Common Libraries for Networked Engineering Applications

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Abstract:

The Internet has become a huge electronic library of information resources. From this vast source of information, knowledge can be extracted and manipulated. Engineering information should, therefore, also be available via this electronic resource. Several Scottish academic establishments have compiled servers specially dedicated to the distribution of Engineering information, a sample of these systems is documented. Further discussion involving the use of a specific common library/repository for Engineers as a catalyst for both present and forthcoming Internet collaboration is also given. Ideas and suggestions on probable future use of the Internet in respect of common networked Engineering applications is highlighted.

1. Introduction:

The Internet has been described as the world's largest library. In such a form it is no more and no less than a huge source of information from which one can retrieve data. This may be of a technical nature, for example, a list of research publications or (at another extreme) the humble phone number of the nearest dial-a-pizza. It is noteworthy that these are all 'one-directional' operations of a 'read-only' nature. Advances in Internet applications now allow business transactions of a 'two-way' form to take place (so it is now possible to order and pay for your pizza via the Net - consumption is still the prerogative of the user!). It is acknowledged that this has been somewhat impeded by fears over the security of credit card and other financial transactions over the Net (1) (2). A growing number of companies have now overcome this problem thus allowing payment for goods and services to apparently be safely conducted via Internet communication (3) (4).

The Engineering community is increasingly using the Internet as a means of accessing and transferring data of a scientific and technical nature. This is the case both for academic research and industrial applications (5) (6). Collaborative project work is aided, as is the exchange of knowledge and expertise, irrespective of whether the joint users are at opposite sides of the world or merely around the corner. For example, it is already possible to tele-manufacture using the Internet (7), future technological advances will undoubtedly allow increasingly complex Engineering applications to be utilised and shared via the Web (8).

The soaring usage seems likely to continue, Internet use is reportedly increasing by 42% per year (9). Engineering users are rapidly realising the potential gains from the use of such technology. Coupled with this increasing use it is inevitable that there will be a demand for more innovative Engineering applications to be available. This paper gives details of several Scottish-based Engineering Internet resources currently available; then documents the use of a specific common library/repository for Engineering applications from both a supplier and a

user viewpoint and, finally, discusses how a new generation of Engineering software tools might be available via the Internet.

2. Information and Collaboration:

Since the Internet was 'born' within academic circles it is not surprising that the first uses of common Engineering information pooling and transferring began in the same environment (10). Such information retrieval systems have lent themselves well to collaborative work and allowed rapid access to shared data and information from digital libraries, without regard to geographic location. The Engineering industry has also realised the potential of this means of information data transfer (11) and hence an increasing number of collaborative data pools and information sources are rapidly becoming available (12).

2.1 Academic Server Examples:

The number of electronic information providers within academia is large and continually expanding. A small selection of these web-based sources are shown by way of example. Heriot-Watt University in Edinburgh has, in common with most academic establishments, a number of electronic information stores available directly via web links. The Internet Resource Centre (IRC), in particular, allows rapid movement to and retrieval of data from a variety of sources. Figure 1 shows, at top level, the information available from both the IRC and other information sources. The Internet Resource Centre is a set of World Wide Web (WWW) pages, bringing together links to a wide variety of information sources on the Internet for learning and research. There are a variety of subject guides included in the material together with a number of search tools. These pages are available on 'H-Web' - the Heriot-Watt University campus-wide information service and can be accessed globally by any web browser at: *http://www.hw.ac.uk/libWWW/irc/ircenter.html* The Internet Resource Centre also publishes a monthly Internet Resources Newsletter listing new and useful information sources, this can be accessed at *http://www.hw.ac.uk/libWWW/irn/irn.html.*

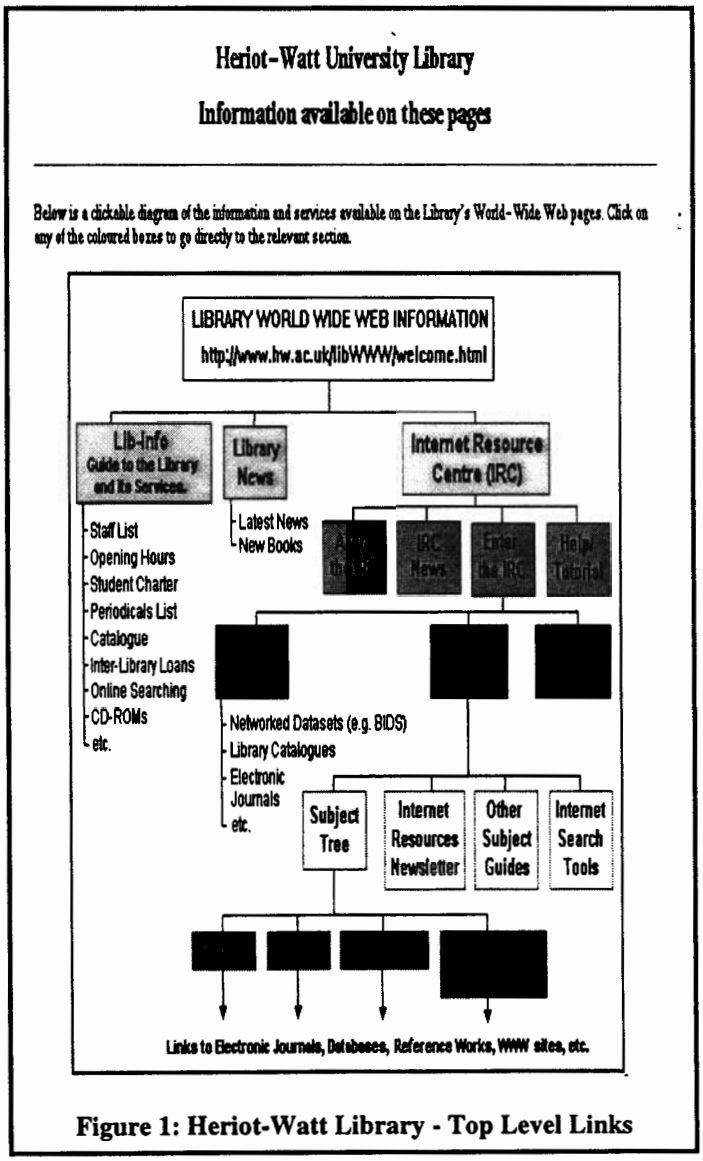

Figure 1: Heriot-Watt Library - Top Level Links

Whilst the Heriot-Watt IRC is a *general information* resource, the fact that it is based at a University with a technological bias means that there is a great deal of information which is significant for Engineers. Significant examples of UK/Scottish based academic servers which are specifically designed for the search and retrieval of *Engineering* information, are the CAD Centre Engineering Information Guide from the University of Strathclyde *(http://www.cad.strath.ac.uk:/EnginfoGuide.html)* and the Edinburgh Engineering Virtual Library (EEVL) at Heriot-Watt University, Edinburgh *(http://www.eevl.ac.uk/welcome.html)* - see figures 2 and 3 for views of the top level of these two servers, respectively. The Strathclyde Engineering Information Guide is a live listing of sites which have relevance to Engineering, and in particular to design research, that have been discovered on the Internet.

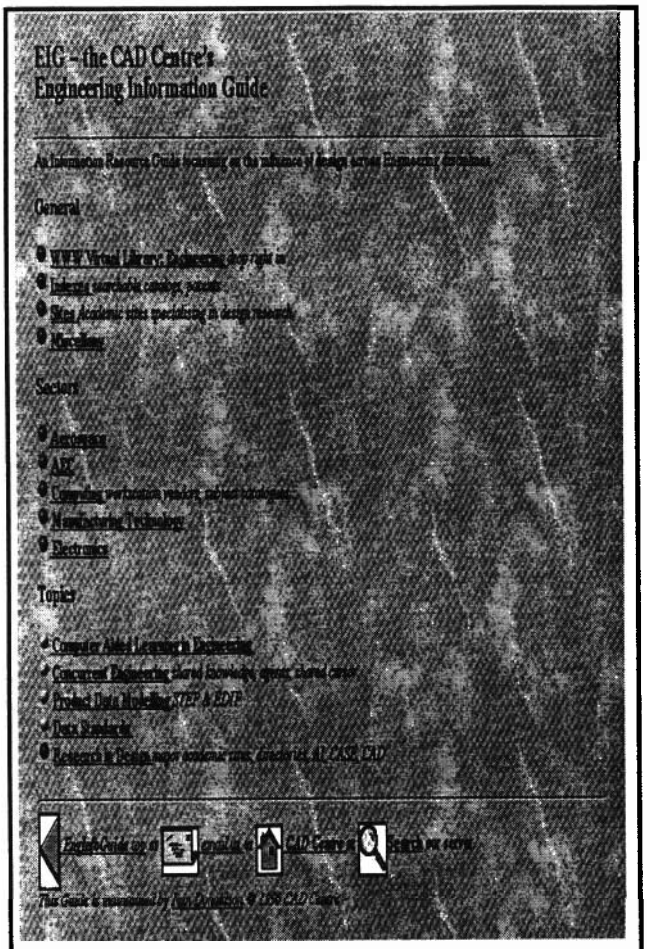

Figure 2: Strathclyde University CAD Centre

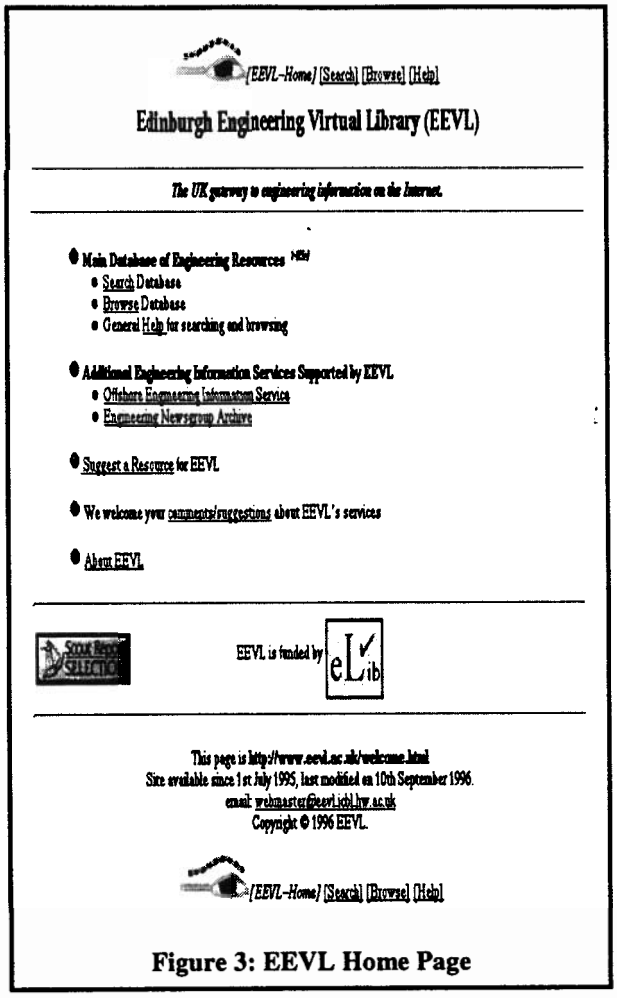

Figure 3: EEVL Home Page

The EEVL is an ongoing project to build a Gateway for the Higher Education and Research Community (HERC) to facilitate access to high quality information resources dedicated to Engineering. The EEVL Gateway is a World-Wide-Web interface to a catalogue of Engineering information resources available on the Internet. It provides a central access point to networked Engineering information for the UK HERC, and anyone else who may be searching for networked Engineering information. Resources being added to the EEVL database are selected, catalogued, classified and subject-indexed by experts to ensure that only current, high-quality or useful resources are included. EEVL collaborates with similar services in other European countries and in the USA. It also works closely with UK-based Engineering professional institutions. In addition to providing access to resources, EEVL encourages the

creation and provision of new Engineering resources, and will give assistance to non-networked Engineering organisations for this purpose. An important part of the Project is to disseminate and promote awareness of the Gateway amongst UK Higher Education Institutions.

Throughout the Project emphasis is placed on the user-friendliness of the EEVL service. The EEVL is a fine example of collaborative work for the provision of a freely-accessible technical web service, the lead site for the EEVL Project being Heriot-Watt University Library. Technical input for the Project is further provided by the Institute for Computer Based Learning (ICBL) also based within Heriot-Watt University, Edinburgh. Project Partners are the University of Edinburgh, Napier University in Edinburgh, Cambridge University, Imperial College of Science, Technology and Medicine in London, The Nottingham Trent University, and the Institution of Electrical Engineers.

Within the Engineering design and manufacturing sectors it was logical to expect that common libraries would be developed as repositories of such information as realistic CAD/CAM data and components. This has been the case, as will be discussed by means of an example of such a currently existing data repository.

2.2 The National Institute of Standards and Technology (NIST) - Design, Planning and Assembly Repository:

The Design, Planning and Assembly Repository within the National Institute of Standards and Technology (NIST) joins government agencies, industry, and academia to provide a library of 'example data' for use by the research community. The ascendancy of the Internet and the World Wide Web has provided the communication medium to build vital on-line libraries having wide user-bases and access. It is the goal of the Repository to give researchers access to a wide variety of problems taken from industry, thus improving the base of common working knowledge for the community and giving students access to both challenging and high-impact problems. The Repository also provides a focal point for collaboration, allowing researchers to post challenging problems to a wide audience, share results, or perform large-scale experiments requiring bigger data sets with industrially relevant data. It is believed that establishment of this Internet-enabled communal library will hasten advances in areas such as Manufacturing Process Planning, Feature Recognition, and Assembly Planning. The repository can be accessed through the World Wide Web at *http://www.parts.nist.gov/parts.*

2.2.1 Repository Contents and Use:

The Repository has initially been designed to serve, primarily, a number of research communities: Manufacturing Process Planning, Feature Recognition, Feature-based Manufacturing and Assembly Planning. The Repository contains parts covering many commonly used manufacturing processes. Because machining has been among the most widely researched manufacturing process, currently the contents of the Repository are biased in this particular direction. Included are many examples from previous research work in machining and assembly planning. Many of these models are taken directly from industrial and/or research areas and describe components whose manufacturing plan might include several distinct steps and processes.

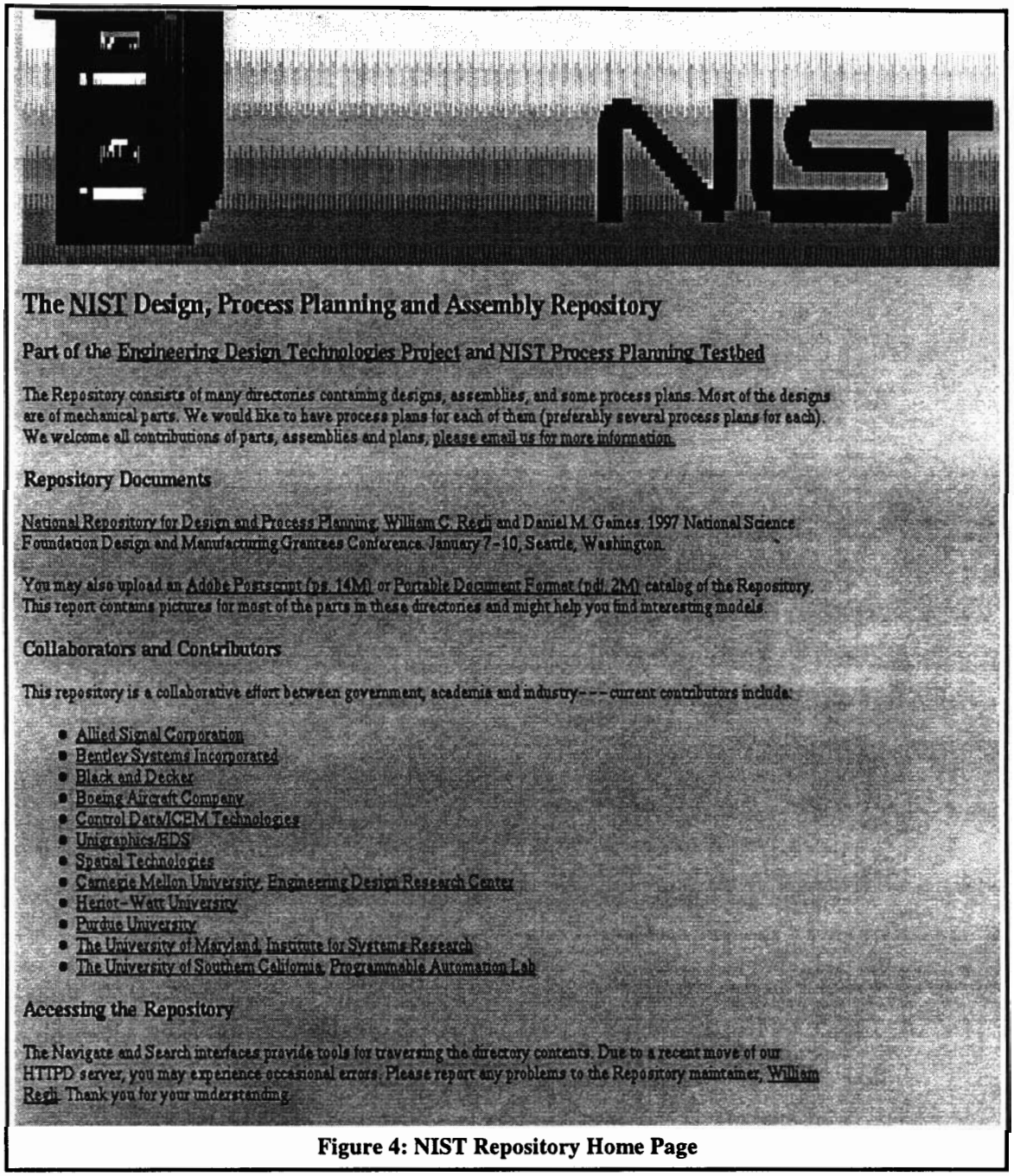

Figure 4: NIST Repository Home Page

Currently the Repository includes around 2500 part models in a variety of formats. All of the models in the repository are stored in at least one of the formats which are established international standards, industry standards, or industry-developed 'open' formats - STEP Application Protocol 203 (ISO 10303-203); IGES; ACIS .sat solid modeler file format; Bentley's MicroStation .dgn; Autodesk AutoCAD .dxf/.dwg; Pro/Engineer files as .prt, .neu, .asm; Parasolid Transmit Files .xmt/.xmt_txt; PADL-2 .pfi files; and several other formats. The Repository also contains a number of image and display formats for model files, including Postscript, CompuServe Graphical Image Format (GIF) and Virtual Reality Modelling Language (VRML).

In its current form, it is anticipated that the Repository might serve as a further prototype collaborative environment (10) for research and in doing so create a number of synergistic outputs. Active use of the Repository should greatly enhance its content, its value as a global resource, as well as benefit enormously the research of those who use it. It is anticipated that the establishment of this Repository, and its growth through the contributions of industry and academia, will lead to faster advances on problems in Engineering design and manufacturing automation.

2.2.2 An End User's Assessment:

As an academic establishment actively involved in Feature-based Manufacturing and Assembly Planning in collaboration with industrial partners, Heriot-Watt University Department of Mechanical & Chemical Engineering is both a contributor to and a user of the NIST Repository. Having already deposited over fifty solid models of both real and idealised Engineering parts within the Repository, the Feature-based Manufacturing group at Heriot-Watt University are currently downloading other models from within the store on which to test their developing software. In using parts from the NIST Repository as 'benchmark components' it is possible to assess more fully the efficiency of the Feature Recognition algorithms under development.

Whilst the above use could be seen as of benefit only to one research group or team, nevertheless, a major area of collaborative work within Feature Recognition research is being undertaken via the NIST repository at this present time and its results will be presented at the 17th ASME International Computers in Engineering Conference in Sacramento, CA in September 1997.

A panel session on Geometric Feature Recognition is being organised as part of the Conference. Following from around two decades of research on Feature Recognition it is felt that now is the time to assess the state of the art. The panel session at the Computers in Engineering Conference is an effort towards this and will be organised in the following manner. Unlike many panel sessions, papers will be publicly solicited from all feature research groups who have implemented Feature Recognition systems. Each paper will discuss the algorithms and implementations of each system and, more importantly, report their test results. Each paper is in reality a status report of each approach and system implemented.

Each participating group in the panel session is asked to submit an example component. The component may have interesting characteristics (e.g. high complexity of feature intersections), may have been used by the group as a benchmark component, and/or may be the one that the group wants to share with the other research groups. The solicited component s will be stored in a portion of the NIST parts repository, and all groups in the panel session will be obliged to test their systems with the components. In this way the NIST Repository is acting as a catalyst for a major collaborative Engineering project on a global scale.

3. Towards the Future:

One current view of the future of computing, is of a world where software is no longer purchased 'off the shelf', but is maintained by the vendor and is then downloaded over the

Internet for a nominal cost every time it is accessed. This year (1996) sees the advent of the Network Computer, a hard-disk-less Personal Computer (PC), which is designed to download its software over a network connection. Initially for companies making use of Intranets (a local 'Internet' only visible from within the company), the technology is scaleable to the world-wide Internet, and offers a cheaper alternative to buying a full specification PC.

It is thought that this will herald the dawn of Network Computing. To maximise the potential of this shift in software buying (or paying) practise, packages should ideally be 'architecture neutral', i.e. able to run on *any* machine platform. This can now be achieved using the Java programming language, which compiles code into binary byte-code, a sort of 'semi-compiled' machine code, which can quickly be recompiled into full machine code on *any specific* platform, running a Java Virtual Machine (JVM). This JVM may be within a Web browser such as Netscape, a standalone application, or indeed may be the entire operating system of a Network Computer.

Currently there are no distributed Engineering applications that make use of this new technology. It is mainly utilised for writing small 'applets', which allow a certain amount of interactivity to previously static web pages. There is in theory no reason why a working Engineering application could not be written in Java right now, to prepare for and test the feasibility of, the Network Computing paradigm. Future research at Heriot-Watt University will address this issue.

Presently, three major obstacles exist in the development of Distributed Computer-Aided Engineering Tools.

a. **Security:** Security issues have already been mentioned (1) (2) (3) (4). Current protocol requires that executable code distributed over the Internet is unable to read or write files on the client (customer) disk. This is unfortunate, since it is where the client's data resides! This may well be resolved by the incorporation of Trusted Applets (13). This is basically Java executable code from reputable, authorised (by the user) servers (sellers), which are given read/write access to selected parts of the client computer. The client can indicate to their computer that applets from *certain* sources (possibly containing an electronic signature), are permitted to read and write to the computer's disk. Specifications for these are, in fact, already being laid down.

b. **Bandwidth:** Engineering Applications may be rather large, requiring a long download time. Bandwidth is increasing all the time. Fibre-optic communications and new compression technologies mean that the amount of data that can be transferred, and the transfer speed is becoming practically limitless.

Meanwhile, however, both of the above issues can be 'worked around' by simulating a network situation using the Java Development Kit Appletviewer (14) (15). The Java Development Kit from Sun, provides a useful environment in which to develop network executable code. The Appletviewer is a package which will run Java code, loaded from the local disk, rather than over the network, and consequently is allowed to read and write to the local disk. In all other respects, the executable code is treated as if it had been loaded over a network from a remote server (seller) site. This can be done today, right now!

c. **Sold Model Data Structure**: The other issue to be addressed, specifically in the areas of Design, CAD/CAM and Feature Recognition etc., is the lack of a (probably) necessary solid-model data structure in Java. While C++ executable code *can* be passed to Java (16), this is compiled code and is therefore platform specific. This may not be an issue on the Appletviewer work-around though, since development will only occur on one machine. As much code as possible should be written in Java, which can then access the C++ ACIS objects when required.

4. Conclusions:

Several Scottish academic establishments, in common with other academic institutions world-wide, have compiled Internet servers specially dedicated for the distribution of Engineering information. These WWW resource providers are readily accessible and regularly updated, thus serving the Engineering community with current information and knowledge.

The development of a common collection of realistic CAD/CAM data and parts is of critical importance for the R&D community. It is believed that the lack of such a collection has been a significant impediment to building consensus on technical issues and research directions, often resulting in redundant or duplicated research effort . To address this, a Design, Planning, and Assembly Repository has been created at the National Institute of Standards and Technology. The deployment of this publicly accessible library will, hopefully, enable many exciting new research problems to be addressed.

As the likelihood of an extendible network architecture for computer-aided Engineering tools becomes a probability rather than a possibility the future of common libraries for networked Engineering applications becomes ever more challenging. In the not too distant future it should be possible to run remote executable applications as and when required. Many Engineering software-driven technical applications are both large (in memory usage terms) and also prohibitively expensive for small to medium sized enterprises. No longer will they have to turn to consultancy houses in order to facilitate themselves of such programs for short periods of time, the advent of distributed Engineering tools will allow them to operate such systems on a pay-per-usage basis. Also, due to the global accessibility of the Internet, the suppliers of such software servicing tools will be able to compete on a world-wide stage.

Disclaimer:

Certain software companies and commercial software systems are identified in this document. Such identification does not imply recommendation or endorsement by NIST or Heriot-Watt University; nor does it imply that the products identified are necessarily the best available for the purpose. The NIST Repository has been made possible with the participation of a number of commercial vendors, industrial users, and universities.

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