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NRA/CAN ECS Overview

Technical Paper

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Abstract

This white paper provides and overview of the ECS related NRA / CAN activities funded by NASA and shows the relevance to ongoing and future ECS activities. Each of the NRA / CAN projects is summarized and evaluated for linkage to ECS architectural concepts, components, or infrastructure layers. A mapping to the relevant Release functionality is provided. None of the NRA/CAN efforts will have direct impact on the IR-1 or Release A activities, design, or implementation. Several projects dealing with the Client and Data Management Subsystem functionality are relevant for evaluation for the Release B and C time frames. The infrastructure related projects are relevant for the Release C time frame. Several projects deal with the issues of value added providers and how they would operate in a more general EOSDIS context and are relevant to the Release B and C time frames.

Keywords: NRA, CAN, Research, ECS, Prototypes, Testbeds, Visualization, Data Management, DBMS, ORB, Value added providers, Distributed Systems, Object, Earth Science, EOSDIS

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1. Introduction

1.1 Purpose

The purpose of this white paper is to provide a synopsis of the NRA / CAN projects and provide direction to the ECS staff as to the relevance of the concepts, technology, prototypes, or testbeds being developed on each NRA/CAN project to the ongoing and future ECS development efforts. The content of the paper was drawn from several sources including: January, 1995 NRA/CAN workshop at Landover, Md., notes and summaries from Judy Feldman, Carl Wheatley, George Percival, Tom Suhrstedt, Bruce Moxon, and Ron Williamson.

1.2 Organization

This paper is organized as follows:

Section 1.0 Introduction and executive summary of the NRA/CAN activities

Section 2.0 Summary of each NRA/CAN project with a brief ECS relevance subsection

Section 3.0 Overall conclusions summary

Section 4.0 Suggested Reading

1.3 Acknowledgments

The following ECS team members contributed to the content and quality of this document, Judy Feldman, Bruce Moxon, Carl Wheatley. The evaluation of each project and the recommendations were a combination of inputs from Ron Williamson, Judy Feldman, Bruce Moxon, Carl Wheatley, George Percival, and Tom Suhrstedt.

1.4 Review and Approval

This White Paper is an informal document approved at the Office Manager level. It does not require formal Government review or approval; however, it is submitted with the intent that review and comments will be forthcoming.

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2. NRA / CAN ECS Evaluation

2.1 NRA/CAN Introduction

2.1.1 Project Summary

Table 2-1 presents a list of the twenty NRA/CAN projects considered in this technical paper. The projects are grouped and sequenced according to the NRA/CAN NASA review presentations. The Groups are: Content Based Search, Data Management and Analysis, Data Dissemination, and Storage and Processing Performance. The ECS Risk column identifies (via risk code defined in Table 2-2) the related risk area identified by the ECS Project, NASA and Science Community. The Risk categories and codes are defined in Table 2-2.

Table 2-3 includes the re-sorted and categorized list of projects into four levels of priority. The first category includes those top priority projects that warrant immediate follow-up and coordination based on direct applicability to the ECS design or that address key ECS Risk areas. The second category are those projects high priority project that warrant follow-up next year in 1996. The third category includes those project with a medium priority relevance to ECS, indicating potential collaboration in two years. Finally, the fourth category includes those projects of lower priority warranting follow-up after three years. The results of all projects have potential impact on ECS and EOSDIS in general. The analysis of these projects and the resulting prioritized list is an attempt to manage the large number of projects and provide quality resources to those that have potentially the highest payoff for ECS.

Table 2-1. NRA / CAN Projects Grouped by Functionality (1 of 2)

	NRA / CAN Project Title / Description	Principal Investigator	Comments	ECS Risk
	Content Based Search Group			
1	GIS for Characterization and modeling of Multiscale Remote-Sensing Data Using Fractals and Spatial Techniques	Lam	Worth tracking. Long term relevance	E1
2	Automatic Cataloging and characterization of Earth science data using SE-Trees	Rymon	Academic interest. Potential long term relevance	E1
3	Phenomena-oriented data mining	Graves	Nieve approach. Long term relevance	E2
4	Intelligent information fusion and management prototype applicable to EOSDIS	Campbell	Valuable partner. Near, Medium and long term.	E2/U4
5	Retrieval of digital images by means of content search	Stone	Long term relevance	E1

Table 2-1. NRA / CAN Projects Grouped by Functionality (2 of 2)

	NRA / CAN Project Title / Description	Principal Investigator	Comments	ECS Risk
	Data Management and Analysis			
6	Extension and application of LinkWinds to EOSDIS	Jacobson	Near, Medium to long term relevance for data visualization	E3/P3
7	Tools and techniques for automating the analysis of EOSDIS data	Emery	Political Must for collaboration Medium to long term relevance	E1
8	Multisource information archival and analysis system	Fussell	Long term relevance	E1
9	Intercomparison, visualization, and analysis testbed system for EOS gloval assimilated data sets and spacecraft	Palaniappan	Mostly visualization Long term relevance	E2/E3
10	End to end problems in EOSDIS	Stonebraker	High visibility. Near Term Data Modeling Relevance. Medium to Long term relevance for design.	E1/T7
	Data Dissemination			
11	Integrating distributed object management technology into EOSDIS	Muntz	Near Term coordination on Distributed Object tracking Long term relevance	E2
12	Usability and interoperability. Public use of NASA's remote sensing data on the Internet	Behrens	Public access browse tool Long term relevance	E1
13	Creating the public connection: interactive experiences with real-time Earth and space science data	Reiff	Public access Long term relevance	E1
14	BDM proposal for the establishment of the remote sensing public access center.	Johnson	Near term coordination Long term relevance	
15	Test applications and digital library technologies in support of puclic access to Earth and space science data	Folk	Near term coordination for HDF access Medium term relevance	P3/E3
	Storage & Processing Performance			
16	Compression and progressive transmission of digital images	Percival	HDF Compression Medium to long term	
17	Paradise clusters as inexpensive scalable support for standardized access to EOSDIS data sets	DeWitt	Data Server Alternative Near team prototyping, medium term relevance	E1/E2/P3
18	Performance modeling of mass storage archives	Johnson	Modeling effort Near term modeling relevance	T5
19	Support for large data sets in EOSDIS	Folk	HDF storage issues Near to medium term relevance	U2/U4
20	Technology and architecture integration project for product generation system design	Lee	Processing architecture Near to medium term relevance	U4

Table 2-2. ECS Risk Categories

Risk Code	Risk Description	Risk Code	Risk Description
	User Interaction		**Evolution**
U-1	Number and Activity of Users	E-1	Evolution Category 3: Paradigm Changes
U-2	Interoperability of Earth Science Data Models	E-2	Evolution Category 2: Planned improvements
U-3	Uncertainty of datasets available for ECS	E-3	Multi-Track Development Process
U-4	Processing and Storage for Standard Products	E-4	Multiple Versions in Op'l Use Simultaneously
U-5	Algorithm Integration Process	E-5	Multiple Spacecraft Accommodation
U-6	Interface with ASTER ICC		**System Operations**
U-7	Toolkits (API Maturity)	S-1	Scope of ECS operations in DAACs
U-8	Product Dependencies	S-2	Automated Operations in Data Distribution
	Architecture	S-3	Automated Ops for Command & Control
A-1	Support Approach for GCDIS/UserDIS	S-4	Automated Operations for Quality Assurance
A-2	Resource Management with Diverse Users	S-5	Paradigm Shift in User Support
A-3	Safety of space assets	S-6	Timeliness of GFE Circuits
A-4	Distributed Scheduling (FOS)		**Programmatics**
A-5	User Interaction with Archived Data	P-1	Software Reuse Process
	Technology	P-2	System Verification Environment
T-1	CORBA Immaturity for Release B	P-3	Compressed Development Schedule
T-2	Earth Science Data Language	P-4	Resources for COTS integration code
T-3	Storage Management Interop. Standards	P-5	Release to Release Transition
T-4	COTS Hierarchical Storage Management	P-6	OO Development Methodology (SW & SE)
T-5	Cost Effective Storage Technology		
T-6	Performance of Communication Infrastructure		
T-7	Data Base Management Systems		
T-8	Scalability & Maintainability of Archive		
T-9	DCE Immaturity for Release A		
T-10	Object Management Framework Availability		

Table 2-3. NRA / CAN Projects Grouped by Hughes ECS Priority (1 of 2)

	NRA / CAN Project Title / Description	Principal Investigator	Comments
	Top Priority: Near term Follow-up		
4	Intelligent information fusion and management prototype applicable to EOSDIS	Campbell	Valuable partner. Near, Medium and long term.
10	End to end problems in EOSDIS	Stonebraker	High visibility. Near term DB eval. Medium to Long term relevance
11	Integrating distributed object management technology into EOSDIS	Muntz	Nearterm coordination on Distributed Object tracking Long term relevance
17	Paradise clusters as inexpensive scalable support for standardized access to EOSDIS data sets	DeWitt	Data Server Alternative Near team prototyping, medium term relevance
19	Support for large data sets in EOSDIS	Folk	HDF storage issues Near to medium term relevance
	High Priority: 1 Year Follow-up		
6	Extension and application of LinkWinds to EOSDIS	Jacobson	Near, Medium to long term relevance for data visualization
7	Tools and techniques for automating the analysis of EOSDIS data	Emery	A Must for collaboration Medium to long term relevance
12	Usability and interoperability. Public use of NASA's remote sensing data on the Internet	Behrens	Public access browse tool Long term relevance.
14	BDM proposal for the establishment of the remote sensing public access center.	Johnson	Near term coordination Long term relevance
	Medium Priority: 2 Year Follow-up		
9	Intercomparison, visualization, and analysis testbed system for EOS gloval assimilated data sets and spacecraft	Palaniappan	Mostly visualization Long term relevance
15	Test applications and digital library technologies in support of puclic access to Earth and space science data	Folk	Near term coordination for HDF access Medium term relevance
16	Compression and progressive transmission of digital images	Percival	HDF Compression Medium to long term
20	Technology and architecture integration project for product generation system design	Lee	Processing architecture Near to medium term relevance

Table 2-3. NRA / CAN Projects Grouped by Hughes ECS Priority (2 of 2)

	NRA / CAN Project Title / Description	Principal Investigator	Comments
	Lower Priority: 3 Year Follow-up		
1	GIS for Characterization and modeling of Multiscale Remote-Sensing Data Using Fractals and Spatial Techniques	Lam	Worth tracking. Long term relevance
2	Automatic Cataloging and characterization of Earth science data using SE-Trees	Rymon	Academic interest. Potential long term relevance
3	Phenomena-oriented data mining	Graves	Nieve approach. Long term relevance
5	Retrieval of digital images by means of content search	Stone	Long term relevance
8	Multisource information archival and analysis system	Fussell	Long term relevance
13	Creating the puclic connection: interactive experiences with real-time Earth and space science data	Reiff	Public access Long term relevance
18	Performance modeling of mass storage archives	Johnson	Modeling effort Near term modeling relevance

2.1.2 Project Groups

Each of the projects are categorized under the following groups:

Content-based Search	Projects 1 through 5
Data Management and Analysis	Projects 6 through 10
Data Dissemination	Projects 11 through 15
Storage and Processing Performance	Projects 16 through 20

2.1.2.1 NRA/CAN Project Coordination and Collaboration

Project 14, BDM's Remote Sensing Public Access Center (RSPAC), will act as a focal point for access to each of the relevant NRA and CAN projects. The project activity will act primarily as a coordination and information exchange testbed for NRA/CAN collaboration. Linkage is still required separate from but coordinated with the RSPAC to the ongoing ECS development, prototyping and testbed activities.

2.1.2.2 Client Related Projects

Projects 6, 9, 12, 13 deal directly with visualization or user interaction issues and are relevant to ongoing Client Subsystem design efforts.

2.1.2.3 Interoperability Related Projects

Projects 10, 11, 14 all relate to the interoperability and communications subsystems in ECS. Each is directly relevant to Release B and C development and prototyping efforts.

2.1.2.4 Data Management and Data Server Related Projects

Projects 1, 2, 3, 4, 5, 7, 8, 15, 16, 17, 19 are all relevant to extensions to or replacements for the data management and data server archive services. Release B and C development and prototyping efforts should track these activities.

2.1.2.2 Modeling Related Projects

Projects 2, 4, 7, 18 relate to both data and performance modeling issues and are relevant to ongoing efforts and medium and long term plans.

2.2 Project 1 -- GIS ... Fractals and Spatial Techniques

Investigator: Nina Lam, Dale Quattrochi, Hong-lie Qiu

Description: A GIS for Characterizing and modeling multiscale remote sensing data using fractals and selected spatial techniques

Organization: Louisiana State University, MSFC

2.2.1 Summary

The objectives of this project are to develop a user-friendly GIS software package for the characterization and analysis of multiscale remote-sensing data for global change and environmental modeling studies. The main techniques include: fractals, boundary delineation, spatial statistics, aggregation and scale analysis. The first year focuses on the design and implementation of the GIS software module. During the second year the researchers with evaluate the reliability and effectiveness of the various algorithms in characterizing remote sensing images at different scales, utilizing the GIS developed in the first year.

2.2.2 Relevance to ECS

The core element of this research is Earth Science data analysis oriented. Relevance to ECS is the characterization of the usage of the Earth Science data for specific forms of scientific analysis. Some of the representations research are relevant to the types of search indices to be employed in the data server. Also relevant is the used of fractal representations for subsetting products for browse purposes.

This project is worth tracking, however not directly relevant to the planned development effort on ECS.

RELEVANT SUBSYSTEMS: Data Server

2.2.3 Further Information

Contact Nina Lam at ganlam@lsuvm.sncc.lsu.edu

2.3 Project 2 -- Automatic Earth Science Data Cataloging

Investigator: Ron Rymon

Description: Automatic cataloging and characterization of Earth Science data using SE-trees

Organization: University of Pittsburgh

2.3.1 Summary

EOS Satellites will produce enormous amount of remote sensing data and a mechanism is needed to provide content based storage and access. The primary challenge addressed in this research project is the development of a universal classifier that will recognize ground truth from sensory input. The potential advantages of the approach are increased accuracy, noise tolerance, flexible tradeoff between time, space and accuracy, and us of other knowledge sources in the classification process. The approach is based on SE-tree based induction using recursive partitioning on multiple attributes. The technique is a more expressive representation than decision trees.

The advantages of SE-tree based induction are: generalization results are in a more expressive representation, a hypothesis-space bias can be specified by the user, it provides a spectrum of sic / accuracy tradeoffs, it is less sensitive to noise, it can extract more information from fewer examples, and it can combine induced knowledge with other knowledge sources. The approach addresses the image interpretation problem where one is given sensory inputs (radiances per pixel), other pixel-based data such as elevation and texture, and other general data such as season, weather. Based on these inputs the problem is to classify each pixel as e.g. urban, agricultural, etc.

2.3.2 Relevance to ECS

Content based search is an element of the future vision for the ECS data server. Track this research for determination of Release C and beyond content based search solutions.

This project is perhaps of more interest to ESDIS than ECS specifically.

RELEVANT SUBSYSTEMS: Data Server

2.3.3 Further Information

Contact Ron Rymon at 412.624.2287 or Rymon@ISP.Pitt.edu

2.4 Project 3 -- Phenomena Oriented Data Mining

Investigator: Sara Graves and Steve Goodman

Description: Phenomena-oriented data mining

Organization: University of Alabama in Huntsville, MSFC

2.4.1 Summary

The amount of data in scientific archives is growing. Scientists need to be able to find a particular data of interest --- proverbial "needle in a haystack".. A phenomena-based search tool will allow scientists to search through the data archives to discover related data in any of several datasets. Key technologies in this research effort include the use of an existing data miner prototype, developed for MSFC DAAC, grid algebra / calculus, object relational DBMS for storage of results, image analysis and pattern recognition / classification and parallel processing. The project proposes using SSMI/I pathfinder data products, case studies for WetNet's Precipitation Intercomparison Project, and field campaign datasets for the convection and precipitation, Electrification Experiment. The potential importance to EOSDIS includes providing multiple levels of content-based searching using advanced techniques, providing capability for interdisciplinary scientist to mine multi-faceted datasets, supplementing EOSDIS IMS with knowledge acquired by the Data Miner prototype, and providing data mining capability to multiple DAACs.

2.4.2 Relevance to ECS

Content based search is an element of the future vision for the ECS data server. Track this research for determination of Release C and beyond content based search solutions.

The results of this project could affect the choice of products on ECS.

RELEVANT SUBSYSTEMS: Data Server

2.4.3 Further Information

Contact Sara Graves at sgraves@cs.uah.edu or

Steven Goodman at steve.goodman@msfc.nasa.gov

2.5 Project 4 -- Intelligent Information Fusion

Investigator: William J. Campell

Description: Intelligent information fusion and management prototype applicable to EOSDIS

Organization: GSFC, U.SW.Louisiana, Clemson U., U. Md., ARC, HSTX

2.5.1 Summary

The objective of this project is to develop a prototype proof of concept Earth Science Data moves the burden of a non-EOS user have to understand the system architecture, data content or system language. The goal is to build on ongoing research in the development of an Intelligent Information Fusion System whit the expressed purpose of incorporating and evaluation state-of-the-art techniques for handling EOS-era scientific data challenges. This will assume high risk without "shocking" the ongoing developments. As technologies mature, the project expects to demonstrate and make available to appropriate "Vx" series developers the technology prototypes and evaluations. The effort will stress transportability of technical developments into other EOS related programmatics (e.g. direct readout).

The project uses a wide range of technologies including object-oriented databases and temporal information, data compression, automated georegistration, browse techniques, data characterization, image search by content, Planning and scheduling for product generation and data analysis tasks, and data representation and visualization. Discipline specific evaluations include landuse studies (AVHRR/LAC and Landsat TM/MSS), ozone/atmospheric studies (TOVS), biodiversity and global carrying capacity (landsat TM, JERS-1 and ERS-1 SAR), and land, oceans, atmosphere, and calibration (MODIS).

2.5.2 Relevance to ECS

This project attempts to cover all aspects of the ECS functionality from the graphical user interface for the ECS Client, through Planning and Scheduling and processing, through mass storage and finally to data management (using OODBMS). Each area warrants coordination and potential collaboration with the local GSFC researchers.

The team is working with the GSFC DAAC and could be considered a broad ECS like prototype recommend we track this project closely.

RELEVANT SUBSYSTEMS: Client, Planning, Data Processing, Data Server.

2.5.3 Further Information

Contact William J. Campbell at Campbell@sauquoit.gsfc.nasa.gov

2.6 CAN Project 5: Retrieval of Digital Images by Means of Content Search

Category: Digital Library Technology Project

Investigator: Harold S. Stone / John Turek

Description: Retrieval of digital images by means of content search

Organization: IBM

2.6.1 Summary

This research is directed toward retrieval by image content from large digital-image databases accessed concurrently by many users. To obtain high performance, the algorithms will search the compressed representations of the images without first decompressing them. IBM will incorporate these algorithms into a testbed system. The new work will draw on experience from several ongoing projects within the IBM Research Division. The testbed together with high performance hardware will be installed at the Remote Sensing Public Access Center (RSPAC) for evaluation and testing by an internet-based community.

A prime research objective is to improve the speed of image-retrieval algorithms for content based search. Current image-retrieval systems are limited by either the kind of search that they can perform, the size of database they can effectively support or both. The proposed testbed will hold up to and test our technology on a corpus containing up to 100GB of information. It is our intent that the techniques developed will be scalable beyond the testbed size and eventually allow efficient and effective access to satellite data libraries containing in excess of 1 petabyte of information.

The user facilities will be developed through consultation with a user group of parties interested in participating in the testing and the evaluation of the digital-image retrieval system. The research team expects the data base to be focused on some class of data, such as data for environmental analysis and land use studies.

2.6.2 Relevance to ECS

Content based search is an element of the future vision for the ECS data server. Track this research for determination of Release C and beyond content based search solutions.

Suggest we track this project in background mode, however, the concepts and results could affect our choice of product for the Data Server in the Release C time frame.

RELEVANT SUBSYSTEMS: Data Server

2.6.3 Further Information

Contact Harold S. Stone, IBM, hstone@watson.ibm.com, John Turek, IBM, jjt@watson.ibm.com

2.7 Project 6 -- LinkWinds Application to EOSDIS

Investigator: Allan S. Jacobson

Description: The extension and application of LinkWinds to EOSDIS

Organization: JPL, UAH, MSFC

2.7.1 Summary

This effort builds on the previous development of the LinkWinds, Linked Windows Interactive Data System, testbed. The system is a visual data analysis environment built on an object-oriented model. Objects on screen are data, displays, and controls. Displays can also contain controls. The objects are made interdependent by interactively linking them. Links are one-way message paths. The interface functions like a graphical spreadsheet. A standard GUI with data-linking rules results in a direct manipulation interface which is highly interactive, easy to learn and retain, and uniform across all applications. The network-based groupware (MUSE) requires minimum bandwidth, and is useful for cooperative scientific research, remote tutorial feedback. The language used also supports rerun script, journal and macro capability.

2.7.2 Relevance to ECS

This effort provides near term capabilities for the Client and Interoperability Subsystems, providing an alternative user interface model for access to Earth Science data. Direct use of the testbed components would not be feasible until the Release B time frame, however near term evaluation and integration with prototypes and Evaluation Packages would be beneficial.

Recommend we track closely for Release B integration and interoperability for mature visualization.

RELEVANT SUBSYSTEMS: Client, Interoperability

2.7.3 Further Information

Contact Allan S. Jacobson, budj@apex.jpl.nasa.gov

2.8 Project 7 -- Automating the Analysis of EOSDIS Data

Investigator: William Emery

Description: Tools and techniques for automating the analysis of EOSDIS data

Organization: University of Colorado

2.8.1 Summary

The objectives of this project are to make it easier for scientists who are not expert in a particular EOSDIS dataset to use that dataset in their analysis and to make it possible for scientists who are experts in particular datasets to analyze much larger volumes of data. To accomplish this the project intends to

- capture the information about each EOSDIS data product that scientists need to conduct data analysis,
- efficiently convey this information to users of the EOSDIS,
- store this information at the scientist's workplace so that it is available and useful to the scientist, and
- let data analysis programs access this information in ways that permit the programs to make many of the decision that scientists formerly had to make themselves.

Four major goals were identified for this project. Provide a mechanism for formally describing all types of EOSDIS data and for formally defining the interfaces to data analysis software modules distributed to users through the EOSDIS. Provide a mechanism for encapsulating EOSDIS data products with all the pertinent metadata and with any needed data definitions, software interface definitions, and software modules. Provide the capability to store and retrieve primary data, metadata, data type definitions, software interface definitions, and software modules on the scientist's local computer. Develop tools that can generate and interpret the metadata that is needed for data analysis.

These capabilities will be embodied in the Science Data Analysis Automation Toolkit (SDAAT).

2.8.2 Relevance to ECS

The effort is of direct relevance to the Release A user modeling and data modeling efforts. Indirectly, the data management and data server subsystem design and analysis efforts could benefit from the lessons learned from the research and the representation proposed by this research effort.

Track closely for the object oriented orientation, data dictionary focus and SCF related architectures relevant to ECS interoperability.

RELEVANT SUBSYSTEMS: Data Management, Data Server, (SDPS Data Modeling)

2.8.3 Further Information

Contact William Emery at emery@orbit.colorado.edu

2.9 Project 8 -- Multi-source Information Archival and Analysis

Investigator: Donald Fussell

Description: Multi-source information archival and analysis system

Organization: University of Texas, Austin

2.9.1 Summary

The design of an information archival and management system, on par with that of ECS, poses a variety of inter-disciplinary research challenges. The goal of this project is to develop an integrated system architecture for EOSDIS which includes an automated assistant to help users locate and access information, a multiresolution database for efficient storage and retrieval of data, network protocols for accessing the various distributed components of the data base, and new multi-resolution computational paradigms for multisensor image modeling, decomposition, and analysis. Furthermore, the University of Texas team proposes to instantiate their research findings by building a multiresolution information management system of EOS by incorporating: (1) a global physical oceanographic study utilizing multiple sensors including altimetry, scatterometry, and imagery from optical sensors; (2) a desert study utilizing data from Landsat, SPOT, ERS-1, aerial photography, as well as airborne polarimetric and interferometric SAR; and (3) a multisensor, rugged terrain study, for which multi-resolution browsing in conjunction with the automated analysis will be necessary even for selection of appropriate data sets.

2.9.2 Relevance to ECS

Low utility to ECS. Concepts may be relevant but the scalability of the approach needs to be demonstrated.

RELEVANT SUBSYSTEMS: Data Server

2.9.3 Further Information

Contact Donald S. Fussell at fussell@cs.utexas.edu

2.10 Project 9 -- EOS Global Assimilated Dataset Testbed

Investigator: K. Palaniappan

Description: Intercomparison, visualization, and analysis testbed system for EOS global assimilated data sets and spacecraft.

Organization: GSFC

2.10.1 Summary

This project intends to apply the Interactive Image SpreadSheet (IISS) environment to EOS global assimilated data sets. The concept of the IISS has been developed to interactively examine and manipulate large remote sensing data sets. The IISS is currently being used to analyze multi-spectral data sets such as complete GOES/VISSR, Landsat TM, AVIRIS and NOAA/AVHRR imagery in anticipation of the data from EOS satellite instruments. The ISS provides a spreadsheet-based visual interface for performing satellite image analysis tasks. Such an interface has been found to be extremely intuitive and highly productive since it eliminates to a large extent the necessity for a user to explicitly deal with input/output based programming as with traditional computer languages. The resulting environment provides the scientist with an effective and powerful visualization tool for concentrating on algorithm development and exploring the information available in the data.

2.10.2 Relevance to ECS

Relevance is mostly in the visualization area. Track as a background effort to determine impact on Client subsystem and resulting service interfaces in Data Management and Data Server.

Recommend background tracking and impact of visualization on ECS interfaces.

RELEVANT SUBSYSTEMS: Client, Data Management, Data Server

2.10.3 Further Information

K. Palaniappan at GSFC, 301.286.8601

2.11 Project 10 -- End to End Problems in EOSDIS

Investigator: Michael Stonebraker

Description: End-to-end problems in EOSDIS

Organization: UCB, UCSB, UCSD

2.11.1 Summary

The prototyping focus of this project is to build on the EOSDIS alternative architecture study and demo conducted by the UCB team lead by Stonebraker. The research focus is to build on the Sequoia 2000 collaboration and infrastructure. The end result will be an alternative EOSDIS architecture and prototype implementation that will contrast with the current ECS architecture and design approach. The prototype focus will be to put everything in a next generation SQL DBMS (Illustra -commercial POSTGRES) using type extensions. The control of the remote sensing production processing "pipeline" will be via DBMS triggers. Optimization of the system throughput will be evaluated through Eager (push processing) versus lazy (pull processing) strategies. Wide area transparency will be provided through distributed DBMS technology. Application logic will be encoded in a scripting language (Tcl/TK) extended with OK.

The goal is to develop a production system at UC Santa Barbara and UCLA. A "join" between remote sensing and simulation data will be performed to show feasibility across sites and disciplines. The final product demonstration of alternate architecture concepts for EOSDIS. A core element of the approach is the use of a common schema across sites and disciplines.

The research focus is tertiary memory. The effort will optimize tertiary memory for "on-line" DBMS applications, work out DBMS to tertiary interfaces, provide parallelism in the I/O system, and include backup and recovery mechanisms.

2.11.2 Relevance to ECS

Broad relevance to the ECS and EOSDIS development efforts. Basically calls for a complete redesign of the current ECS approach. Some of the DBMS concepts and tertiary storage concepts apply in the near term, especially with the use of Illustra as an option for the Data Server.

Because of the high visibility of the players recommend tracking closely for near and long term benefit to ECS development and prototyping activities.

RELEVANT SUBSYSTEMS: All subsystems.

2.11.3 Further Information

Michael Stonebraker at UCB and Illustra. mike@cs.berkeley.edu

2.12 Project 11: Integrating Distributed Object Management Technology into EOSDIS

Investigator: Richard Muntz, Edmond Mesrobian, et.al.

Description: Integrating Distributed Object Management Technology into EOSDIS.

Organization: UCLA, JPL, Scripps Institute of Oceanography UCSD

2.12.1 Summary

The overall goal of this project is to design and implement an object hierarchy suitable as a framework for building a DOMS-based user Science Computing Facility (SCF) providing a seamless environment for scientific data analysis, knowledge discovery, visualization, and collaboration. While the concept of logical abstractions of objects has existed for many years, the ability to share objects across heterogeneous platforms has only recently become feasible due to the emerging distributed object management system (DOMS) standard developed by the Object Management Group (OMG). OMG's Common Object Request Broker Architecture (CORBA) standard calls for a common architecture by which all objects will communicate whit one another. The far-reaching implications of this de-facto standard can be witnessed today as software developers are hurrying to re-tool their products to become "CORBA-compliant", thereby ensuring that their applications will operate in the distributed, open systems of tomorrow.

2.12.2 Relevance to ECS

The Scientist Workbench application being developed by the Muntz team at UCLA should provide insights for similar efforts within SDPS during the Release B time frame. The development of a distributed object infrastructure is relevant to the Release C time frame from both the CSMS and SDPS components.

Because of the possibility of code reuse related to the development of a CORBA infrastructure, recommend tracking closely for near term lessons learned and potential prototyping reuse.

RELEVANT SUBSYSTEMS: Data Server, Interoperability, CSS, Data Management, Client

2.12.3 Further Information

Contact Richard Muntz, muntz@cs.ucla.edu

UCLA Department of Computer Science URL: http://www.cs.ucla.edu/

2.13 CAN Project 12: Universal Spatial Data Access Consortium

Category: Digital Library Technology Project

Investigator: Clifford A. Behrens

Description: Usability and interoperability: enabling broader public use of NASA's remote sensing data on the Internet

Organization: Bellcore and Universal Spatial Data Access Consortium (USDAC)

2.13.1 Summary

This project will apply innovative digital library technology to making NASA's remote sensing data available to a broader public on the Internet. The work will be performed by members of a consortium consisting of Bell Communications Research, Rutgers University's Center for Remote Sensing and Spatial Analysis, Camber Corporation, the Open GIS Foundation, GSFC.

The team proposes to develop new tools for locating, accessing, browsing, transporting and reusing NASA imagery together with other geospatial data. The tools will integrate existing software in the public domain with new software modules that represent state-of-the-art advances in graphical user interface design, data screening, data compression and distributed database technology. The team is dedicated to producing tools that are usable by a heterogeneous community of end-users, consistent with the principle of "universal access," yet capable of resolving network interoperability issues. Greater usability will be ensured by a "consensus approach" to defining requirements, drawing participation from industry, government and academia, and usability testing at critical points throughout this project.

Interoperability will be accomplished by encapsulating imagery and ancillary geospatial data in objects, consistent with the Virtual Geodata Model (VGM) specified in the Open Geodata Interoperability Specification (OGIS), and by developing data access servers and software applications whose architecture is CORBA compliant.

The proposed work will be performed over three years. The first year's effort will design and implement the VGM to build objects for a subset of NASA's Earth Science datasets. In the second year, they will develop data access servers and build objects for more datasets, including ancillary geospatial data. the third year will focus on the development, testing and evaluation of applications, and transfer of tools to the public through sites on the OGIS testbed and DAACS.

2.13.2 Relevance to ECS

Relevant to the broader access to the Data Server at the Release C time frame. Track the work related to VGM in OGIS and the CORBA compliance.

The OGIS interaction is beneficial, recommend tracking moderately in the medium term.

RELEVANT SUBSYSTEMS: Data Server

2.13.3 Further Information

Contact Clifford A. Behrens, cliff@bellcore.com

2.14 Project 13 -- Creating the Public Connection

Category: Digital Library Technology Project

Investigator: Patricia H. Reiff

Description: Creating the public connection: interactive experiences with real-time Earth and space science data

Organization: William Marsh Rice University

2.14.1 Summary

The Houston Museum of Natural Science, with over 2 million visitors annually, is less than two miles from Rice University, a major hub on the Internet. This grant proposes to link these two institutions so that NASA near-real-time data and imagery can flow via Rice to the Museum where it will then reach the public in the form of planetarium programs, computer-based interactive kiosks, and space and earth science problem-solving simulations. Through this program at least 200,000 visitors annually (including every 4th and 7th grader in the Houston Independent School District) will have direct exposure to the earth and space research being conducted by NASA and available over the Internet. Each information conduit established between Rice University and the Houston Museum of Natural Science will become a model for public information dissemination that can be replicated nationally in museums, planetariums, Challenger Centers and schools.

This implementation grant relies on the experience of the Space Physics and Astronomy Department of Rice University in organizing and updating data and image databases, combined with the Museum's expertise in developing public software interfaces, planetarium programs, interactive science curricula, and problem-solving computer simulations. Data will be reaching the public within three months of the grant funding with continuous evaluation and expansion of the program thereafter. The Rice-Museum collaboration will deliver NASA near real-time data to five different museum environments: a "Space Update" kiosk in the Museum's Entry Hall. a Sun-Earth Environment Interactive Exhibit, Planetarium school and public programs, the Challenger Learning Center Mission control, and the Earth Forum Information Network.

This grant will fund a continually updated server collecting and organizing data and image databases from materials found on the Internet, either retrieved directly from various network sources or generated by real-time models running at Rice or at the University of Alaska, and a T1 line connecting Rice to the Museum. The Museum's display computers will automatically, periodically access the server at Rice University for these near real-time images and data. Once a program module is installed and tested at the Museum, it will be evaluated in two school settings where the real-time databases provided will be related to existing earth science curricula via student activities and teacher guides. In the grant's third year, the program will be replicated in at least one non-Houston planetarium, museum, Challenger Center, and school.

2.14.2 Relevance to ECS

Good concepts for the Client Subsystem in developing a user friendly interface based on the "kiosk" concepts. Relevant to the Release B and beyond design and development efforts on ECS but track human factors issues in the near and medium term.

Track in the background for long term impact of value added providers on the ECS interfaces.

RELEVANT SUBSYSTEMS: Client

2.14.3 Further Information

Contact Patricia H. Reiff, reiff@alfven.rice.edu

2.15 CAN Project 14: Establishment of the Remote Sensing Public Access Center

Category: Remote Sensing Public Access Center

Investigator: James T. Johnson BDM Federal jjohnson@rspac.ivv.nasa.gov

Description: BDM's proposal for the establishment of the remote sensing public access center (RSPAC)

Organization: BDM Federal

2.15.1 Summary

BDM Federal, Inc., of McLean, Va., will establish a Remote Sensing Public Access Center (RSPAC) for demonstrating, testing and transferring technology to help provide public use of earth and space science data over the Internet. Other members of the BDM team include West Virginia University, Jardon and Howard Technologies, and the National Center for Supercomputing Applications (NCSA).

The intent of the new center is to stimulate broad public use, via the Internet, of the very large remote sensing databases -- maintained by NASA and other agencies -- to stimulate U.S. economic growth and contribute to the implementation of a National Information Infrastructure. RSPAC will serve the non-scientific internet general public, NASA, and other CAN project developers in three major functional areas: Public Outreach, Test and Evaluation, and Integration:

Public Outreach

IITA Virtual Showcase: Actively promote the applications/technologies created by the developers to the general public via the World Wide Web (WWW) and traditional internet services (i.e., ftp, gopher, listserv, newsgroups, ...).

Promotion of Developers' Projects: Communicate with established user groups (e.g., state boards of education, industry organizations and publications, mass media) to promote developers' applications/technologies.

On-line Help: A predominantly e-mail based service to answer the general public's questions about the developers' projects, the field of remote sensing, and the internet.

Project Tutorials: Web based (HTML) overviews to assist the general public in using the remote sensing applications and digital library technologies (where appropriate).

Introduction to Remote Sensing: A Web based (HTML) overview to provide the general public with information about the field of remote sensing and its uses.

Introduction to Internet: A Web based (HTML) overview to provide the general public with information about the internet.

Test and Evaluation (T&E)

Test and Evaluation Assistance: In concert with the project developers, provide an individually-tailored functional test and evaluation service to assist the developers in producing a quality application or technology product.

Testbed Facility: A suite of workstation and personal computers to support broad-based testing of the developer's' applications and technologies under varied operating environments.

Integration

Project Integration: Provide developers' with technical assistance in internet tools, remote sensing data set selection and retrieval, and general computer and networking support.

Interproject Communication: Actively investigate RSD and DLT developed technologies and techniques that can be used by others in the developer community.

2.15.2 Relevance to ECS

Could act as a bridge between the EOSDIS testbeds and the NRA community. Use of WWW technology would provide hands on lessons learned in the M&O of large WWW systems.

Again this project has value added provider relevance to the ECS interfaces, track in the background for long term impact.

RELEVANT SUBSYSTEMS: Client, Data Server

2.15.3 Further Information

Contact James T. Johnson BDM Federal jjohnson@rspac.ivv.nasa.gov

2.16 CAN Project 15: Project Horizon Public Access to Science Data

Category: Digital Library Technology Project

Investigator: Michael J. Folk, NCSA, Univ. of Illinois, mfolk@ncsa.uiuc.edu

Description: Test applications and digital library technologies in support of public access to Earth and space science data

Organization: NCSA

2.16.1 Summary

The proposed project will provide easy-to-use, scalable digital library technologies for the public to locate, integrate move, and analyze both earth and space science data via the Internet. Activities include:

1. Development of a "scientific data server" that integrates earth and space science data that is available in many common formats, and that employs advanced data storage and access methods to deal with very large images and data sets.
2. Enhancement of key client software: extend Mosaic, the NCSA Internet browser, to simplify viewing of data and other information by untrained users; develop an API enabling Mosaic to communicate with other applications; expand existing client applications to support functionality not yet available in Mosaic that is particularly suited to public use.
3. Application of scientific data server software to two public access servers: (1) The Daily Planet (TM), an environmental information server giving access to NASA earth science data, multimedia educational modules, and distributed archives of weather and climate data; 2) a space and astronomy server emphasizing images that inspire curiosity-driven learning about the Universe and our scientific understanding of planets, stars and galaxies.
4. Research and development on scalable servers and information systems, including R & D on technology to support scaling the number of users and connections on World Wide Web servers, development of software for dealing with data on tertiary storage, and R & D aimed at answering the question "How can items of interest be located in the enormous mass of image data from NASA and other archives?"

2.16.2 Relevance to ECS

Directly relevant to future Data Server design and implementation during the Release B time frame and the concepts and implementation of future "value added provider" sites.

Track closely for the impact on the Release B product selection and design.

RELEVANT SUBSYSTEMS: Data Server

2.16.3 Further Information

Contact Michael J. Folk, NCSA, Univ. of Illinois, mfolk@ncsa.uiuc.edu

2.17 Project 16 -- Digital Image Compression and Transmission

Category: Digital Library Technology Project

Investigator: Percival

Description: Compression and progressive transmission of digital images.

Organization: University of Wisconsin

2.17.1 Summary

A significant problem for any digital library is the network bandwidth required to transmit large digital images. The bandwidth consumption scales with the number of images needed by a single user, and with the number of users requesting the services of the library. The popularity of database browsers such as Gopher and Mosaic has serious implications for the administrators of digital image libraries.

The team proposes to provide a system comprising an innovative new compression scheme and transmission protocol that has been shown in an existing prototype version to reduce bandwidth requirements for many users by factors as large as 100, along with software servers and visualization programs for the digital library user. This system will allow both quick-look and full-image access to digital archives, ranging from a very-low-bandwidth browse mode suitable for looking at many images very quickly, to completely lossless transfer of images.

Our approach unites a newly developed compression scheme with an existing machine-independent transmission protocol to achieve progressive transmission of images, which allows a user to reconstruct, view, and optionally reject an image as it arrives, rather than waiting for the whole image, compressed or not, to arrive.

The proposed system would be an important contribution in support of general public and educational access to digital image libraries, because many of these users have only low-bandwidth connections to the Internet, and a method of producing useful images in minutes or seconds instead of hours will make a crucial difference in how these people use digital archives and how productive their digital library experience can be.

2.17.2 Relevance to ECS

Relevant to both the Client and Data Server Subsystems for investigation of compression and distribution techniques for large products. Release B and beyond time frame.

Track moderately for potential Release B payoff.

RELEVANT SUBSYSTEMS: Client, Data Server

2.17.3 Further Information

Contact Jeffrey W. Percival, University of Wisconsin - Madison, jwp@bernie.sal.wisc.edu

2.18 Project 17 -- Paradise, A Parallel Geographic Information System

Investigator: David DeWitt

Description: Paradise clusters used as inexpensive scalable support for standardized access to EOSDIS data sets.

Organization: University of Wisconsin

2.18.1 Summary

The goals of this project are to design, implement, and distribute a DBMS capable of storing and manipulating massive data sets such as those that will be produced by NASA's EOSDIS project. The approach will use industry standard object-oriented data models and query languages, will support raster, polygon, point, and polyline data, will include scalable parallelism, will provide integrated support for tertiary storage, and will use a DBMS to store all data. The data model used is an object-relational data model with three type constructors: extent, tuple, and reference. Each Parts of one or more extents, each extent consists of a set of objects of the same type (an extent is itself an object).

2.18.2 Relevance to ECS

Relevant to the Data Server architecture, design and implementation in near term prototypes in support of Release A and Release B design and development efforts.

Because of high visibility track closely for data server design implications and possible prototype collaboration in the near term.

RELEVANT SUBSYSTEMS: Data Server

2.18.3 Further Information

Contact David DeWitt, University of Wisconsin, dewitt@cs.wisc.edu

2.19 Project 18 -- Performance Modeling of Mass Storage Archives

Investigator: Theodore Johnson

Description: Performance modeling of mass storage archives

2.19.1 Summary

The project proposes to develop performance models of mass storage archives that can be used to optimize access to the archive data. The approach builds on existing performance models developed for the local university environment. The core of the EOSDIS is a set of mass storage archives. These archives are large, complex, and expensive systems. The EOSDIS storage requirements are considerably greater than that of any previous mass storage archive. Effective use of a mass storage archive requires performance models for capacity planning, acquisition planning, and for performance improvement studies. This project proposes to develop performance characterizations and analytical performance models of mass storage archives to guide the development of the EOSDIS storage capabilities. The performance models will help to answer questions about capacity planning, acquisition planning, and performance optimization.

The goal is to develop a set of performance characterizations and analytical performance models of the storage scientific archives. The team will characterize how users access archived data by studying log files which record the user accesses. The team will develop analytical models of important system components, such as the jukebox and the disk farm. They will also develop simple models to provide insight and fast answers, an complex models to provide more accurate results. The component models will be combined into a system performance model. The analytical models will be coded in C and Matlab, and provided to EOSDIS sites.

2.19.2 Relevance to ECS

The models presented seemed to lack the fidelity needed to explore the Data Server design. Significant interaction would be required in order to make the project relevant to ECS.

Track in the background for complementary results to the ECS Performance Modeling team.

RELEVANT SUBSYSTEMS: Data Server, (Performance Modeling Team)

2.19.3 Further Information

Contact Theodore Johnson, 904.392.1492.

2.20 CAN Project 19 -- Support for Large Datasets in EOSDIS

Investigator: PI: Michael J. Folk, NCSA, Univ. of Illinois, mfolk@ncsa.uiuc.edu

Description: Support for large data sets in EOSDIS

Organization: NCSA

2.20.1 Summary

The goal of this project is to produce data management techniques needed for the large dataset expected in EOSDIS in the next decade, on both sequential and parallel machines. The research investigations will include alternative physical layouts for large data sets on disk to support fast access, techniques for archiving and compressing large data sets, facilities for offering alternative "views" of a single data set, implications of different architectures, support for data sets too large to fit in a single file, and abstract data types. HDF implementations will be included to support new data structures and architectures, and will produce a "wrapper" library for HDF to hide the details of physical storage.

The effort will develop data management techniques and I/O libraries to improve performance for large multidimensional arrays in scientific computation. Several architectures will be targeted including sequential, parallel, and network-of--workstations (NOW). A portable API and library for I/O for raw datasets will be provided and the library will be ported to support HDF data types. The effort will support general and Earth Science specific compression in HDF, and will pursue R&D in Earth Science data compression. HDF will be adapted to support very large objects (>2GB). The effort will examine the problem of supporting large archival data products while providing rapid architecture independent access. Finally, the effort will develop an abstract data type system for scientific data.

2.20.2 Relevance to ECS

Directly relevant to the Data Server design and implementation during the Release A and B time frame. Development of the Data Model, ESDT's and CSDT's is of direct and immediate relevance. Also relevant to "value-added" provider concepts and implementation strategies.

Track closely in the near term for relevance to the HDF storage issues in the data server.

RELEVANT SUBSYSTEMS: Data Server

2.20.3 Further Information

Contact Michael J. Folk, NCSA, Univ. of Illinois, mfolk@ncsa.uiuc.edu

2.21 Project 20 -- Product Generation System Design

Investigator: Meemong Lee

Description: A technology and architecture integration project for product generation system design

Organization: JPL, University of Minnesota, California Institute of Technology, University of Colorado

2.21.1 Summary

The approach in this project is to build on on-going development efforts to develop a prototype system architecture design for a product generation system. The current developments include GEM, a graphics execution manager; Hilary/Rodm, a remote observation dynamics model server; DDLIB, a parallel architecture data distribution library, and a prototype system architecture design including Myranet based point-point connection workstation cluster, a FDDI based local area workstation cluster, and an Ethernet based wide area workstation cluster.

The team will provide an integrated system engineering solution for prototyping the processing elements of the EOSDIS Product Generation System to evaluate suitable system architectures with respect to throughput, available and foreseen technology,, algorithm design, evolvability, scalability, robustness and cost. This project is pertinent to those EOS instruments that require advanced, innovative approaches in order to produce standard data products in a practical manner. The team proposes to study, as typical models, the science algorithms of several of the EOS instruments, including MISR, MODIS and TES, to develop a comprehensive computational model to describe system-specific characteristics and to develop quantifiable technology evaluation metrics for candidate software and hardware architectures. The concepts will be demonstrated and confirmed by implementing a prototype processing architecture for MISR, thereby obtaining quantified design and performance evaluation criteria.

2.21.2 Relevance to ECS

Could be a valuable contribution to the Planning and Data Processing Subsystem design in the Release B time frame.

Track the effort and the progress of the prototype and MISR algorithms evaluation.

RELEVANT SUBSYSTEMS: Data Processing

2.21.3 Further Information

Contact Meemong Lee, JPL, meemong@elroy.jpl.nasa.gov

3. NRA / CAN Conclusions Summary

3.1 NRA/CAN Conclusions / Recommendations

Overall the NRA / CAN efforts are relevant to the ongoing and future ECS Development efforts. The contributions of each project range from providing alternatives to the ECS architecture and design concepts as a whole, to providing alternative approaches for individual subsystems or components, to providing future capabilities beyond the scope of the ECS effort but within the scope of the EOSDIS and UserDIS context.

Those with direct relevance to near and medium term ECS development efforts were identified in Table 2-2 in Section 2.0 under the Top Priority category. Those with direct relevance but with payoffs in the longer term were identified in Table 2-2 in the second Medium Priority category. Those with indirect or beyond ECS relevance were identified in Table 2-2 in the third Lower Priority Category.

Since potentially substantial effort on both NASA's and the ECS teams part would be required to monitor, coordinate and collaborate with each of the relevant NRA / CAN projects, the ECS Team needs to develop a process and a framework for interaction that maximizes the information and technology flow between the researchers and the ECS development staff.

NASA has proposed a testbed and periodic reviews as a bridge between the NRA / CAN research efforts and the ECS Development team. The testbed would consist of the V0 testbed and associated interfaces, the HAIS End-to-End (or Collaborative) Prototype, the CAN RSPAC, and a joint HAIS/NASA testbed based on the Landover based STL (Science Technology Laboratory). The testbed concept is illustrated in Figure 3-1.

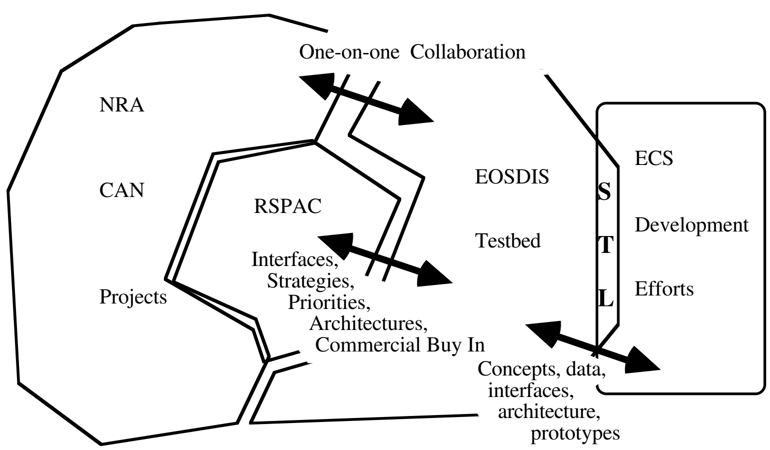

Figure 3-1. NRA/CAN Interaction with ECS

Since most of the research and the EOSDIS / ECS architecture is distributed the EOSDIS testbed should itself be distributed with research technology provider nodes at each researcher's site (including the RSPAC site(s)) and a node (or nodes) at the ECS STL. The STL node would act as a local access port into each of the research efforts and would provide a "one-stop-shopping" mechanism to demonstrate individual and collaborative NRA / CAN efforts. The STL node would also act as a conduit into the NRA / CAN research efforts, providing testbed data (initially from the V0 pilot / pathfinder collections) and ECS architecture interfaces.

Recommendations

Management and Coordination

- Emphasize the need for collaboration in the development of Earth science data models and related standard benchmarks.
- Provide online access to ECS interfaces (as they are developed), realistic data collections, ECS modeling results.
- Provide online access to NRA/CAN research papers, results, and data
- Encourage the NRA/CAN researchers and the testbed "maintainers" to maintain (in a low overhead manner) online documentation accessible via WWW home pages
- Encourage the NRA/CAN researchers to provide WWW gateways to support access to prototypes to support easy access and research discovery by ECS developers, NASA, and other researchers
- Encourage informal peer review of NRA/CAN research efforts in support of determining utility of the individual and collaborative research efforts to ECS and EOSDIS.
- Recommend an annual meeting, such as that held in January 1995, combining the NRA/CAN teams and representatives of the ECS Team.

Technical

- Support a distributed (electronic) testbed via the STL at Landover, V0 Testbed, RSPAC CAN, and Hi-bandwidth network efforts
- Use ECS architecture concepts (value-added providers, service provider sites, advertising services, distributed access to services) to structure, advertise, and manage the distributed testbed
- Ensure that the projects work with realistic Earth Science data that supports valid science research.
- Recommend the use of the pilot migration data sets and the data sampler from EP4 as available data for the NRA / CANs.

4. Suggested Reading

NRA RELATED

EOSDIS NRA / CAN Workshop Home Page,
URL: http://mitrews.gsfc.nasa.gov/nracan/homepage.html

ECS RELATED

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Schwaller, M. 1993: Science Data Plan for EOSDIS Covering EOSDIS Version 0 and Beyond. NASA/GSFC. Anonymous ftp host: eos.nasa.gov. Change directory to /EosDis/Daacs/Docs/ScienceDataPlan.

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Tyahla, L. 1994: 19400548 User Scenario Functional Analysis. URL: http://edhs1.gsfc.nasa.gov/

Unninayar, S. and Bergman, K., 1993: Modeling of the Earth System in the Mission to Planet Earth Era. NASA Headquarters.

West, S., 1994: 19400549 ECS Scientist User Survey (ESUS). URL: http://edhs1.gsfc.nasa.gov/

Williamson, R.C, 1995, 420-TP-003-001, SDPS End to End Scenarios Overview, URL: http://edhs1.gsfc.nasa.gov/

Wingo, T. 1994: 19400312 User Characterization and Requirements Analysis. URL: http://edhs1.gsfc.nasa.gov/

Acronyms

API	Application Program Interfaces
AVHRR	Advanced Very High-Resolution Radiometer
CAN	Cooperative Agreement Notice
CORBA	Common Object Request Broker Architecture
CSDT	Computer Science Data Type
CSS	Communication Systems Subsystem
DAAC	Distributed Active Archive Center
DBMS	Data Base Management System
DOMS	Distributed Object Management System
ECS	EOSDIS Core System
EOSDIS	Earth Observing System Data and Information System
ESDT	Earth Science Data Type
GIS	Geographic Information System
GSFC	Goddard Space Flight Center
GUI	Graphical User Interface
HAIS	Hughes Applied Information Systems
HDF	Hierarchical Data Format
HRL	Hughes Research Laboratories
HTML	Hyper Text Markup Language
IR-1	Interim Release - 1
MISR	Multi-angle Imaging SpectroRadiometer
MODIS	Moderate Resolution Imaging Spectroradiometer
MSFC	Marshall Space Flight Center
NCSA	National Center for Supercomputing Applications
NOW	Network of Workstations
NRA	NASA Research Agreement
OMG	Object Management Group
OODBMS	Object-Oriented Database Management System

ORB	Object Request Broker
RSPAC	Remote Sensing Public Access Center
SDPS	Science Data Processing Segment
STL	Science Technology Laboratory
TES	Tropospheric Emission Spectrometer
VGM	Virtual Geodata Model
WWW	World Wide Web