Global Ring Network for Advanced Applications Development

NSF IRNC Meeting, March 11, 2005

Greg Cole, Research Director, UT-ORNL Joint Institute for Computational Sciences (PI)

Natasha Bulashova, Research Scientist, UT-ORNL Joint Institute for Computational Sciences (Co-PI)

NSF IRNC Cooperative Agreement University of Tennessee \$4.2M/5 years Began January 1, 2005

Animation by Chinese Academy of Sciences Computer Network Information Center



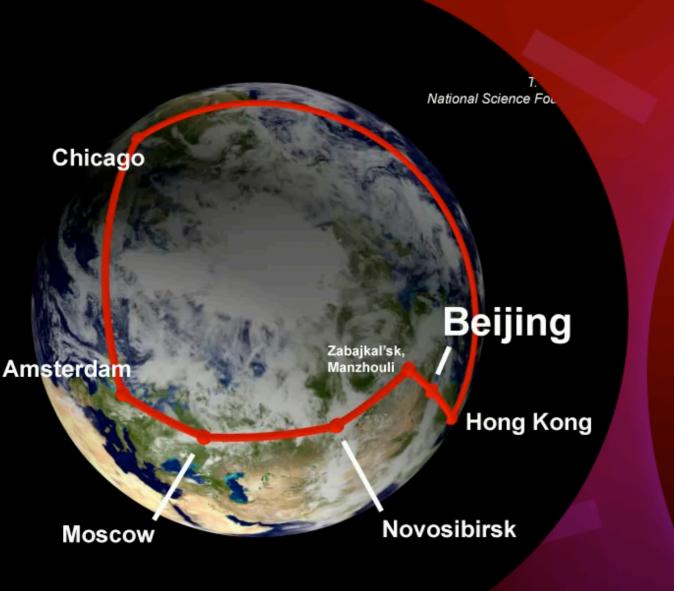
http://www.gloriad.org/

CUCD | Telecommunications

Presentation



GLORIAD



An Advanced network "ring" around the northern hemisphere linking Russia, US, China, Korea, Netherlands, Canada and others

155/622 Mbps today, 1 Gbps in two months, 10 Gbps in early 2006, Nx10G in 2008

Hybrid circuit-(L1/L2) and packet-switched service (L3)

Program to Develop/Deploy Advanced Cyberinfrastructure between partnering countries (and others) as effort to expand science collaboration

Follow-on to NSF-/Russian MinSci-Funded MIRnet and NaukaNet programs (1998-2004)

Why?

SEVILLE

CHICAGO

Leverage jointly developed/ funded/operated S&E network to expand S&E cooperation between partnering countries (with initial emphasis on US-Russia-China)

To support specific S&E applications not supported by commodity networks

To enable scientists to build their own specialized networks and for short durations of time

To provide a test-bed for advanced network research

Why?

NOVOSIBIRSK

*As part of the international community of science, we share common concerns that reach across national borders. As we all aim to strengthen our nations' capabilities in research, we also aim to contribute to the cumulative knowledge that lifts the prospects of people everywhere.

This new network serves as both a physical and symbolic reminder of our common goal of solving problems and building a world of peace and prosperity."

Dec. 21, 2003, NSF Press Release



Rita Colwell, former NSF Director, Dec. 2003 press release

KHABAROVSK

BEIJING

HONG KONG 🧲

GLORIAD First Steps Began With US-Russia Internet Traffic Exchange in December, 1993 (US-China followed shortly afterwards)

From: goldstein@nsf.gov To: mak@merit.edu

Cc: steve@cise.cise.nsf.gov, nacr@icm1.icp.net, "Dr. Alexei P. PLATONOV,Director,ROSNIIROS" <plat@kiae.su>, Spartak Belyaev <bst@bstw.kiae.su>, "Dr. Viacheslav Shkarupin" <slava@prs.isf.kiev.ua>, ncc@ripe.net, ccirn@csa1.lbl.gov, RICHARD KC HSIEH <HSIEH@lhc.nlm.nih.gov>, Andrej Mendkovich <KEL2BS@vms2.uni-c.dk>, IETF@CNRI.Reston.VA.US Subject: Routing of FSU traffic on NSFNET Backbone Service, please begin Reply-To: goldstein@nsf.gov Date: Thu, 02 Dec 93 15:26:35 -0500 X-Orig-Sender: sgoldste@nsf.gov

Dear Mark,

Following consideration of the issues by, and and instructions received from the National Science Board, NSF asks that traffic from the countries of the former Soviet Union which satisfies the NSFNET Backbone Appropriate Use Policy guidelines be routed by the NSFNET Backbone Service, effective as (reasonably) soon as Merit can implement the changes.

Thank you,

Steve Goldstein (for Steve Wolff) || Program Director, Interagency & International Networking Coordination || || Div. of Networking and Communications Research & Infrastructure || || National Science Foundation ||



Steve Goldstein

1996: Local Networking



1998: Int'l Networking



1994: Community Building



When/How?



1994: US-Russia Communitynetworking effort called "Friends & Partners" begins

1996: US-Russia "Civic Networking" begins (focus on local infrastructure)

1998: US-Russia "MIRnet/ NaukaNet" begins (high performance international)

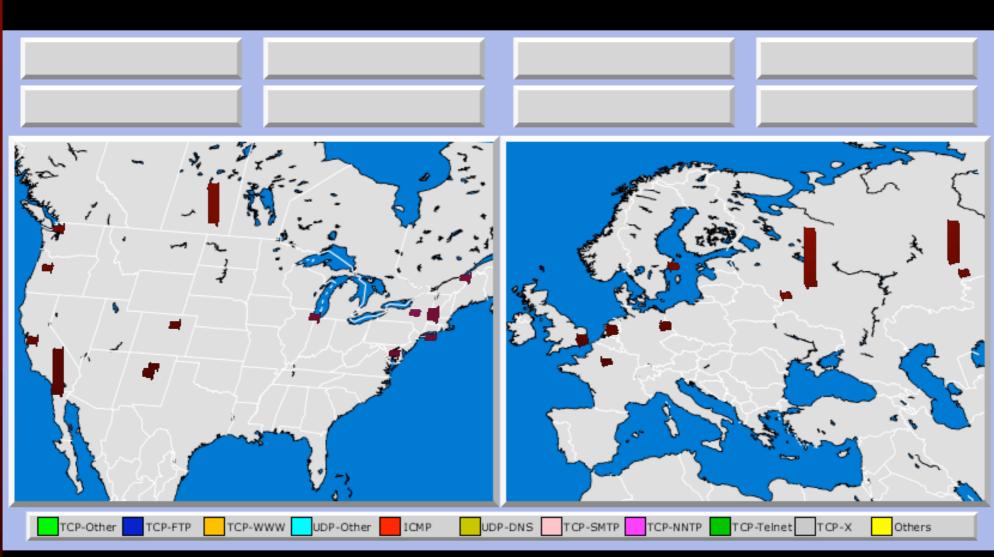
2002: Work begins on **GLORIAD**

2004: "Little GLORIAD" launched

2005: January 1 - GLORIAD begins

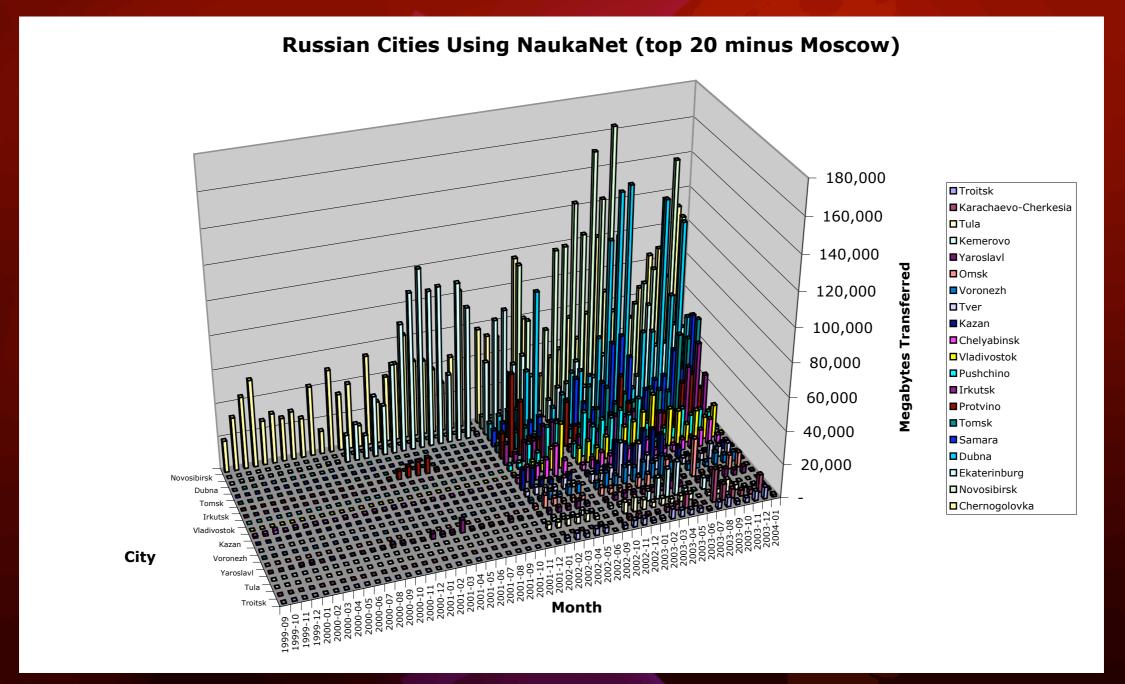
GLORIAD HISTORY

Began as the US-Russia 6 Mbps MIRnet Program in 1998, Limited Primarily to Moscow/region



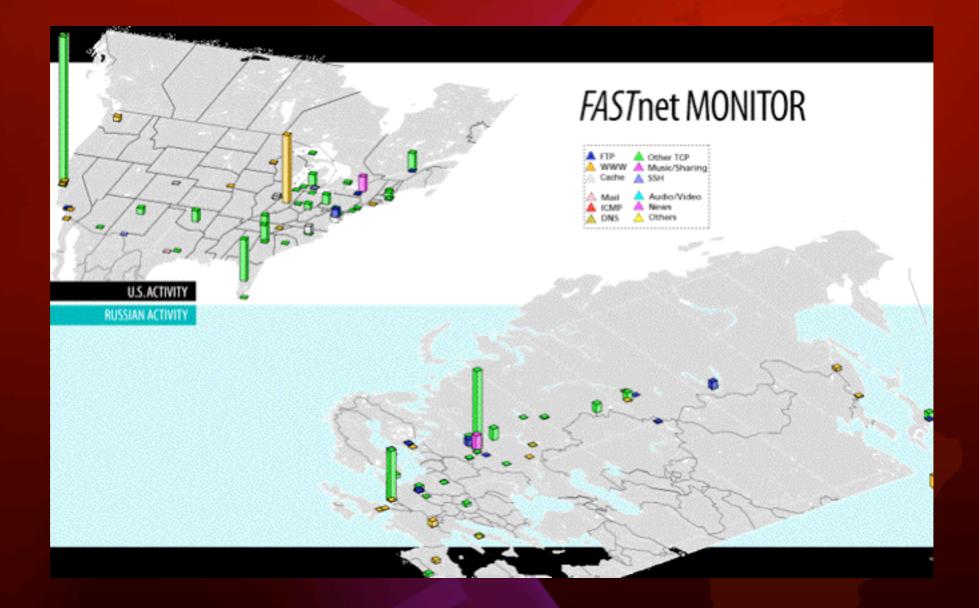
2001-01-24 05:09 (GMT)

GLORIAD HISTORY MIRnet served limited community in Russia; in December 2001, Expanded across Russia



GLORIAD HISTORY

Transitioned to the US-Russia 45 Mbps FastNet Program in Dec. 2001, and then the 155 Mbps NaukaNet in 2002



GLORIAD First Steps



Work began in early 2002 after Moscow visit

First Meeting with Chinese Partners in December 2002 (initial agreement signed between US-Russia-China)

Launched "Little GLORIAD" (155 Mbps ring around the earth) in January, 2004

Proposal to US NSF in June, 2004 (funded in December, 2004)

Presentation

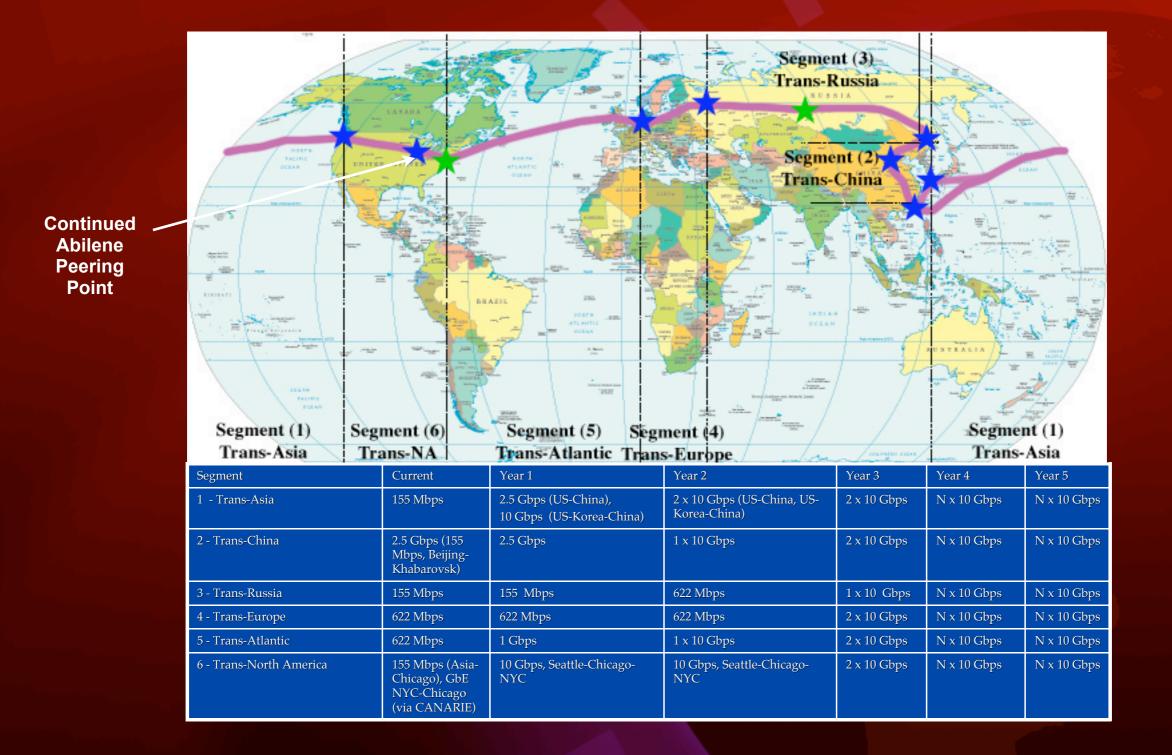


GLORIAD TODAY

unking US, Russian, and Chinese Science with High-Performance Network Service 155/622 Mbps Ring Around Northern Hemisphere
622 Mbps Moscow-AMS-NYC
622 Mbps Moscow-AMS-NYC
1 GbE NYC-Chicago (CANARIE)
155 Mbps Chicago-Hong Kong
2.5 Gbps Hong Kong-Beijing
155 Mbps Beijing-Khabarovsk-Moscow

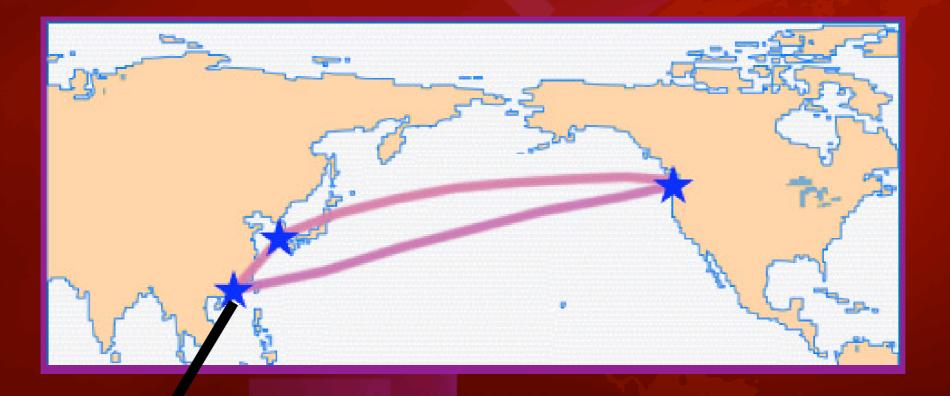
This year: 2.5 Gbps US-China link, 10 Gbps US-Korea-China link in July, 10 Gbps US-AMS and US-China circuits in January, 2006

The GLORIAD Network Topology Current, Years 1-5



Trans-Pacific Portion (Segment 1)

(illustrating Hong-Kong—Seattle and Hong-Kong—Pusan—Seattle paths)



Hong Kong Light (HKLight) Open Exchange Point Other exchange points include Starlight (Chicago), Pacific Wave (Seattle), Netherlight (Amsterdam), RussiaLight (Moscow)

Architecture Motivation

General S&E Applications – needs met by "best effort" routed infrastructure (but minimize congestion/packet loss)

Specialized Applications requiring high capacity, low-latency and/or controlled jitter (i.e., dedicated end-to-end circuits)



Network research/experimentation testbed



Backup/protection services for partnering S&E networks

Network Design

Using optical termination devices (i.e., Ciena CoreDirector, Cisco ONS 15454, etc.) and switches, provide layer-one infrastructure

Enable user community (and applications) to dynamically provision their own circuits across the core (and end-to-end where possible)

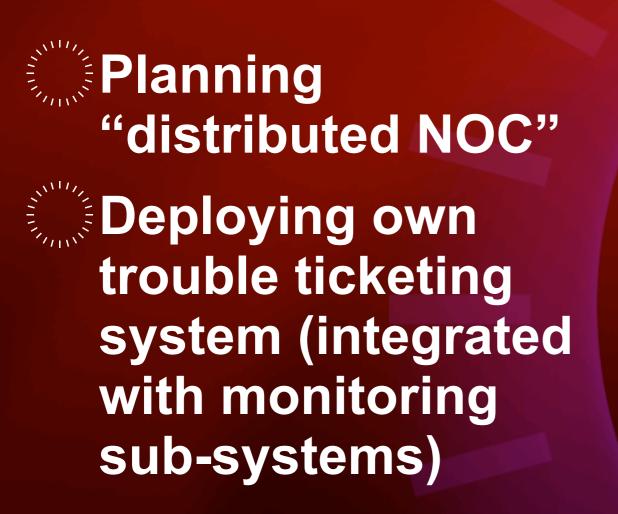


Use N x GbE for layer-3 routed infrastructure



Big emphasis on monitoring: (1) utilization, (2) performance, (3) security

Network Operations



000	Tickets Database System								
A A C + C	http://www	w.friends-partners.org/bugs	/tickets/index.htr	nl	Q , Goog	le	\supset		
☐ Address Book ▼ Moscow	TV F&P	GLORIAD Weather Work v	News v Food v	Diet ▼ MapQuest	Finance	▼ Apple Stuff ▼	>>>		
Tickets Database System									
			Т	ickets Da	taba	•			
huge				Gillespie-Norder,		<u>B</u> 2000-04-07	UGS		
ULE S	<u>008135</u>	Louise McKay : General I	nformation	Marcia A.	Closed	10:41:52 AM			
	008133	Keith Pilcher : OTHER		Gillespie-Norder, Marcia A.	Closed	2000-04-07 10:39:43 AM			
Edit Menu Add	008132	Bob Massengill : OTHER		Gillespie-Norder, Marcia A.	Closed	2000-04-07 10:14:33 AM			
(optional username)	<u>008170</u>	arevels : E-mail Client Co	nfiguration	Cross, Adam	Closed	2000-04-07 10:00:07 PM			
Delete	008169	Connie Gillespie : AIM Pr	roblem	Cunningham, Michael TANK	Closed	2000-04-07 09:48:58 PM			
List Menu	008167	Paulette Hammond : OTH	ER	Cunningham, Michael TANK	Closed	2000-04-07 08:50:12 PM			
List Records Status	008166	kend : User Cancel		Cross, Adam	Closed	2000-04-07 08:15:56 PM			
Priority Review	008164	kend : User Signup		Cross, Adam	Closed	2000-04-07 07:43:10 PM			
Staff	008163	Gary Marks : OTHER		Cunningham, Michael TANK	Closed	2000-04-07 07:26:21 PM			
Ticket Type	008160	Kieth Pilcher : Cannot Co	nnect at all	Cunningham, Michael TANK	Closed	2000-04-07 06:44:37 PM			
Client ID	008159	Dorothy Hayes : User Sig	nup	Cunningham, Michael TANK	Closed	2000-04-07 06:15:03 PM			
Ticket Title		Ron Nolcken : E-mail Clie Configuration	ent	Gillespie-Norder, Marcia A.	Closed	2000-04-07 03:57:37 PM			
Create Time	008156	Ed Nicholson : Internet Ex	xplorer Setup	Gillespie-Norder, Marcia A.	Closed	2000-04-07 03:48:55 PM			
Full Text	008154	Walt Bigney : Cannot Cor	nnect at all	Gillespie-Norder, Marcia A.	Closed	2000-04-07 03:14:04 PM			
Client Username	008153	gmarks : OTHER		Gillespie-Norder, Marcia A.	Closed	2000-04-07 03:11:10 PM			
Telephone	008152	Octavia Mallory : User Sig	gnup	Gillespie-Norder, Marcia A.	Closed	2000-04-07 03:05:29 PM	4		
				Cillernie Menden		2000 04 07			

Working Groups / Governance

Working Groups **Dealing with: Networking Issues** Monitoring/Security Issues **Science Disciplines** Project Management

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A A C + A http://www.gloriad.org/mailman/admin O ^ Q- Google					
Address Book * Moscow TV F&P GLORIAD Weather	Work▼ News▼	Food T Diet	MapQuest	»	
www.gloriad.org mailing li					

www.gloriad.org mailing lists - Admin Links

Welcome!

Below is the collection of publicly-advertised <u>Mailman</u> mailing lists on www.gloriad.org. Click on a list name to visit the configuration pages for that list.To visit the administrators configuration page for an unadvertised list, open a URL similar to this one, but with a '/' and the list name appended. If you have the proper authority, you can also <u>create a new mailing list</u>.

General list information can be found at the mailing list overview page.

(Send questions and comments to mailman@gloriad.org.)

List Description

	•
Engineering	GLORIAD Engineering List
glo-amp	GLORIAD Active Measurement Working Group
<u>glo-ast</u>	GLORIAD Astronomical Sciences Working Group
glo-atm	GLORIAD Atmospheric Sciences Working Group
<u>glo-ca</u>	GLORIAD Central Asia Working Group
glo-cls	GLORIAD Classroom Working Group
glo-com	GLORIAD Computational Sciences Working Group
glo-eng	GLORIAD Engineering List
<u>glo-exe</u>	GLORIAD Executive Board Listserver
<u>glo-hep</u>	GLORIAD High Energy Physics Working Group
<u>glo-htv</u>	GLORIAD High Definition Stream TV Working Group
<u>glo-itr</u>	GLORIAD ITER/Fusion Energy Working Group
glo-med	GLORIAD Medical/Health Sciences Working Group
glo-mon	GLORIAD General Monitoring Activity Working Group
<u>glo-nnp</u>	GLORIAD Nuclear Non-Proliferation Working Group
glo-noc	GLORIAD Network Operations Center List
<u>glo-pr</u>	GLORIAD Public Relations Working Group
glo-sec	GLORIAD Security Working Group Listserver
<u> </u>	

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Presentation



Who in Russia?



Acad. Evgeny Velikhov, President, Kurchatov Institute, Academician-Secretary, Russian Academy of Sciences

Ministry of Science & Education, Agency of Communications, Agency of Atomic Energy, Moscow State University, Joint Supercomputing Center

Russian Backbone Network (RBNet)

Who in China?

URUMCHE		SHOLAZHUANG
	X	LAN BELJ
	LANZHOU	TATYUAN
	XINING	Including
	CHENGDU	HEF
	ν. γ	VUHAN
	~ /	CHANGSHA
	/	GUTYANG
	б кылм	

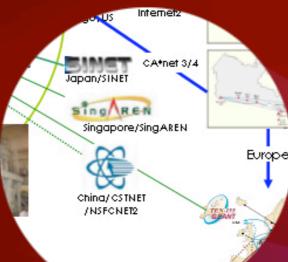
Dr. Mianheng Jiang, Vice
 President, Chinese Academy of
 Sciences, Telecomm/IT Developer
 (signatory of first GLORIAD
 agreement)

Dr. Baoping Yan, Director, Computer Network Information Center (CNIC), Chinese Academy of Sciences

China Science & Technology Network (CSTnet)



Who in Korea?





Dr. Young-Hwa Cho, Director, Korea Institute of Science and Technology Information (KISTI)

Dr. Jysoo Lee, Director, Supercomputing Center, KISTI

Dr. Ok-Hwan Byeon, KREONet2, KISTI

Korea Research Education Network (KREONet)

Who in Europe?



Kees Neggers, Executive Director, SURFnet, Amsterdam, The Netherlands

Erik-Jan Bos, Chief Network Engineer, SURFnet, Amsterdam, The Netherlands

SURFnet, Netherlight Network

Who in Canada?



 Bill St. Arnaud, Senior Director, Advanced Networks, CANARIE
 Rene' Hatem, Thomas Tam, Chief network engineers, CANARIE
 CANARIE

Who in USA

Greg Cole and Natasha Bulashova, Research Director/Research Scientist, UT-ORNL Joint Institute for Computational Sciences, PI/Co-PI, NSF GLORIAD Agreement

Anita Colliate Howard (Research Assoc.), John Lankford (Network Architect/Engineer), Lyn Prowse-Bishop (Exec. Asst), 2 REU students (coming), Ana Preston, Predrag

Sponsor: National Science Foundation (~\$9.5M since 1998), Other sponsors of US-Russia work: NATO, Sun Microsystems, US State Department, Ford Foundation, Eurasia Foundation, US AID

Many other partners: Harvey Newman (Chief Scientist) (~ 40 other scientists/ educators/others on advisory board), Starlight, Pacific Wave, others

Networks: National Lambda Rail, ESnet, NASA R&E Networks, Internet2/Abilene (peering), Federal Networks, etc.

Oak Ridge National Laboratory

Who Ties it Together?



Tyco Global Networks: Trans-Atlantic and Trans-Pacific Provider; is both important service provider and research partner since the beginning of GLORIAD

Russia: RosTelecomm China: China Netcom North America: CANARIE

Presentation



Monitoring Program

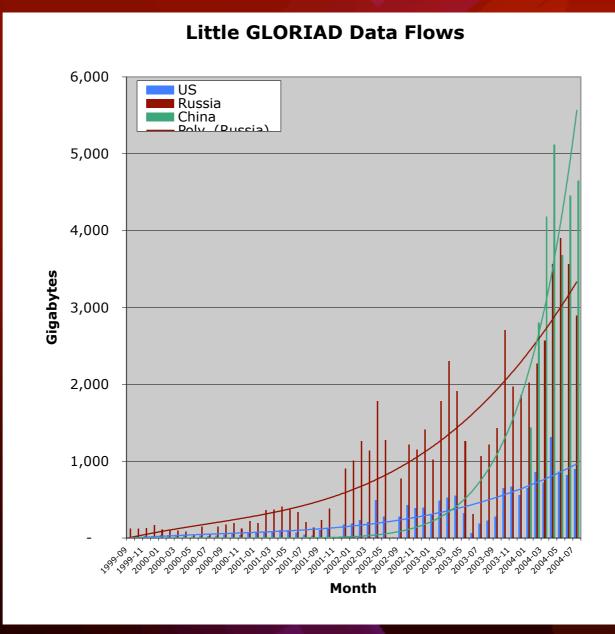
Utilization Monitoring (netflowbased, circuit up-time, utilization, institutional and application reporting)



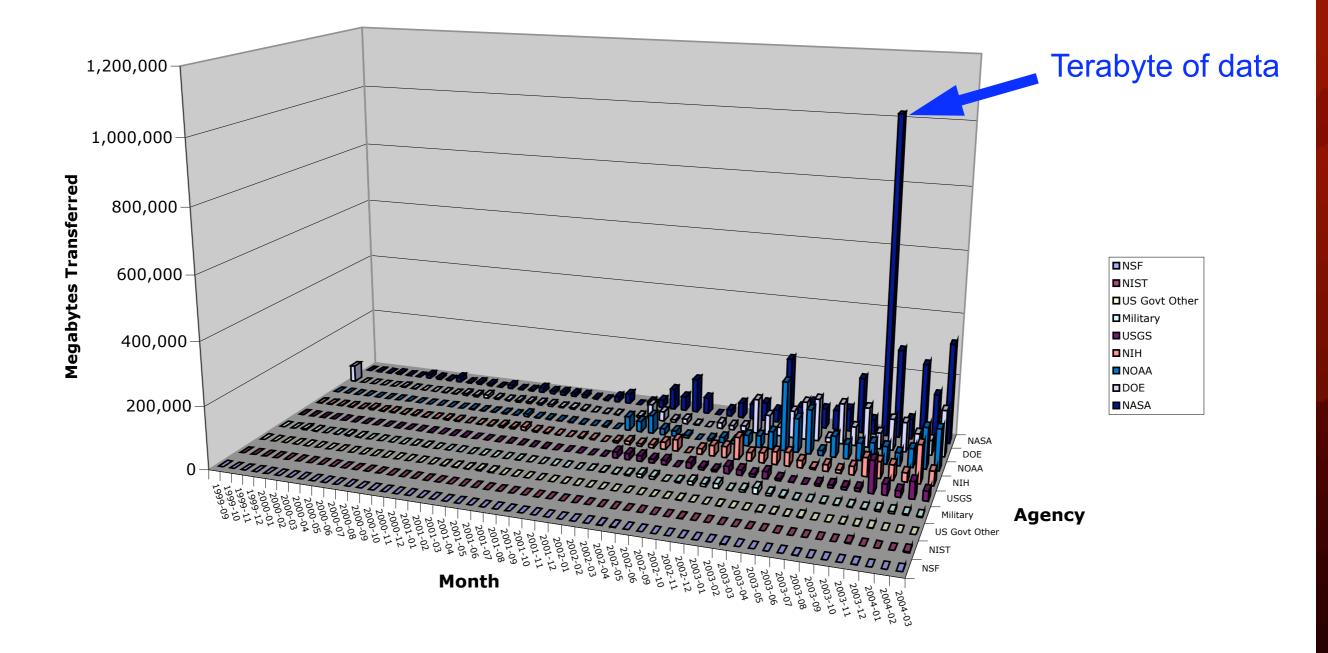
Performance Monitoring (Intl AMP Mesh w/NLANR)



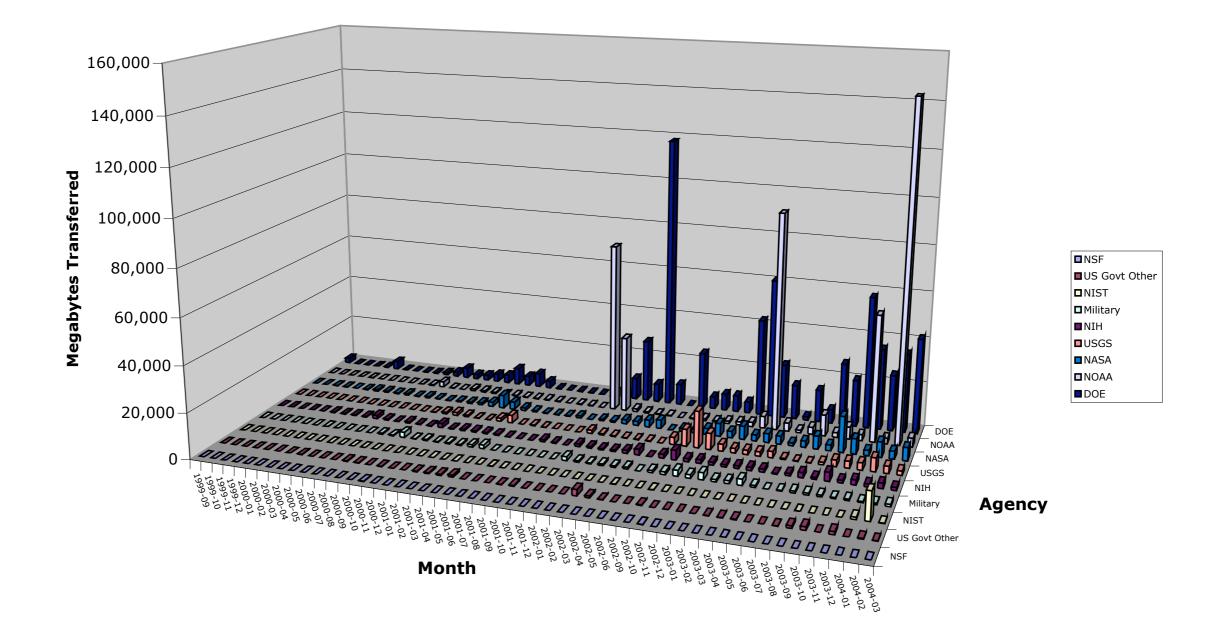
Overall Traffic Growth

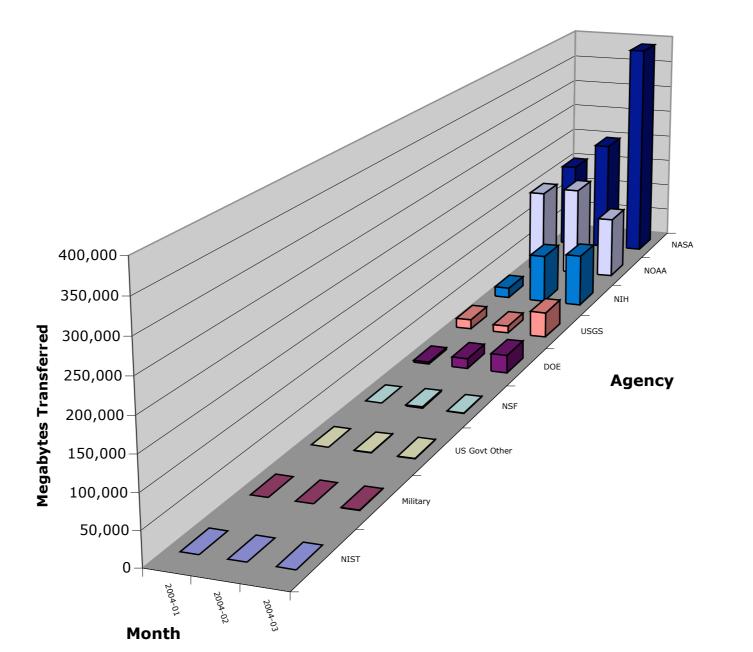


Top US Govt Agencies Supplying Data to Russia via GLORIAD



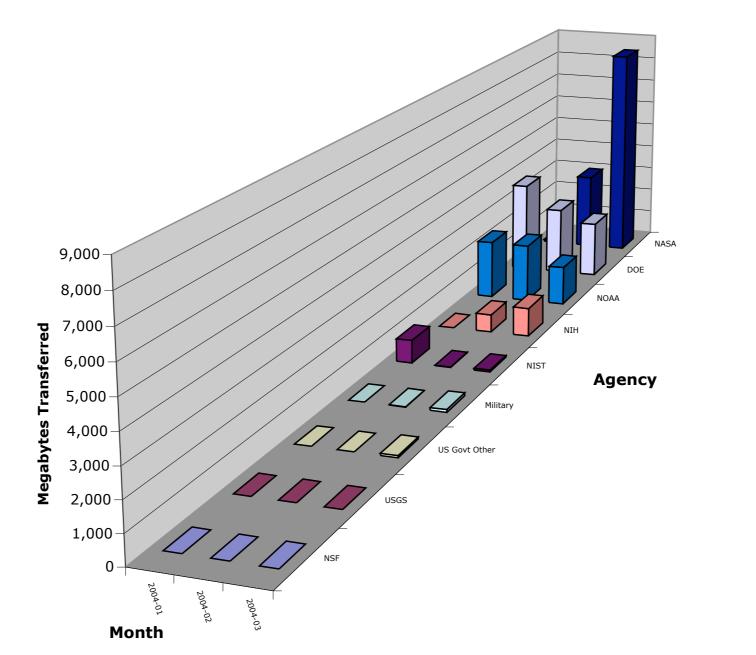
Top US Govt Agencies Receiving Data from Russia via GLORIAD





Top US Govt Agencies Supplying Data to China via GLORIAD





Top US Govt Agencies Receiving Data from China via GLORIAD

NSF
USGS
US Govt Other
Military
NIST
NIH
NOAA
DOE
NASA

GLORIAD Traffic from China January, 2004

to Russia

to US

Traditution	City	Manahuta -	0/ Total	Tuetitutien	City	Manahuta -	0/ Tatal
Institution	City	Megabytes	% Total	Institution	City	Megabytes	% Total
Moscow State University	Moscow	6,407	8.13	U of Illinois Urbana-Champaign	Urbana	8,072	12.69
FREEnet Web	Moscow	6,050	7.68	Columbia University	New York	7,660	12.05
Joint Institute for Nuclear Research (Dubna)	Dubna	4,861	6.17	Princeton University	Princeton	4,087	6.43
Bauman Moscow State Tech Univ	Moscow	3,412	4.33	U of Michigan	Ann Arbor	3,112	4.89
FREEnet		2,575	3.27	U of Chicago	Chicago	2,044	3.21
Institute for Information Transmission Problems	Moscow	2,491	3.16	U of Tennessee, Knoxville	Knoxville	1,913	3.01
Tomsk Education Network	Tomsk	2,337	2.96	National Oceanic and Atmosphere Administration	Suitland	1,844	2.90
Joint Institute for Nuclear Research (Dubna)	Dubna	2,193	2.78	U of Colorado Boulder	Boulder	1,800	2.83
nsc.ru (Novosibirsk)	Novosibirsk	2,007	2.55	Rochester Inst of Tech	Rochester	1,450	2.28
Institute for High Energy Physics (Protvino)	Protvino	1,946	2.47	U of Maryland	College Park	1,406	2.21
troitsk.ru	Troitsk	1,432	1.82	Univ of Georgia-Athens	Athens	1,367	2.15
Kurchatov Inst	Moscow	1,336	1.69	Georgia Inst. Of Technology	Atlanta	1,359	2.14
nsk.ru (Novosibirsk)	Novosibirsk	1,274	1.62	University of Hawaii	Honolulu	1,167	1.84
Russian Academy of Sciences	Moscow	1,024	1.30	Fermi National Laboratory	Batavia	1,158	1.82
Russian Space Science Internet	Moscow	814	1.03	Univ of Delaware	Newark	1,130	1.78
Institute of Theoretical and Experimental Physics	Moscow	754	0.96	Colorado State University	Fort Collins	1,044	1.64
Kurchatov Inst	Moscow	744	0.94	U of Illinois Chicago	Chicago	960	1.51
RELARN	Moscow	730	0.93	U of Oklahoma	Norman	948	1.49
Ural State University	Ekaterinburg	680	0.86	Natl Inst of Standards and Tech	Boulder	828	1.30
Krasnoyarsk Science Center	Krasnoyarsk	675	0.86	Boston University	Boston	755	1.19
Moscow Technical Univ of Communications & Informatic Moscow		670	0.85	Oak Ridge Natl Lab	Oak Ridge	672	1.06
Other		34,400	43.64	Other		18,831	29.58
Total		78,811	100.00	Total		63,608	100.00

GLORIAD Traffic from Russia January, 2004

% Total

2.90 2.73 2.70

2.56

2.51

2.04

2.02

1.94

1.73

1.58

1.51

1.44

1.35 1.24

1.22

1.19

1.16

1.15

1.14

1.12

1.10

63.67

100.00

5,006

291,133

457,111

Pittsburgh

to China	а			to	US	
Institution	City	Megabytes	% Total	Institution	City N	Megabytes
China (unidentified)		9,075	65.78	Fermi National Laboratory	Batavia	13,256
Chinese Academy of Sciences (general)	Beijing	1,392	10.09	U of Michigan	Ann Arbor	12,467
China Education and Research Network		324	2.35	Purdue University - W Lafayette	West Lafayet	12,333
Academy of Math and Systems Science, CAS	Beijing	303	2.19	Stanford University	Los Angeles	11,680
Institute of Software, CAS	Beijing	77	0.56	U of California San Diego	La Jolla	11,478
Lanzhou, China, CAS	Lanzhou	12	0.09	Mass. Inst. of Technology	Cambridge	9,338
Library of Chinese Academy of Sciences	Beijing	10	0.07	Georgia Inst. Of Technology	Atlanta	9,232
China Academy of Sciences		9	0.06	Princeton University	Princeton	8,862
Institute of Zoology, CAS	Beijing	7	0.05	Brookhaven National Laboratory	Long Island	7,911
Institute of Automation, CAS	Beijing	5	0.04	Jefferson Lab	Newport New	7,238
Institute of Mechanics, CAS	Beijing	4	0.03	Boston University	Boston	6,912
China Internet Network Information Ctr, CAS	Beijing	4	0.03	U of Pennsylvania	Philadelphia	6,557
Beijing Institute of System Engineering, CAS	Beijing	4	0.03	U of California Los Angeles	Los Angeles	6,171
Institute of Physics & Chemistry, CAS	Beijing	4	0.03	New York University	New York	5,667
Guangzhou Institute of Chemistry, CAS	Guangzhou	3	0.02	Univ of California Davis	Davis	5,566
Institute of Hydrobiology, CAS	Beijing	2	0.02	State U of NY at Buffalo	Buffalo	5,450
Institute of Atmospheric Physics, CAS	Beijing	2	0.02	Iowa State University	Ames	5,287
Institute of Computing Technology, CAS	Beijing	2	0.01	Michigan State University	East Lansing	5,239
Institute of Microbiology, CAS	Beijing	1	0.01	Rochester Inst of Tech	Rochester	5,216
Institute of Chemistry, CAS	Beijing	1	0.01	U of S California	Los Angeles	5,110

0.01

Other

Total

18.50

100.00

1 2,555

13,797

Carnegie Mellon University

Beijing

Other

Total

Institute of Biophysics, CAS

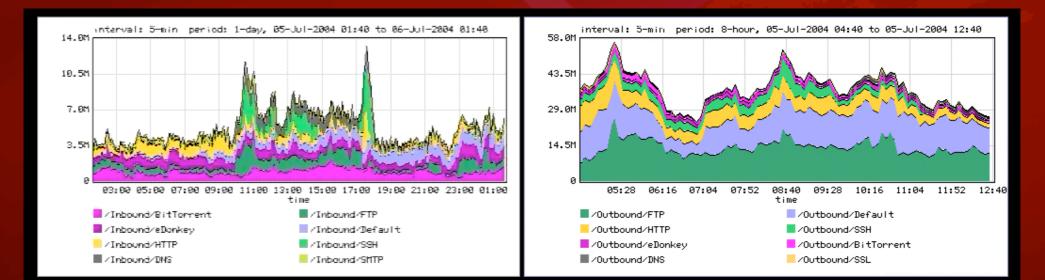
GLORIAD Traffic from US January, 2004

to	Rus	eia
U	1103	0010

to China

Institution	City	Megabytes	% Total	Institution	City	Megabytes	% Total
Moscow State University	Moscow	172,059	12.05	Chinese Academy of Sciences (general)	Beijing	317,151	41.38
Chernogolovka Science Center	Chernogolovk	168,853	11.83	Institute of Atmospheric Physics, CAS	Beijing	139,011	18.14
Russian Space Science Internet	Moscow	94,352	6.61	Natl Astronomical Observatory, CAS	Beijing	100,627	13.13
Russian Academy of Sciences	Moscow	82,351	5.77	China (unidentified)		65,672	8.57
nsc.ru (Novosibirsk)	Novosibirsk	72,436	5.07	Institute of Hydrobiology, CAS	Beijing	61,506	8.02
Radio Moscow State University Network	Moscow	71,069	4.98	Institute of Computing Technology, CAS	Beijing	11,036	1.44
smr.ru (Samara)	Samara	64,951	4.55	Library of Chinese Academy of Sciences	Beijing	7,660	1.00
Joint Institute for Nuclear Research (Dubna)	Dubna	45,694	3.20	Guangzhou Institute of Chemistry, CAS	Guangzhou	7,448	0.97
Bauman Moscow State Tech Univ	Moscow	30,960	2.17	Academy of Mathematics and Systems Science, CAS	Beijing	6,820	0.89
RELARN	Moscow	25,500	1.79	Institute of Software, CAS	Beijing	6,678	0.87
FREEnet Web	Moscow	24,028	1.68	Academy of Preventive Medicine, CAS	Beijing	5,049	0.66
Institute for High Energy Physics (Protvino)	Protvino	23,603	1.65	Institute of Computational Math and S/E Computing, (CA Beijing	4,551	0.59
irk.ru (Irkutsk)	Irkutsk	20,222	1.42	Institute of Zoology, CAS	Beijing	4,399	0.57
Russian IR Cache	Moscow	18,548	1.30	Institute of Biophysics, CAS	Beijing	4,169	0.54
Tomsk Education Network	Tomsk	17,226	1.21	Lanzhou, China, CAS	Lanzhou	3,829	0.50
nsk.ru (Novosibirsk)	Novosibirsk	16,862	1.18	Institute of Automation, CAS	Beijing	3,706	0.48
Tomsk State University	Tomsk	15,375	1.08	Institute of Theoretical Physics, CAS	Beijing	2,437	0.32
Instiute for Information Transmission Problems	Moscow	15,100	1.06	Institute of Microbiology, CAS	Beijing	2,128	0.28
Saratov State University	Saratov	15,024	1.05	Institute of Mechanics, CAS	Beijing	1,929	0.25
Ural Branch of the Russian Academy of Science	Ekaterinburg	11,852	0.83	China Academy of Sciences (other)		1,840	0.24
Kurchatov Inst	Moscow	11,758	0.82	China Internet Network Information Ctr, CAS	Beijing	1,192	0.16
Other		410,050	28.70	Other		7,596	1.00
Total		1,427,873	100.00	Total		766,435	100.00

GLORIAD Application Utilization Monitoring System (using Packeteer Boxes)



Monitoring Institutional Use Applications Use Basic Performance metrics

Network "anomalies"

AMP (One-way) Measurements to Russia

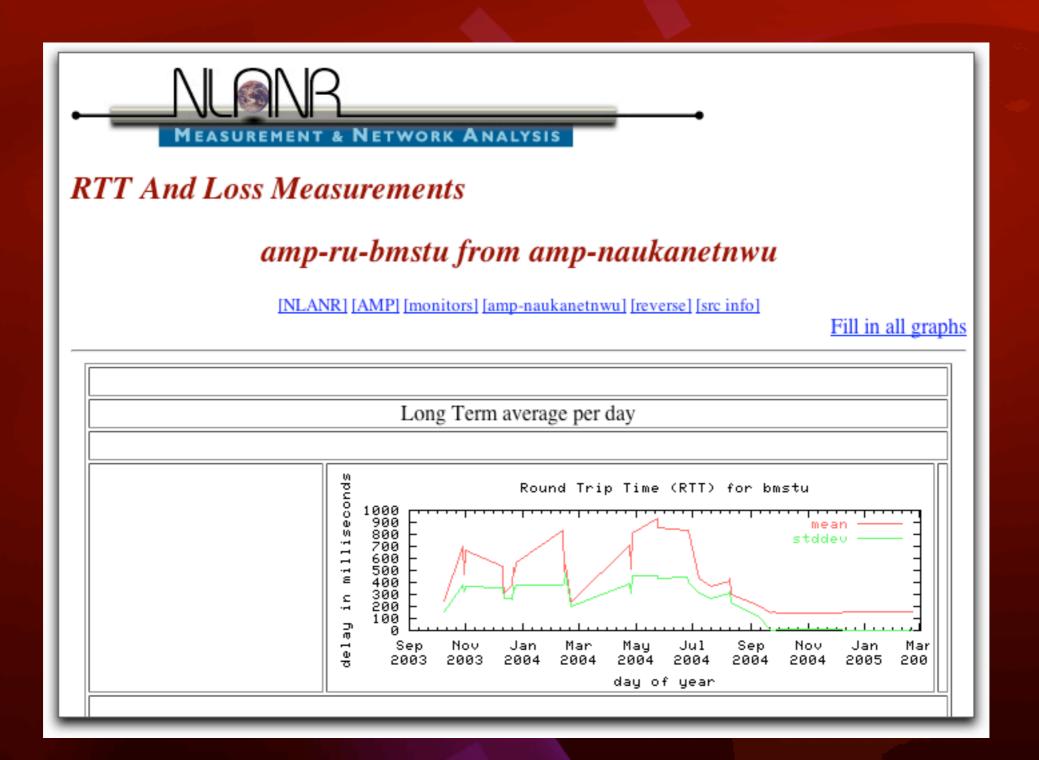
MEASUREMENT & NETWORK ANALYSIS										
"amn-n	aukanetnwu russia	resul	ts"							
ump-n										
	[NLANR] [AMP] [Monito	ors] [rou	te summ	nary][sum	mary gra	aph] [site	e info]			
[Site Name - Graph	Min	Mean	Max	Stddev	Loss	Stats from			
	She Hane - Graph	(ms)	(ms)	(ms)	(ms)	(%)	Stats it offi			
	bmstu		149.59			0.42	2005/3/9			
	ccas		151.20		14.61	1.39	2005/3/9			
	<u>chg</u>	146.00	148.62	209.00	2.61	1.32	2005/3/9			
	<u>chph-ras</u>	0.00	0.00	0.00	0.00	100.00	2005/3/9			
	core-gw-3-se-0-3-1-mtts-ksu	0.00	0.00	0.00	0.00	100.00	2005/3/9			
	dvo	262.00	276.96	513.00	16.78	6.18	2005/3/9			
	earth-crust-irk	0.00	0.00	0.00	0.00	100.00	2005/3/9			
	freeNet	145.00	145.86	179.00	1.19	1.25	2005/3/9			
	friends-partners	147.00	149.68	229.00	4.77	7.15	2005/3/9			
	gpi	145.00	158.24	477.00	34.47	2.01	2005/3/9			
	<u>gpntb</u>	147.00	149.11	450.00	8.25	3.06	2005/3/9			
	ihep.su	147.00	150.16	168.00	2.02	0.35	2005/3/9			
	iitp	0.00	0.00	0.00	0.00	100.00	2005/3/9			
	ikia-ircache	144.00	145.05	168.00	1.12	0.62	2005/3/9			
	ioc-ac	145.00	146.66	202.00	2.17	4.31	2005/3/9			
	<u>ipmce</u>	0.00	0.00	0.00	0.00	100.00	2005/3/9			
	ippe-obninsk	155.00	242.33	3227.00	165.72	10.69	2005/3/9			
	iskran-iip	145.00	148.11	192.00	1.72	0.49	2005/3/9			
	itep	144.00	146.60	237.00	7.13	0.97	2005/3/9			
	ivep-khv	731.00	944.14	1753.00	188.55	1.67	2005/3/9			
	jinr	148.00	155.30	273.00	14.49	0.49	2005/3/9			
	keldysh	146.00	148.36	187.00	3.16	3.82	2005/3/9			

					1	1
<u>kiae</u>	146.00	152.56	274.00	10.02	1.74	2005/3/9
krasn	192.00	547.68	1079.00	280.42	2.22	2005/3/9
kubsu	168.00	172.78	213.00	3.78	0.90	2005/3/9
lebedev	147.00	149.70	161.00	1.81	0.49	2005/3/9
<u>mipt</u>	145.00	149.76	375.00	8.27	1.32	2005/3/9
mpei-ac	146.00	149.21	291.00	7.08	3.89	2005/3/9
nsc	0.00	0.00	0.00	0.00	100.00	2005/3/9
<u>pfu</u>	146.00	169.07	386.00	37.40	7.71	2005/3/9
pmc	146.00	152.02	224.00	7.04	0.49	2005/3/9
<u>psn</u>	155.00	176.03	439.00	34.03	2.57	2005/3/9
<u>radio-msu</u>	145.00	148.05	167.00	2.39	0.56	2005/3/9
<u>relarn</u>	0.00	0.00	0.00	0.00	100.00	2005/3/9
rssi	144.00	145.64	267.00	4.88	1.18	2005/3/9
<u>rsuh</u>	145.00	148.03	179.00	2.51	2.57	2005/3/9
<u>sgu</u>	163.00	240.47	909.00	109.12	10.00	2005/3/9
<u>sinp-msu</u>	145.00	146.81	176.00	1.53	1.63	2005/3/9
siobc-ras	147.00	157.51	336.00	21.22	1.11	2005/3/9
smr	161.00	163.64	185.00	2.48	1.39	2005/3/9
<u>stankin</u>	0.00	0.00	0.00	0.00	100.00	2005/3/9
<u>tversu</u>	0.00	0.00	0.00	0.00	100.00	2005/3/9
unn	150.00	163.63	316.00	19.51	1.11	2005/3/9
<u>urc-ac</u>	181.00	828.43	2362.00	535.89	7.22	2005/3/9
<u>usu</u>	0.00	0.00	0.00	0.00	100.00	2005/3/9
vigg	150.00	222.85	741.00	43.09	20.56	2005/3/9
<u>vspu</u>	182.00	463.21	1771.00	255.60	9.65	2005/3/9
<u>vsu</u>	157.00	173.38	286.00	14.48	1.04	2005/3/9
<u>x-atom</u>	150.00	161.36	517.00	25.24	8.33	2005/3/9

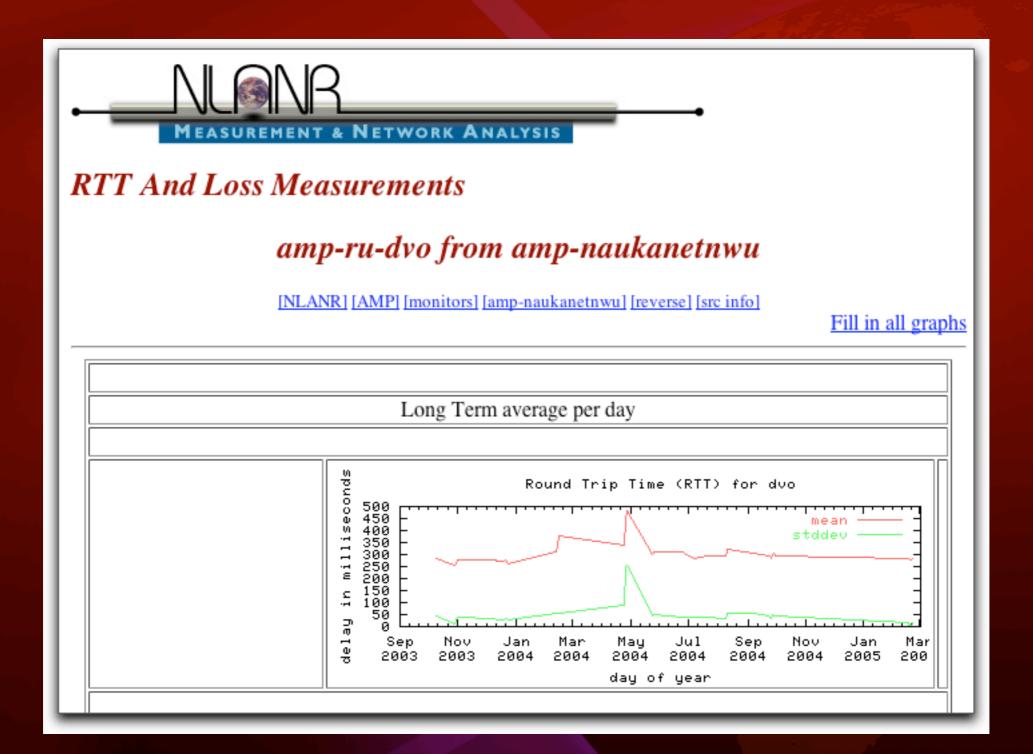
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Top last modified: 10 Mar 2005 Tony McGregor Comments, questions are welcome: Feedback

AMP Measurements to Moscow BMSTU



AMP Measurements to Vladivostok



AMP Measurements from China/CNIC

MEASUREMENT & NETWORK ANALYSIS

"amp-cnic international results"

[NLANR] [AMP] [Monitors] [route summary][summary graph] [site info]

	·									
Site Name - Graph	Min (ms)	Mean (ms)	Max (ms)	Stddev (ms)	Loss (%)	Stats from				
AARNet		319.45			0.07	2005/3/9				
AMPATH-Miami		294.73			0.00	2005/3/9				
Asian Pacific Advanced Network, Tokyo	86.00		86.00		0.00	2005/3/9				
Columbia University		303.94			0.00	2005/3/9				
Corp. Univ. Desarrollo de Internet		335.61			2.43	2005/3/9				
		411.42		5.49	0.00	2005/3/9				
ELTENET, Hungary										
Florida International University		317.80			0.00	2005/3/9				
HEANet, Ireland	0.00		0.00	0.00		2005/3/9				
HUT Finland	409.00	423.70	478.00	6.40	0.00	2005/3/9				
KREONet2, KOREA	0.00	0.00	0.00	0.00	100.00	2005/3/9				
NaukaNetNWU	419.00	424.45	431.00	2.66	0.14	2005/3/9				
Norwegian University of Science and Technology, <u>NO</u>	417.00	431.48	450.00	5.39	0.00	2005/3/9				
Pittsburg Supercomputing Center	314.00	317.56	328.00	6.08	88.40	2005/3/9				
Rice University	254.00	256.82	317.00	5.04	0.00	2005/3/9				
SURFnet Amsterdam	375.00	389.50	402.00	5.46	0.00	2005/3/9				
San Diego Supercomputer Center	204.00	271.93	300.00	6.42	0.42	2005/3/9				
<u>Startap</u>	268.00	282.29	301.00	5.22	0.00	2005/3/9				
TANet2, Taiwan	0.00	0.00	0.00	0.00	100.00	2005/3/9				
UniNet Thailand	359.00	522.47	1804.00	339.65	0.00	2005/3/9				
University of Cambridge, England	371.00	385.43	398.00	5.49	0.00	2005/3/9				
University of Maryland, College Park	286.00	306.59	320.00	5.55	0.00	2005/3/9				

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SURFnet Amsterdam	375.00	389.50	402.00	5.46	0.00	2005/3/9
San Diego Supercomputer Center	204.00	271.93	300.00	6.42	0.42	2005/3/9
<u>Startap</u>	268.00	282.29	301.00	5.22	0.00	2005/3/9
TANet2, Taiwan	0.00	0.00	0.00	0.00	100.00	2005/3/9
UniNet Thailand	359.00	522.47	1804.00	339.65	0.00	2005/3/9
University of Cambridge, England	371.00	385.43	398.00	5.49	0.00	2005/3/9
University of Maryland, College Park	286.00	306.59	320.00	5.55	0.00	2005/3/9
University of Waikato, NZ	284.00	295.58	845.00	16.36	0.69	2005/3/9

Generated at Thu Mar 10 00:53:41 2005.

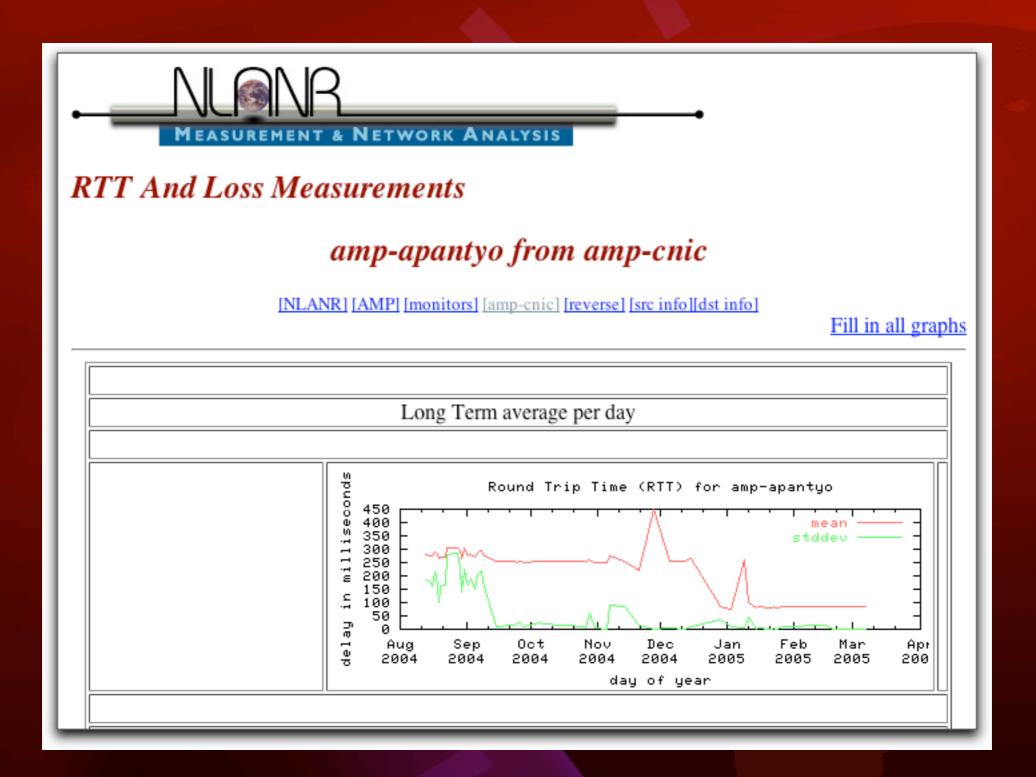
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NLONR

AMP Measurements from China/CNIC



Presentation



GLORIAD: more than a network



Serving ITER, High Energy Physics, Astronomy, Atmos. Sciences, Earth Sciences, Bio Sciences, Telemedicine, Materials Sciences and many others

Serving Nuclear Non-Proliferation, Materials Protection, Anti-Terrorism, International Security

Serving Educators: Edu-Cultural Digital TV Channel,Intl Science Fairs, Junior Achievement, "Simple Words", Virtual Museums

Serving Advanced Networking: Wavelength Disk Drive, IPv6, Collaboration Infrastructure

Driving Disciplines



High Energy Physics (HEP)

Most immediate driver for international high performance S&E networking

Large Hadron Collider (LHC) experiments will begin generating petabytes of data in 2007-2008, exabytes by 2005

Community has developed international infrastructure for sharing data for shared analysis

Heaviest single community user of GLORIAD today (40% of traffic some days)

Propose need for GbEs immediately

Physics (HEP)

sics (HEP)

Home SLORIAD Apps pps by Country Canada China Korea Netherlands Russia USA ps by Discipline Energy Physics n Energy/ITER spheric Science

Astronomy

Network Computing

Others

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Geosciences

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High Energy Physics (HEP)

The HEP community sets the pace for all in mapping out plans for handling enormous computational and data requirements – as wel required network infrastructure. The Large Hadron Collider (LHC) a example, more than 6,000 scientists and engineers from 250 universes and laboratories in 60 countries. These collaborators participate in experiments that will accumulate more than 10 petabytes each du 2007-08 and this will rise to the exabyte range by 2015, introducing unprecedented challenges in data access, distribution and collaborator analysis.

🕙 http://www.gloriad.org/gloriad/disciplines/hep/index

The <u>Compact Muon Solenoid (CMS)</u>Compact Muon Solenoid (CMS) Collaboration at CERN provides another example where GLORIAD the need of cutting-edge science. Approximately 40 percent of the physicists at work on the CMS collaboration call the US, Russia or home. They, along with the 2,000 scientists involved in CMS will n high-capacity network to transmit results of these experiments.

Other non-LHC HEP experiments underway at Fermilab, SLAC and face similar challenges on a "smaller but still daunting scale." The communities are already heavy users of NaukaNet and GLORIAD and project the need for 300M/622M/1-2.5G capacity for major HE centers in Russia, China and Korea in 2004/2005/2006 respective collaborators with HEP in Russia and China include universities and national laboratories throughout the US.

The following point to additional information about high energy phi applications:

Description of High Energy Physics Applications in Russia(Projects progress)(High Energy Physics)

Fusion Energy

International Thermonuclear Experimental Reactor

- GLORIAD to some degree developed to help serve ITER community (US, Russia, China, Korea, Europe, Japan)
- \$Multi-billion construction to begin when site decision is made (either France or Japan); #1 science/facility priority for US Department of Energy
- Will require GbE around GLORIAD ring initially; 10G circuit by 2008
- Heavy user of computational resources (at ORNL), need to cooperatively control experiments remotely, massive data storage and transmission requirements



GLORIAD/ITER-Grid Meeting, December 21, 2003

Astronomy

- International Virtual Observatory Project (involving US, Russia, China, Korea, Europe, others) proposes generation of 10 petabytes of data annually
- International Very Long Baseline Interferometry (VLBI) involves very high capacity network access to radio telescopes in Netherlands, US, Russia, China, Australia, elsewhere; network access to require multiple DWDM wavelengths

Home GLORIAD Apps Apps by Country Canada China Netherlands Russia USA

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Apps by Discipline High Energy Physics Fusion Energy/ITER Atmospheric Science Astronomy Geosciences Medical Sciences Network Grids/Computing Others

> GLORIAD Team Management Operations onitoring System Sponsors IAD Classroom ation Outreach ail Listservers Chat Room earch Tools

Astronomy

Progress in astronomical research requires access to all the astronomical data, since insight comes from correlating data different wavelengths and with different techniques, and of the observational results with astrophysical simulations.

Astronomy

🕙 http://www.gloriad.org/gloriad/disciplines/asti

Problems in making this vision a reality include lack of su bandwidth and the inhomogeneity of the data and the and access methods.

The <u>International Virtual Observatory</u> project, scheduled f 2008, will produce 10 petabytes of data per year, yet the on networks such as GLORIAD to solve the issue of bandw transmit enormous sums of data. GLORIAD will enable US access IVO data resources in Russia and China and vice-w will enable real-time very long baseline interferometry be Long Baseline Array in the U.S. and radio telescopes in th Russia, China, and Korea.

The <u>International Square Kilometer Ray Consortium</u> will reto provide network services for baseline interferometry be Long Baseline Array (VLBA) with partner countries, and all the distributed SKA paradigm.

KOREA: Korean Virtual Observatory Project

The virtual observatory projects are being develop national levels at about 15 countries including Kore Virtual Observatory (KVO, http://kvo.kao.re.kr) wa February 2003 by astronomers in Korea Astronomiand some universities.

Earth Sciences

US, Russia, China, Canada together comprise large percentage of earth's surface and already have large domestic infrastructure for sensing seismic activity, atmospheric conditions, environmental conditions, satellite-based imagery coverage, etc.

GLORIAD proposes to ensure higher capacity/easier data sharing between major earth science initiatives – seismic monitoring, satellite imagery, environmental monitoring, forestry/wildfire studies, etc.

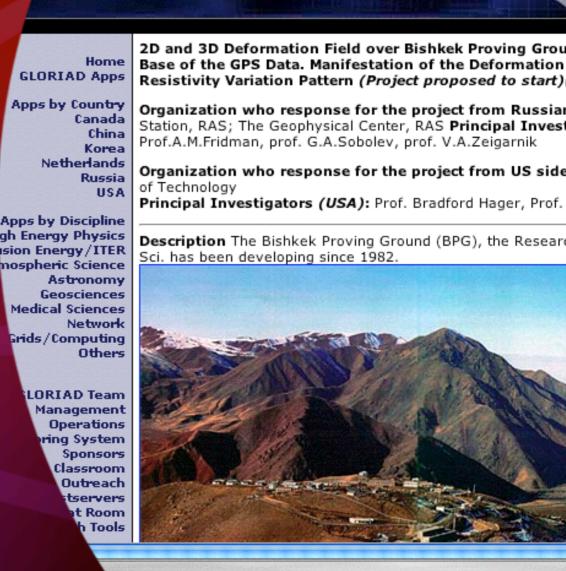
Special emphasis in GLORIAD on extending access to Central Asia generally and to the Bishkek Geologic Proving Ground specifically

Deformation Field over Bishkek Proving Ground Develops of start) (GeoScience)

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Atmospheric Sciences

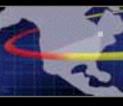
THORpex <i>(Project in progress)(Atmospheric Science)

Shttp://www.gloriad.org/gloriad/projects/ru/project20040

Programs include general atmospheric modeling, climate change studies, weather prediction, etc.

Data transmission requirements requiring GbE+ (also enormous shared computational and data storage)

Special emphasis on International THORPEX program – established in 2003 as a 10-year global atmospheric R&D program – emphasis on mitigating effects of natural weather-related phenomena by providing much more accurate 1 -14 day forecasts. ct in progress)(Atmospheric Science)



Home AD Apps y Country Canada China Korea etherlands Russia USA Discipline y Physics A Global Atmospheric Research Programme THORPEY is a ten-year

A Global Atmospheric Research Programme THORPEX is a ten-year rgy/ITER international research programme, under the auspices of the Comm ic Science of the Atmospheric Science, and its World Weather Research Progra tronomy (WWRP). The purpose of THORPEX is to accelerate improvements in sciences short-range (up to 3 days), medium-range (3 to 7 days) and extend Sciences range (week-two) weather predictions and the social value of advar Network forecast products. THORPEX would examine global-to-regional influe nputing on the predictability of high-impact weather and establish the potent Others produce significant statistically-verifiable improvements in forecasts those time scales. Team

2. Scientific background

nent

ons

The success of numerical weather prediction represents one of the r significant scientific, technological and societal achievements of the century. Despite the notable increase in forecast skill over the past quarter century (Fig.1), there is a necessity for further improvemen particularly, in high-impact weather forecasts and in the use of weat formation. High-impact weather forecasts are defined by their effeciety and the economy. They are typically associated with forecast

Network Research

With its hybrid architecture, GLORIAD will provide an experimental "sandbox" for network researchers – enabling experimentation without putting production services at risk

One proposed project is the Canadian Wavelength Disk Drive (WDD) – treating a service across the GLORIAD ring as a "disk drive" – circulating data around the earth with "readers" and "writers" at various locations – useful for data needed by international parties at approximately the same time

Another is the Canadian User Controlled Lightpath (UCLP) Home GLORIAD Apps Apps by Country Canada China Korea Netherlands Russia USA pps by Discipline Energy Physics

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Network Experimentation: Wavelength Disk Dr (WDD)

Networking

🕙 http://www.gloriad.org/gloriad/disciplines/netwo

The circuit-oriented service on GLORIAD is designed not onl individual science applications but to provide a test bed for i research. In the case of CANARIE's WDD, it actually serves This is a novel concept developed by Canadian network rese which treats a large-scale multi-wavelength network as thou large disk drive -with each wavelength being a separate tradevices on the network (running the WDD software) acting a heads. The hard/software injects a data record into the netw flow. When the next WDD node receives a packet it is forwa next node, resulting in packets continuously circulating arou network. CANARIE and GLORIAD will test capability of the qu GLORIAD network to prove the concept in the ring around the hemisphere – while much less capacity, it is a longer path the given unit capacity to carry more data. There are application from Russia for using the WDD to enable global monitoring of and time-critical data streams.

Other Areas of Collaboration

- Grids and Shared use of Computational Resources
- Network Security
- Materials Science (ORNL's SNS)
- Bioinformatics/Bioengineering
- Telemedicine (US-Russia effort in cancer research)
- Nuclear Materials Protection and Non-proliferation programs
- Emergency Response
- Joint Anti-terrorism Programs

edical mormation system (imis, Dimot)<1>(Figer in progress)(medical science)<7

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Others part exp inst GLORIAD Team Management Operations Monitoring System Sponsors GLORIAD Classroom Education Outreach Email Listservers Chat Room

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of the most complicated situations, exchange with statistical data regarding the procedure and results of the most important and complicated procedures and operations. In order to reach the above mentioned aims it is necessary to have a possibility to hold on-line teleand video-conferences, to exchange with electronic records of patients, with medical diagnosis images (X-ray, ultra sound examinations, and tomography) and angiographic films. The strictest measures should be undertaken in the INIS to guarantee confidentiality of medical information in order to prevent unauthorized access to the servers of medical institutions. Creation of IMIS will be exclusively beneficial for all the participants of this project. IMIS will make it possible to disperse experience in health care, the latest achievements in medical instrumentation, methods of diagnosis and treatment of the most complicated diseases.

mistic is possible to carry out medical consultat

In Russian Federation there has been created a hard-and-software complex DIMOL by the developers of the Russian research Center "Kurchatov Institute" in cooperation with the Scientific and Practical center of Intervening Cardiology. The DIMOL complex is intended for automation of medical procedure processes in cardiological clinics. Such complex has been working during more than five years at the Scientific and Practical center of Intervening Cardiology in Moscow.

Fig.1. Author of the project DIMOL.From left to right: Gnedenko V.G., faineberg E.M., Iosseliani D.G., Velikhov E.P.

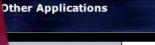
LORIAD's sponsors clude the US National cience Foundation, a onsortium of science rganizations and linistries in Russia and the chinese Academy of cciences. LORIAD's US home is at

elecommunications

LORIAD'S US home is at e NCSA of the University illinois at Urbanahampaign. barpatign. tore in the pohigh capacity mostly by th computerizat

Cardiology is one of the main and most rapidly developing directions of treating cardio-vascular diseases. The methods of intervening cardioangiology are intended for mass implementation; they are distinguished for being low traumatizing, provide patients to recover during minimum possible period of time. The positive results obtained and the high capacity of the method are caused mostly by the degree of its automation and computerization. The DIMOL complex provides practically full automation of this process, reduce the time required to make right





GLORIAD Apps

Countra

Canada

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Korea Hands Russia

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Energy/ITER pheric Science Astronomy Geosciences dical Sciences

Other Areas

Other science disciplines supported by the GLORIAD network include: nuclear materials protection and materials accounting and control, next generation optical network research and design, use of the ORNL-sited Spallation Neutron Source, nanomaterials, bioinformatics, bioengineering, telemedical applications, and various educational programs.



Presentation



Education & Outreach

- Central Asian and Western Eurasian networking extension
- GLORIAD Classroom
- EduCultural Channel
- Collaboration Infrastructure (IP Telephony Network (using Cisco donation) and HEP/VRVS)
- <u>"Simple Words</u>" Essay Program
- "Junior Achievement" Partnership
- Virtual Science Museum of China

Presentation



Challenges



Year 1 Plans

- Grand Opening Ceremony, New Operating Agreement
- Complete Architectural Plans, Landing Sites/Equipment Deployment, New Circuits (AMS, Moscow, Hong Kong, Pusan)
- Governance Structure, Working Groups Operational
- GLORIAD Classroom
- EduCultural Channel
- Collaboration Infrastructure Deployed (IP Telephony, VRVS Reflectors)
- BRO Box deployed, integrated with router
- New Monitoring System (using Packeteer/Netflow product)
- New Web Site
- "Simple Words" Pilot in US

This is all made possible by ...

NSF (6+ years of support) and our other sponsors in Russia, China, Korea (and others)



US partners - UT/ORNL (Homer Fisher, Bill Snyder), NCSA, UT/ORNL (again), Jim Olson, Mike Rieger, Bill Marra (Tyco), Starlight partners: Tom, Joe, Maxine; IRNC partners, Harvey Newman, Steve Goldstein, Tom Greene, Aubrey Bush, Yves Poppes, partners at US govt agencies (and many, many others)



Email, the Internet, Trans-oceanic/contintental circuits, "Friends and Partners"

Global Ring Network for Advanced Applications Development

NSF IRNC Meeting, March 11, 2005

Greg Cole, Research Director, UT-ORNL Joint Institute for Computational Sciences (PI)

Natasha Bulashova, Research Scientists, UT-ORNL Joint Institute for Computational Sciences (Co-PI)

http://www.gloriad.org/

Animation by Chinese Academy of Sciences Computer Network Information Center





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