Distributed Knowledge System for Spacecraft Design Data

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Abstract

NASA Ames Research Center has developed several advanced distributed information systems to assist the dissemination, analysis and management of data from aeronautical design systems. A new project has been started to create a similar system for spacecraft design teams. This paper discusses the information systems that enable distributed access to computational results and the management of the derived knowledge generated by users of the system.

1 Introduction

NASA Ames Research Center is using advanced information systems technology to support the data, information and knowledge management for integrated design systems. One of the key projects, called Space-IDS (or spacecraft integrated design system), will permit space transportation design data and results to be produced and made available to industry and NASA partners faster and cheaper. This paper will describe the Distributed Workspace Environment developments, the incorporation of some knowledge management systems, and the potential integration with on-line numerical simulations.

The objective of Space-IDS project is to develop an information and knowledge management system to support the integrated aeroshell design process. The operational premise of the system is to gather data, which are considered immutable; to extract and present the information to the user; and then to manage the resulting knowledge that will be created by the user. These data, information, and knowledge will be shared over a distributed system to all of the NASA spacecraft design centers, enabling rapid dissemination and analysis.

In the Space-IDS system, the aeroshell design is a key process. Tools of various fidelities are employed with the fidelity increasing in the latter stages of the design process. For actual hardware design, the aeroshell's reentry air-flow environments are generated using full chemical-reacting, computational-fluid-dynamic (CFD) calculations generated along the entire entry trajectory. These calculations are used to size the thermal protection system, perform the vehicle stability and control analysis, size the structure, design the parachute, Wind-tunnel, arc-jets, and, other experimental tests are primarily used for component performance verification. Coupling the outputs from the disparate numerical simulations and the experimental data sources into a cohesive aeroshell design system is what the DARWIN-derived [1] technologies and architecture provides to Space-IDS.

The previous systems, like NASA Ames Research Center's DARWIN, have excelled at distributed data management, but have had limited capability to capture and manage user generated knowledge. Some other NASA distributed information systems, such as ADAPT or PostDoc [2], handle documentation very well, but are lacking in managing raw data.

2 Space IDS Infrastructure

The Space-IDS distributed aerospace information system is shown in Figure 1. This consists of the Distributed Workspace, the client systems at the remote user sites, and the central Space-IDS server. These systems are all connected utilizing NASA's DARWINnet at Ames and NASA's wide area networks for national connectivity.

The remote access system is based on distributed web framework. The first server is the Space-IDS MetaServer, running an HTTP (hypertext transport protocol) or web server, the supporting central executive server software, and the meta-database. The remote client system hosts the Distributed Workspace Environment (DWE) that is composed of a web browser, an executive, and additional visualization and collaboration software. Many of the small remote applications are written in Java or Javascript as remote agents that are either executed or started by the client's browser. The larger applications, such as the collaboration whiteboards, remote video tools, and higher end data visualization tools are authorized and initiated by the executive software on the client or through the central MetaServer.

The fundamental framework of a distributed data repository is used to support three NASA Centers: Ames, Langley, and the Jet Propulsion Laboratory. A central meta-database at Ames is used to manage the data. The client analysis tools are web-based as in DARWIN [3,4], but customized to support primarily computational, not experimental studies [5]. Automatic data loading from CFD programs will be enabled in the initial implementation of the Space-IDS information system. Also individual computational results could be uploaded from clients and stored in the meta-database or in the knowledge management system described later in the paper.

The DWE can directly display or plot most of the raw data files in the Space IDS meta-database and file system. The browser's point-and-click interface allows the user to interrogate specific runs by querying appropriate meta-data

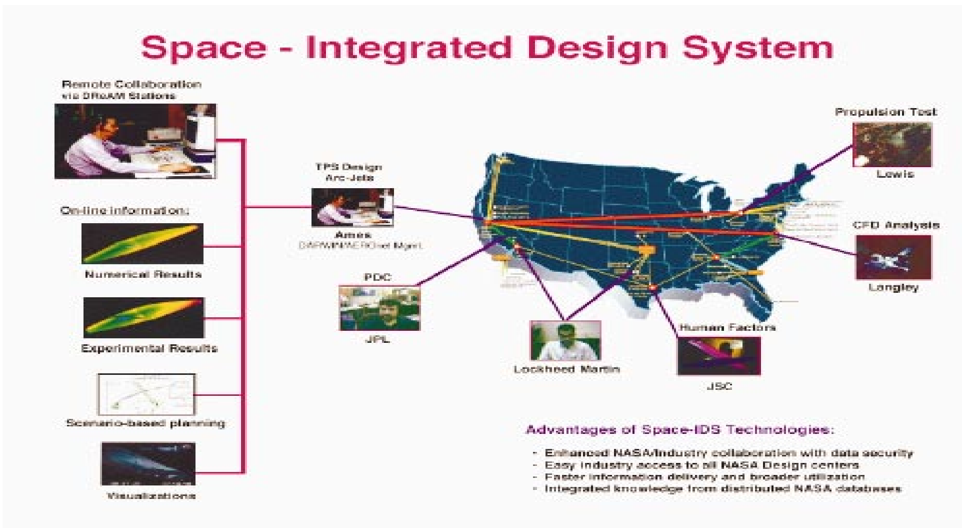

Figure 1 - Space-IDS Distributed Information System

and then automatically retrieve and present the information. Dynamic plots of the data are generated using a graphing package written in Java. The user may also customize the display of data by using a form-based interface to specify preferences for what plots should be generated and what columns should appear in the summary tables. The linkage between the information presented and the related data sets is the enabling factor in being able to dynamically access the data and generate knowledge from the data.

Once the Space-IDS design system has generated the data (e.g., a solver has produced a converged solution) the Space-IDS data server posts the solution file and meta-data to the database. Then the test engineer can use a feature extractor component to check for expected flow features such as shocks or vortices. Fluid dynamicists could also use this system to start computations and track the solutions, as well as have access to experimental data for analysis and review.

2 Distributed Information Management

The DWE software controls user authentication and privacy, data security, advanced video and interactive conferencing tools, remote control of cameras, interactive database access, and custom tools for data visualization and analysis. The framework for the DWE is composed of a web browser, specifically Netscape Navigator™ v4.05+ that can display HTML containing text, Javascript code, and Java applets; the DARWIN executive software; and supporting data analysis applications. The browser and the applications are all resident on the client workstation. The web pages, the dynamic results of the executive software, are retrieved from the Space IDS server.

The executive software provides the communication link between the web browser and the specialized data analysis tools. The executive software is written in PERL, Java, and JavaScript. The executive's role is to coordinate the data and information pages to be displayed. All of the pages are dynamically generated on the MetaServer from the information available in the meta-database. The information infrastructure is the same as the DARWIN systems already developed for the NASA aeronautics community.

3 Distributed Knowledge Management

There is a new knowledge management system being designed and built for the Space-IDS systems as well as the other distributed information systems [6] being developed at NASA Ames Research Center. The user of the distributed information system will be creating derived knowledge from the computational data and information. For the resultant user-created knowledge, the DWE is being extended to manage the information and additional user input (documentation files, slides, etc.).

documents, datasets, subfolders, or links. This is a hierarchical grouping to make organizing and accessing the information easier. Links are uniform resource locator (URL) hypertext links to other distributed information

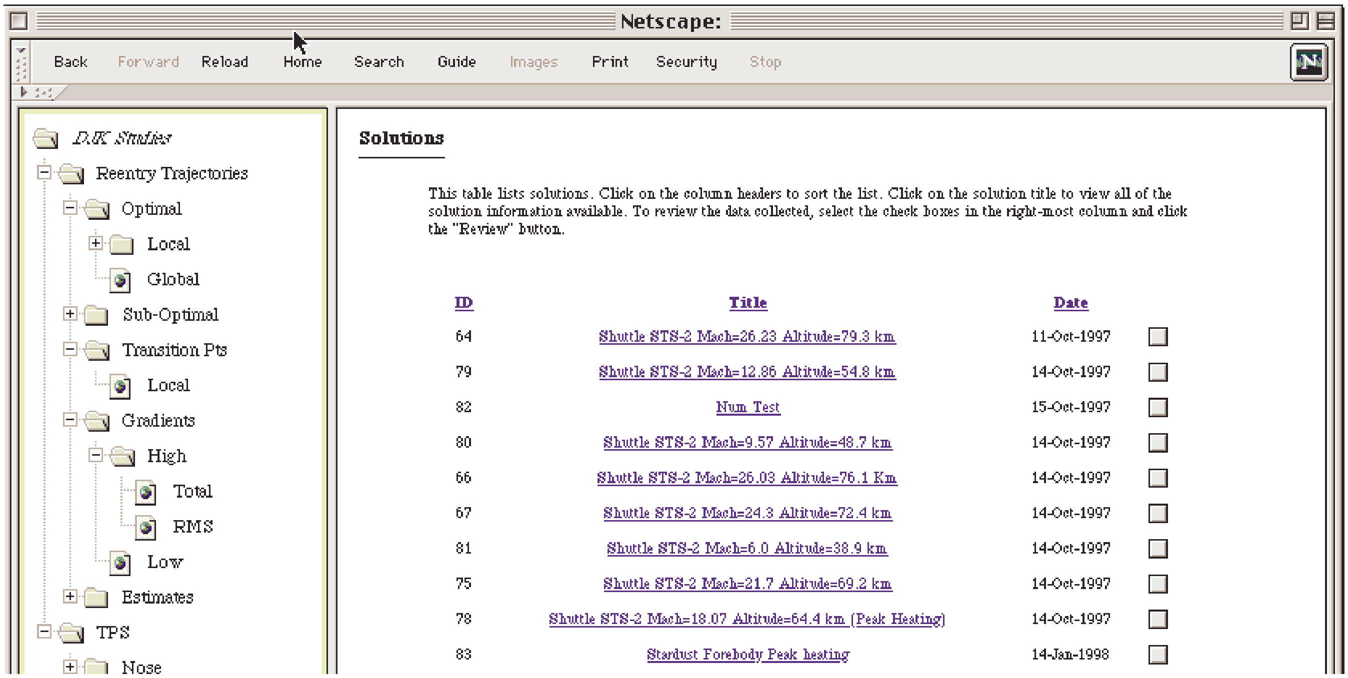

Figure 2 – Prototype Knowledge Management Interface

systems. These allow the inclusion of information that is resident and controlled outside of the DWE data system. Other information sources on the world-wide-web or ftp sites are examples of these link sources.

Figure 2 shows what the prototype interface to one aspect of the knowledge management system looks like. On the left side is a folder tree structure that shows the relationship between documents and datasets. “Document” is the generic term to describe externally created information or data. Documents are often research notes that are context information from the DWE and provide traceability for the researcher. Documents can also be papers, presentation files, or additional raw data that have been generated by the researcher but not input into the overall databases.

The “dataset” is the structured data and information developed by the DWE that is not a stand-alone document but a “page” or set of pages that represents some of the raw data and information after analysis within the DWE. For example the following Figure 3 shows a page from the DWE analysis system. The graph and table are dynamically generated by the system and permit interactions to modify the graph parameters and display options. This is a dataset page. It can contain data from multiple sources. When it is accessed, the latest data is refreshed from the various data sources and databases to ensure that accurate data is used in the analytical process.

Within the knowledge management (KM) system there are documents and datasets (both described above), folders, and links. Folders are, as the name suggests, a collection of

The permission and access control to folders is being designed with the UNIX file system as a model. ‘World’, ‘group’, and ‘user’ categories will have read, write, and execute permission on the folders, documents, datasets, and links within the KM system. This permission information and the management of the folder structure, documents, pointers to the datasets, and links are managed by a relational database architected for this purpose.

The KM database will have pointers to the datasets that are generated by the DWE component of the Space-IDS system. These pointers will have the state information of “which data” and “where” in the analytical process the user was when this dataset was “saved” to the KM system. To the user this will behave as a live document that reloads all of the appropriate data in the proper format.

4 Conclusions

The Space-IDS DWE for remote analysis and the KM management systems will give researchers and engineers the capability to remotely evaluate and share the analytical data and resultant knowledge derived from it. In addition,

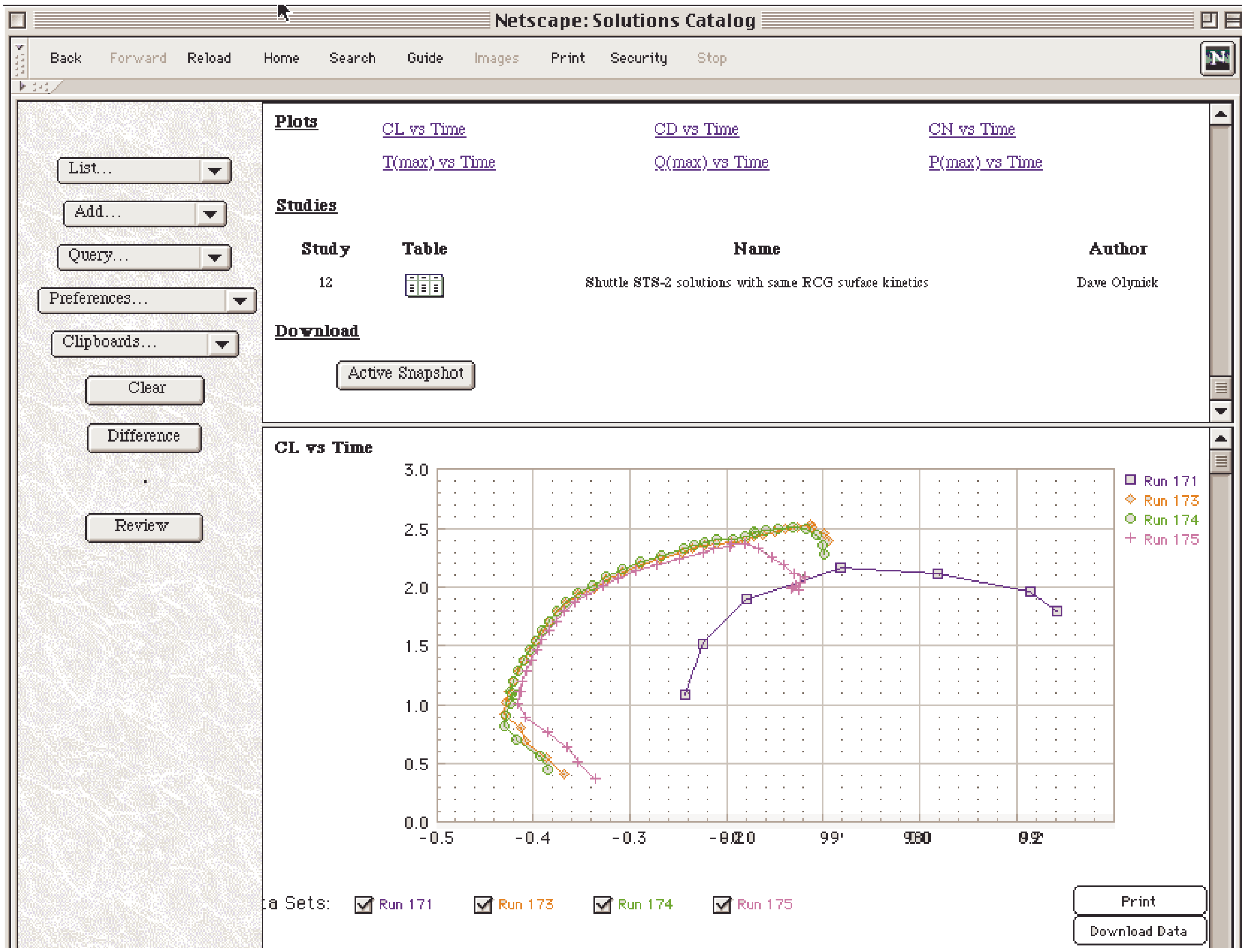

Figure 3 – Prototype Dataset Page

Space-IDS allow for cross comparisons between data sets and a link to the CFD design system for starting numerical simulations. This system is designed to provide the aerospace customer with the necessary information access to greatly improve the design cycle process by rapidly gleaning and sharing knowledge from available design data and thus providing the capability to perform true integrated design iterations.

References

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