



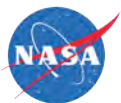
GSFC High End Computer Network (HECN) Availability

Topics

- **Brief Intro to HECN at GSFC**
- **Recent GSFC HECN Applications Support**
 - **SC06 Demos**
 - **Achieving Network Throughput Performance Gains**

J. Patrick (Pat) Gary
Network Projects Leader
Networks and Information Technology Security Group (Code 606.1)
Computational and Information Sciences and Technology Office
NASA Goddard Space Flight Center

For Job Shadow Day February 1, 2007 Meeting at GSFC



2/1/07

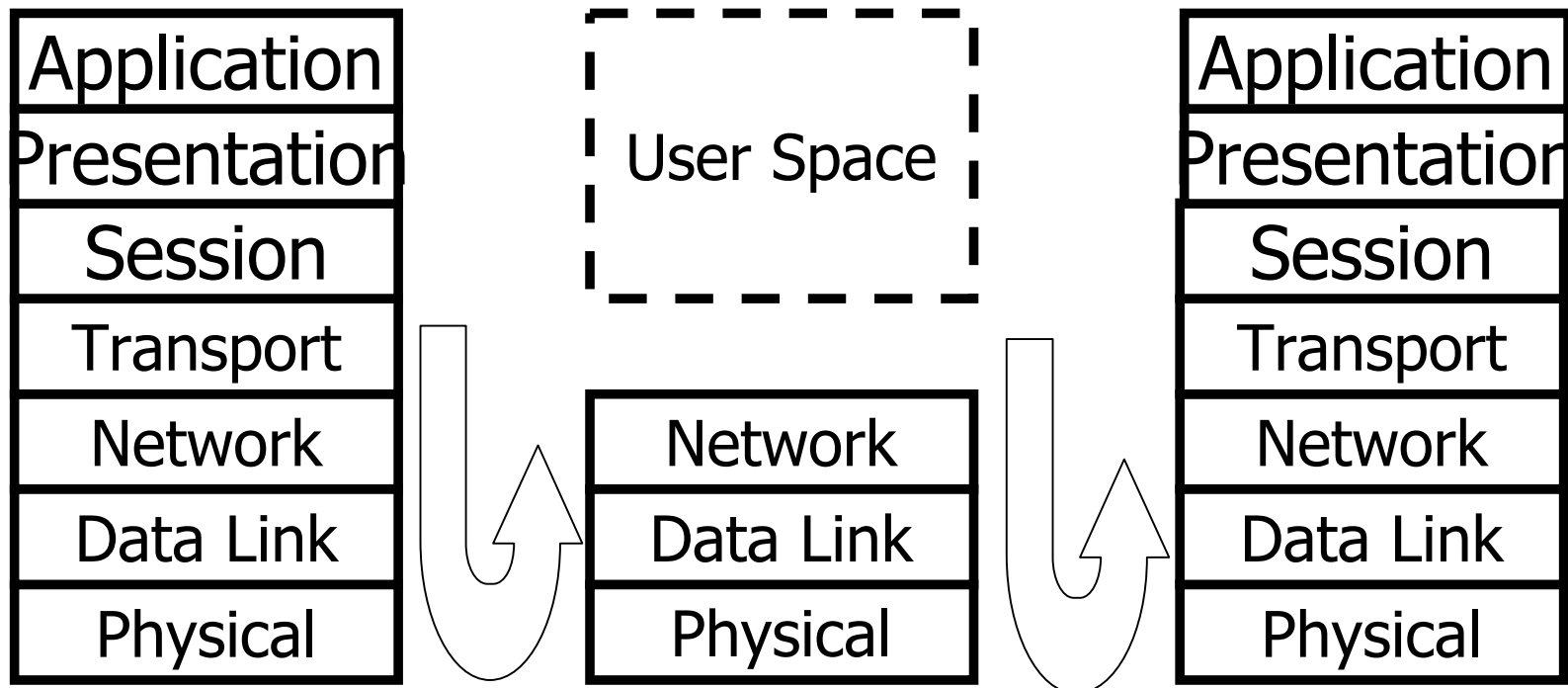
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Seven Layer ISO Reference Model



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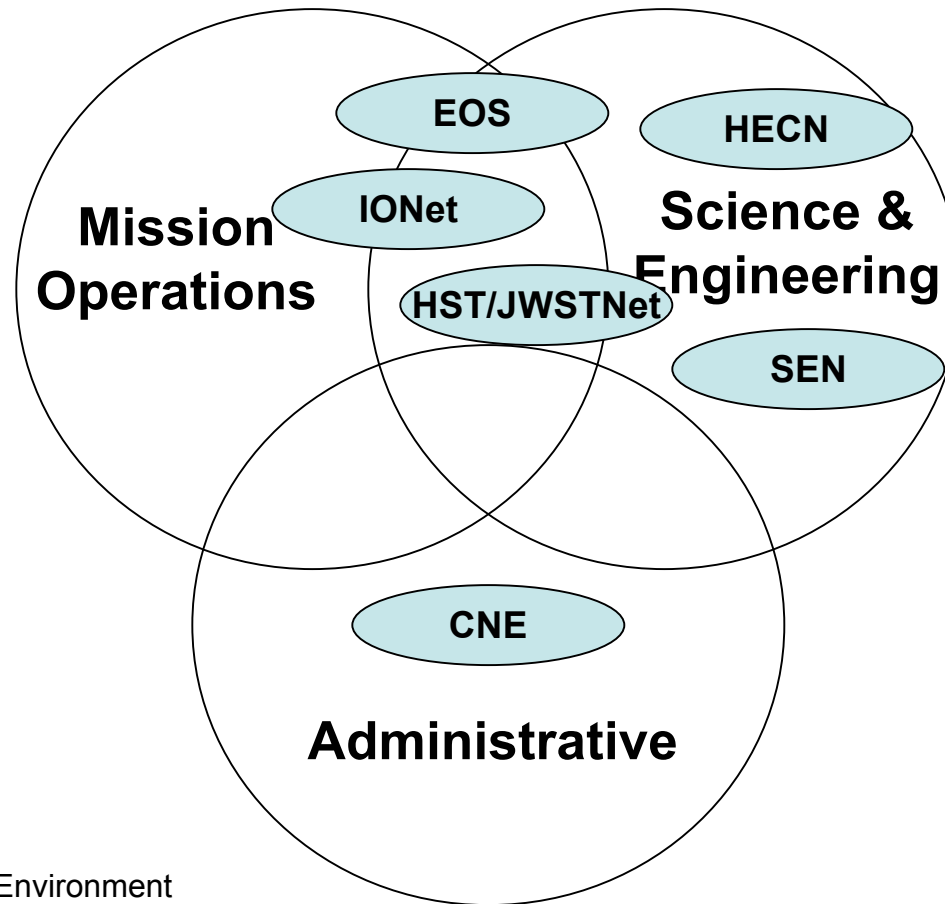
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GSFC Managed Networks



CNE: Center Network Environment

EOS: Earth Observing System

HECN: High End Computing Network

HST/JWSTNet: Hubble Space Telescope/James Webb Space Telescope Network

IONet: IP Operational Network

SEN: Science & Engineering Network



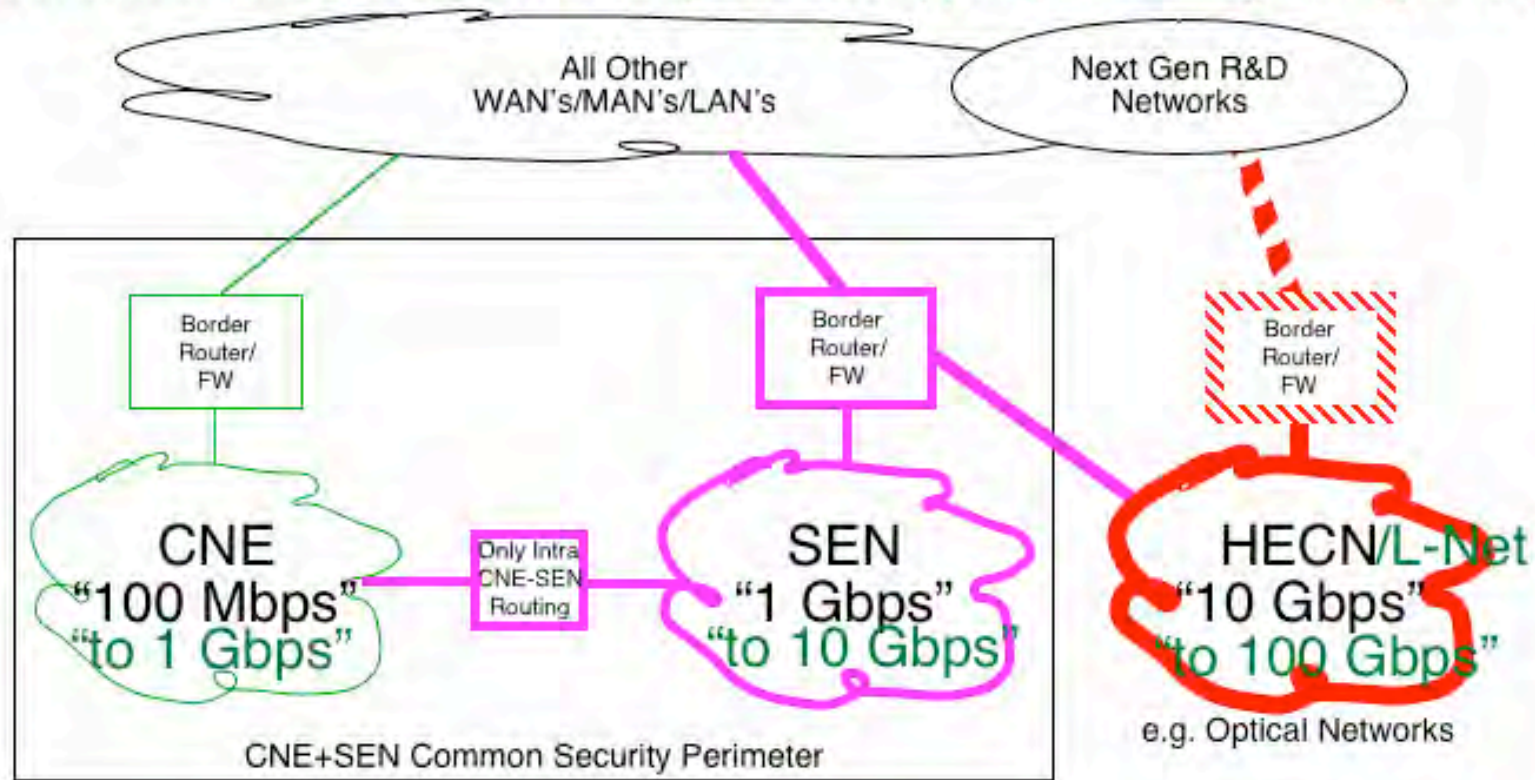
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Notional Key Characteristics of GSFC's Scientific and Engineering Network (SEN) and High End Computer Network (HECN/L-Net)

[Note: Some data flows/paths are restricted by GSFC security policy and/or management agreement]



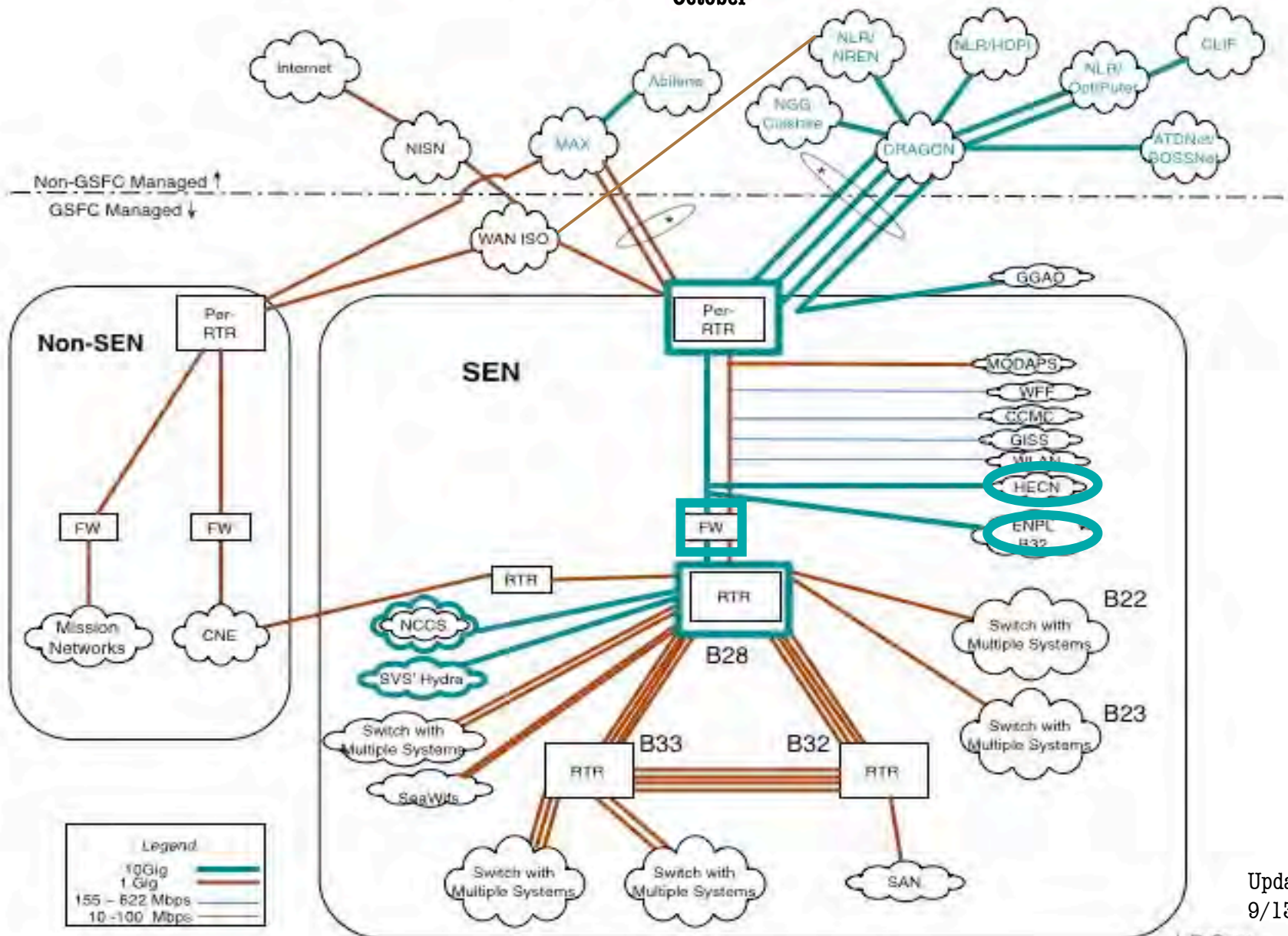
02/27/06

JPG 02/25/04

GSFC Scientific and Engineering Network (SEN) Major Links

Circa 1 ~~March~~ 2006

October



* Using one SEN physical fiber pair and several Unique LAMBDA

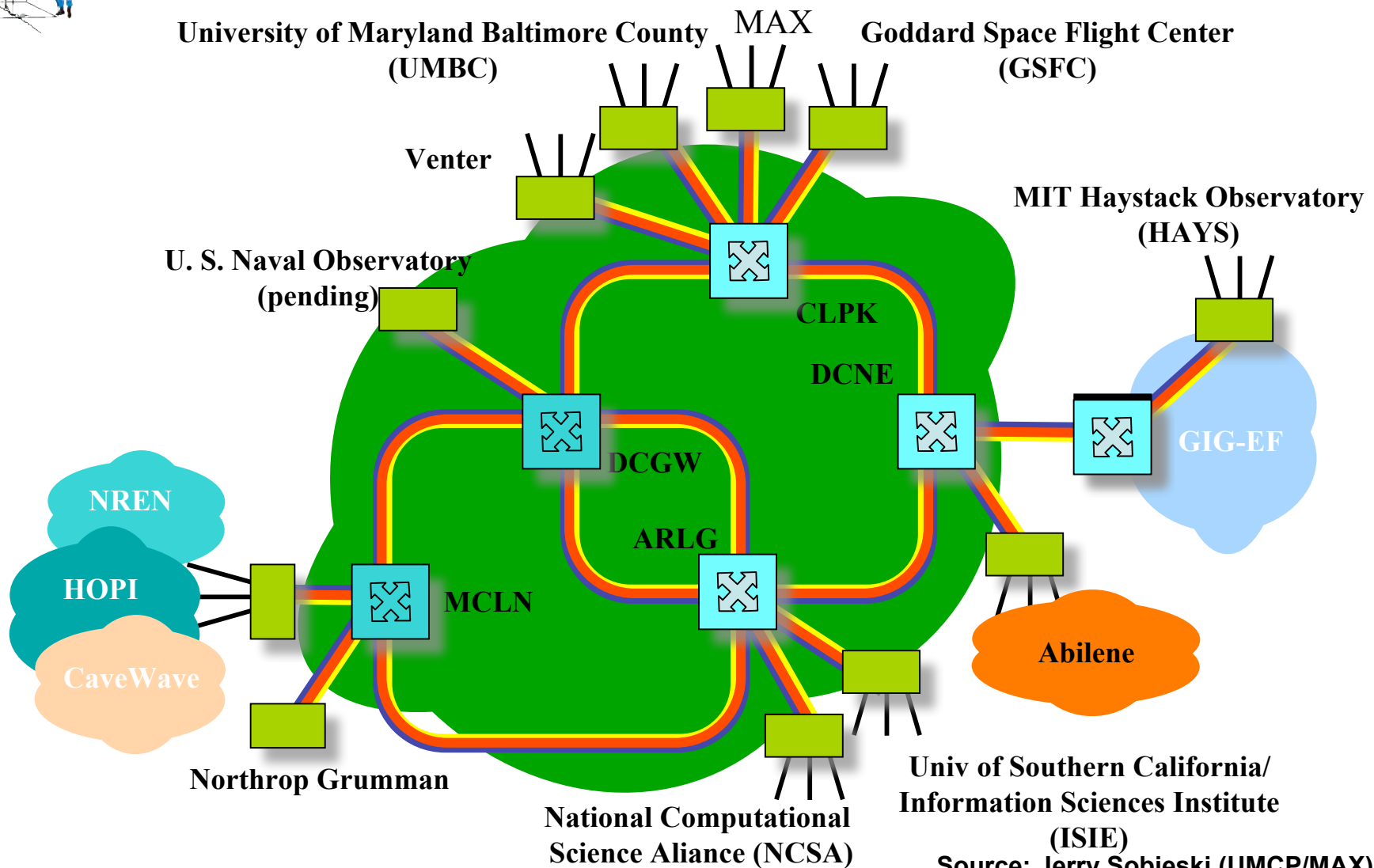
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3/22/06

Updated
9/13/06



The DRAGON Testbed

Washington, DC metro region



Source: Jerry Sobieski (UMCP/MAX)



Regional Optical Networks (RONs)

- At least 26 RON projects in 40+ states
- Nearly 30,000 miles of fiber collectively
- Providing:
 - Internet / Internet2 access
 - Peering for R&E and commodity
 - Circuits (often gigabit Ethernet)
 - Overlay networks

Source: Mark Johnson (NCCM)
May 3, 2005



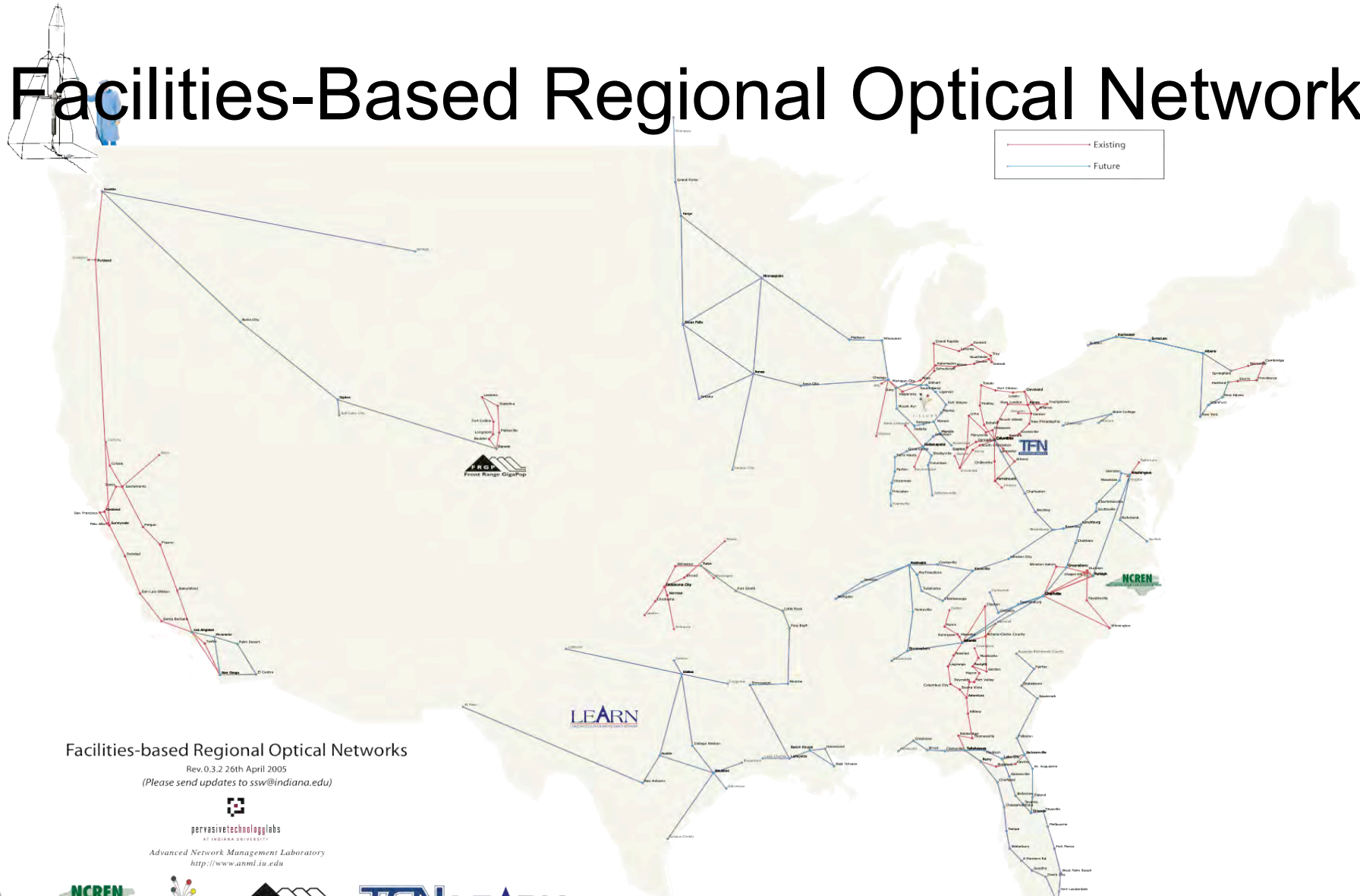
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Facilities-Based Regional Optical Networks




Facilities-based Regional Optical Networks

Rev. 0.3.2 26th April 2005
 (Please send updates to ssw@indiana.edu)

 pervasive technology labs
 107 W. 10th St. #100
 Advanced Network Management Laboratory
<http://www.atnml.iu.edu>



MCNC | I-LIGHT Grid Computing & Networking Services

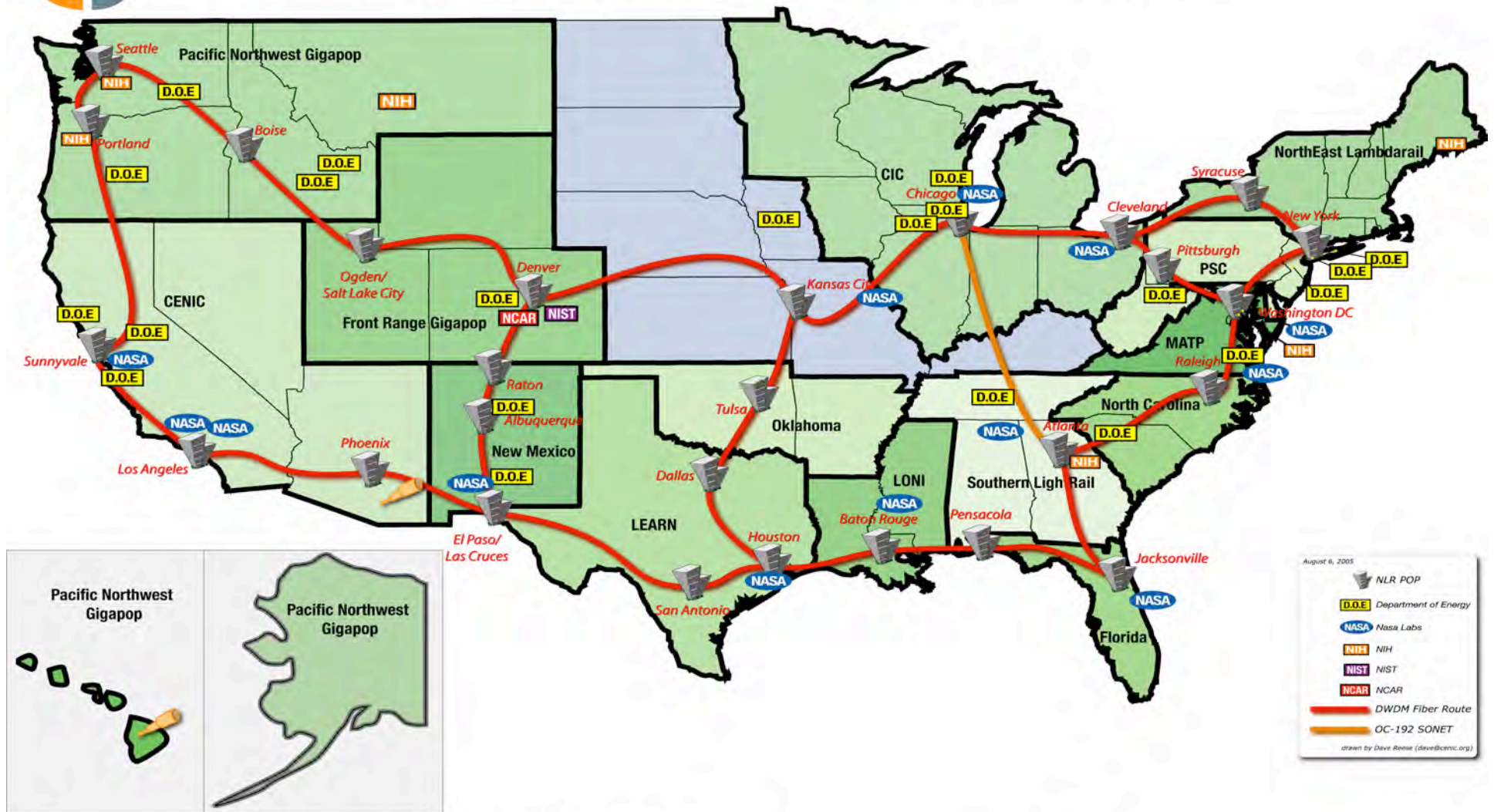
 2/1/07 | GODDARD SPACE FLIGHT CENTER

Source: Mark Johnson (NCCM)
 May 3, 2005

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National LambdaRail Architecture



August 6, 2005

- NLR POP
- D.O.E. Department of Energy
- NASA Nasa Labs
- NIH NIH
- NIST NIST
- NCAR NCAR
- DWDM Fiber Route
- OC-192 SONET

drawn by Dave Reine (dave@cmic.org)

© 2005 National LambdaRail

For more information regarding NLR see <http://www.nlr.net> or contact info@nlr.net

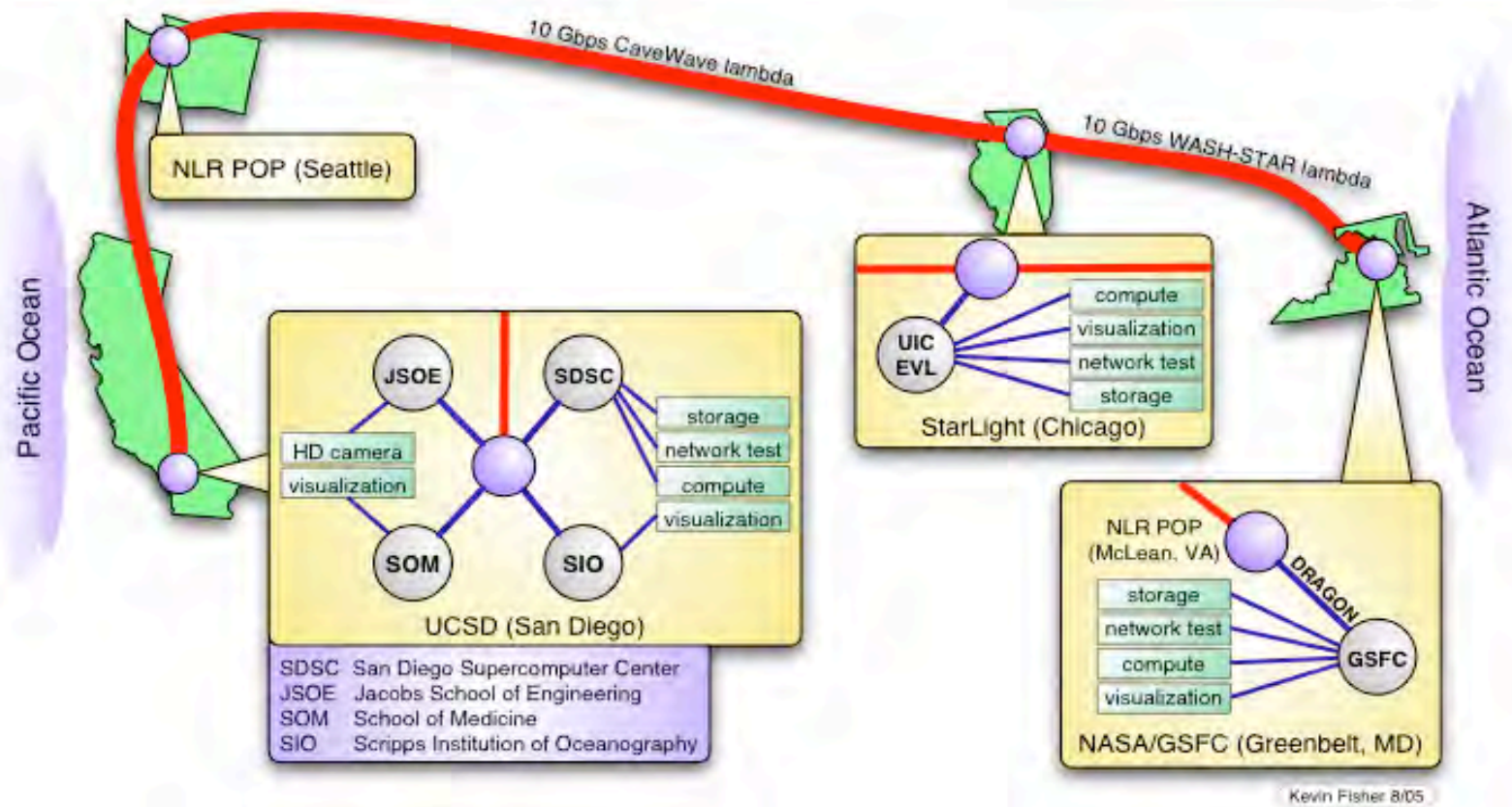


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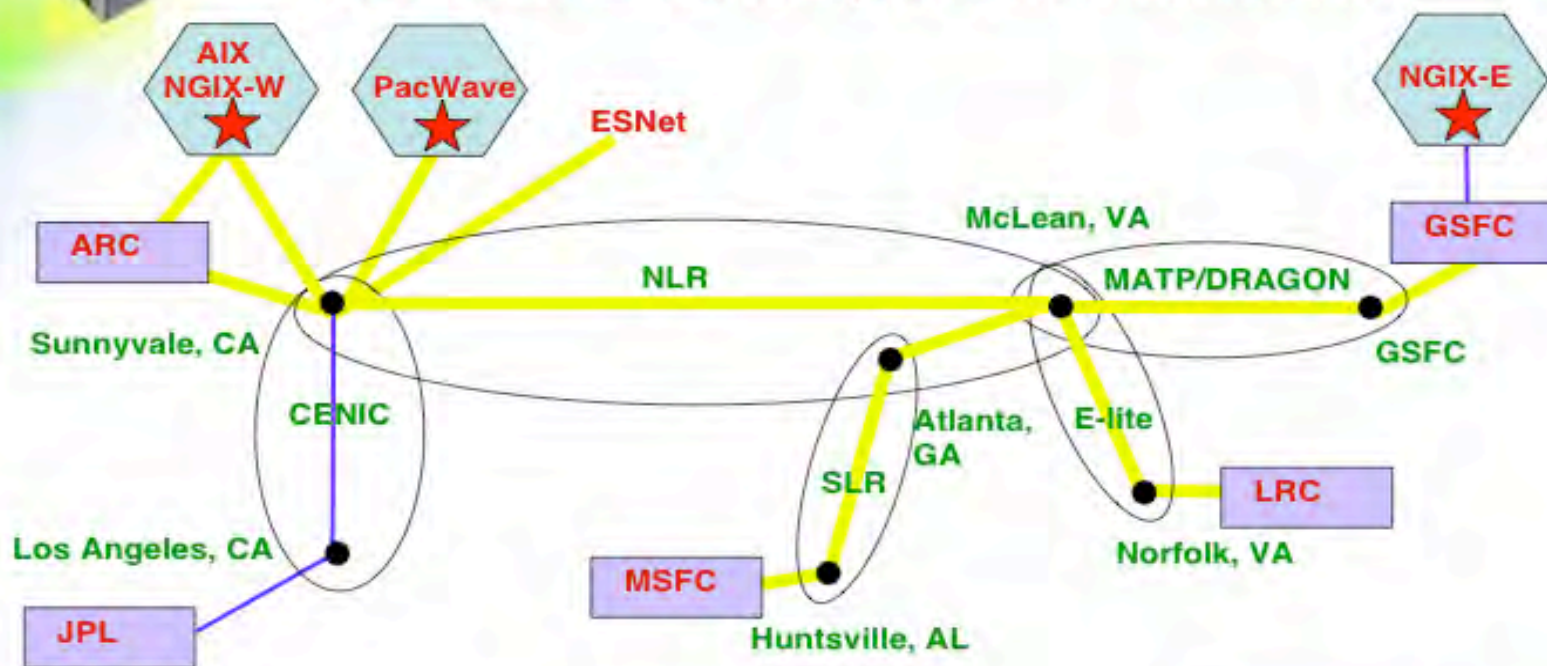
NASA GSFC Tests with OptIPuter Across the National LambdaRail



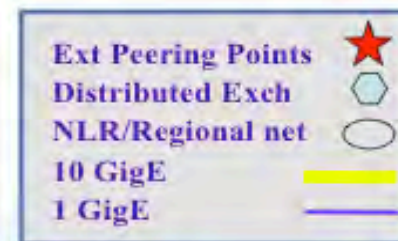


NREN Target FY06

10G waves at the core, dark fiber to end sites



- National and Regional optical networks provide links over which 10 Gbps and 1 Gbps waves can be established.
- Distributed exchange points provide interconnect in metro and regional areas to other networks and research facilities

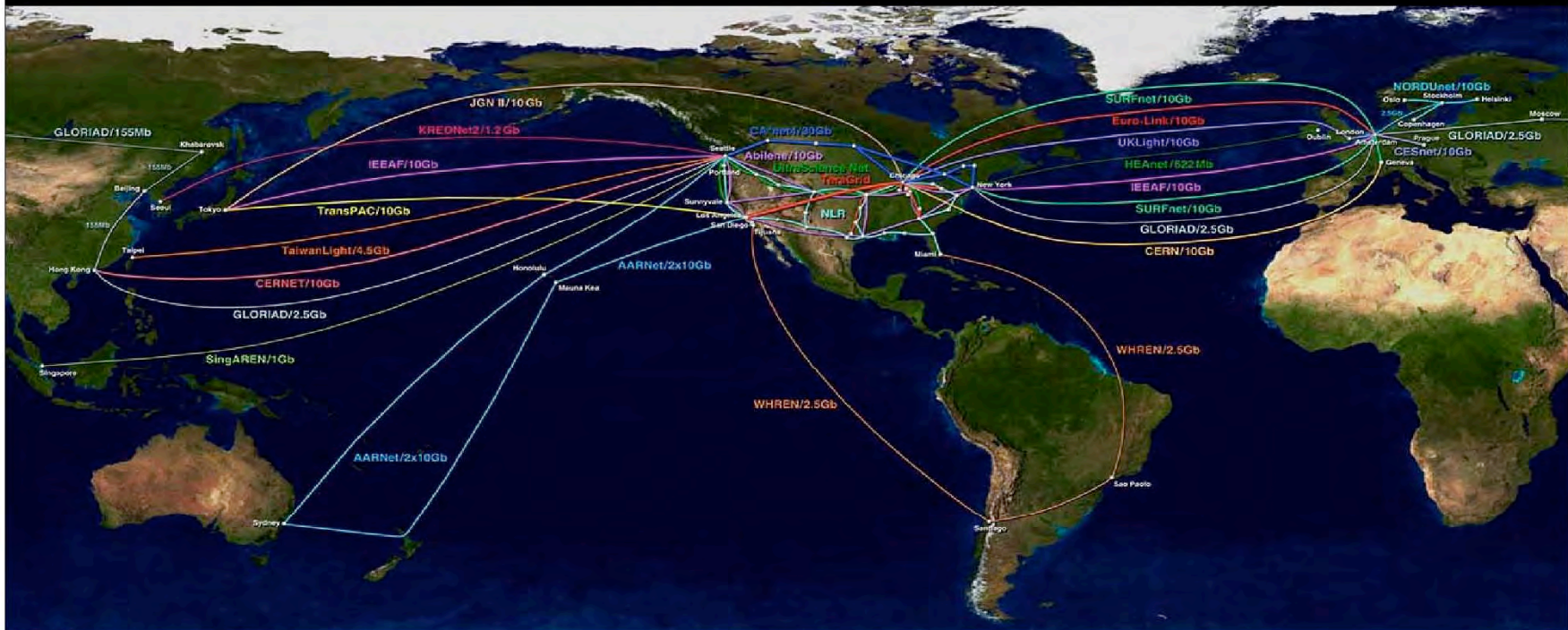


Source: Mark Foster (ARC)



Global Lambda Integrated Facility World Map – December 2004

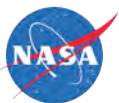
Predicted international Research & Education Network bandwidth, to be made available for scheduled application and middleware research experiments by December 2004.



www.glif.is

Visualization courtesy of
Bob Patterson, NCSA.

STARLIGHTSM



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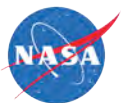
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Security Services of GSFC SEN and HECN Summarized for GSFC DCIO for EA (7/7/06)

http://cisto.gsfc.nasa.gov/SENUserdocs/SEN_Network_Security_070706.pdf

- Infrastructure-Oriented
 - Perimeter Control
 - Hardware/Software Maintenance
 - Authentication and Configuration Control
 - Staff Training
- User-Oriented
 - Subnetting and VLANs
 - Firewall Management
 - Network Scans
 - Patch Monitoring via PatchLink
 - NIST SP 800-47 Compliant Interconnection Agreements in Testbeds for Advanced IP Services



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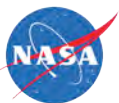
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Selected Security Services of GSFC SEN and HECN

- Firewalls and/or Access Control Lists (ACLs) for each GSFC-managed security domain/zone
 - Compliant with policies generated by GSFC's PCB
 - Moderately segmented network
 - ~15 subnets
 - ~50 VLANs
- Formal firewall waiver request process (similar to the CNE's)
- Separate subnets and/or VLANs for interfaces to console/management ports
- Kerberos V5 software-based authentication and access controls
- MOU with Code 700's Network Security Monitoring Team



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SC06 Demos Supported By GSFC's HECN



• DRAGON's XNET Demo

- Ability to dynamically establish application specific networks that exhibit deterministic, predictable, and repeatable performance characteristics
- On demand provisioning of optical lambda and VLAN layer network services linking to facilities in Japan, Europe, and across the US to create a */dedicated/* distributed environments for scientific collaboration
- <http://dragon.maxgigapop.net/twiki/bin/view/DRAGON/SuperComputingPlanning2006>

• TeraFlow Testbed Demo

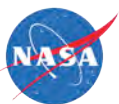
- An international application testbed for exploring, integrating, analyzing, and detecting changes in massive and distributed data over wide area high performance networks
- <http://www.ncdm.uic.edu/> & <http://sdss.ncdm.uic.edu/>

• OptIPuter Demo

- The California Institute for Telecommunications and Information Technology (Calit2), the Center for Earth Observations and Applications (CEOA), the National Center for Microscopy and Imaging Research (NCMIR), and the Electronic Visualization Laboratory (EVL) at the University of Illinois at Chicago present collaborative research on sensor networks and instrument grids.
- http://iebms.heiexpo.com/iebms/oep/oep_p2_details.aspx?sessionid=ejnff5ei1fb6fg7ei8&OrderNbr=1626&rescode=3101X62&newrestype=3101

• DICE Demo

- Live data intensive computing environment between multiple booths
- http://www.avetec.org/dice/SC06_overview.htm



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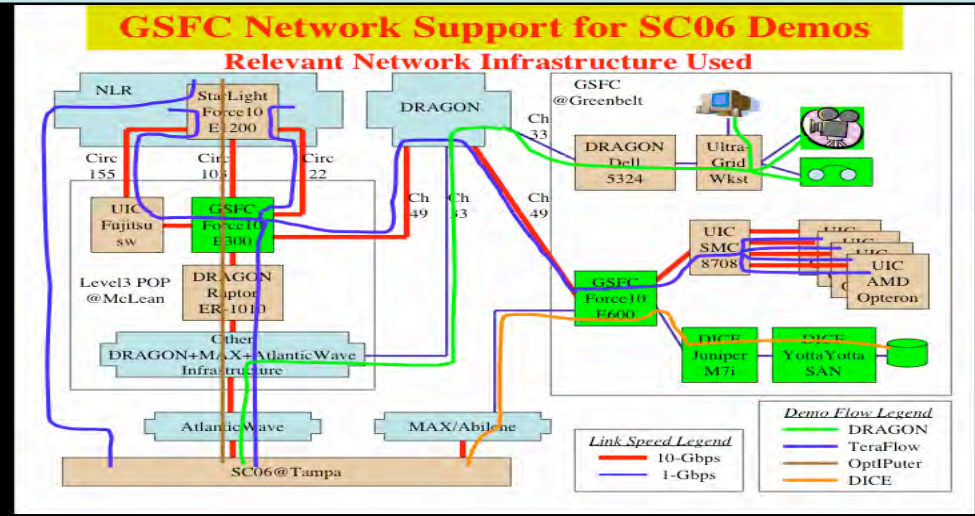
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GSFC HECN Team Supports Four Realtime Demonstrations at SC2006

- GSFC's High End Computer Network (HECN) Team supported four realtime high performance networking data flow demonstrations into the showroom floor of the International Conference for High Performance Computing, Networking and Storage, a.k.a. SC2006, hosted in Tampa, FL, November 11-17, 2006.
- The demos supported were those of the following projects:
 - DRAGON: <http://dragon.maxgigapop.net/>
 - TeraFlow Testbed: <http://www.teraflowtestbed.net/>
 - OptIPuter: <http://www.optiputer.net/>
 - DICE: <http://www.avetec.org/dice/>
- The provided support was in the form of either HECN's physical network infrastructure used in the critical path of a demo's realtime data flows as illustrated in the top right figure, or HD video streaming and network engineering or troubleshooting expertise to help setup the demo as illustrated in the bottom right figure.
- Additional information about the projects supported, their SC06 demos, and the data flows across the relevant network infrastructure used is provided at http://cisto.gsfc.nasa.gov/private_implementation/SC06_GSFC_netsupport.pdf.



GSFC Network Support for DRAGON Xnet Demo During SC06
 Streaming NASA HD Video Uncompressed in Realtime from GSFC to the SC2006 Showroom Floor in Tampa

The block contains a network diagram and several photographs of the demo setup. Red arrows indicate the flow of data from GSFC to the SC2006 booth.

IP Packets in LightPaths

HD Video

HD Video

High level network diagram, prepared by DRAGON's Chris Tracy, showing the optical WAN pathways between GSFC and the five booths at SC06 hosting DRAGON's Xnet demo.

At the Internet2 booth at SC06 (one of five hosting DRAGON's Xnet demo) realtime uncompressed HD video from the High End Computer Network (HECN) Team's lab at GSFC is displayed to SC06 attendees.

UltraGrid software and a HD video capture/compression card, loaned from USC/ISI-East's Tom Lehman, in HECN's Pentium4 IP-packetizes and transmits the digital video at 1-Gbps through an optical WAN path dynamically provisioned by DRAGON's network control-plane software.

A Panasonic AJ-HD1200AP HD player, loaned from GSFC's TV Studio (courtesy of Pat Kennedy), provides one of the HD video stream sources.

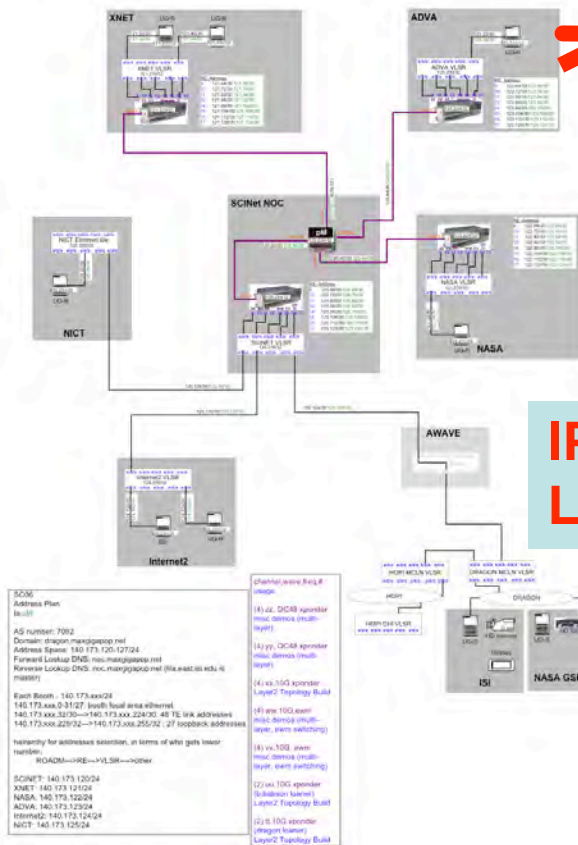
A Hitachi SK-5010P HD camera, loaned from GSFC's TV Studio (courtesy of Pat Kennedy), provides one of the realtime HD video stream sources.



GSFC Network Support for DRAGON Xnet Demo During SC06

Streaming NASA HD Video Uncompressed in Realtime from GSFC to the SC2006 Showroom Floor in Tampa

SC2006 Demo Diagram



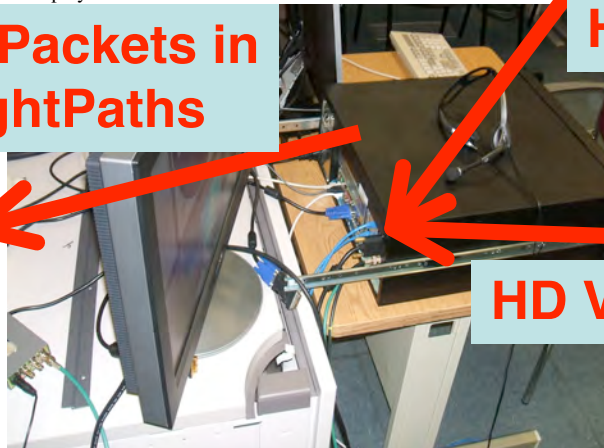
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IP Packets in LightPaths

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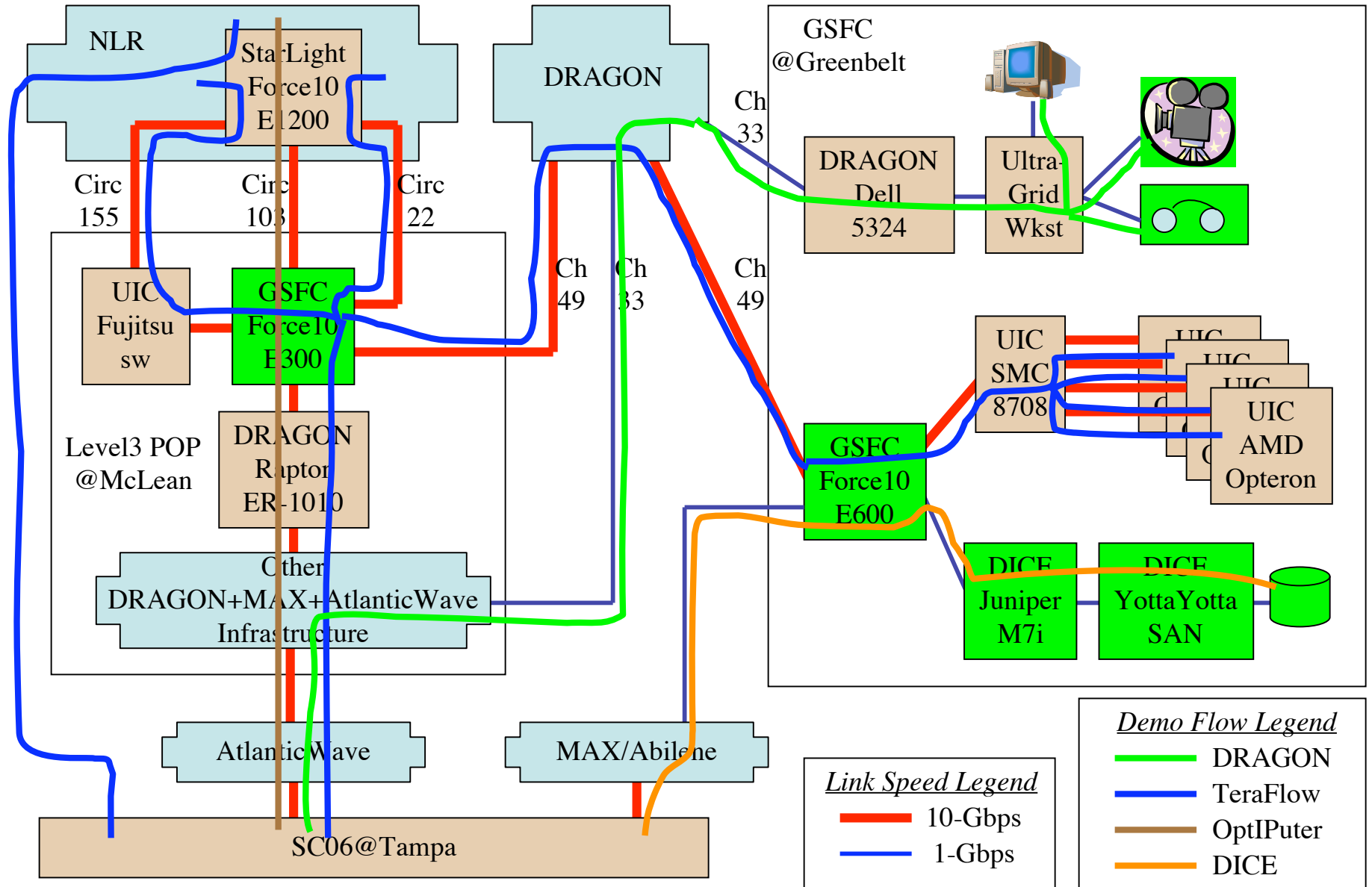
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A Hitachi SK-3010P HD camera, loaned from GSFC's TV Studio (courtesy of Pat Kennedy), provides one of the realtime HD video stream sources.

GSFC Network Support for SC06 Demos

Relevant Network Infrastructure Used





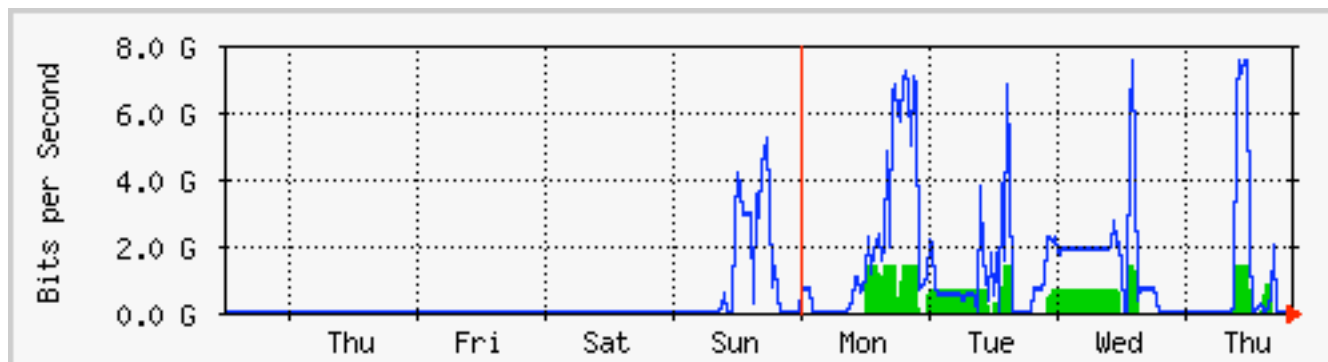
GSFC Network Support for SC06 Demos

Combined TeraFlow and OptIPuter Data Flows to/from SC06

GSFC High End Computer Network (HECN)
Mrtg-based Graphs
Bits per second **In** and **Out**
On Selected Interfaces

“Weekly”
30 Minute Averages
16 November 2006

Measured At:



Max **In**:1515.8 Mb/s (15.2%) Average **In**:198.2 Mb/s (2.0%) Current **In**:56.0 b/s (0.0%)
Max **Out**:7533.7 Mb/s (75.3%) Average **Out**: 795.4 Mb/s (8.0%) Current **Out**:0.0 b/s (0.0%)

GSFC/HECN's Force10
E300 10-GE Interface
with DRAGON's Raptor
(and then AtlanticWave)
in Level3 POP at McLean



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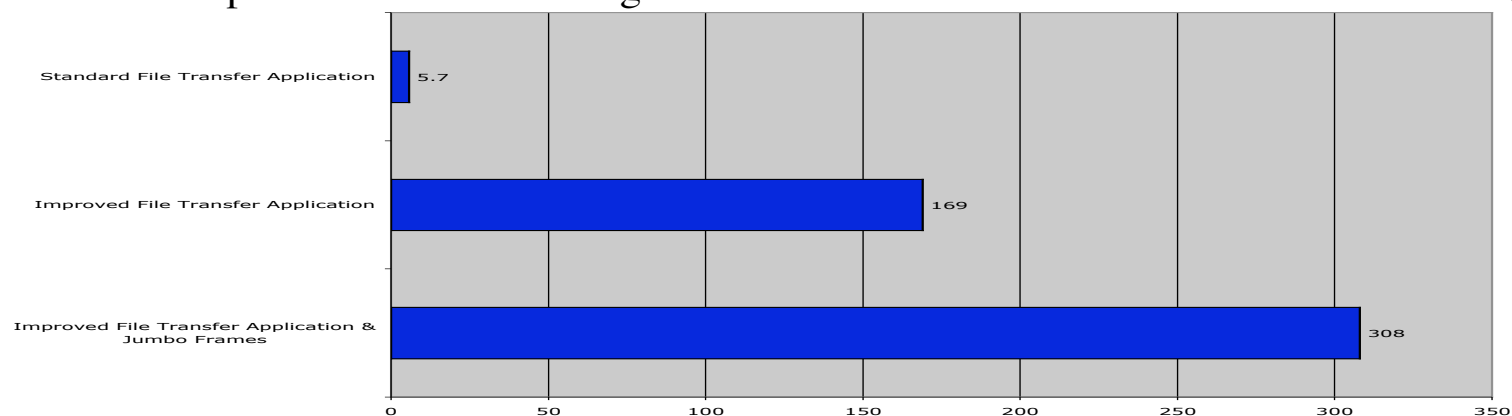


54 Times Network Throughput Performance Gains Through Improved File Transfer Tool and End System Host/Network Adjustments

Team members from the NASA Research and Engineering Network (NREN) at Ames and the Science and Engineering Network (SEN) at Goddard worked together to help network users from Goddard's 3-D Cloud-Resolving Model project increase data transfer performance through improved file transfer tools and end system host adjustments.

The 3-D Cloud-Resolving Model team had been utilizing the standard file transfer application called Secure Copy (SCP), resulting in maximum sustainable data transfer rates of 5.7 Mbps, between Goddard and Ames. By utilizing the improved multi-stream file transfer application, BBFTP, these data transfer rates were improved to a maximum sustainable data transfer rate of 169 Mbps. Furthermore, by moving the user host to the Science and Engineering Network at Goddard allowed for the application of Jumbo Frames. This improvement resulted in an improved maximum sustainable data transfer rate of 308 Mbps, where the disk I/O speed of the user's local desktop machine is now suspected to be the limiting factor.

Source: Ken Freeman (ARC)



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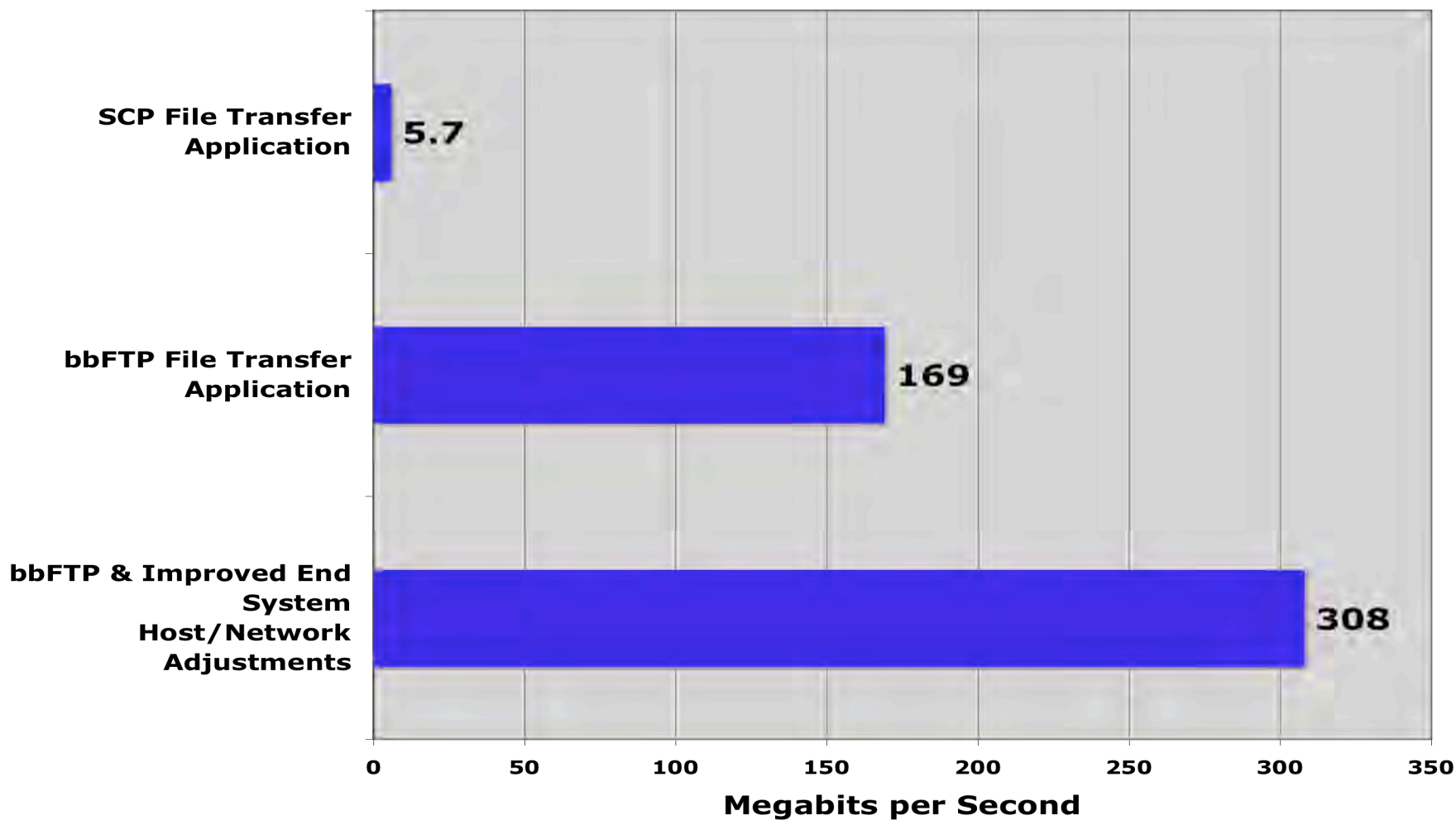
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54 Times Network Throughput Performance Gains Through Improved File Transfer Tool and End System Host/Network Adjustments



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54 Times Network Throughput Performance Gains Through Improved File Transfer Tool and End System Host/Network Adjustments

From

Change 1

- SCP
 - Encrypts all data, wasting cpu
 - Small transport window hard-coded “defaultly”
 - [Typically single stream flows]
- TCP window defaulted to 64KB

Change 2

- Max 1500 byte standard Ethernet frame size via Apple’s 1-GE NIC
- CNE intra-building, inter-building & firewall infrastructure

To

- o bbFTP
 - Encrypts only the user’s password
 - Large transport window via user-provided parameter (UPP)
 - [Multi-stream flows via UPP]
- o Tuned to Bandwidth x Delay
- o Max 9000 byte jumbo frame size via new 1-GE NIC (Intel Pro/1000)
- o SEN intra-building, inter-building & firewall infrastructure



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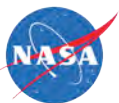
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Excerpts from SEN's User-oriented Webpages at <http://cisto.gsfc.nasa.gov/SENUserdocs/SENUser.html> #Throughput

Throughput Performance Tuning Information

- System Specific Notes for System Administrators (and Privileged Users):
<http://www.psc.edu/networking/projects/tcptune/>
- TCP Tuning Guide: <http://www-didc.lbl.gov/TCP-tuning>
- M. Mathis, et al, "NPAD/pathdiag unleashed", ESCC/Internet2 Joint Techs Workshop, Madison, July, 2006: <http://events.internet2.edu/2006/jt-madison/sessionDetails.cfm?session=2753&event=253>
- Phil Dykstra's [tutorial at SC06](#):
http://cisto.gsfc.nasa.gov/SENUserdocs/M07_tutorial.pdf
- Significant improvements in network throughput performance obtained by Code 613.1's Roger Shi's "hurricane" workstation/server:
<http://cisto.gsfc.nasa.gov/SENUserdocs/BBFTP-Jumbo-HL.110806.pdf>
- [NREN-provided info](#) on Jumbo Frames, TCP Performance Tuning on End Systems, Multistream File Transfers (e.g., bbFTP), etc.:
<http://www.nren.nasa.gov/customer.php>

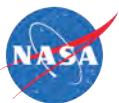




Potential GSFC SEN and HECN User Advance Topics for a Future IA@G Meeting

Previous and/or On-Going Applications Support

- Using ARC/NAS/Columbia Supercomputer (w/NREN)
- Distributed ESMF Computing R&D (w/Code 610.3)
- eVLBI (w/MIT-Haystack, ...)
- OptIPuter & Multi-channel Collaboration/Video Streaming Technologies(w/UCSD & UIC)
- 3D HDTV-over-IP R&D (w/Physical Optics Corporation)
- SAN-over-IP (w/UMIACS, NGC & NCCS/DICE)



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Columbia Supercomputer

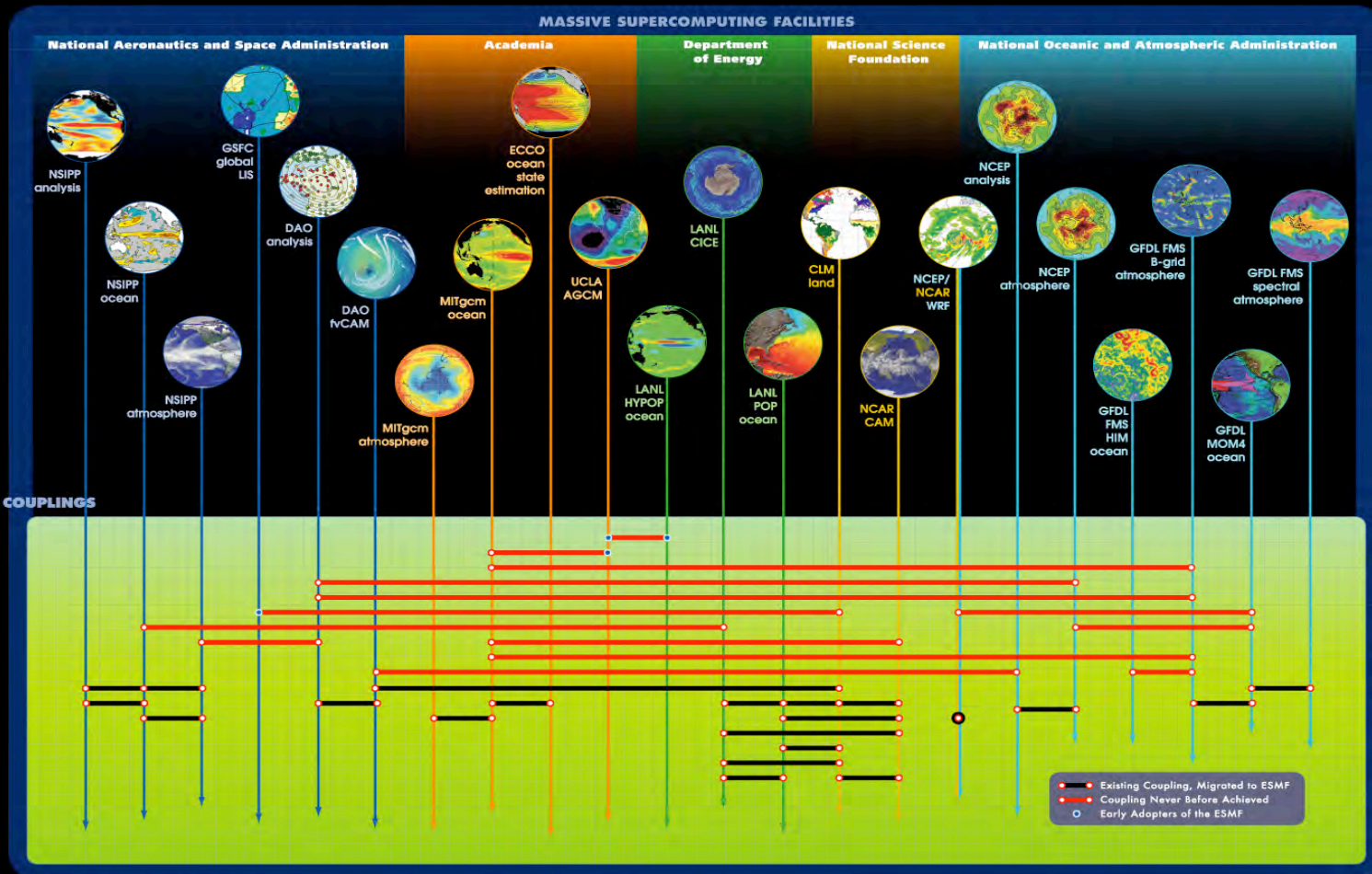
- 10,240 1.6 GHz CPUs
- Configured as twenty 512 CPU single-system image nodes via NUMA
- SGI Altix 3700 Architecture, runs Linux
- 1 Terabyte shared memory per node
- Over 500 terabytes of online disk space



ESMF

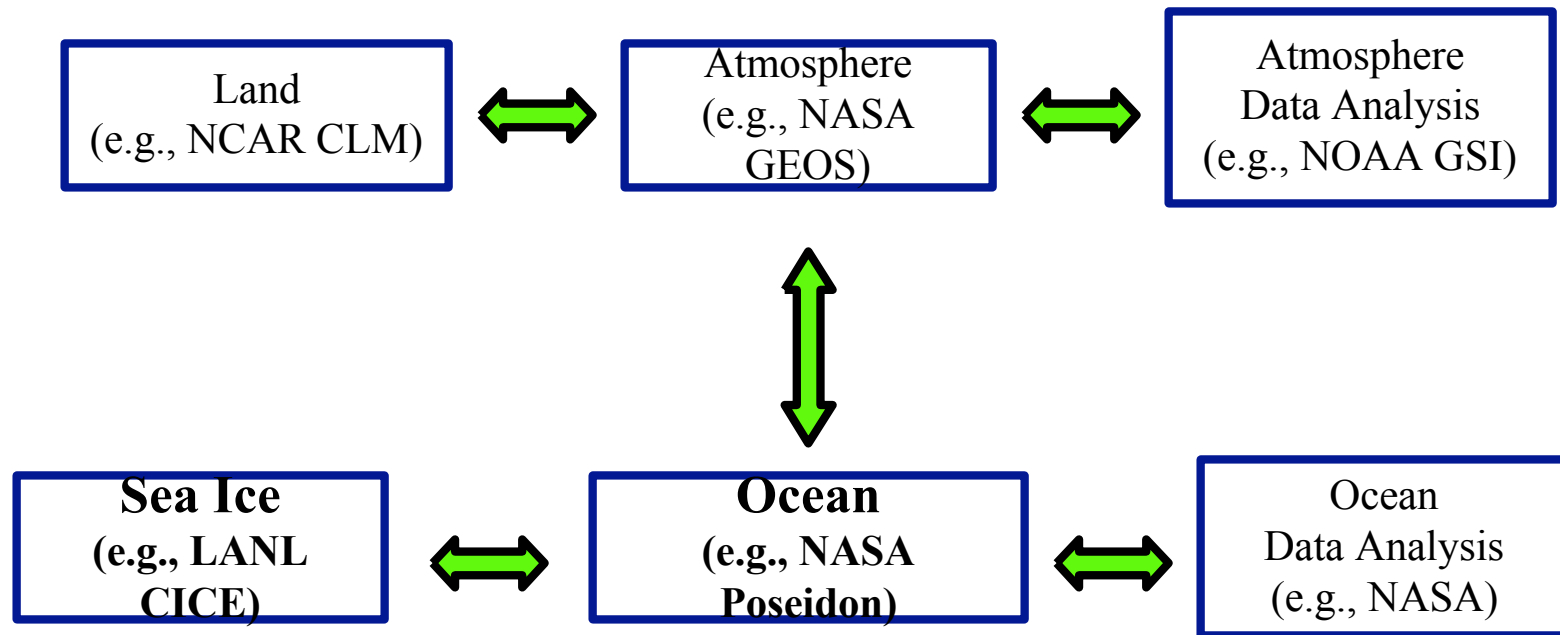
EARTH SYSTEM MODELING FRAMEWORK

MODEL COMPONENTS



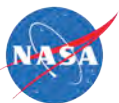


ESMF-Enabled Coupled Models

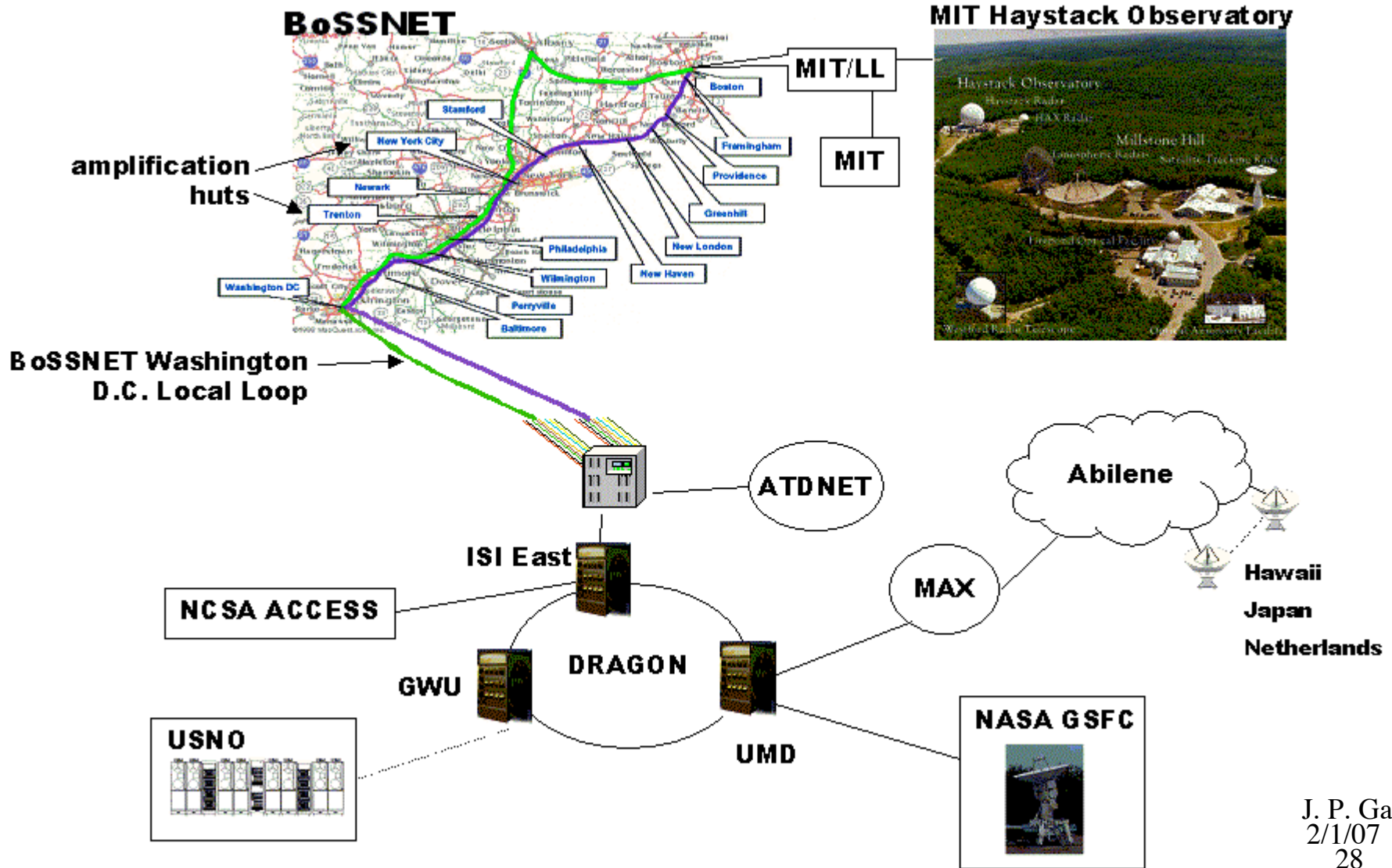


 ESMF Coupler

 ESMF Component



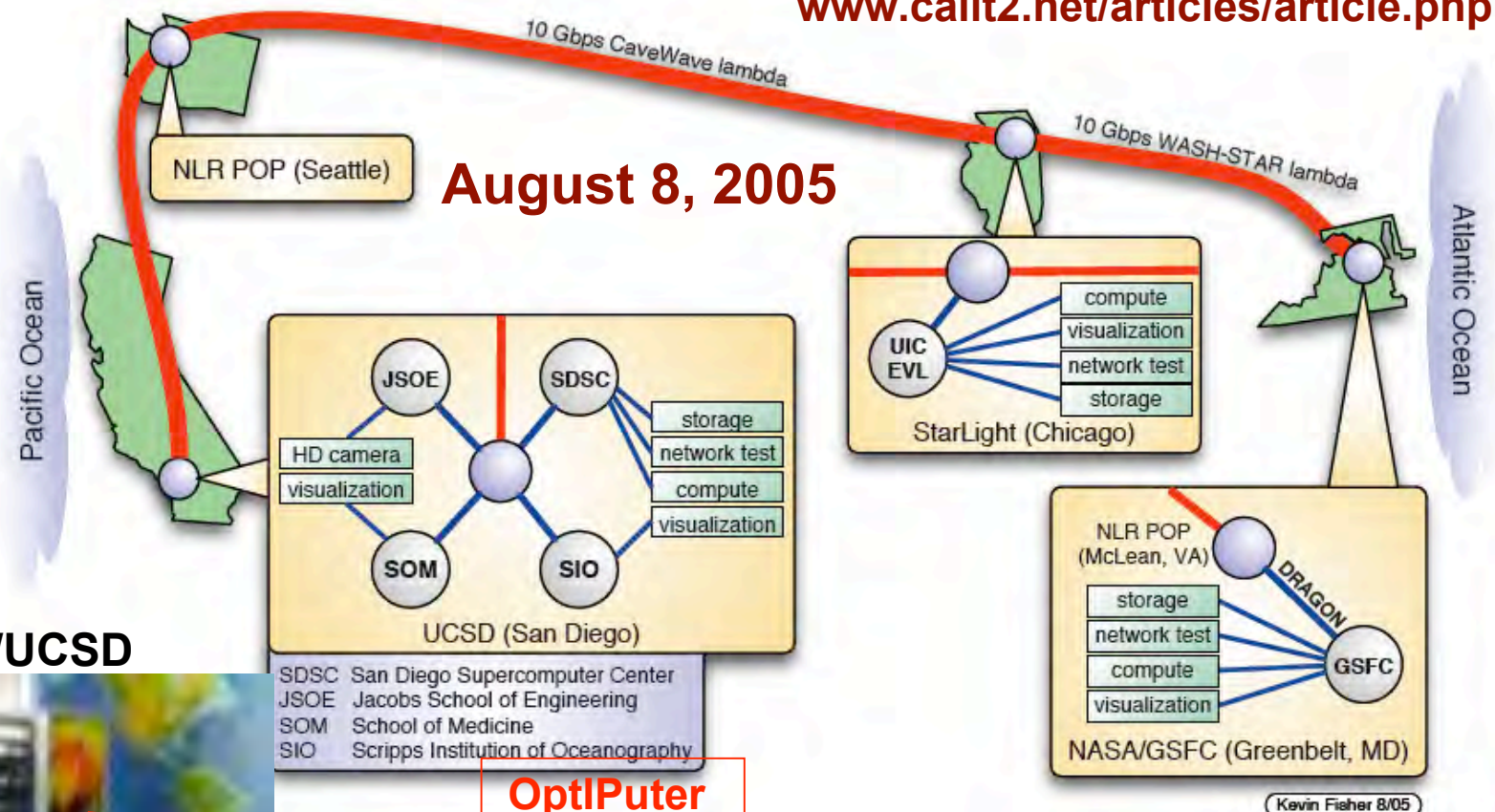
DRAGON eVLBI Experiment Configuration





Combining Telepresence with Remote Interactive Analysis of Data Over NLR

www.calit2.net/articles/article.php?id=660



SIO/UCSD



SDSC San Diego Supercomputer Center
 JSOE Jacobs School of Engineering
 SOM School of Medicine
 SIO Scripps Institution of Oceanography

**OptIPuter
 Visualized
 Data**

**HDTV Over
 Lambda**



Kevin Fisher 8/05

**NASA
 Goddard**



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iGrid 2005 Workshop, 26-29Sep05, UCSD/CalIT2

Accelerating the Use of Multi-10Gigabit per Second International and National Networks: www.igrid2005.org



GSFC's Ben Kobler (left) and POC's Sookwang Ro and Kirill Kolesnikov (right) work to set up POC's 35" x 35" holographic 3D HDTV video display system (center) prior to the start of iGrid 2005.

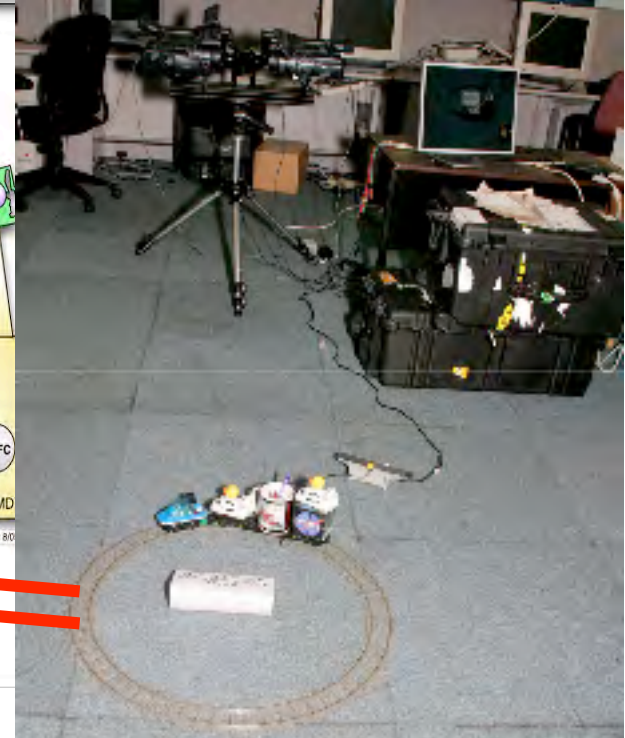
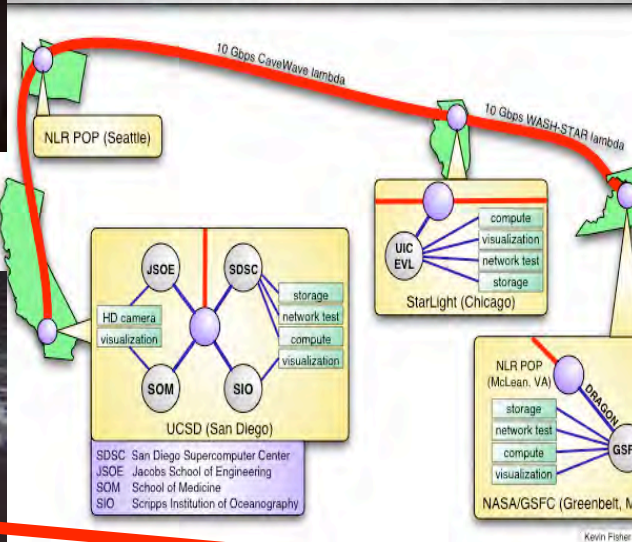


Only a non-stereo image of the True-3D display is captured in this photo of the real-time stereo-HDTV images transmitted from GSFC.

US130: Real-Time True-3D/HDTV (No Goggles) Visualization Over the National LambdaRail

NASA and Physical Optics Corporation demonstrate a holographic 3D HDTV video display system that does not require goggles or other special head gear, using a live cross-country video feed from NASA Goddard Space Flight Center to the iGrid 2005 site in San Diego. POC is a NASA SBIR Phase 1 awardee, and worked with NASA GSFC on this project.

www.poc.com/emerging_products/3d_display/default.asp



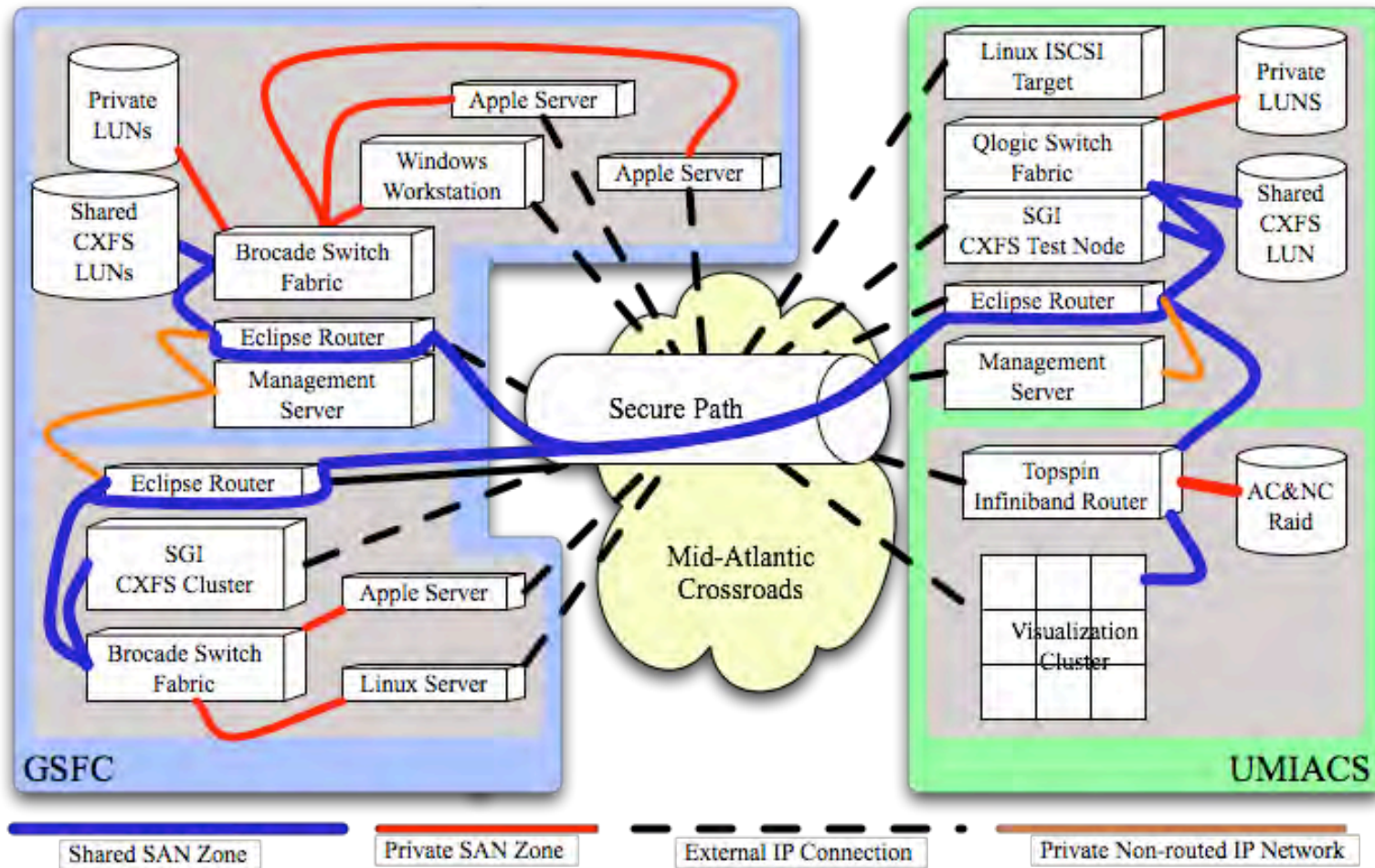
Stereoscopically-aligned Sony HDV 1080i HDR-FX1HDTV cameras and the viewed targets at GSFC.

3D HDTV Over Lambda

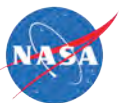


Current SAN-over-IP Test-bed

GSFC-UMIACS IP SAN Test Bed

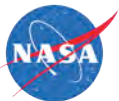


Source: Fritz McCall (UMIACS)





~~NETWORK BOTTLENECKS~~



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Additional Information

- **SEN:**

<http://cisto.gsfc.nasa.gov/SENUserdocs/SENUser.html>

- **HECN:**

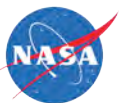
http://cisto.gsfc.nasa.gov/IRAD_Lambda.html

- **For further information about the SEN's or HECN's goals and present capabilities or about new users being attached to the SEN or HECN, please contact:**

- **J. Patrick Gary (606.1), SEN Engineering Board Chair and HECN Project Manager/Leader**

- **301-286-9539**

- pat.gary@nasa.gov



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GSFC High End Computer Network (HECN) Availability

Backup Slides



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GSFC High End Computer Network (HECN) Project's Research Partners and Collaborators

- **DRAGON Project:** <http://dragon.maxgigapop.net/twiki/bin/view/DRAGON/WebHome>
 - PI: Jerry Sobieski (UMCP)
 - GSFC L-Net on DRAGON network diagram: <http://dragon.maxgigapop.net/twiki/bin/view/DRAGON/Network>
- **e-VLBI Project:** <http://web.haystack.mit.edu/e-vlbi/evlbi.html>
 - PI: Alan Whitney (MIT/Haystack)
 - GSFC L-Net on e-VLBI network diagram: http://cisto.gsfc.nasa.gov/L-Netpdfs/SC04_eVLBI_network.pdf
- **GLIF:** <http://www.glif.is/>
 - Chair: Kees Neggers (SURFnet)
 - GLIF network diagrams: <http://www.glif.is/publications/#maps>
- **NGC IT Sector:** <http://www.it.northropgrumman.com/index.html>
 - PI: Brice Womack (NGC)
 - GSFC L-Net on NGC IT Sector Colshire network diagram: http://cisto.gsfc.nasa.gov/L-Netpdfs/DRAGON_NGC_030606.pdf
- **NLR:** <http://www.nlr.net/>
 - CEO: Tom West (NLR)
 - NLR network diagram: <http://www.nlr.net/infrastructure/>
- **NREN Project:** <http://www.nren.nasa.gov/>
 - PM: Ken Freeman (ARC)
 - GSFC L-Net/SEN on NREN network diagram: http://cisto.gsfc.nasa.gov/L-Netpdfs/CENIC2006_13_mfoster_excerpts.pdf
- **OptIPuter Project:** <http://www.optiputer.net/>
 - PI: Larry Smarr (UCSD)
 - GSFC L-Net on OptIPuter network diagram: <http://cisto.gsfc.nasa.gov/L-Netpdfs/SMARR-OptIPuter-AHM-gold.pdf>
- **TeraFlow Testbed Project:** <http://www.teraflowtestbed.net/>
 - PI: Robert Grossman (UIC)
 - GSFC L-Net on TeraFlow Testbed network diagram: <http://www.ncdm.uic.edu/maps/index.jpeg>



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NASA 2006 Group Achievement Honor Award Presented to GSFC's HECN Team



In recognition of the outstanding teamwork and technical excellence exemplified by the HECN Team members in making the first coast-to-coast 10 Gigabit per second network over the National LambdaRail a reality. [(from left) Mike Stefanelli, Bill Fink, Mary Shugrue, Paul Lang, Pat Gary, Jeff Martz, Aruna Muppalla, Kevin Fisher, Kevin Kranacs]



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