The three tier system design architecture based on web technologies using Java / Java 2 Enterprise Edition viz., Applets, Java Server Pages (JSP) and Java Database Connectivity (JDBC). JSP has its unique features providing a simplified and faster way to create the WebPages that display dynamically generated content and JDBC represents the de facto industry standard for connecting to the database from Java/Web Applications etc.

Further, CDMS uses Asynchronous JavaScript and XML (AJAX) [4] which involves transmitting small amount of information to and from the server asynchronously in order to give the user the most responsive experience, as AJAX is an intermediate layer to handle this communication as detailed in Fig.3. At present, Microsoft (MS) Access is used as the back end database and more than ten tables with relations to each other are created for the Meta Data management. The

Apache Tomcat, a user friendly open source platform is chosen as the web server to deploy the CDMS. The MS Access database resides along with the Apache Tomcat server in the same system. The CDMS interacts with the NAS to search and download the file for the server to respond to the user's request.

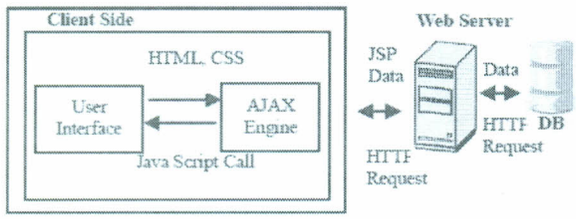


Fig. 3 CDMS Implementation details.

5. System Operational Features

The features that have been incorporated into the CDMS are detailed below:

5.1 Designer login features:

5.1.1 Login ID to authenticate the access.

5.1.2 Carryout web based search for the latest and old drawing details separately (Fig. 4) based on keywords viz.,-Drawing Number, Part name, Modeler Name etc .

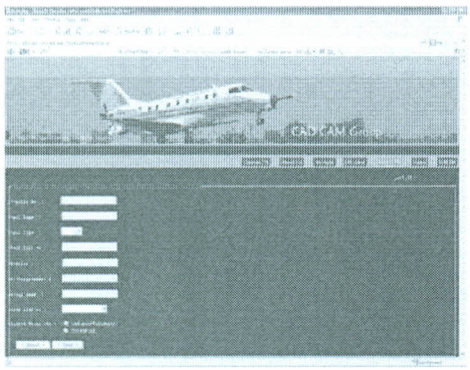


Fig. 4 Search Database form.

5.1.3 Obtain the Meta Data Search Results for the above entry (Fig.5).

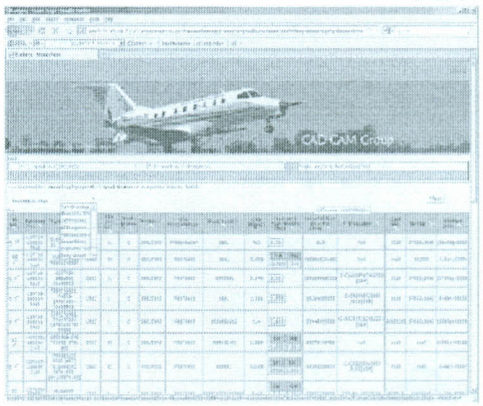


Fig. 5 Search Result page.

In the Meta Data search result page,

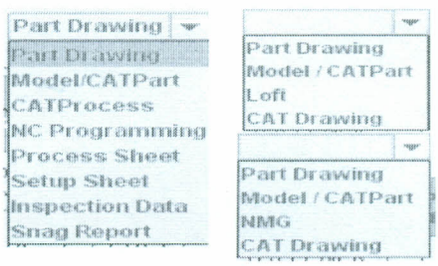
5.1.3.1 Titles on HTML table header viz., "CAD weight", "Machined Part weight" and "Material Size", will have a tool tip on a mouse over action with calculated Total CAD weight, Total Machined Part weight, and their difference respectively for that result page.

- Total CAD weight = ∑ (CAD weight of part * Quantity of parts per Aircraft)
- Total Machined Part weight = ∑(Machined Part weight)
- Difference = Total Machined Part weight – Total CAD weight

5.1.3.2 On a mouse over action to the corresponding columns, the tool tip indicates the respective Total Machined Part weight and the Difference. The CAD Weight of the part is available against the respective Drawing Number in the corresponding cell and does not require a mouse over action for its display.

5.1.4 In addition to the above, the user will be able to view the actual design by selecting the items from the list (which is created using applet) as shown in Table I for the design drawing, which requires CNC Machining or for sheet metal parts requiring a Lofts or a NMG.

Table I: Listing of CNC & Sheet metal part supporting files



Based on selection of any of the above parameters with their corresponding drawing number in the

search result, the respective file will be displayed in the corresponding editor in the Read Only form. Sample results are shown in Fig 6a-6c.

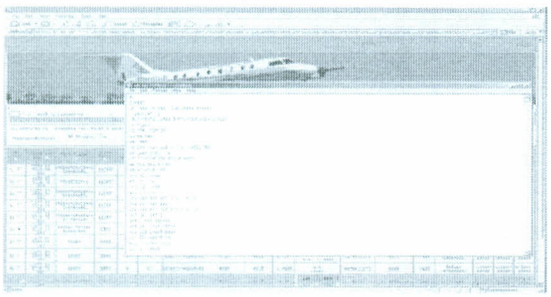


Fig. 6(a) Opening of CNC program in a Notepad referring to a manufactured part.

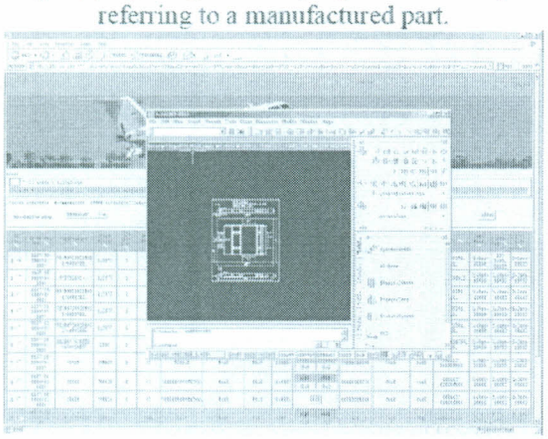


Fig. 6(b) Opening a Setup sheet of the CNC Part in AutoCAD.

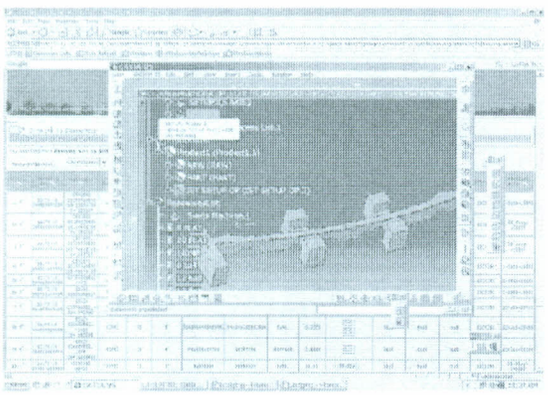


Fig. 6(c) Opening a CAT process referring to a CNC part in CATIA. V5

5.2 Team Member (TM) login features:

i) List of activities designated against the TM for Modeling, CNC Programming and Machining or generation of Lofts or NMG.

ii)On selecting a particular TM name in the list, the respective activity details are displayed for Modeling, CNC programming, machining and generation of Lofts or NMG separately (Fig 7).

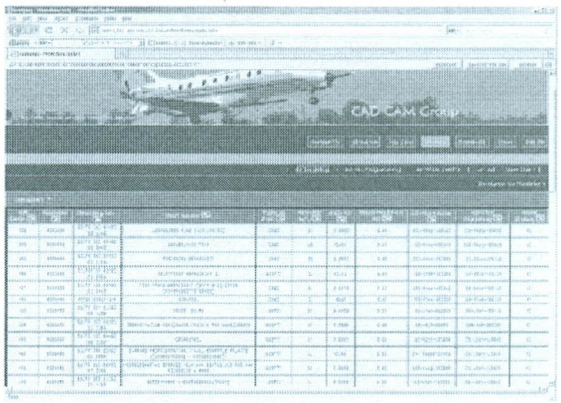


Fig. 7 Drawing details referring to a designer.

iii) List of activities which are over due as on date is also shown.

iv) Details of all the authorized users to login to the system are also accessible.

5.3 Admin Login features:

In addition to the features listed for TM login, the following database updating feature is included for the Admin login ID.

5.3.1 User Interface (Edit DB Interface) is designed in such a way to enter all the fields.

5.3.1.1 As soon as the user enters the drawing number, the other corresponding fields will be entered automatically if the details are already available in the database, so that it is easy to modify the existing data rather than entering them again. Also it helps in upgrading the drawing version for different types of design drawings like Project Slip, Revised Project Slip or aircraft tooling drawings.

5.3.1.2 The preview screen is provided to confirm when the user is sure about the data entered or the user can go to previous screen to edit if required.

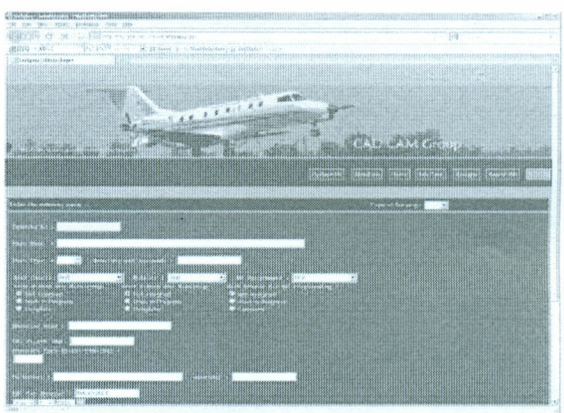


Fig. 8 Edit DB Interface.

5.3.1.3 A confirmation page is provided with the details entered in a database.

5.3.1.4 For a session, the user can edit/enter as many drawing details as he wants. Also any user can view the drawings entered during this login.

5.3.1.5 In this screen, a field viz., 'CAD weight', with a tool tip is provided which contains the total CAD weight (based on all the drawing details entered in the database as on then), which will be helpful while entering a new CAD weight for the new drawing. This also helps in comparing the difference between CAD weight and the actual machined weight.

5.3.2 User details – This interface provides the user to view add/modify/delete the login details of all the users such as User Name, User ID and User password.

6. Visual Perception

The system also brings in visual salience like color, alert note, animated keywords, relative positioning etc., for effective and quick understanding of the results wherein "the distinct subjective perceptual quality makes some items in the world stand out from their neighbors and immediately grab out attention" [5]. The CDMS has incorporated these features which can trigger the secondary task depending on the cognitive load to execute the primary task. The Search result features in three flavors for Work Status viz., Complete (C), Work in Progress (P) and Not Assigned (NA) (Color code: Green, Red and Blue for the background respectively.). The tool tip on the titles– CAD Weight, Machined Part Weight and Material Size is helpful in calculating the total CAD weight, total machined part weight and the difference between these two with reference to the drawing details based on the search given. For example, if the user wants to know the drawings related to belly fairing region of the aircraft, the list of drawings pertaining to that region alone will be displayed in the search result window, where in one can find the total CAD weight, total machined part weight and the difference between these two with reference to the region which is the input for the search. In addition to this, if the part drawing demands CNC manufacturing, Loft or a NMG, only the respective files can be viewed.

7. CDMS Differentials

The CDMS is implemented as a functional program, with the utility functions like formatting the search result layout, viewing the drawing related files by interacting and invoking the corresponding editor/tool to view the files such as CATIA V5 for CAT Process, Auto CAD for drawing files, Acrobat Reader for pdf files to name a few. The programming style leads to general and widely reusable methods, minimizes the programming effort and thereby facilitates scalable and reusable result.

As a consequence of this open source and portable features of Java and JSP, the entire text is stored in memory before any part of it is displayed on the web browser. Since the HTML text is generated by JSP there will be no delay to get the web result. All noticeable delay is either by the web browser interpreting the HTML page or due to delay in invoking the process to start the corresponding editor/tool in the local system or if the file size to be opened is large (search and download time from NAS and traffic in the network).

As this is session based due to the Java/ JSP technology, there is no limitation on the number of clients accessing the system at any point of time, and separate sessions will be maintained for each user without hampering the result at the user-end. A major point to be noted here is that, as there is a session maintained between the CDMS system and the user, there is no limit to number of files to view corresponding to a drawing. The main highlight here is that if a particular file is viewed by the user in a particular session and if the user wants to view it for the second time in the same session, the time to search for the drawing and a file from the database and from the NAS is insignificant, as the server maintains all the links to the viewed files in a session and thus makes it easy to access it subsequently. Further, by incorporating a database management system to handle the engineering information, a high level reuse of system functionality is accomplished which otherwise requires reimplementation since the DBMS can automatically support storage management, meta-data, query processing and transactions [6].

As it is a pure client server and web browser based interaction between the system and the user, the load on the client is very minimal (which involves interaction with AJAX process) and the low end user (minimum configuration, with a Java enabled web browser) system will suffice to interact with the server.

In this project, analysis of performance can be thought of in terms of request size, interpretation and communication of a computer system's speed or capacity. The response time is defined as the time elapsed from the moment the user requests and gets the response in terms of Metadata or a file to open. Random studies were made from the remote systems on LAN and from the local system on the Server to study the time taken to get the response. The results are shown in Fig. 9.

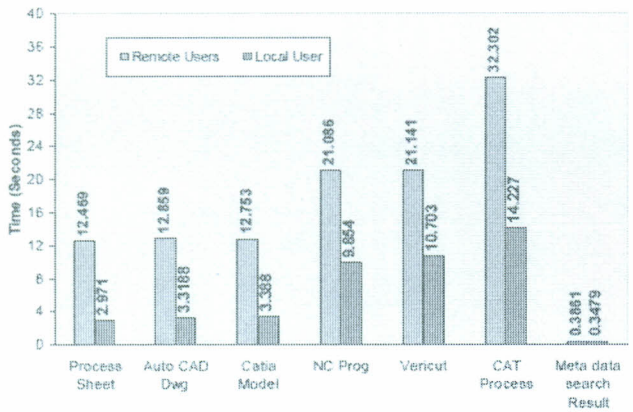


Fig. 9 Time Chart.

8. Conclusion

The CDMS is now fully operational in the CAD/CAM group and the first version has shown that it can effectively manage the voluminous engineering data of varied formats, integrating all the heterogeneous software environments successfully and providing coherent information to the users. The CDMS offers unique access to data and provides better documentation. The future work includes development of a module to interact between the users viz., Group Leader with the team members and external vendors along with a reminder to alert the team members about scheduled completion of activities, based on the expected date of completion. As this is a customized program for an aircraft development project, the system requires additional secured and reliable features to interact with the other divisions within the organization, which forms the future course of work. It is further proposed to build in the production planning and routing procedures into the software, the implementation of which forms a major challenge in the years to come.

9. Acknowledgment

Our sincere thanks to Dr. HNV Dutt, Project Director-SARAS, C-CADD, CSIR-NAL, Bangalore for his support and technical advice during the implementation of this project.

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