Preparing Goddard for Large Scale Team Science in the 21st Century: Enabling an All Optical Goddard Network Cyberinfrastructure

J. Patrick Gary
Network Projects Leader/606
NASA Goddard Space Flight Center
Science Driver

• New NASA Science Needing Gigabit per Second (Gbps) Networks
  - Coordinated Earth Observing Program
  - Hurricane Predictions
  - Global Aerosols
  - Remote viewing & Manipulation of Large Earth Science Data Sets
  - Integration of Laser and Radar Topographic Data with Land Cover Data
  - Large-Scale Geodynamics Ensemble Simulations

• Advances in Networking Technology
  - National LambdaRail (NLR) implementation
  - Global Lambda Integrated Facility (GLIF) cooperation
Accessing 300TB’s of Observational Data in Tokyo and 100TB’s of Model Assimilation Data in MPI in Hamburg -- Analyzing Remote Data Using GRaD-DODS at These Sites Using OptIPuter Technology Over the NLR and Starlight

Note Current Throughput 15-45 Mbps: OptIPuter 2005 Goal is ~10 Gbps!

Source: Milt Halem, NASA GSFC
OptIPuter and NLR will Enable Daily Land Information System Assimilations

• The Challenge:
  – More Than Dozen Parameters at ~ 50 GB per Parameter, Produced Six Times A Day, Need to be Analyzed

• The LambdaGrid Solution:
  – Sending this Amount of Data to NASA Goddard from Project Columbia at NASA Ames for Human Analysis Would Require < 15 Minutes/Day Over NLR

• The Science Result:
  – Making Feasible Running This Land Assimilation System Remotely in Real Time

Source: Milt Halem, NASA GSFC
The NASA Finite-Volume General Circulation Model (fvGCM) has been producing real-time, high-resolution (~25 km) weather forecasts focused on improving hurricane track and intensity forecasts.

During the active 2004 Atlantic hurricane season, the fvGCM provided landfall forecasts with an accuracy of ~100 km up to 5 days in advance.

The 50–100 Mbps throughput available between fvGCM users at GSFC and the Columbia supercomputer at ARC greatly hindered carrying out time-critical simulations of the hurricanes that devastated Florida.

The 10 Gbps NLR access will enable remote, 3D visualization analysis as soon as forecast variables become available.

Key Contacts: Ricky Rood, Bob Atlas, Horace Mitchell, GSFC; Chris Henze, ARC.

In an fvGCM forecast, Hurricane Frances makes landfall on the Gulf Coast of Florida while Hurricane Ivan intensifies in the tropical Atlantic. Visualization by J. Williams, GST.

http://fvnwp.gsfc.nasa.gov
Project Atmospheric Brown Clouds (ABC) is an international effort to discover and analyze areas of brown colored atmosphere to learn how dust and pollution particles are transported and what impacts they have on the environment, climate, agricultural cycles, and quality of life.

GSFC and the Scripps Institution of Oceanography (SIO) are planning a collaboration to predict the flow of aerosols from Asia across the Pacific to the U.S. on timescales of days to a week.

GSFC will provide an aerosol chemical tracer model (GOCAR) embedded in a high-resolution regional model (MM5) that can assimilate data from Indo-Asian and Pacific ground stations, satellites, and aircraft.

Remote computing and analysis tools running over the NLR will enable acquisition and assimilation of the Project ABC data.

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Strategically located ground stations in the Indo-Asian and Pacific regions monitor atmospheric pollution.

The global nature of brown clouds is apparent in analysis of NASA MODIS Data. Research by V. Ramanathan, C. Corrigan, and M. Ramana, SIO.

http://www-abc-asia.ucsd.edu
Remote viewing and manipulation of data sets at GSFC and JPL is needed to support EOSDIS and Earth system modeling.

GSFC’s EOSDIS Clearing House (ECHO) and JPL’s GENESIS prototype science analysis system (iEarth) will become connected over the NLR. The link will enable comparison of hundreds of terabytes of data, generating large, multi-year climate records.

Initial work will focus on the Estimating the Circulation and Climate of the Ocean (ECCO) modeling team. Besides ready access to the NLR, the team will need versatile subsetting and other data manipulation functions to reduce compute and bandwidth requirements as well as a set of Grid-accessible statistical analysis and modeling operators to refine and validate the ECCO models.

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NASA has executed two advanced missions to create an accurate high-resolution topographic model of the Earth: the Shuttle Radar Topography Mission (SRTM) and ICESat, with its Geoscience Laser Altimeter System (GLAS).

The agency now has the opportunity to merge the two data sets, using SRTM to achieve good coverage and GLAS to generate calibrated profiles. Proper interpretation requires extracting land cover information from Landsat, MODIS, ASTER, and other data archived in multiple DAACs.

Use of the NLR and local data mining and subsetting tools will permit systematic fusion of global data sets, which are not possible with current bandwidth.

Key Contacts: Bernard Minster, SIO; Tom Yunck, JPL; Dave Harding, Claudia Carabajal, GSFC.

http://icesat.gsfc.nasa.gov
http://www2.jpl.nasa.gov/srtm
http://glcf.umiacs.umd.edu/data/modis/vcf
High speed networking and Grid computing for large-scale simulation in geodynamics

W. Kuang\(^1\), W. Jiang\(^1\), S. Zhou\(^1\), F. Gary\(^1\), M. Seablon\(^1\), W. Truszkowski\(^1\), J. Oudahiyi\(^1\), D. Liu\(^2\), J. Palencia\(^3\), G. Gardner\(^4\)

\(^1\) NASA Goddard Space Flight Center, 2) ICET, UMBC, 3 Northrop Grumman IT/TASC, 4) Bowie State University, 5) Raytheon TSS, 6) INDECO

Introduction

Now large-scale simulation has been widespread in many disciplines of solid Earth science research. A typical numerical test in the simulation can easily reach 10^9 steps and beyond.

Out such research problems that we are working on now is to establish a framework on predicting geomagnetic secular variation on decadal and longer-time scales, utilizing surface geomagnetic/paleomagnetic records and our MoSST core dynamics model (Figure 1). In this approach, model forecast results and observations are weighted to provide initial state for assimilation (Figure 2). Typically 30 independent numerical tests are necessary for a reasonable ensemble size. This would easily require a computing cycle on order of petabytes and larger.

Grid computing can be a much better choice so that independent numerical tests can be carried out independently on different systems. However, researchers (users) have to deal with heterogeneous systems and other problems, such as network communication.

In this poster, we discuss our activities in GSFC on application of grid computer to geodynamics modeling.

Prototype on MoSST simulation with independent systems

The objective of this prototype work is to test the capability of executing our MoSST core dynamics model on independent computing systems. Individual computing units are slaved out from selected components of the MoSST system to make independent computing environment. The prototype program for grid computing is built upon scalable framework (JavaScada). See Figure 3 for a conceptual layout of our prototype experiment.

Our prototype experiment is very successful. With this experiment, we can proceed further our test on real remote systems. Also with this experiment, we can identify the needs from the user’s considerations on supporting environment and other middleware that makes grid computing “friendly”.

Proposed solutions

1. Our research on geomagnetic data assimilation can greatly benefit from grid computing.
2. Our prototype experiment is successful and can be readily expanded to system with similar settings and SSH/SCP communication protocol.
3. Our prototype experiment is limited in many areas, such as handling network communication between independent systems (e.g. event feedback from remote systems to host systems), heterogeneous environment (e.g. poor knowledge on participating systems is necessary), authentication (e.g. prototype cannot handle high level access security requirement). Therefore, further experiment is needed to improve our work, such as integrating our work with other (developed and developing) middleware handling the problems.
Dr. Zhou is working on applying Grid Computing and High-Speed Network to large-scale distributed computing in Earth and Space Science. More details can be found at http://esto.nasa.gov/conferences/estc2004/papers/a4p1.pdf.
NLR Will Provide an Experimental Network Infrastructure for U.S. Scientists & Researchers

"National LambdaRail" Partnership
Serves Very High-End Experimental and Research Applications
4 x 10Gb Wavelengths Initially
Capable of 40 x 10Gb wavelengths at Buildout

First Light
September 2004

For more information regarding NLR see http://www.nlr.net or contact info@nlr.net
Global Lambda Integrated Facility:
Coupled 1-10 Gb/s Research Lambdas

Predicted Bandwidth, to be Made Available for Scheduled Application and Middleware Research Experiments by December 2004

Visualization courtesy of Bob Patterson, NCSA

www.glif.is

Cal-IT² Sept 2005

OptIPuter

Visualization courtesy of Bob Patterson, NCSA
Task Objective

• “...establish a “Lambda Network” (in this case using optical wavelength technology and 10 Gbps Ethernet per wavelength) from GSFC’s Earth science Greenbelt facility in MD to the Scripps Institute of Oceanography (SIO) through the University of California, San Diego (UCSD) facility over the National Lambda Rail (NLR), a new national dark optical fiber infrastructure.”

• “...make data residing on Goddard’s high speed computer disks available to SIO with access speeds as if the data were on their own desktop servers or PC’s.”

• “…enable scientists at both institutions to share and use compute intensive community models, complex data base mining and multi-dimensional streaming visualization over this highly distributed, virtual working environment.”
Accomplishments for the Year

• Partner with NSF-funded OptIPuter Project - national leaders in optical WAN networking, distributed cluster computing, and mega-pixel visualization display research
  – Early 10-GE connection with NLR/CAVEwave lambda
  – Free use of 10-Gbps WASH-STAR lambda
  – OptIPuter networking with Scripps Institute of Oceanography

• Partner with NSF-funded DRAGON Project - national leaders in optical MAN networking research
  – Two 10-Gbps and three 2.4-Gbps lambdas initially, of 40 possible

• Access to Other 10-Gbps NLR lambdas: Shared IP, GE VLANs, HOPI

• First 10-Gbps network within GSFC

• Leading NASA’s way in NLR use for ARC’s Project Columbia
NASA GSFC Among First 10 Users of the NLR

- GSFC’s initial 10-Gbps connection to the NLR was enabled via cooperation with the National Science Foundation (NSF)-funded OptIPuter Project (http://www.optiputer.net)

- GSFC’s initial 10-Gbps NLR connection was used to transmit Earth science data sets in real time to an OptIPuter 15-screen tiled display at the SC2004 conference in Pittsburgh, PA.

- “The involvement of NASA Goddard demonstrated the capabilities of NLR and showed just how researchers in ‘big science’ will need this kind of capacity to make new discoveries about aspects of our world and to help transfer this knowledge to practical uses by others in carrying out important tasks that improve our lives.”
  - Tom West, President and CEO of the NLR
NASA GSFC in the NLR booth with the OptIPuter-provided 15-screen tiled display cluster during SC2004

Photo Sources: Randall Jones, NASA GSFC
Future Work

- MAP Core Integration LambdaGrid Infrastructure
  - New science drivers and evaluators of NLR interconnection among USCD/SIO, UIC, GSFC, JPL, ARC
    - Coordinated Earth Observing Program
    - Hurricane Predictions
    - Global Aerosols
    - Remote viewing & Manipulation of Large Earth Science Data Sets
    - Integration of Laser and Radar Topographic Data with Land Cover Data
  - Collaboration among PI Larry Smarr (UCSD/Cal-(IT)2), Co-I’s John Orcutt (UCSD/SIO), Tom DeFanti (UIC), Milt Halem (UMBC), and several scientists at GSFC, JPL, & ARC

- High-Speed Networking, Grid Computing, and Large-Scale Ensemble Simulations in Geodynamics, Weijia Kuang (GSFC), Shujia Zhou (GSFC) et al

- Expanding 10-GE L-Net
  - More science buildings/clusters within GSFC; More NLR dedicated lambdas, e.g: ARC, ORNL, GISS; Wide Area SAN for NCCS; Optical switching within GSFC
GSFC Internal

- IT Pathfinder Working Group
  - Chair: Dr. Milton Halem/Emeritus & UMBC
  - Applications Lead: Mike Seablom/610.3
  - Middleware Lead: Walt Truszkowski/588
  - Network Lead: Pat Gary/606.1

- High End Computer Network Team
  - Bill Fink/606.1
  - Kevin Kranacs/585
  - Paul Lang/ADNET/606.1
  - Aruna Muppalla/ADNET/606.1
  - Jeff Martz/CSC/606.2
  - Mike Steffenelli/CSC/606.2
  - George Uhli/SWALES/423
  - Steve Booth/SWALES/423
  - Kevin Fisher/586/UMBC coop

GSFC External

- National LambdaRail
  - CEO: Tom West
  - Net Eng Lead: Debbie Montano

- OptIPuter Project (NSF-funded)
  - PI: Dr. Larry Smarr/UCSD
  - Co-PI: Dr. Tom DeFanti/UIC
  - PM: Maxine Brown/UIC
  - UCSD Net Eng: Greg Hidley, Arron Chin, Phil Papodopolos
  - UCIC Net Eng: Alan Verlo, Linda Winkler

- DRAGON Project (NSF-funded)
  - PI: Jerry Sobieski/UMCP
  - Co-I: Tom Lehman/USC-ISI/E
  - Net Eng: Chris Tracy

- NASA Research and Education Network
  - DPM: Kevin Jones/ARC
Principal Investigator & Co-Investigators

- **Name:** Pat Gary (930) & Jeff Smith (585) Co-PI’s & GSFC’s Information Technology Pathfinder Working Group (ITPWG) as Co-I’s
- **Organizations:** Code 420, Code 580, Code 920, & Code 930
- **Telephone:** 301-286-9539 & 301-614-5038 for Co-PI’s
- **E-mail:** Pat.Gary@nasa.gov, JeffSmith@nasa.gov for Co-PI’s

Project Website

Backup Slides
End of Year Review for
GSFC Technology Management Office
February 18, 2005

J. Patrick Gary
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Computational & Information Sciences and Technology Office/606
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Outline for End of Year Review

• Motivation
  - Advances in Networking Technology
  - Enabling New NASA Science Needs

• Goals

• Key Challenges and Solution Designs

• Implementation Status

• Next Steps
Motivation Outline

• Advances in Networking Technology
  – Bandwidth growth rate greater than Tflops growth rate
  – National LambdaRail (NLR) implementation
  – Global Lambda Integrated Facility (GLIF) cooperation
  – Latest Internet2 IPv4 Land Speed Record
  – Personal Computer Interface

• New NASA Science Needing Gigabit per Second (Gbps) Networks
  – Coordinated Earth Observing Program (CEOP)
  – Hurricane Predictions
  – Global Aerosols
  – Remote viewing & Manipulation of Large Earth Science Data Sets
  – Integration of Laser and Radar Topographic Data with Land Cover Data
  – Large-Scale Geodynamics Ensemble Simulations
Optical WAN Research Bandwidth Has Grown Much Faster than Supercomputer Speed!

Source: Timothy Lance, President, NYSERNet
NLR Will Provide an Experimental Network Infrastructure for U.S. Scientists & Researchers

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www.glif.is

Cal-(IT)² Sept 2005
**Internet2 Land Speed Record**

(Rules and current records: [http://lsr.internet2.edu/](http://lsr.internet2.edu/))

**Latest IPv4 Single Stream Record** ([http://data-reservoir.adm.s.u-tokyo.ac.jp/lsr](http://data-reservoir.adm.s.u-tokyo.ac.jp/lsr))

- **7.21 Gbps** (TCP payload), standard frame, 148.850 Petabit meter / second
- **20,645 km** connection between SC2004 booth and CERN through Tokyo, Latency 433 ms RTT

Network used in the experiment
Personal Computer Interface (PCI) Advances

- **Shared Parallel Bus**
  - PCI 1.0 (32-bit, 33 MHz): 1.056 Gbps (1 direction at a time)
  - PCI 2.3 (64-bit, 66 MHz): 4.224 Gbps (1 direction at a time)
  - PCI-X 1.0 (64-bit, 133 MHz): 8.448 Gbps (1 direction at a time)
  - PCI-X 2.0 (64-bit, 266 MHz): 16.896 Gbps (1 direction at a time)

- **Dedicated Serial Interface (4 wires per “lane”)**
  - PCI Express:
    - 2.5 Gbps (raw) per lane each direction
    - 2.0 Gbps (without encoding overhead) per lane each direction (maximally 4.0 Gbps bi-directional)
    - Up to 32 lanes
Next Step: OptIPuter, NLR, and Starlight Enabling Coordinated Earth Observing Program (CEOP)

Source: Milt Halem, NASA GSFC

Accessing 300TB’s of Observational Data in Tokyo and 100TB’s of Model Assimilation Data in MPI in Hamburg -- Analyzing Remote Data Using GRaD-DODS at These Sites Using OptIPuter Technology Over the NLR and Starlight

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http://ensight.eos.nasa.gov/Organizations/ceop/index.shtml
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http://www.ecco-group.org

Near-surface (15-m) ocean current speed from an eddy-permitting integration of the cubed-sphere ECCO ocean circulation model. Research by JPL and MIT. Visualization by C. Henze, Ames.
NASA has executed two advanced missions to create an accurate high-resolution topographic model of the Earth: the Shuttle Radar Topography Mission (SRTM) and ICESat, with its Geoscience Laser Altimeter System (GLAS).

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http://icesat.gsfc.nasa.gov
http://www2.jpl.nasa.gov/srtm
http://glcf.umbc.umd.edu/data/modis/vcf
High speed networking and Grid computing for large-scale simulation in geodynamics

W. Kuang1, W. Jiang2, S. Zhou1, P. Gary1, M. Seahblom1, W. Truszewski1, J. Odubiyi4, D. Liu2, J. Palencia5, G. Gardner6

1 NASA Goddard Space Flight Center, 2 JCE, UMBC, 3 Northrop Grumman IT/TASC, 4 Bowie State University, 5 Raytheon TSS, 6 INDUSCORP

Introduction

Now large-scale simulation has been widespread in many disciplines of solid Earth science research. A typical numerical test in the simulation can easily reach 10^3-10^4 steps and beyond. Our research on geomagnetic data assimilation can greatly benefit from grid computing. To do so, we need to consider several factors, such as computational demands, compatibility requirements, and other software dependencies.

One such research problem that we are working on is to establish a framework on predicting geomagnetic secular variation on decadal and longer-time scales, utilizing surface geomagnetic/paleomagnetic records and our MoSST core dynamics model (Figure 1). In this approach, model forecast results and observations are weighted to provide initial state for assimilation (Figure 2). Typically 30 independent numerical tests are necessary for a reasonable ensemble size. This would easily require a computing cycle on order of petabytes and larger.

A single super-computing facility for such studies is not an optimal choice due to many limitations in particular on user management and administration. But it is relatively easy for users (researchers) to manage because of a unified user environment.

Grid computing can be a much better choice so that independent numerical tests can be carried out independently on different systems. However, researchers (users) have to deal with heterogeneous systems and other problems, such as network communication.

In this poster, we discuss our activities in the GSC on an application of grid computing to geodynamics modeling.

Prototype on MoSST simulation with independent systems

The objective of this prototype work is to test the capability of executing our MoSST core dynamics model on independent computing systems. Individual computing units are slatted out from selected components of our hardware system to mimic independent computing environment. The prototype program for grid computing is built upon scapy framework (http://www.secdev.org/scapy) (Figure 3). The prototype experiment is very successful. With this experiment, we can proceed further our testing on real remote systems. Also with this experiment, we can identify the needs from the user’s considerations on supporting environment and other middleware that makes grid computing “friendlier”.

Discussions

1. Our research on geomagnetic data assimilation can greatly benefit from grid computing.
2. Our prototype experiment is successful and can be easily scaled to systems with identical settings and SSH communication protocol.
3. Our prototype experiment is limited in many areas, such as handling network communication and remote systems (e.g., different speed of remote systems to host systems). Future experiments on participating systems is necessary, authentication (e.g., no prior knowledge on participating systems is necessary), and other middleware that makes grid computing “friendlier”.

Figure 4. Prototype Operation Script (left) and Screen Capture (right)

Reference

- P. Giordano and M. Seablom, Goddard
- A. P. Kontos and S. Zhou, Goddard
- R. Y. K. F. and T. S. J., Goddard
- D. Liu and J. Palencia, Goddard
- J. Palencia and D. Liu, Goddard
- J. Palencia and B. S., Goddard
- J. Palencia and D. Liu, Goddard
- D. Liu and J. Palencia, Goddard
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Dr. Zhou is working on applying Grid Computing and High-Speed Network to large-scale distributed computing in Earth and Space Science. More details can be found at http://esto.nasa.gov/conferences/estc2004/papers/a4p1.pdf.
Project Goals

- "...establish a "Lambda Network" (in this case using optical wavelength technology and 10 Gbps Ethernet per wavelength) from GSFC's Earth science Greenbelt facility in MD to the Scripps Institute of Oceanography (SIO) through the University of California, San Diego (UCSD) facility over the National Lambda Rail (NLR), a new national dark optical fiber infrastructure."

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- "...enable scientists at both institutions to share and use compute intensive community models, complex data base mining and multi-dimensional streaming visualization over this highly distributed, virtual working environment."
Key Challenges and Solution Designs Outline (1 of 2)

• Implementing 10-Gbps Computer Networks End-to-End (ISO Layers 1-3)
  - Transcontinental Network Part
    • NLR Phase 1/Year 1
  - Regional Network Part
    • DRAGON Phase 1/Year 1
  - Local Area Network Part
    • 10-GE upgrade to GSFC’s Scientific and Engineering Network
NLR Phase 1 - Installation Schedule
Will Complete Aug 2004

- Seattle
- Portland
- Cleveland
- Kansas
- Denver
- June
- StarLight
- Pitts
- Wash DC
- Chicago
- Complete
- Complete
- Complete
- Complete
- Complete
- Complete
- Complete
- Complete
- May
- August
- June
- July
- 42

15808 Terminal
15808 Regen (or Terminal)
15808 OADM
15454 Terminal
15808 LH System
15808 ELH System
15454 Metro System
CENIC 15808 LH System
NLR Wavelengths

• Initial complement of 4 λs installed and available at outset
  – One λ for national switched Ethernet experimental network
  – Another λ for national 10 Gbps IP network to support internetworking and end-to-end transport protocol experiments
    • Similar to Internet2’s Abilene except routers will be available for measurement and experimentation
  – Third λ will serve as a quick start facility for new research projects
  – Fourth λ will be used by Internet2’s HOPI testbed

More λs will be activated as needed to support the research and operational objectives of the community
Dynamic Resource Allocation with GMPLS on Optical Networks (DRAGON) Configuration
Key Challenges and Solution Designs Outline (2 of 2)

• Tuning Applications for High Performance Networks Use (ISO Layers 4-7)
  – Large round-trip-time latencies for packet acknowledgements
    • TCP Alternates or Enhancements
  – Slow disk access times
    • Pre-fetch caching to RAM
  – Interactive data steaming to 100 mega-pixel displays
    • Multiple GE interfaces to visualization clusters
  – GrADS/DODS
    • Porting to OptIPuter connected hosts
Outline for End of Year Review

- Motivation
- Goals
- Key Challenges and Solution Designs
- Implementation Status
- Next Steps
DRAGON eVLBI Experiment Configuration

[Diagram showing network connections and locations such as MIT, BOSSNET, NCSA ACCESS, etc.]
GSFC’s initial 10-Gbps connection to the NLR was enabled via cooperation with the National Science Foundation (NSF)-funded OptIPuter Project (http://www.optiputer.net) and the NLR (http://www.nlr.net).

GSFC’s initial 10-Gbps NLR connection was used to transmit Earth science data sets in real time to an OptIPuter 15-screen tiled display at the SC2004 conference in Pittsburgh, PA.

“The involvement of NASA Goddard demonstrated the capabilities of NLR and showed just how researchers in ‘big science’ will need this kind of capacity to make new discoveries about aspects of our world and to help transfer this knowledge to practical uses by others in carrying out important tasks that improve our lives.”

- Tom West, President and CEO of the NLR
• Earth science data sets created by GSFC’s Scientific Visualization Studio were retrieved across the NLR in real time and displayed at the SC2004 in Pittsburgh

• Animated Earth (http://aes.gsfc.nasa.gov/) data sets were retrieved from OptIPuter servers in Chicago and San Diego and from GSFC servers in McLean, VA

• Land Information System (http://lis.gsfc.nasa.gov/) data sets were retrieved from OptIPuter servers in Chicago, San Diego, & Amsterdam
Interactive Retrieval and Hyperwall Display of Earth Sciences Images on a National Scale

Enables Scientists To Perform Coordinated Studies Of Multiple Remote-Sensing Or Simulation Datasets

Source: Milt Halem & Randall Jones, NASA GSFC & Maxine Brown, UIC EVL

Earth science data sets created by GSFC's Scientific Visualization Studio were retrieved across the NLR in real time from OptIPuter servers in Chicago and San Diego and from GSFC servers in McLean, VA, and displayed at the SC2004 in Pittsburgh.

Global 1 km x 1 km Assimilated Surface Observations Analysis
Remotely Viewing ~ 50 GB per Parameter
NASA GSFC in the NLR booth with the OptIPuter-provided 15-screen tiled display cluster during SC2004

Photo Sources: Randall Jones, NASA GSFC
NASA GSFC Among First 10 Users of the NLR

- Presently GSFC’s computers connected to the NLR are located in the NLR suite at the Level3 Communications’ optical fiber “carrier hotel” facility in McLean, VA

- In early March of 2005, two 10-Gbps connections will be enabled across the NSF-funded multi-wavelength Dynamic Resource Allocation via GMPLS Optical Network (DRAGON) research network (http://dragon.east.isi.edu)

- These DRAGON-based connections will link NLR/McLean with several high-performance computers at GSFC’s main site in Greenbelt, MD, as well as with computers at other sites on the Washington, DC-area DRAGON

- Access to other 10-Gbps NLR lambdas is planned via membership in Mid-Atlantic Terascale Partnership (for the Shared IP and GE VLAN lambdas) and participation in Internet2’s Hybrid Optical and Packet Infrastructure
MATP Aggregation Facility Architecture

DRAFT

MATP Member Sites

MATP Optical Services Router

Experimental IP Network

Layer 2 gigE Service

Pittsburg

NLR

Commodity ISPs Peers

MAX

Raleigh

10 gigE or OC192
1 gigE
Expansion not limited to number of lines shown
WDM
Outline for End of Year Review

- Motivation
- Goals
- Key Challenges and Solution Designs
- Implementation Status
- Next Steps
High Performance Remote Data Access
Via GSFC L-Net Follow-ons

- Extending 10-GE L-Net within GSFC to more science buildings/clusters
- Dedicated 10-GE NLR lambda(s) between GSFC and:
  - NASA ARC
  - UCSD/SIO & OptIPuter
  - ORNL
  - UIC/OptIPuter
- GISS on shared or dedicated 10-GE NLR lambda
- Wide Area SAN: CXFS-SGI between NAS and NCCS
- Optical switch for both GSFC’s East and West campuses
High Performance Networking and Remote Data Access
GSFC L-Net for NCCS and Science Buildings

Legend
- Dark Fiber
- 10 Gbps GE
- 2 Gbps FC
- 1 Gbps GE

High Performance Remote Data Cache Facility
creating Inter-Facility virtual SANs using SAN-over-IP technologies

GSFC at Greenbelt

NCCS “Classic”
GSFC L-Net Enabling New NASA Science Needs

- New science drivers and evaluators of NLR interconnection among USCD/SIO, UIC, GSFC, JPL, ARC
  - Coordinated Earth Observing Program
  - Hurricane Predictions
  - Global Aerosols
  - Remote viewing & Manipulation of Large Earth Science Data Sets
  - Integration of Laser and Radar Topographic Data with Land Cover Data

Reference: “MAP Core Integration LambdaGrid Infrastructure” proposal, January 14, 2005
- PI: Larry Smarr (UCSD/Cal-(IT)2)
- Co-I’s: John Orcutt (UCSD/SIO), Tom DeFanti (UIC), Milt Halem (UMBC)

- W. Kuang et al., “High Speed Networking and Large-Scale Simulation in Geodynamics”, abstract/poster, Fall AGU 2004

Major Significance (1 of 2)

- Partner with NSF-funded OptIPuter Project
  - Collaboration with national leaders in optical WAN networking, distributed cluster computing, and mega-pixel visualization display research
  - Early 10-GE connection with NLR/CAVEwave lambda
  - Free use of 10-Gbps WASH-STAR lambda
  - OptIPuter networking with Scripps Institute of Oceanography

- Partner with NSF-funded DRAGON Project
  - Collaboration with national leaders in optical MAN networking research
  - Two 10-Gbps and three 2.4-Gbps lambdas initially, of 40 possible

- Access to Other 10-Gbps NLR lambdas
  - Shared IP and GE VLANs via membership in Mid-Atlantic Terascale Partnership
  - Internet2’s Hybrid Optical and Packet Infrastructure
Major Significance (2 of 2)

• First 10-Gbps network within GSFC: inter- and intra-buildings connecting with science user compute/storage/visualization clusters

• Enabling new NASA science needs
  - Coordinated Earth Observing Program (CEOP)
  - Hurricane Predictions
  - Global Aerosols
  - Remote viewing & Manipulation of Large Earth Science Data Sets
  - Integration of Laser and Radar Topographic Data with Land Cover Data
  - Large-Scale Geodynamics Ensemble Simulations

• Leading the way in NLR use for ARC’s Project Columbia
Special Acknowledgements

GSFC Internal

- IT Pathfinder Working Group
  - Chair: Dr. Milton Halem/Emeritus & UMBC
  - Applications Lead: Mike Seablom/610.3
  - Middleware Lead: Walt Truszkowski/588
  - Network Lead: Pat Gary/606.1

- High End Computer Network Team
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  - Kevin Kranacs/585
  - Paul Lang/ADNET/606.1
  - Aruna Muppalla/ADNET/606.1
  - Jeff Martz/CSC/606.2
  - Mike Steffenelli/CSC/606.2
  - George Uhl/SWALES/423
  - Steve Booth/SWALES/423
  - Kevin Fisher/586/UMBC coop

GSFC External

- Nationa LambdaRail
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  - Net Eng Lead: Debbie Montano

- OptIPuter Project (NSF-funded)
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  - Co-PI: Dr. Tom DeFanti/UIC
  - PM: Maxine Brown/UIC
  - UCSD Net Eng: Greg Hidley, Arron Chin, Phil Papodopolos
  - UCIC Net Eng: Alan Verlo, Linda Winkler

- DRAGON Project (NSF-funded)
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  - Co-I: Tom Lehman/USC-ISI/E
  - Net Eng: Chris Tracy

- NASA Research and Education Network
  - DPM: Kevin Jones/ARC
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**Project Website**