Research and Development of High-End Computer Networks at GSFC

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http://esto.nasa.gov/conferences/esto2003/

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Research and Development of High-End Computer Networks at GSFC

Outline

- Motivation
- Challenge
- nuttcp Performance Testing Tool
- Evaluations in Large Bandwidth*Delay Networks
  - » Examples of Pre-2000 Efforts
  - » Examples of Current Evaluations
- Conclusion

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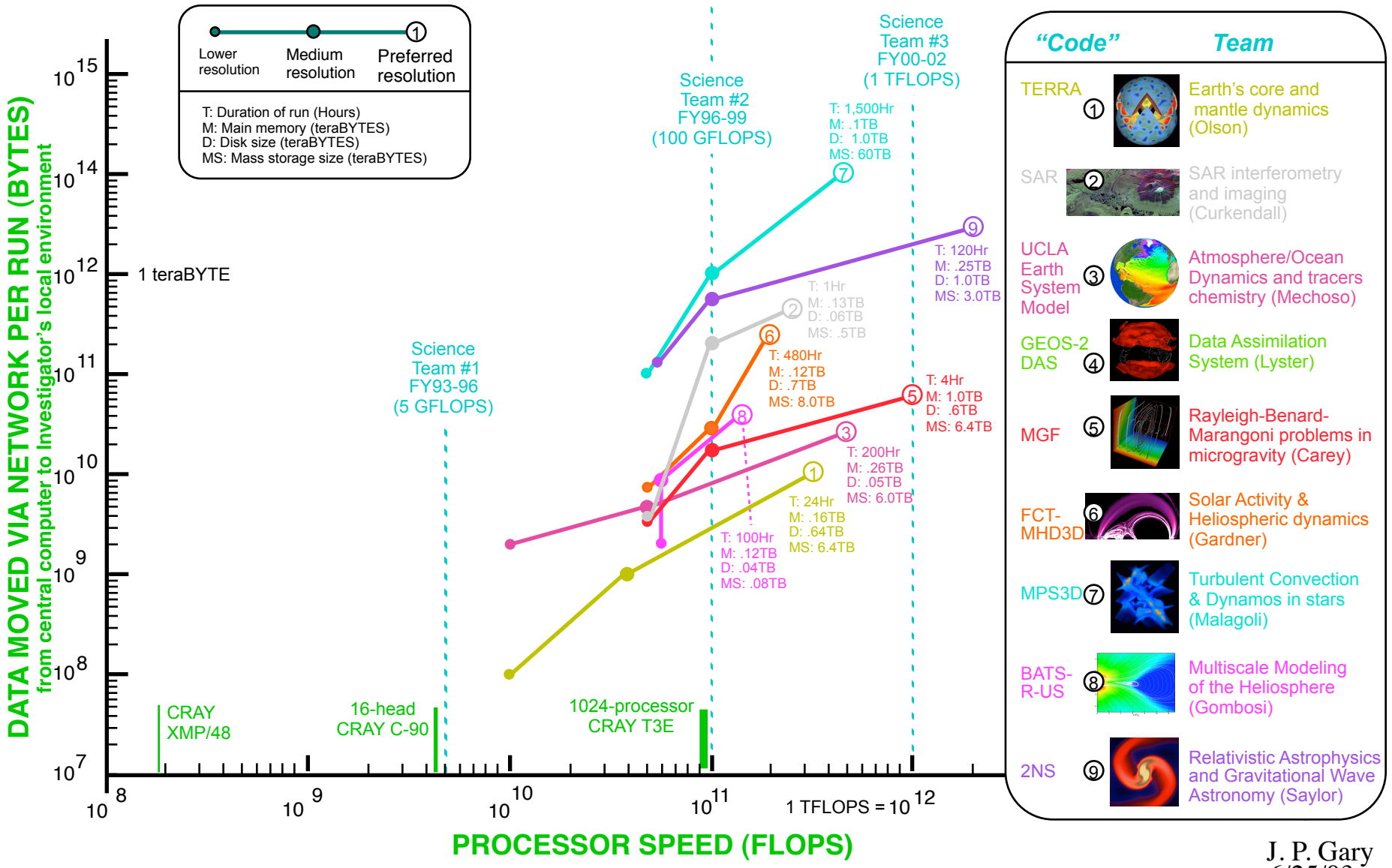
Motivation

- Availability of new high-bandwidth networking technologies, e.g.:
  - 1-10 Gigabit Ethernet switches/routers
  - Wave division multiplexing on dark fiber
- New (and old) types of bandwidth-demanding applications, e.g.:
  - Streaming HDTV and other real-time data over IP networks
  - Storage Area Networks over IP networks
  - High end computing

Long Haul Network vs CPU Requirements

of ESS Grand Challenge Investigators (Science Team #2)



"Code"	Team
TERRA ①	Earth's core and mantle dynamics (Olson)
SAR ②	SAR interferometry and imaging (Curkendall)
UCLA Earth System Model ③	Atmosphere/Ocean Dynamics and tracers chemistry (Mechoso)
GEOS-2 DAS ④	Data Assimilation System (Lyster)
MGF ⑤	Rayleigh-Benard-Marangoni problems in microgravity (Carey)
FCT-MHD3D ⑥	Solar Activity & Heliospheric dynamics (Gardner)
MPS3D ⑦	Turbulent Convection & Dynamos in stars (Malagoli)
BATS-R-US ⑧	Multiscale Modeling of the Heliosphere (Gombosi)
2NS ⑨	Relativistic Astrophysics and Gravitational Wave Astronomy (Saylor)

J.Fischer/NASA GSFC, 981208

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Challenges

- Network users still do not always get the throughput performance that they should get or need to get
- Common factors affecting throughput performance
  - » Bandwidth or message size limitations in intermediate links of the end-to-end network path
  - » Limitations of the hardware/software network interfaces of the end user client workstations or servers
- Appropriate evaluation environment
  - » Large-scale fielding of advanced networking technologies
  - » Effective measurement and analysis tools, plus expertise to use
  - » Real applications/users willing to risk network testbed availability

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nuttcp Throughput Performance Analysis Tool

- Developed by GSFC's Bill Fink
- Determines raw TCP or UDP network layer throughput
  - » Transfers memory buffers from a source system across an interconnecting network to a destination system
  - » Transfers either a specified number of buffers or for a specified time interval, optionally with pacing or as multiple simultaneous streams
  - » Reports many statistics, including:
    - – achieved network throughput in Mbps
    - – user, system, and wall-clock time
    - – transmitter and receiver CPU utilization
    - – loss percentage (for UDP transfers)

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nuttcp Throughput Performance Analysis Tool (continued)

- Recognized in SC2002 tutorial as the recommended "great successor" to ttcp
- Already in extensive use in GSFC, DREN, Supernet, and MAX networks
- Example use:

  [user@transmit_host]# nuttcp -t -T10 -w512 -b receive_host
  1183.125 MB / 10.01 sec = 991.7452 Mbps 82 %TX 37 %RX

- ftp://ftp.lcp.nrl.navy.mil/u/bill/beta/nuttcp/

GSFC <-> NRL OC-12 1 TB Challenge

shasta-a.nasa.atd.net

Sun UltraSPARC-2/300
Solaris 2.6 (128M)
SunATM-622 (2.1)

Using nttcp to transfer 1 TB of data
via Classical IP
(-l8192, -n134217728, -w512)

(5 h 52 m 26 s)
77% - 415.9686 Mbps - 85%

For comparison purposes, at T1 speed,
it would take more than 66 days
to transfer 1 TB of data

fozzie-a.lcp.nrl.navy.mil

Sun UltraSPARC-2/300
Solaris 2.6 (128M)
SunATM-622 (2.1)

HPCC ATM — ATDnet — NRL ATM

OC-12c ATM
MTU = 9180

Round Trip Time (RTT) ~ 1.4 ms
Maximum OC-12c ATM TCP Performance ~ 540 Mbps
Bandwidth*Delay ~ 92 KB

http://www.nasa.atd.net/images/gsfc-nrl_oc12_1_TB.gif

NASA Goddard - BF - 3/3/98

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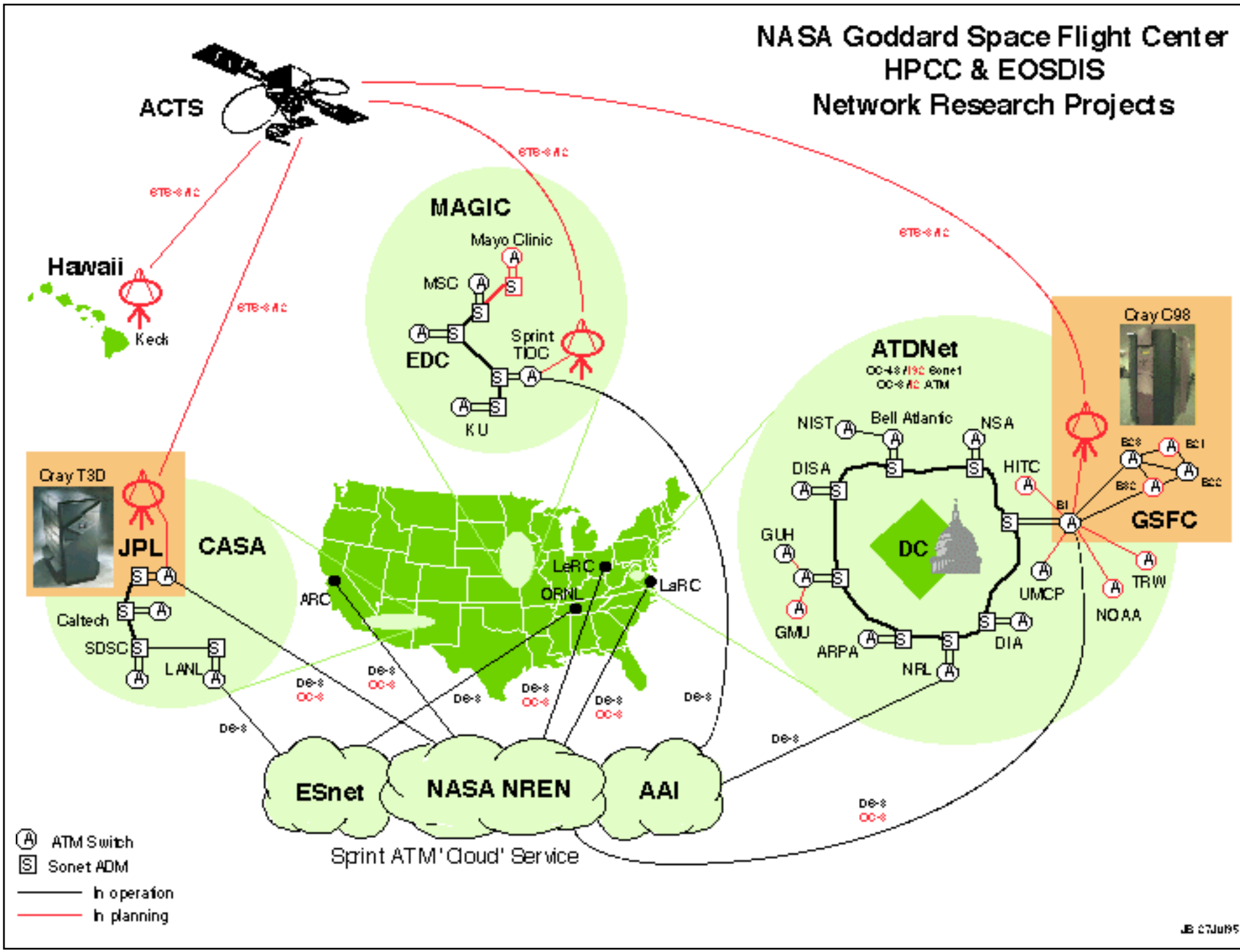
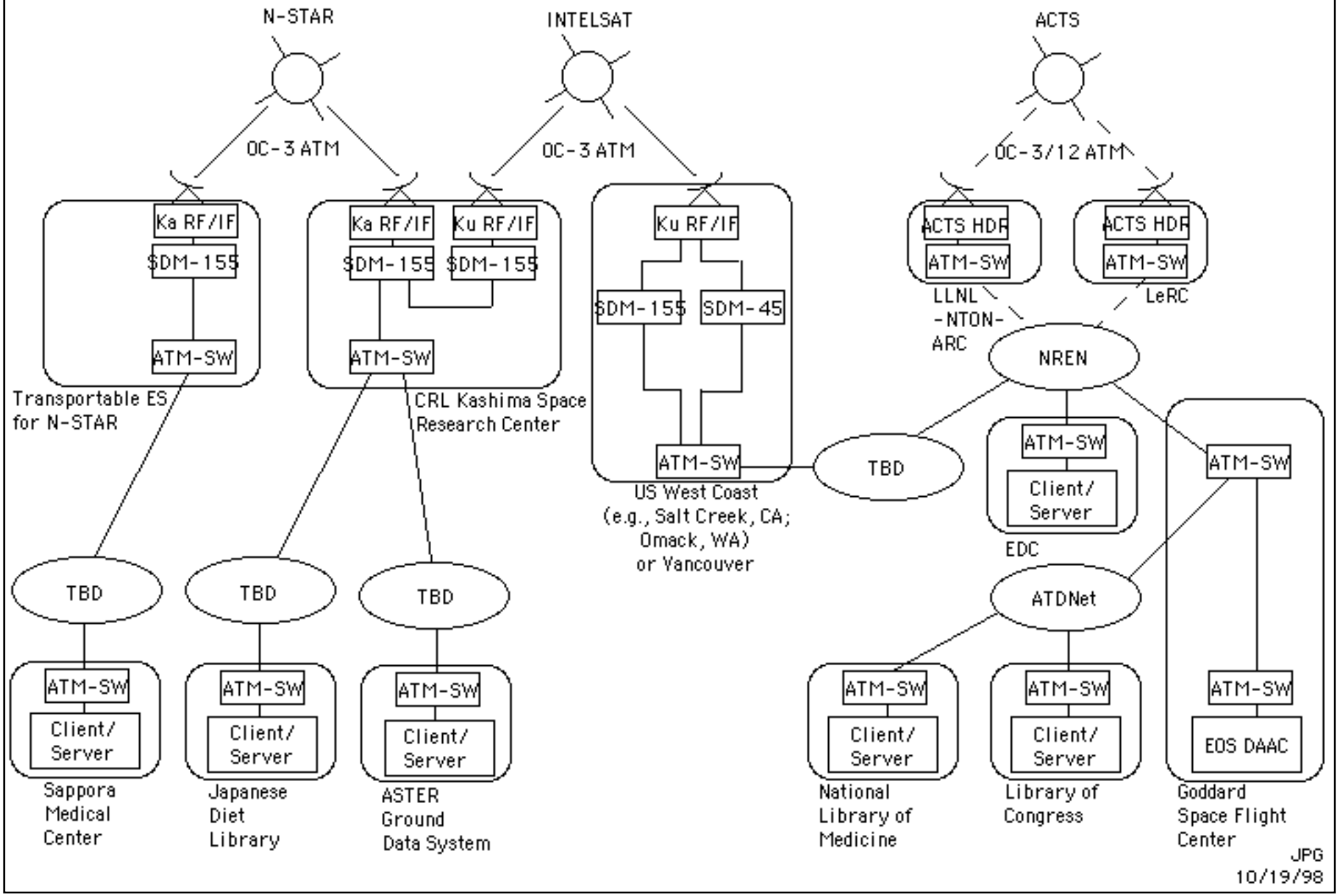

NASA Goddard Space Flight Center
HPCC & EOSDIS
Network Research Projects
ACTS
Hawaii
Keck
MAGIC
Mayo Clinic
MSC
EDC
Sprint TIDC
KU
Cray T3D
JPL
CASA
Caltech
SDSC
LANL
ARC
LeRC
ORNL
LaRC
ATDNet
NIST
Bell Atlantic
NSA
DISA
HITC
GLH
DC
GMU
ARPA
NRL
DIA
UMCP
NOAA
TRW
Cray C98
GSFC
ESnet
NASA NREN
AAI
Sprint ATM 'Cloud' Service
ATM Switch
Sonet ADM
In operation
In planning

Configuration of Networks for Trans-Pacific Digital Library Experiment

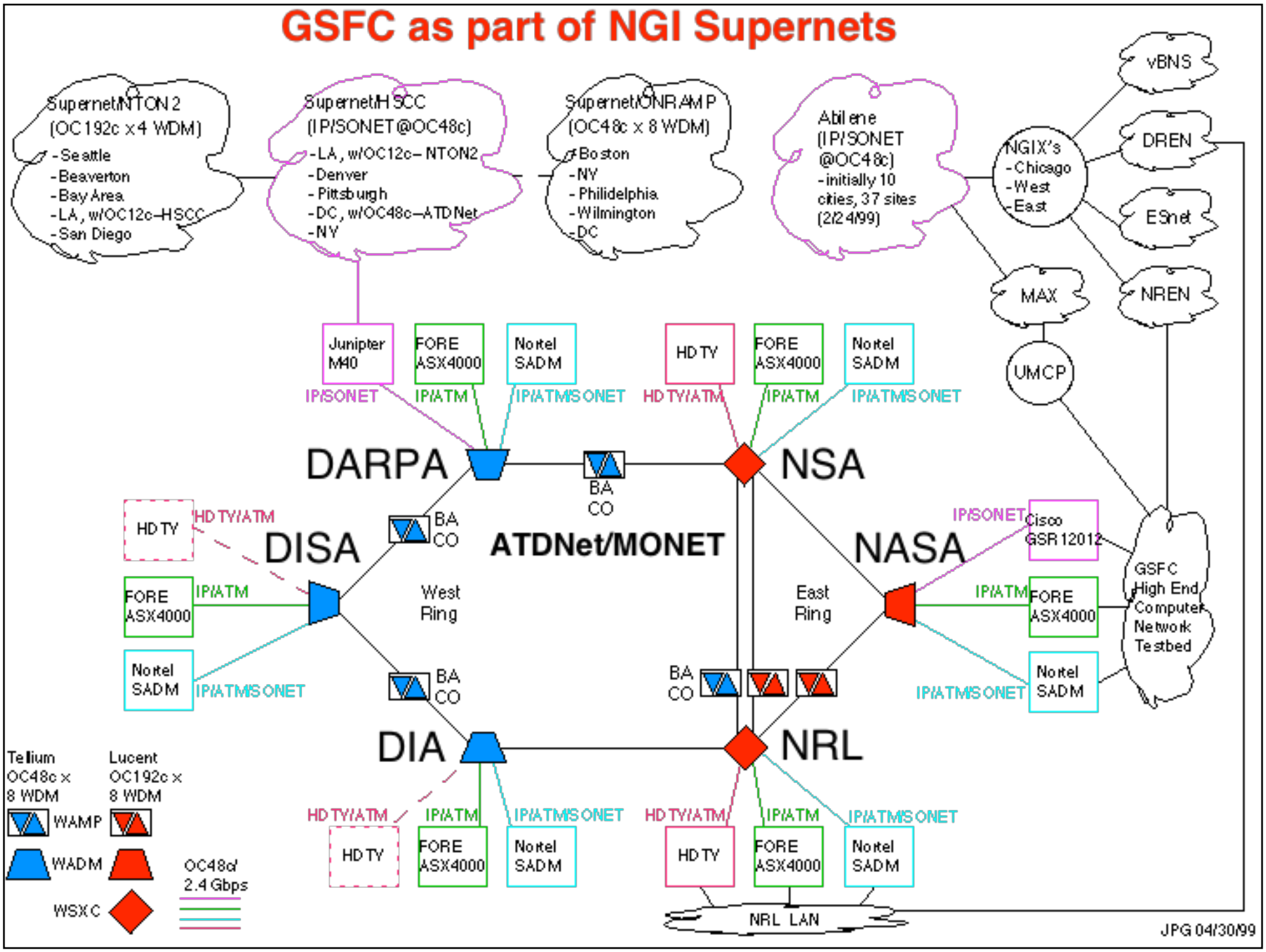


GSFC Benchmark Test Script & Key Findings in TPD

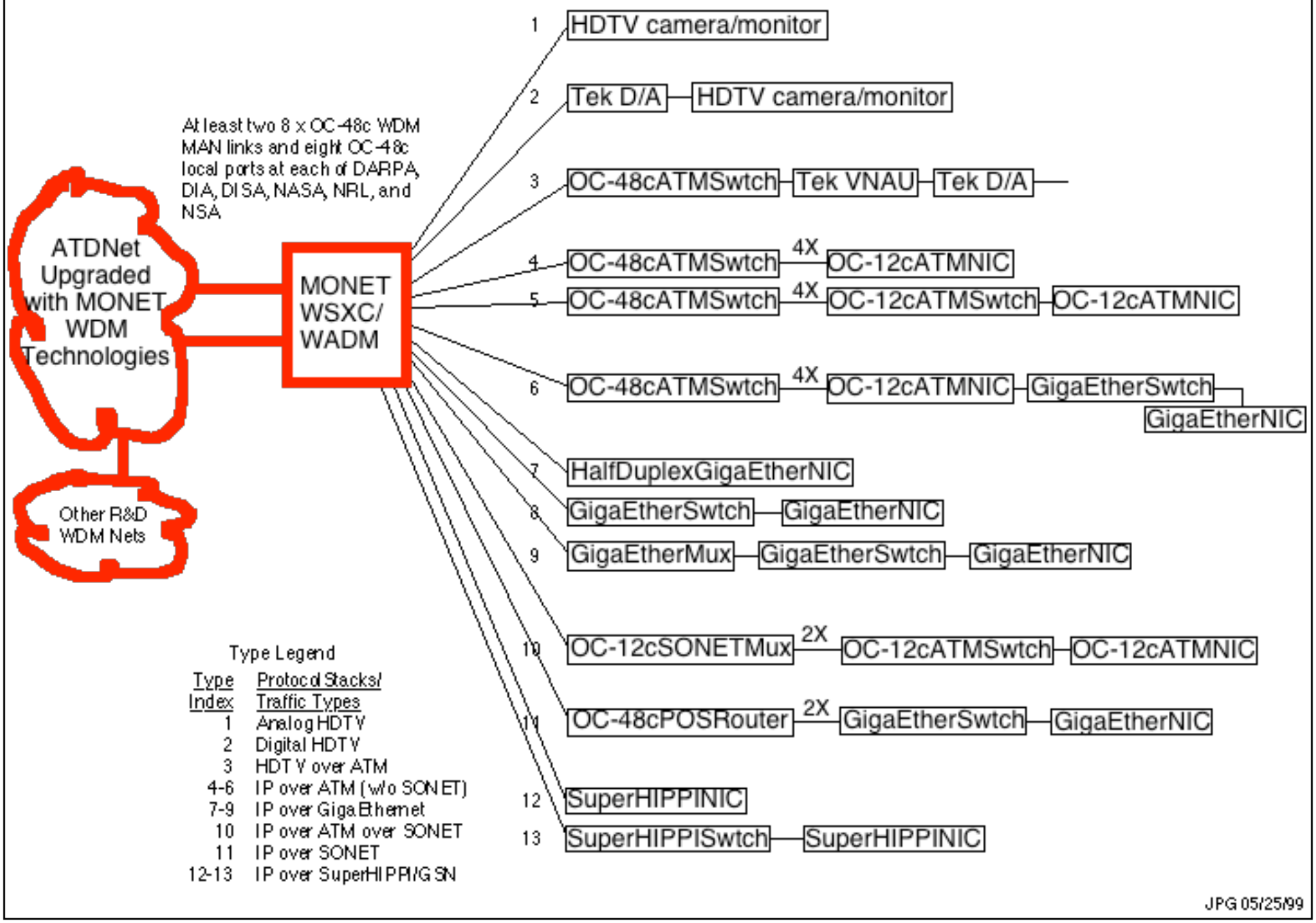
- Written to check and save information on the characteristics of the link prior to each Visible Human Viewer test run
- Test Script Checks
  - Roundtrip time (RTT) (using ping with small and large packet sizes)
  - Router hops (traceroute with small and large packets in both directions)
  - Transfer rates (ftp and nttcp of 7MB of data (size of largest image))

Path #	Path	Via	SkyX Proc	RTT(ms) 65B/1500B	#Hops -> <-	ftp(Mbps) 15KB/7MB	nttcp(Mbps) 7MB
1	SMU-GSFC	Intelsat	Yes	1124/1127	14/14	/15.2	11.9
2	SMU-NLM	Intelsat	Yes	1127/1130	16/16	10.9/15.2	11.9
3	SMU-NLM	Intelsat	No	1127/1130	16/16	.026/.224	0.225
4	SMU-GSFC	TransPAC	No	191/224	16/14	/.817	0.732

where Intelsat is the satellite path and TransPAC is the terrestrial path


GSFC as part of NGI Supernets
SupernetNTON2
(OC192c x4 WDM)
- Seattle
- Beaverton
- Bay Area
- LA, w/OC12c–HSCC
- San Diego
SupernetHSCC
(IP/SONET@OC48c)
- LA, w/OC12c– NTON2
- Denver
- Pittsburgh
- DC, w/OC48c–ATDNet
- NY
SupernetCONRAMP
(OC48c x 8 WDM)
- Boston
- NY
- Philidelphia
- Wilmington
- DC
Abilene
(IP/SONET
@OC48c)
- initially 10
cities, 37 sites
(2/24/99)
vBNS
DREN
ESnet
NREN
NGIX's
- Chicago
- West
- East
MAX
UMCP
Juniper
M40
FORE
ASX4000
Nortel
SADM
IP/SONET
IP/ATM
IP/ATM/SONET
HDTV
HDTV/ATM
DARPA
NSA
BA
CO
DISA
ATDNet/MONET
NASA
IP/SONET
Cisco
GSR 12012
GSFC
High End
Computer
Network
Testbed
West
Ring
East
Ring
DIA
NRL
NRL LAN
Tellium
OC48c x
8 WDM
Lucent
OC192c x
8 WDM
WAMP
WADM
WSXC
OC48c/
2.4 Gbps
JPG 04/30/99

Different Protocol Stacks/Traffic Types in ATDNet/MONET

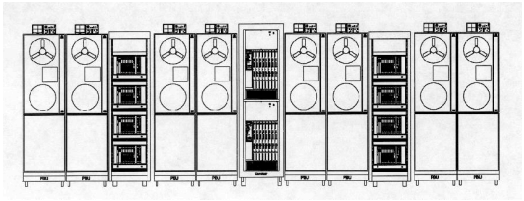


Schematic of Gbps e-VLBI Demonstration Experiment

Westford

~1.5 km

Mark 4
Correlator



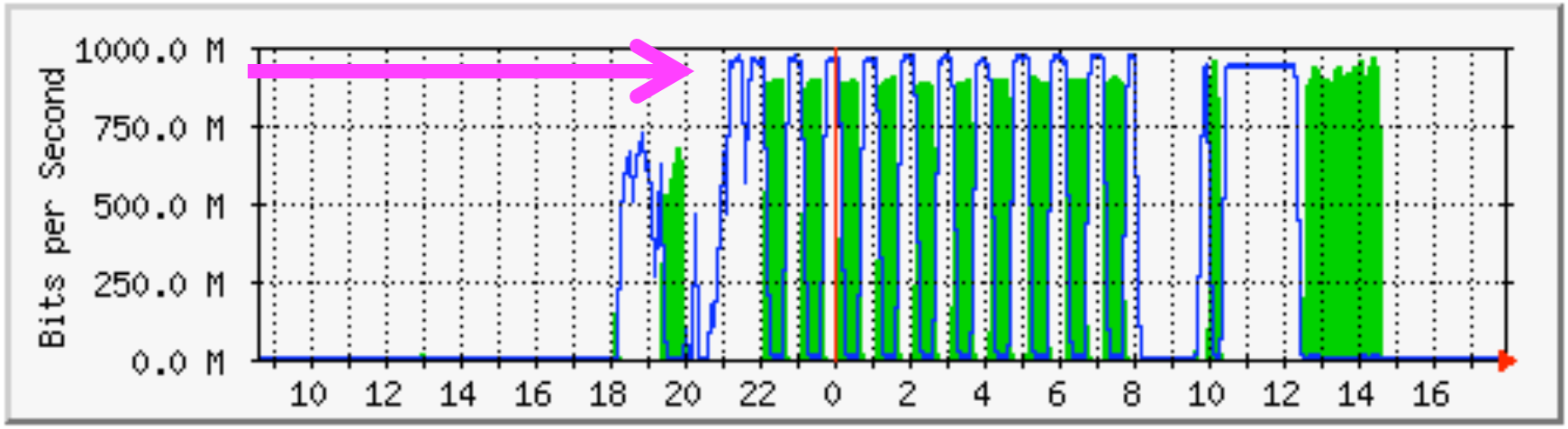
Haystack Observatory

~650 km

NASA/GSFC

Glownet, Bossnet, MAX, NASA/HECN network segments

e-VLBI GGAO-Haystack Data Rates Sustained During a 16-Hour-Long Evaluation Test



Max In:970.5 Mb/s (97.1%) Average In:210.8 Mb/s (21.1%) Current In:168.0 b/s (0.0%)
Max Out:978.1 Mb/s (97.8%) Average Out:263.6 Mb/s (26.4%) Current Out:216.0 b/s (0.0%)

Ethernet Jumbo Frame versus Standard Frame: Effect on Data Access Performance

(Tests Performed by GSFC's Bill Fink, 10/30/02)

- Test configuration
  - Data Server: Maximum Throughput Sledgehammer SH 200 network attached storage
  - Data Client: 867 MHz Macintosh G4
  - Access Protocol: NFS v3.0
  - Interconnection Network: Extreme Network Summit 51 Gigabit Ethernet switch (includes jumbo frame capability)
- Performance (MegaBytes per second) with jumbo frames (MTU=9000, NFS rsize=8192,wsize=8192)

<----------Transmit---------->			<---------- Receive---------->		
Min	Avg	Max	Min	Avg	Max
38.1592	38.4785	38.8381	36.0036	44.9774	52.7600

- Performance (MegaBytes per second) with standard frames (MTU=1500, NFS rsize=1024,wsize=1024)

<----------Transmit---------->			<---------- Receive---------->		
Min	Avg	Max	Min	Avg	Max
4.6198	4.6387	4.6593	4.6263	4.6392	4.6456

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Conclusion

- Inexpensive 1 and 10 Gbps GigE and WDM optical networking technologies can significantly enable Earth science applications
- But knowledgeable selection and use of those technologies can only be achieved through advanced network technology evaluations
- GSFC's HECN Project continues to be every successful at these advanced network technology evaluations

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Acknowledgments

- Jim Fischer (GSFC), ESTO/CT Project Manager
- Bill Fink (GSFC), developer of nuttcp and technical lead on most HECN advanced technology evaluations
- Rest of the present HECN Team: Herb Durbeck (GSFC), Kevin Kranacs (GSFC), Lee Foster (GSFC), Paul Lang (ADNET), Aruna Muppalla (ADNET), Wei-Li Liu (ADNET), and Chandu Rathod (ADNET)
- Former HECN Team members: Kalyan Kidambi, Marian Stagarescu, and Sanjiv Duggal (all then RITSS)
- Jeff Martz (CSC), wiring and network equipment installation super-expert

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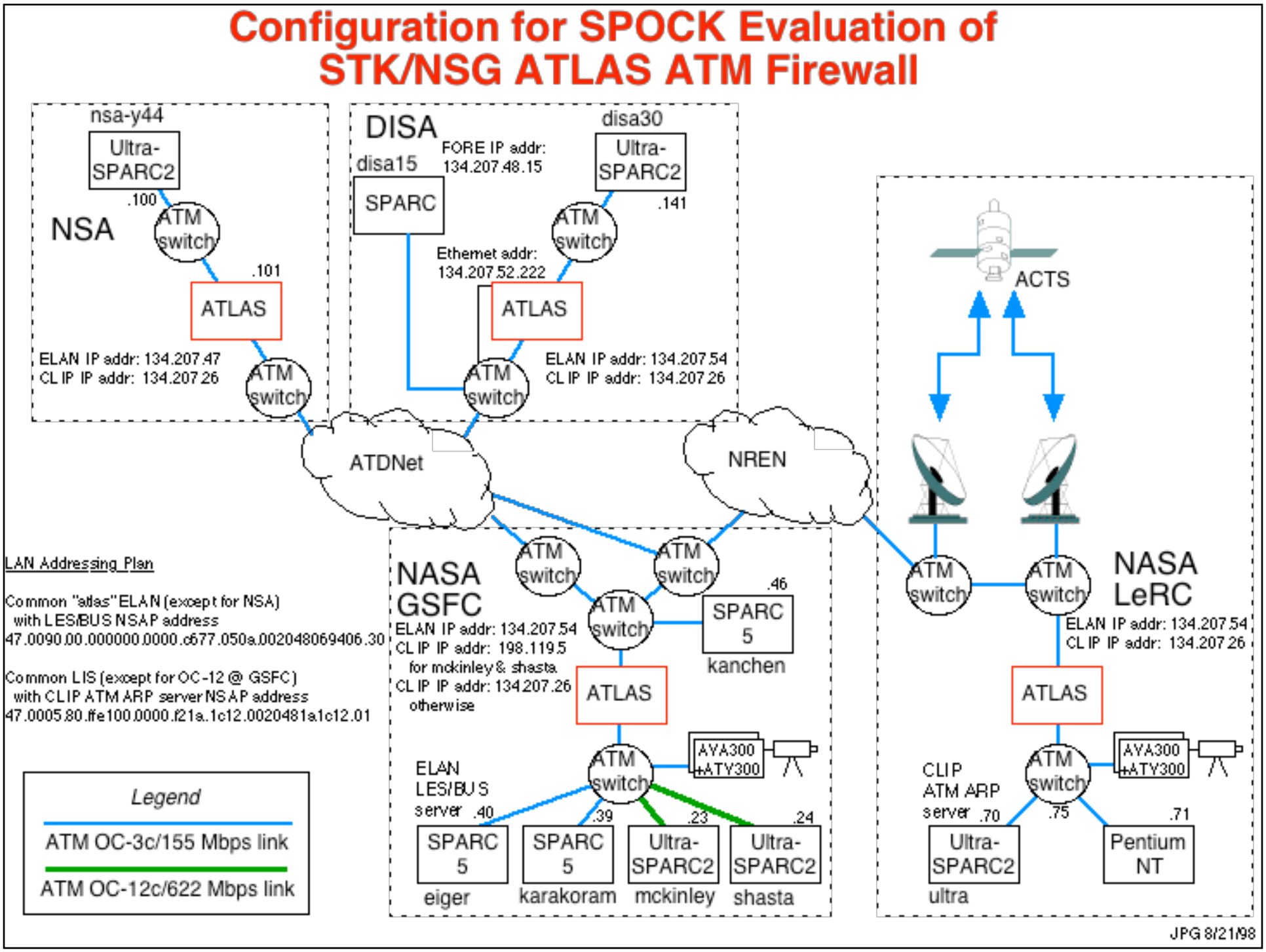
Backup Charts

Usage (transmitter): nuttcp -t [-options] host [<in]

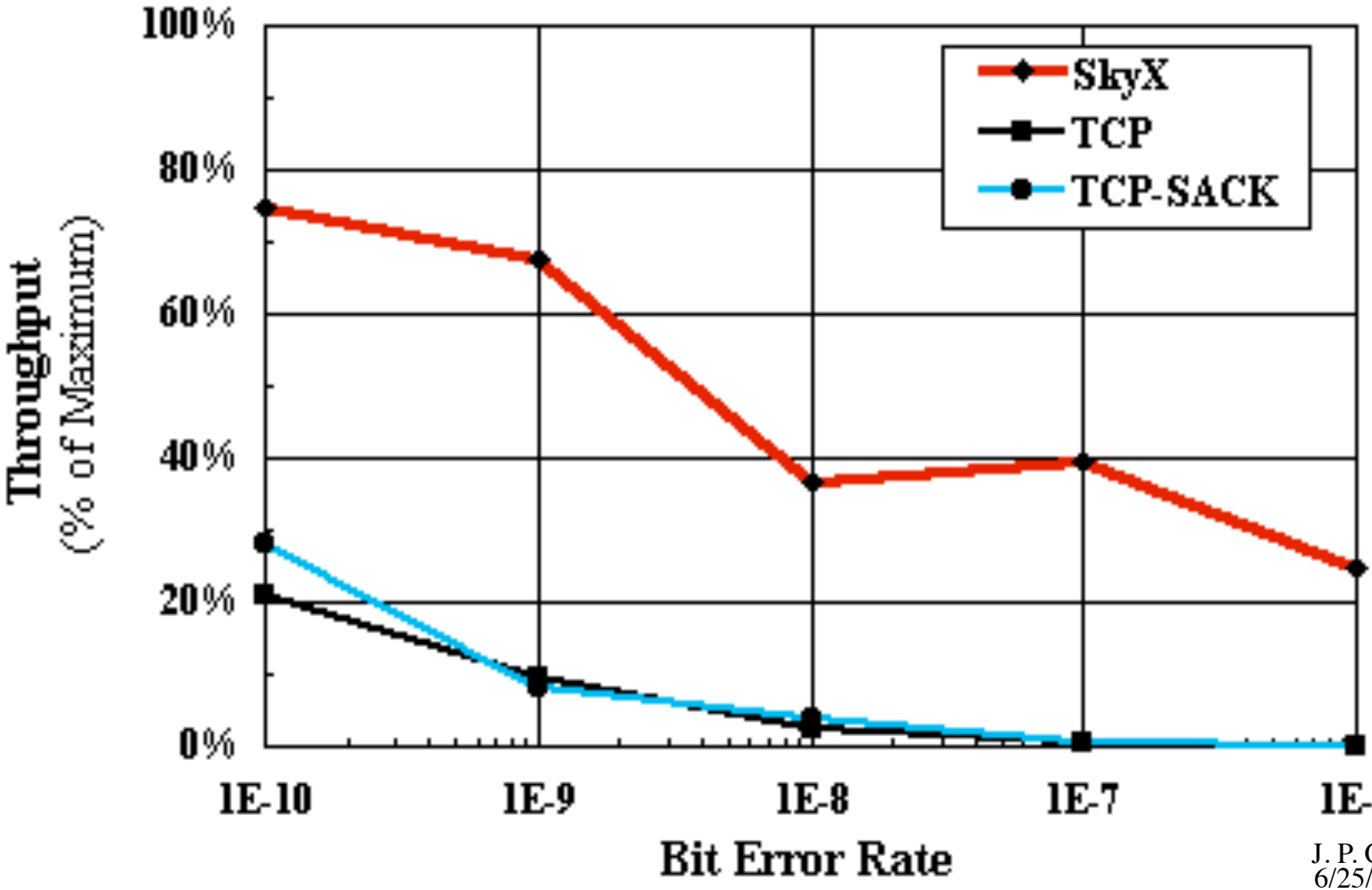
```
-l##    length of network write buf (default 8192/udp, 65536/tcp)
-s      don't source a pattern to network, use stdin
-n##    number of source bufs written to network (default 2048)
-w##    transmitter window size in KB
-ws##   server receive window size in KB
-wb     braindead Solaris 2.8 (sets both xmit and rcv windows)
-p##    port number to send to (default 5001)
-P##    port number for control connection (default 5000)
-u      use UDP instead of TCP
-D      don't buffer TCP writes (sets TCP_NODELAY socket option)
-N##    number of streams (starting at port number)
-R##    transmit rate limit in Kbps (or (m|M)bps or (g|G)bps)
-T##    transmit timeout interval in seconds (or (m|M)inutes)
-i##    server interval reporting in seconds (or (m|M)inutes)
-Ixxx   identifier for nuttcp output (max of 40 characters)
-F      flip option to reverse direction of data connection open
-xP##   set nuttcp process priority (must be root)
-d      set TCP SO_DEBUG option on data socket
-v      verbose output
-b      brief output
```

Configuration for SPOCK Evaluation of STK/NSG ATLAS ATM Firewall



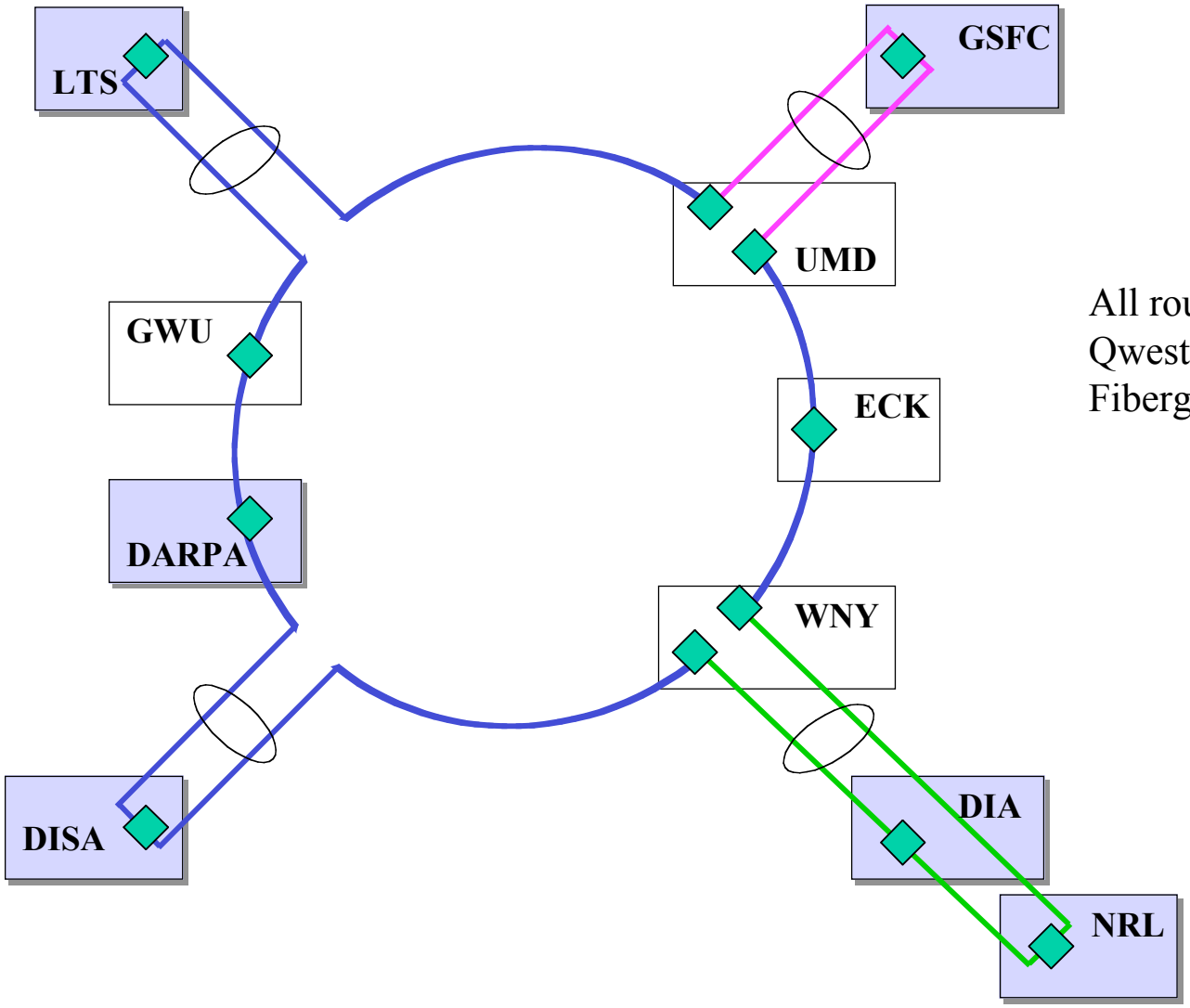
SkyX and TCP Throughput vs. BER

Satellite Conditions: RTT = 540 ms



ATDnet(V2) Ring Topology

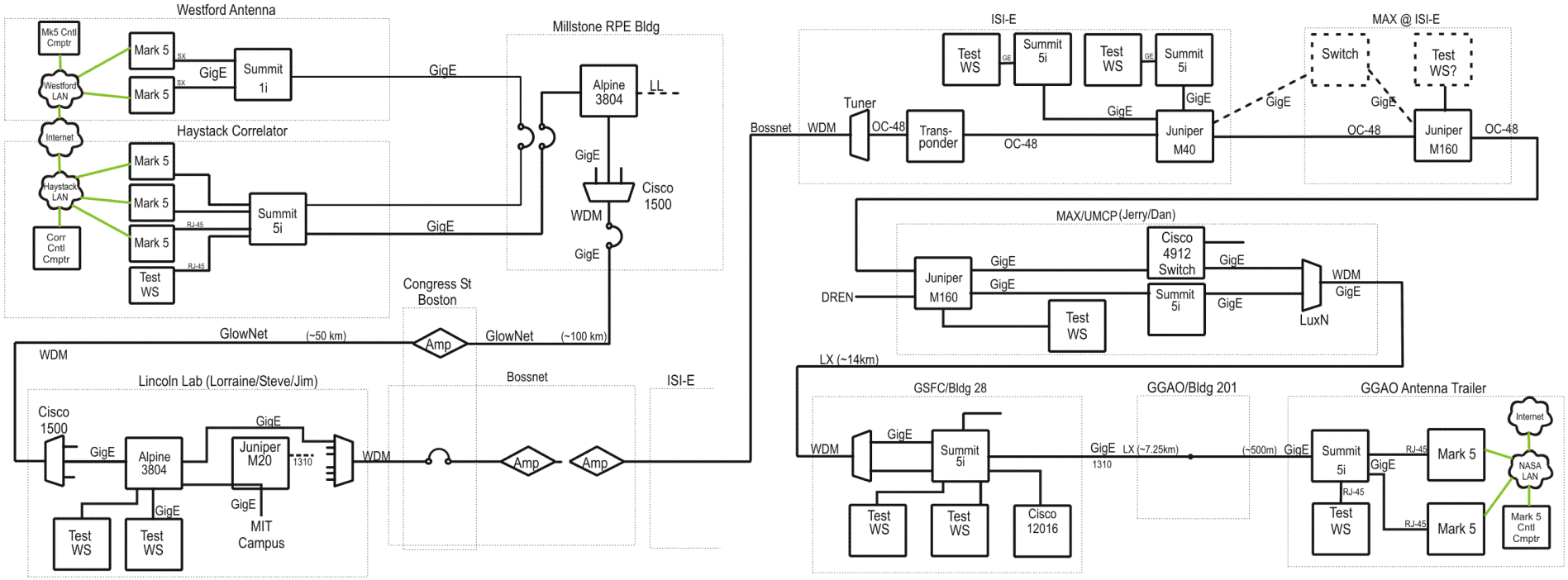
Basic configuration using Qwest to reach LTS



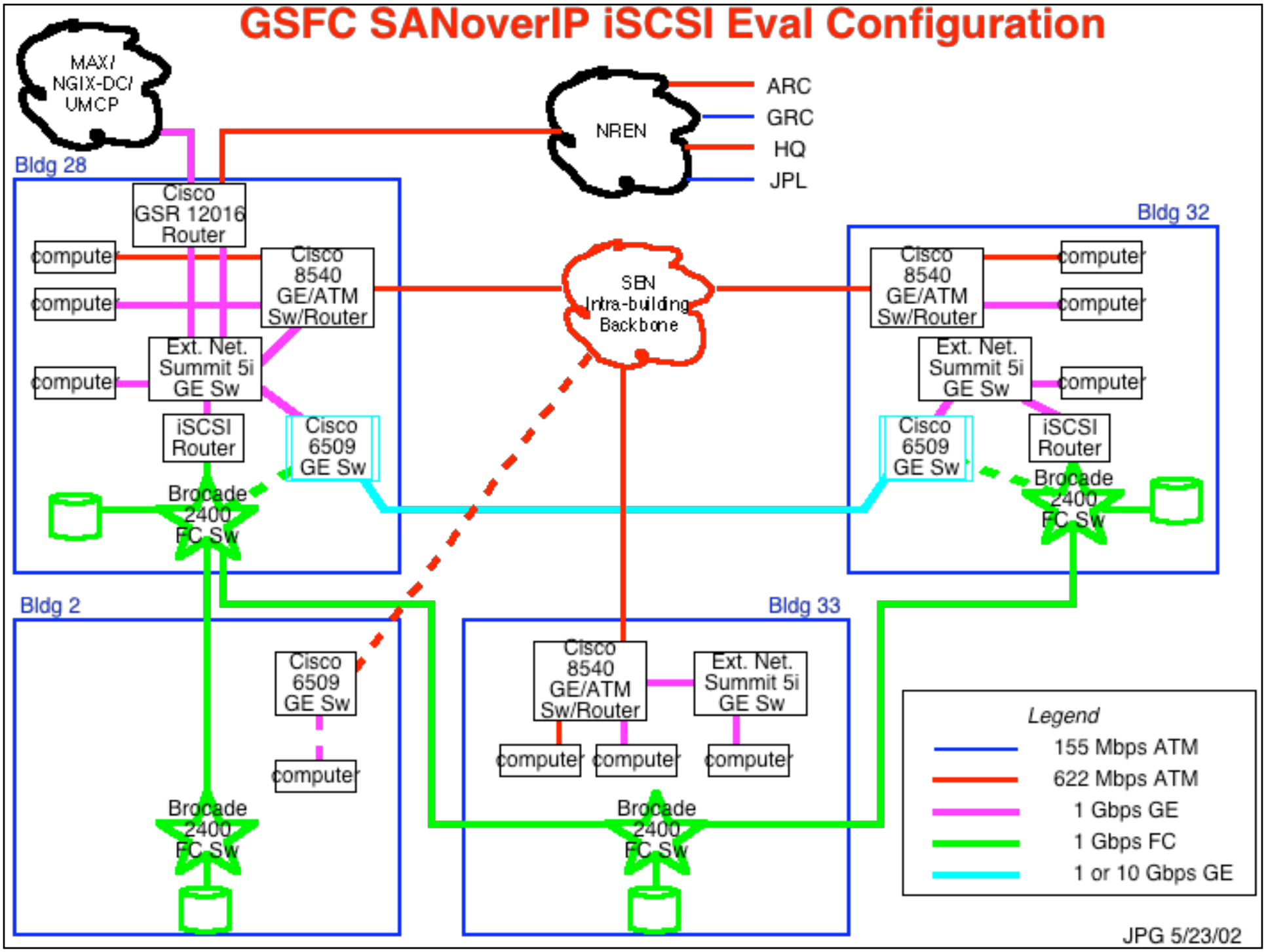
All routes are 2 strands fiber
Qwest routes are Lucent Truewave
Fibergate routes are SMF28

Fiber bundle
Cross-connect
Primary site
Ancillary site
Qwest fiber
Fibergate fiber
Govt supplied fiber

Details of the e-VLBI Network Path



For more info see ftp://web.haystack.edu/pub/e-vlbi/demo_report.pdf.


GSFC SANoverIP iSCSI Eval Configuration
MAX/
NGIX-DC/
UMCP
NREN
ARC
GRC
HQ
JPL
Bldg 28
Cisco
GSR 12016
Router
compute
compute
Cisco
8540
GE/ATM
Sw/Router
compute
Ext. Net.
Summit 5i
GE Sw
iSCSI
Router
Cisco
6509
GE Sw
Brocade
2400
FC Sw
SBN
Intra-building
Backbone
Bldg 32
Cisco
8540
GE/ATM
Sw/Router
compute
compute
Ext. Net.
Summit 5i
GE Sw
compute
Cisco
6509
GE Sw
iSCSI
Router
Brocade
2400
FC Sw
Bldg 2
Cisco
6509
GE Sw
compute
Brocade
2400
FC Sw
Bldg 33
Cisco
8540
GE/ATM
Sw/Router
Ext. Net.
Summit 5i
GE Sw
compute
compute
compute
Brocade
2400
FC Sw
Legend
155 Mbps ATM
622 Mbps ATM
1 Gbps GE
1 Gbps FC
1 or 10 Gbps GE
JPG 5/23/02