Ultra High Definition Media over Optical Networks (CineGrid)

Cees de Laat

University of Amsterdam

Contents

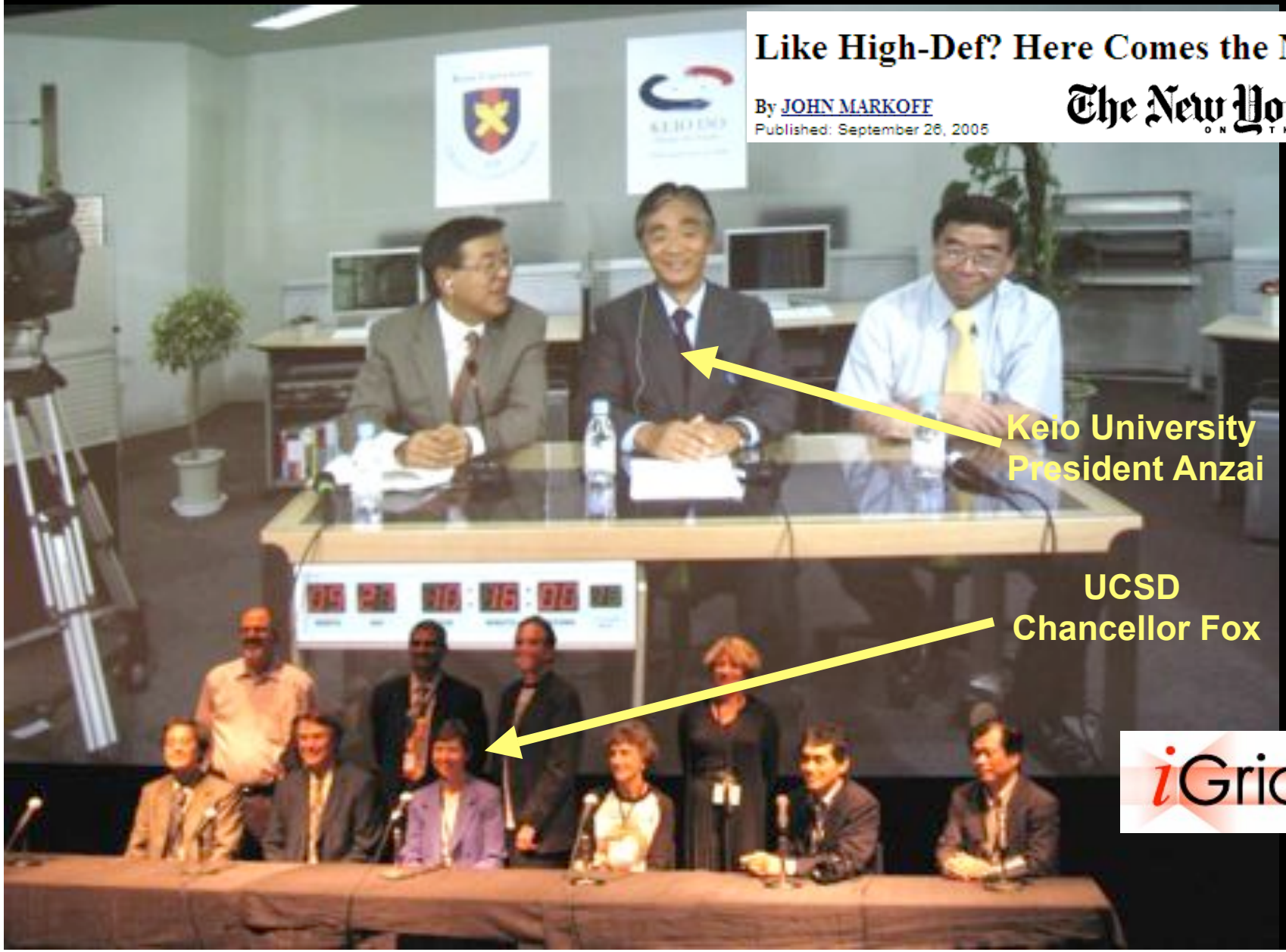
1. Use cases CineGrid & Networks
2. Formats - Numbers - Bits
3. Global Lambda Integrated Facility
4. A LightPath
5. Transport Protocol issues
6. End System Issues
7. Network Storage
8. Q/A

CineGrid Mission

To build an interdisciplinary community that is focused on the research, development, and demonstration of networked collaborative tools to enable the production, use and exchange of very-high-quality digital media over photonic networks.

http://www.cinegrid.org/

Keio/Calit2 Collaboration: Trans-Pacific 4K Teleconference



Like High-Def? Here Comes the Next Level

By JOHN MARKOFF
Published: September 26, 2005

The New York Times ON THE WEB

Keio University President Anzai

UCSD Chancellor Fox

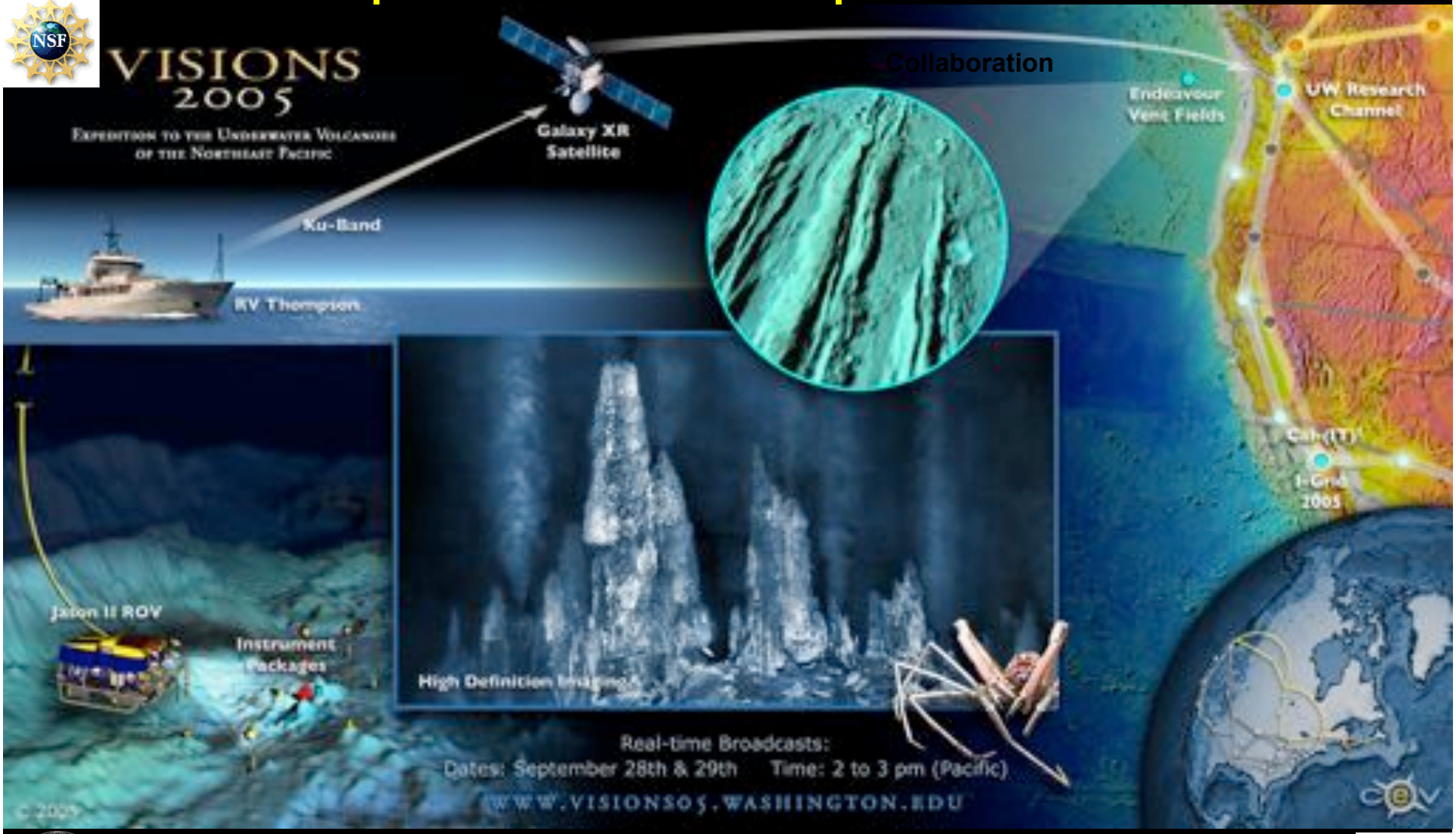
Used 1Gbps Dedicated

Sony NTT SGI

iGrid 2005

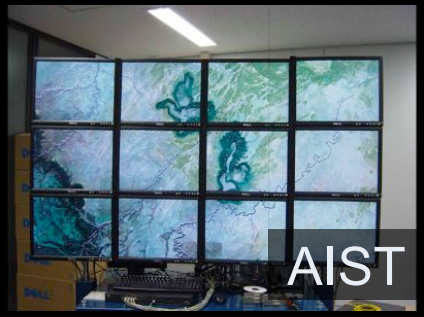
CineGrid@SARA

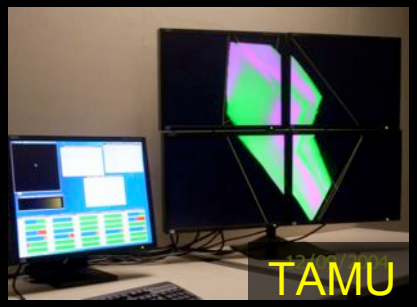
First Remote Interactive High Definition Video Exploration of Deep Sea Vents



Source John Delaney & Deborah Kelley, UWash

US and International OptIPortal Sites





CineGrid

The “Dead Cat” demo

SC2004 & iGrid2005

SC2004,
Pittsburgh,
Nov. 6 to 12, 2004
iGrid2005,
San Diego,
sept. 2005

Produced by:
Michael Scarpa
Robert Belleman
Peter Sloot

Many thanks to:
AMC
SARA
GigaPort
UvA/AIR
Silicon Graphics, Inc.
Zoölogisch Museum

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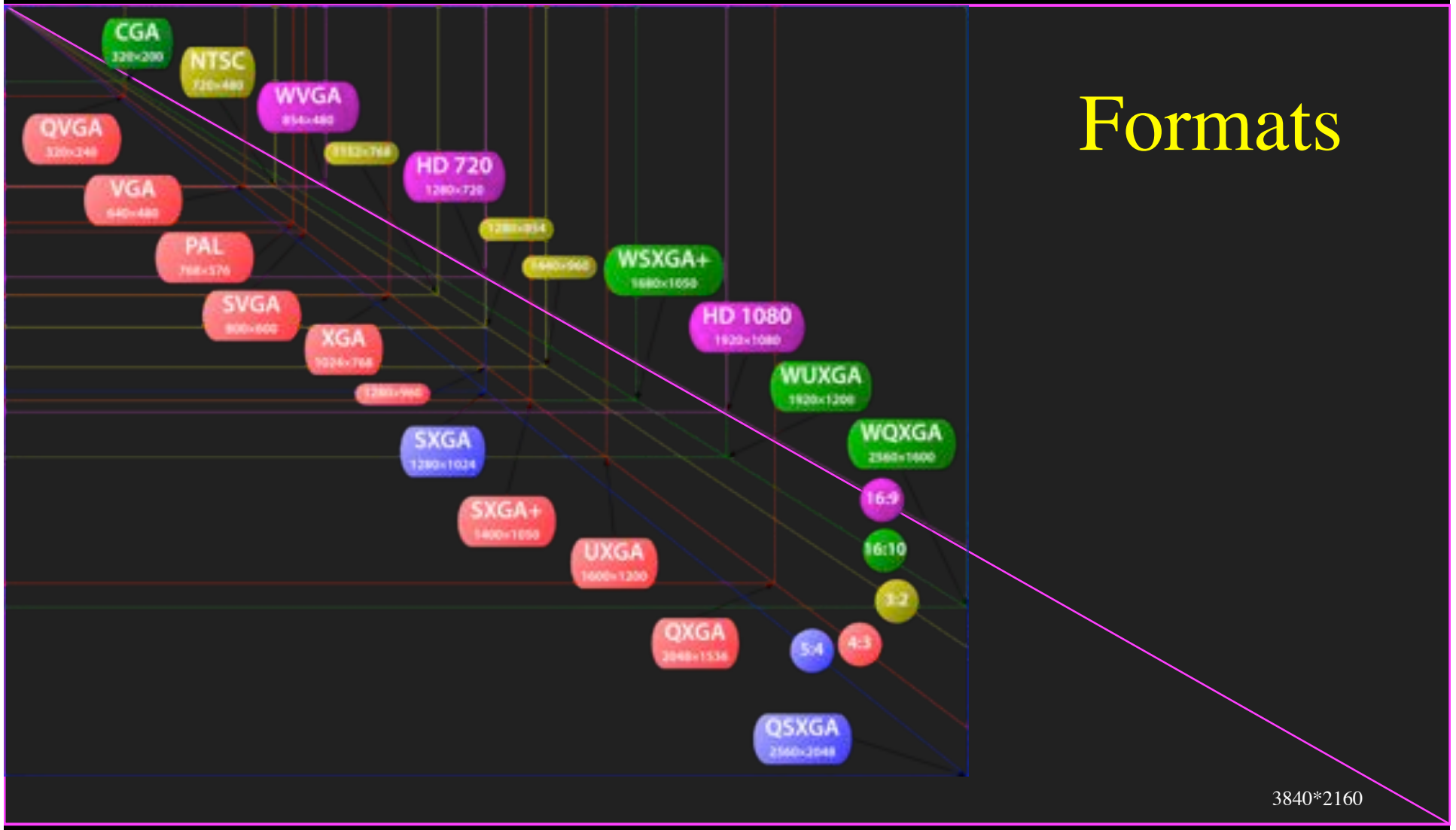
Formats



Note for space reasons the following formats are not shown:

- 4096x2160 (DCI specification for 4K)
- 7680x4320 (NHK specification for 8K)

Format - Numbers - Bits (examples!)

Format	X	Y	Rate /s	Color bits/pix	Frame pix	Frame MByte	Raw Stream Gbit/s
720p HD	1280	720	60	24	921600	2.8	1.3
1080p HD	1920	1080	30	24	2073600	6.2	1.5
2k	2048	1080	24	36	2211840	10	1.2
SHD	3840	2160	30	24	8294400	25	6.0
4k	4096	2160	24	36	8847360	40	7.6

Note: this is excluding sound and these numbers are raw uncompressed data rates (frames*pix*bit/pix) excluding framing overhead!

Formats - Numbers - Bits

- Formats:
  - uncompressed from camera - UMF — 3/4 GBytesec
  - jpeg2000 NTT — 300 - 700 Mbit/s
  - uncompressed TIFF — 1.2 GB/s, 4.3 TB/h
  - compressed in DXT — 300 - 800 Mbit/s
- Warning; do not compress away the science!
- Storage requirement
  - Holland festival shooting uncompressed about 12 TByte

Number, numbers and more numbers!

- Digital Motion Picture for Audio Post-Production
  - 1 TV Episode Dubbing Reference 1 GB
  - 1 Theatrical 5.1 Final Mix 8 GB
  - 1 Theatrical Feature Dubbing reference 30 GB
- Digital Motion Picture Acquisition
  - 6:1 up to 20:1 shooting ratios
  - 4k @ 24 FPS @ 10bit/color: ~48MB/Frame uncompressed
  - ~8TB for Finished 2 Hr Feature
- Digital Dailies
  - HD compressed MPEG-2 @ 25Mb/s
  - Data Size: ~22GB for 2 Hours
- Digital Post-production and Visual Effects
  - Terabytes, Gigabytes, Megabytes To Select Sites Depending on Project
- Digital Motion Picture Distribution
  - Film Printing in Regions
    - Features ~8TB
    - Trailers ~200GB
  - Digital Cinema to Theatres
    - Features ~200 - 300GB DCP
    - Trailers ~2 - 4GB DCP
- Online Download
  - Features ~1.3GB
  - TV Shows ~600MB

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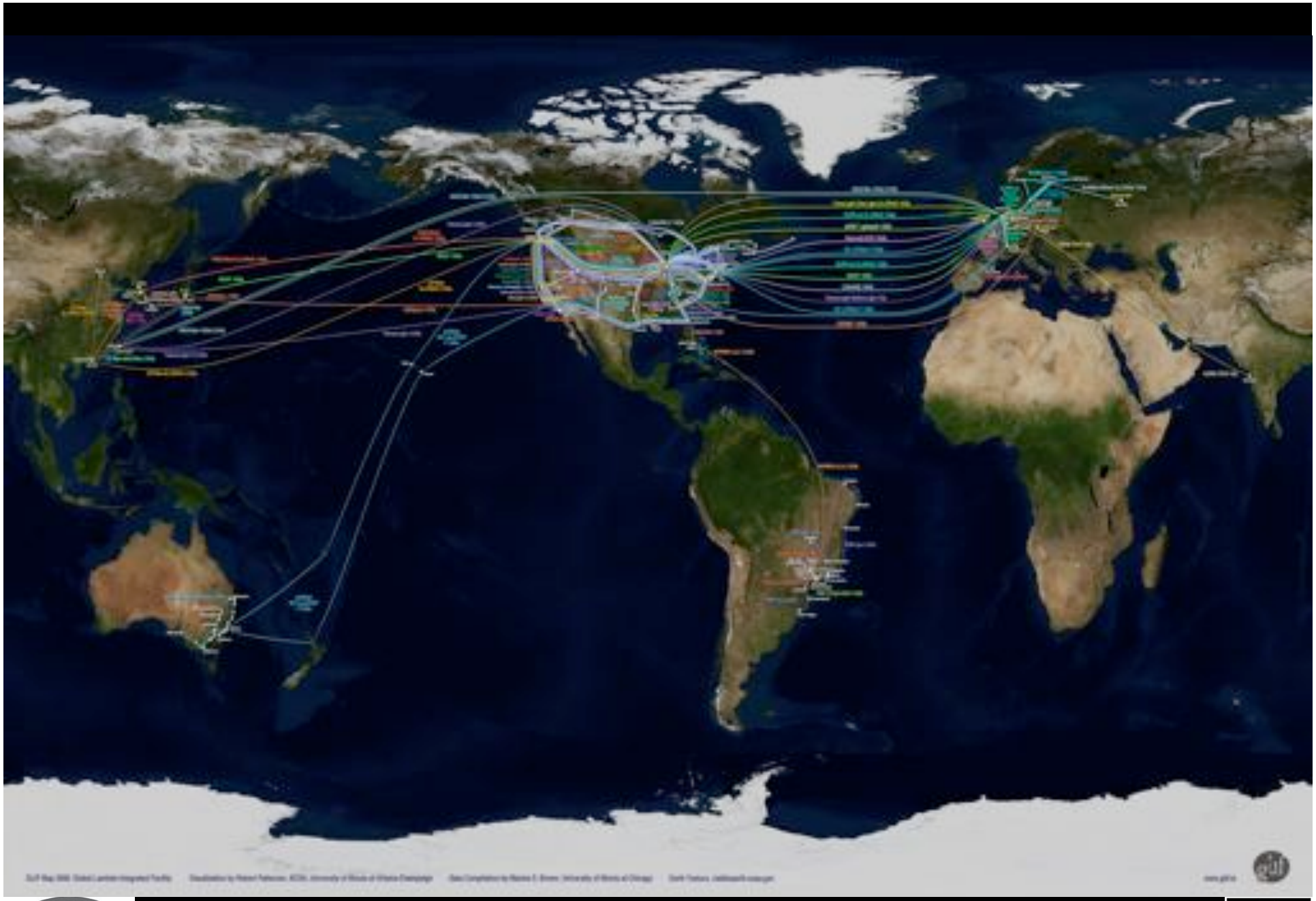
GLIF Mission Statement

- **GLIF is a world-scale Lambda-based Laboratory for application and middleware development on emerging LambdaGrids, where applications rely on dynamically configured networks based on optical wavelengths**

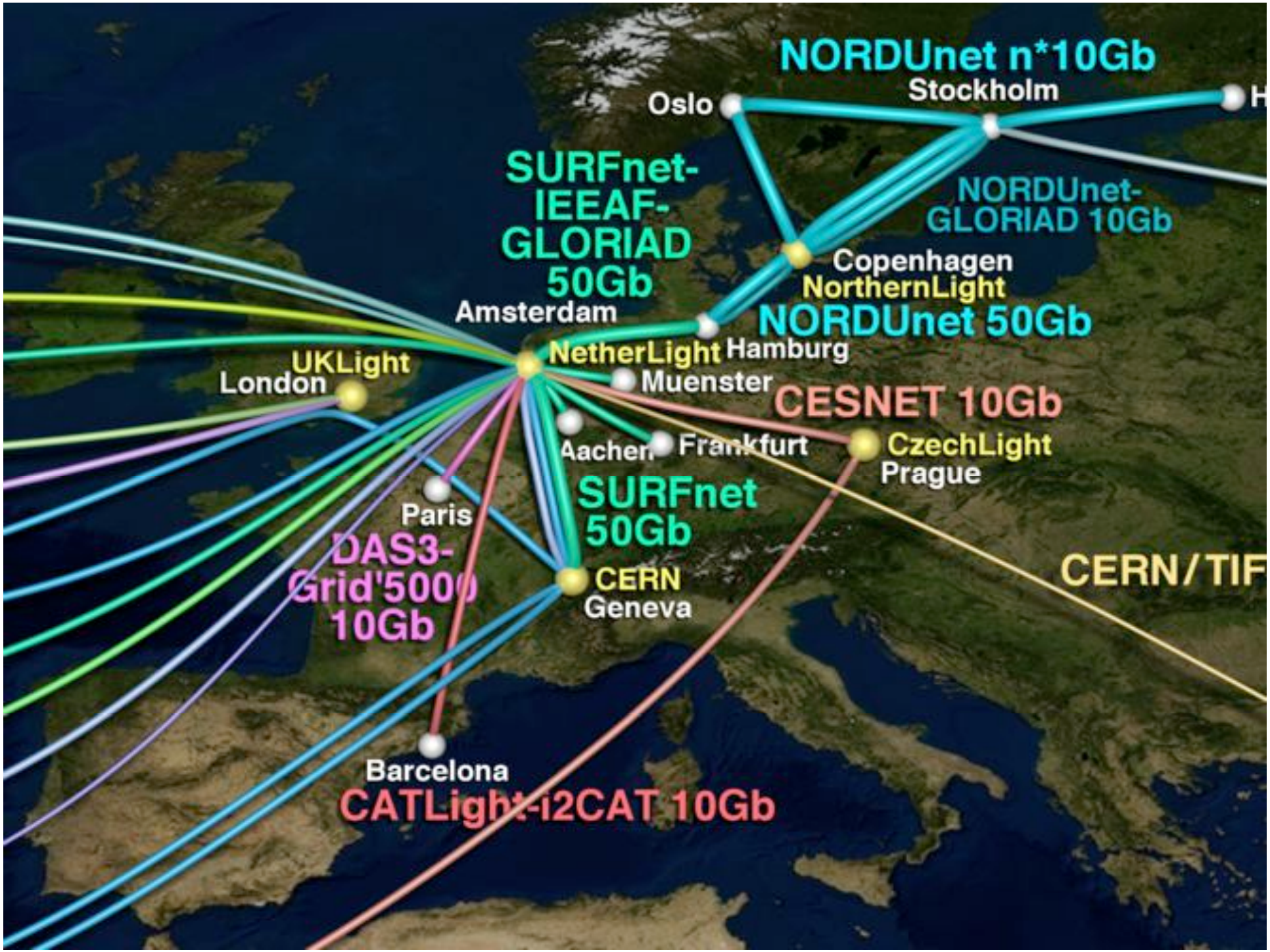
- **GLIF is an environment (networking infrastructure, network engineering, system integration, middleware, applications) to accomplish real work**

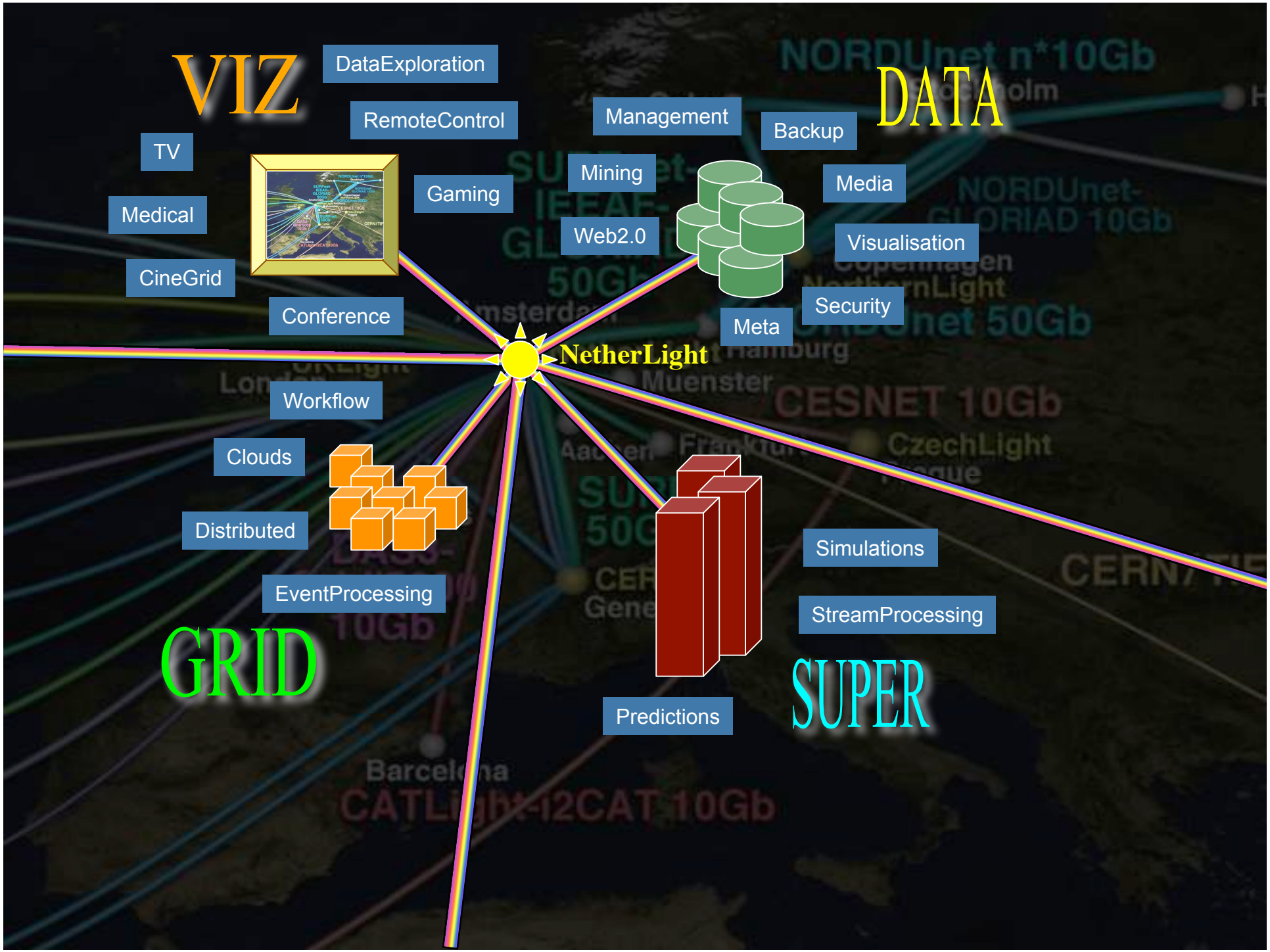


GLIF 2008

Visualization courtesy of Bob Patterson, NCSA
Data collection by Maxine Brown.

CENIC Connects to 10Gb Research and Education Networks Nationwide and Worldwide


NORDUnet n*10Gb
Stockholm
Oslo
SURFnet-
IEEAF-
GLORIAD
50Gb
NORDUnet-
GLORIAD 10Gb
Copenhagen
NorthernLight
NORDUnet 50Gb
Amsterdam
NetherLight
Hamburg
UKLight
London
Muenster
CESNET 10Gb
Aachen
Frankfurt
CzechLight
Prague
SURFnet
50Gb
Paris
DAS3-
Grid'5000
10Gb
CERN
Geneva
CERN/TIF
Barcelona
CATLight-i2CAT 10Gb


VIZ
DataExploration
RemoteControl
TV
Medical
CineGrid
Conference
Gaming
DATA
Management
Backup
Mining
Media
Web2.0
Visualisation
Security
Meta
NetherLight
Workflow
Clouds
Distributed
EventProcessing
GRID
Simulations
StreamProcessing
Predictions
SUPER

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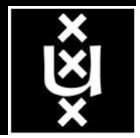
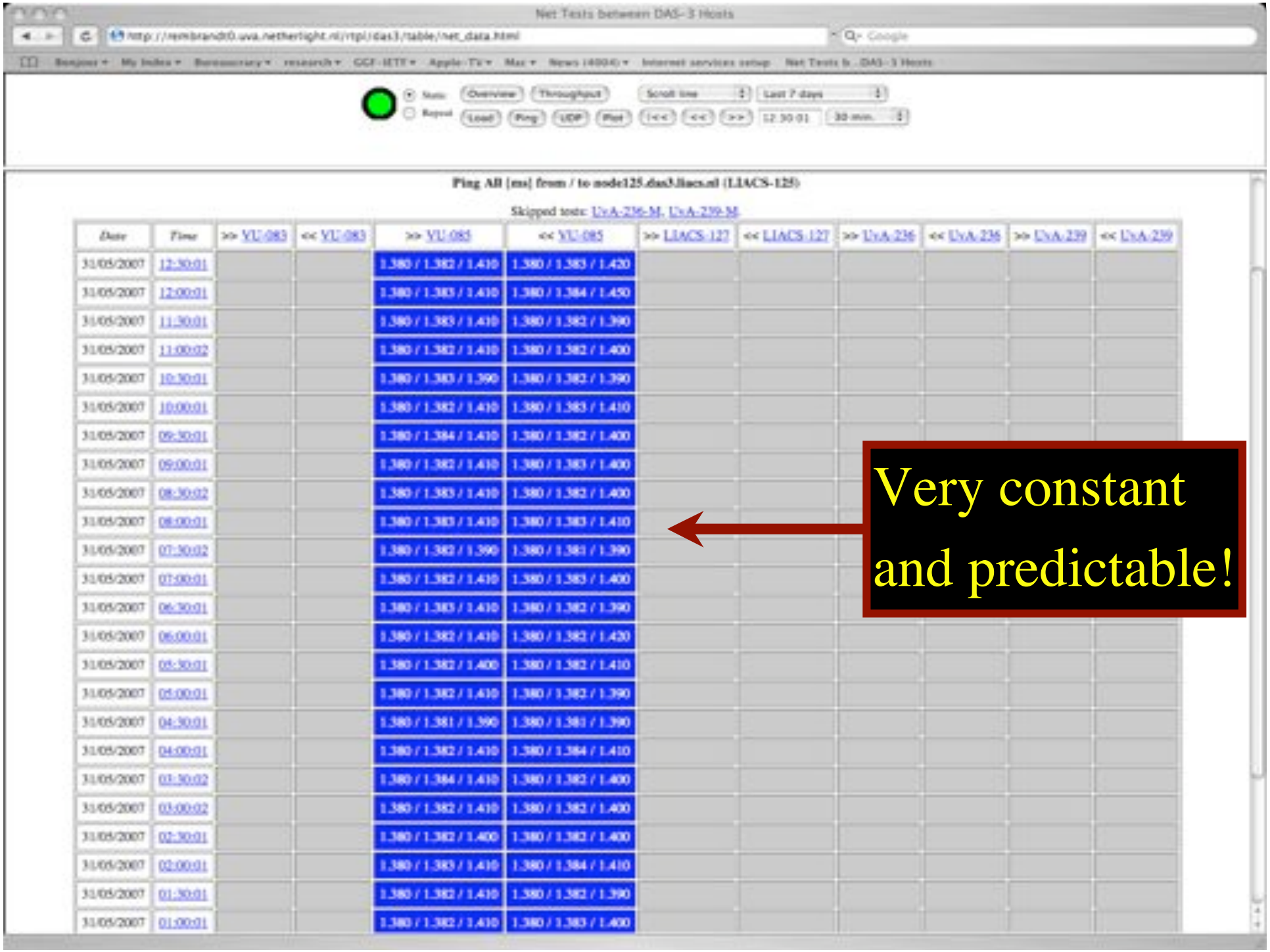
What is a LightPath

- A LightPath is a circuit like connection that connects end systems to each other. This uses usually the same infrastructure as the Internet, but a LightPath gets dedicated resources next to Internet.
- A LightPath can be a combination of:
  - A color in a fiber (Lambda)
  - Sonet/sdh circuit in a sonet infrastructure
  - Vlans and dedicated ports in an ethernet switch
  - Etc.
- Aim is to get predictable and knowable connection characteristics
- Let us look at examples setups used recently!





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31/05/2007	12:30:01			1.380 / 1.382 / 1.410	1.380 / 1.383 / 1.420						
31/05/2007	12:00:01			1.380 / 1.383 / 1.410	1.380 / 1.384 / 1.450						
31/05/2007	11:30:01			1.380 / 1.383 / 1.410	1.380 / 1.382 / 1.390						
31/05/2007	11:00:02			1.380 / 1.382 / 1.410	1.380 / 1.382 / 1.400						
31/05/2007	10:30:01			1.380 / 1.383 / 1.390	1.380 / 1.382 / 1.390						
31/05/2007	10:00:01			1.380 / 1.382 / 1.410	1.380 / 1.383 / 1.410						
31/05/2007	09:30:01			1.380 / 1.384 / 1.410	1.380 / 1.382 / 1.400						
31/05/2007	09:00:01			1.380 / 1.382 / 1.410	1.380 / 1.383 / 1.400						
31/05/2007	08:30:02			1.380 / 1.383 / 1.410	1.380 / 1.382 / 1.400						
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31/05/2007	07:30:02			1.380 / 1.382 / 1.390	1.380 / 1.381 / 1.390						
31/05/2007	07:00:01			1.380 / 1.382 / 1.410	1.380 / 1.383 / 1.400						
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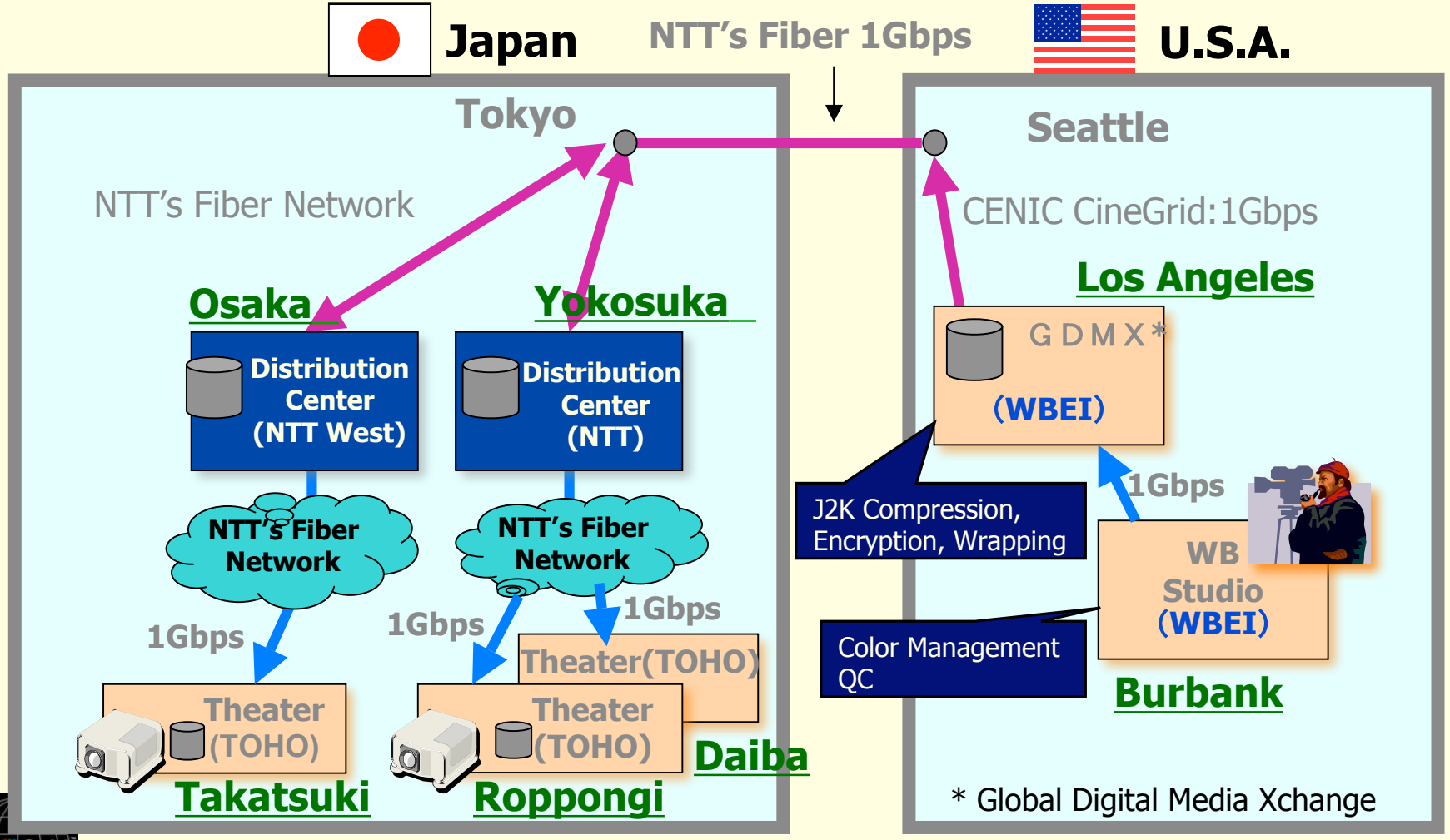
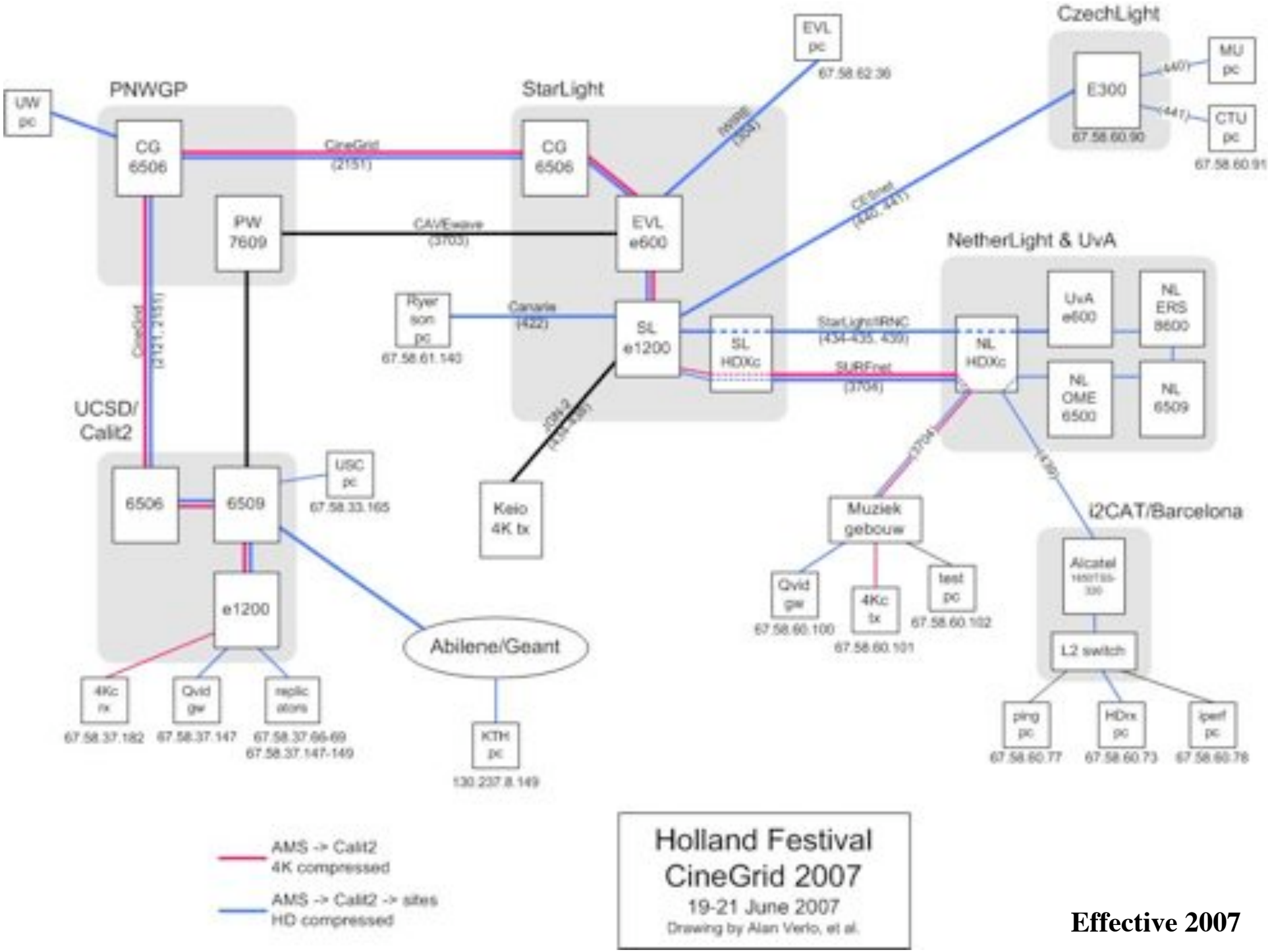
31/05/2007	05:30:01			1.380 / 1.382 / 1.400	1.380 / 1.382 / 1.410						
31/05/2007	05:00:01			1.380 / 1.382 / 1.410	1.380 / 1.382 / 1.390						
31/05/2007	04:30:01			1.380 / 1.381 / 1.390	1.380 / 1.381 / 1.390						
31/05/2007	04:00:01			1.380 / 1.382 / 1.410	1.380 / 1.384 / 1.410						
31/05/2007	03:30:02			1.380 / 1.384 / 1.410	1.380 / 1.382 / 1.400						
31/05/2007	03:00:02			1.380 / 1.382 / 1.410	1.380 / 1.382 / 1.400						
31/05/2007	02:30:01			1.380 / 1.382 / 1.400	1.380 / 1.382 / 1.400						
31/05/2007	02:00:01			1.380 / 1.383 / 1.410	1.380 / 1.384 / 1.410						
31/05/2007	01:30:01			1.380 / 1.382 / 1.410	1.380 / 1.382 / 1.390						
31/05/2007	01:00:01			1.380 / 1.382 / 1.410	1.380 / 1.383 / 1.400						

Network for “4K Pure Cinema” Trial

DCP is directly transferred from GDMX in LA to distribution centers in Japan via fiber network. Within Japan, DCP is distributed from the distribution centers to TOHO theaters. Key is distributed from Osaka center, based on the contract between WB Japan and TOHO cinemas.

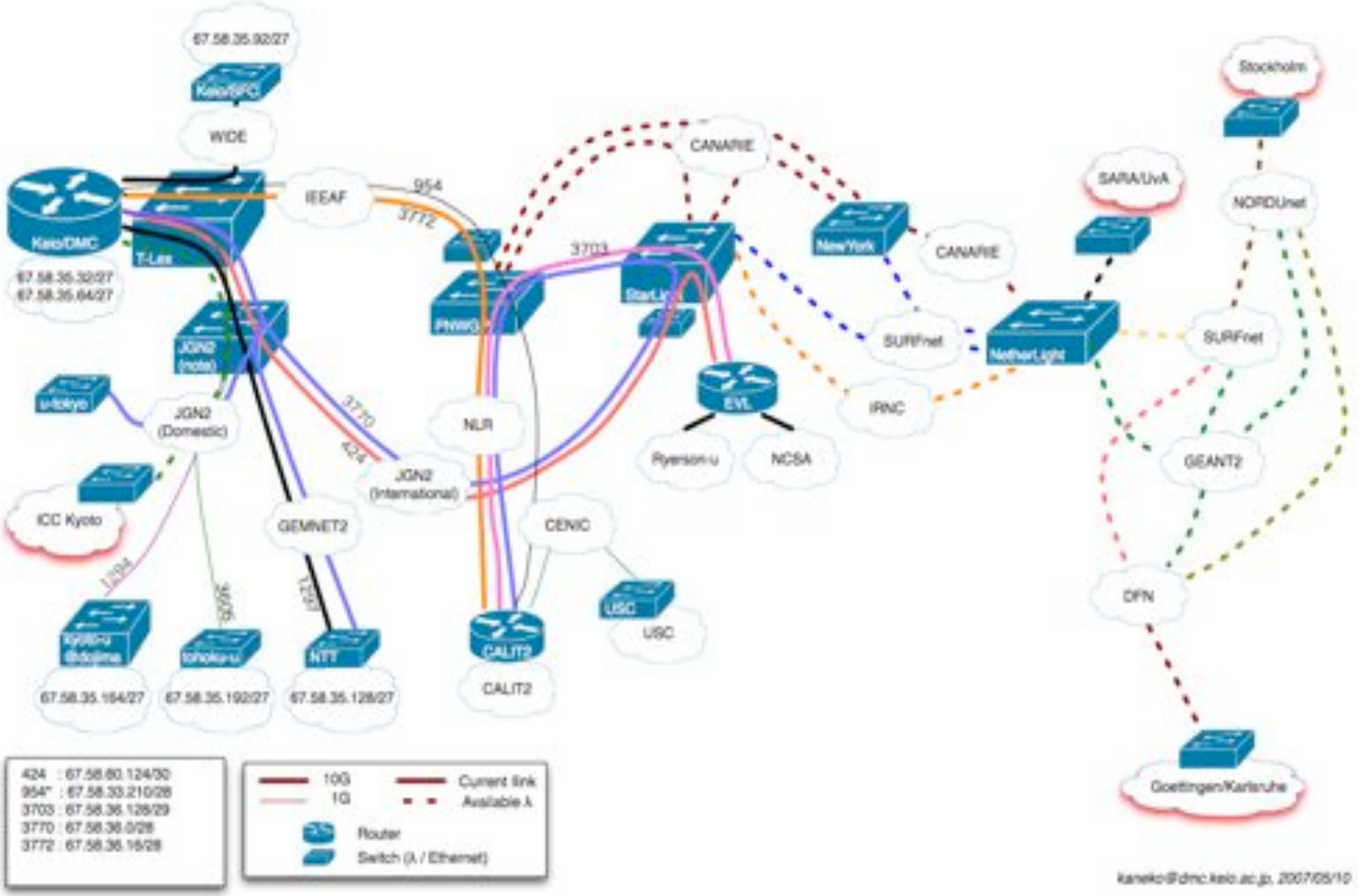


Effective 2005 - 2007



Effective 2007

Current Links & Available Links for Kyoto Prize Events



kaneko@dmc.keio.ac.jp, 2007/05/10

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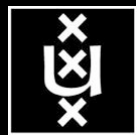
Internet Transport Protocols

- IP = Internet Protocol
  - Connectionless packet transport service
  - Datagrams of max 64 kByte
  - Can be fragmented down the way
  - Packets can get lost, duplicated or out of order!
- TCP/IP = Transmission Control Protocol
  - Reliable byte-stream over potentially unreliable packet service
  - Connection oriented, exactly once and in order, end to end duplex
- UDP = User Datagram Protocol
  - Packet service up to 64 kByte
  - Connectionless, unidirectional, L2 switches may start flooding
  - Unreliable delivery, can get out of order, duplicated, lost



Flow control vs Congestion control

- Flow control
  - To prevent a fast sender overflowing a slow receiver
  - Receiver signals sender so it can adapt
- Congestion control
  - Traffic jams in the Internet: packets may get lost
  - For TCP protocol control loops via ack's and ICMP packets
  - TCP is friendly protocol, can adapt but performance usually takes severe hit
  - RTT is reaction and recovery time

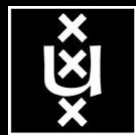
Windows and buffering for reliable protocols

- Round Trip Time (rtt) is time it takes to send a shortest message and get the answer back (unix tool ping)
- That is the shortest time the sender can know that traffic arrived at the other end
- Sender can only discard old data after receiving ack's
- Lightspeed in fiber = 200000 km/s
- 100 km = 200 km round trip = 1/1000 sec = 1 ms rtt
  - Amsterdam - Geneve ≈ 20 ms
  - Amsterdam - Chicago ≈ 90 ms
  - Amsterdam - San Diego ≈ 160 ms
  - Amsterdam - Tokyo ≈ 250 ms
  - Amsterdam - Sydney ≈ 300 ms

Buffer space

Window = RTT * BW

RTT	100 Mbit/s	1 Gbit/s	10 Gbit/s
1	12.5 kB	125 kB	1.25 MB
2	25 kB	250 kB	2.5 MB
5	62.5 kB	615 kB	6.15 MB
10	125 kB	1.25 MB	12.5 MB
20	250 kB	2.5 MB	25 MB
50	625 kB	6.25 MB	62.5 MB
100	1.25 MB	12.5 MB	125 MB
200	2.5 MB	25 MB	250 MB
500	6.25 MB	62.5 MB	625 MB
1000	12.5 MB	125 MB	1250 MB

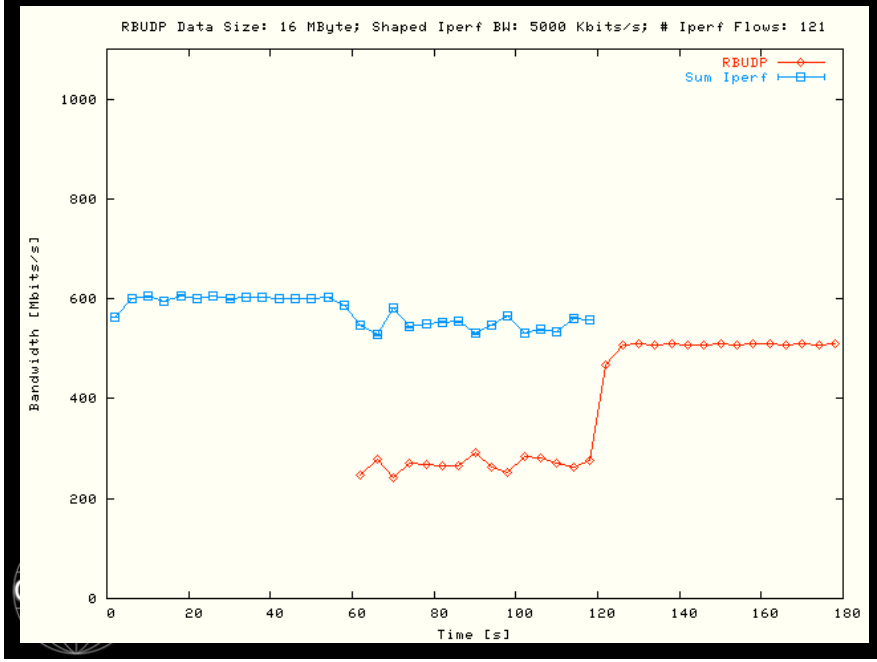


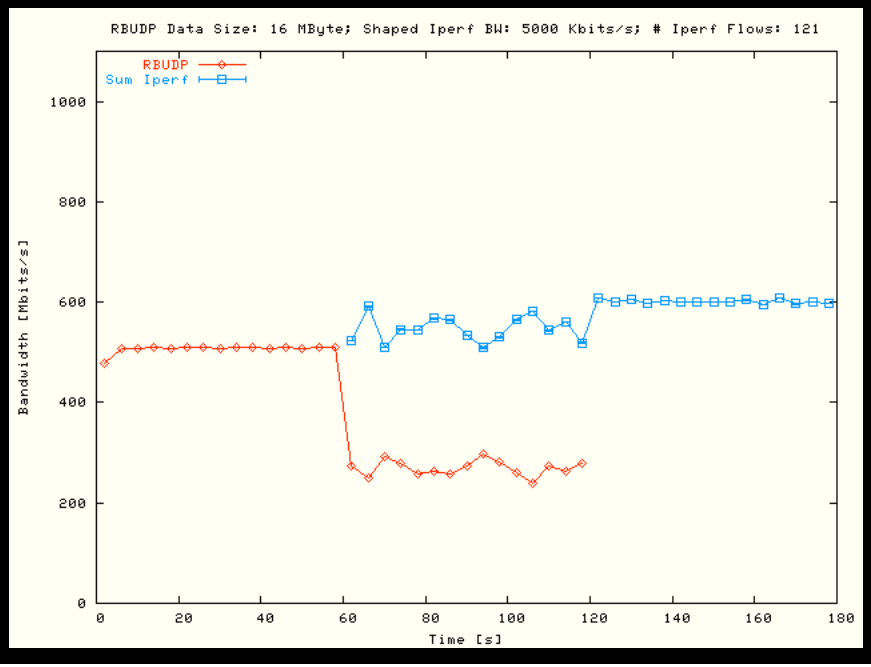
TCP Tuning (if not auto-tuning)

- 1 Gbit/s on 160 ms RTT (= Amsterdam - San Diego) :
  - sysctl -w kern.ipc.maxsockbuf=50000000
  - sysctl -w net.inet.tcp.sendspace=21000000
  - sysctl -w net.inet.tcp.recvspace=21000000
  - sysctl -w net.inet.udp.maxdgram=57344
  - sysctl -w net.inet.udp.recvspace=74848
  - sysctl -w net.local.stream.sendspace=32768
  - sysctl -w net.local.stream.recvspace=32768
  - sysctl -w kern.ipc.somaxconn=512
  - sysctl -w net.inet.tcp.mssdflt=1460
  - sysctl -w net.inet.tcp.delayed_ack=2
  - sysctl -w net.inet.tcp.rfc1323=1
  - sysctl -w net.inet.tcp.rfc1644=1
  - sysctl -w net.inet.tcp.newreno=1

Other issues & protocols

- When using UDP watch for bottleneck!
- About 10 other non standard protocols
- FAST TCP
  - Modified receiver algorithms
- RBUDP
  - Runs on top of UDP, simple back-off and retransmission scheme





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End System Issues

- Ethernet card interface to computer bus system
  - PCI-X
    - 32/64 bit 66/133/266 MHZ -> about 8 Gbit/s max in 133 MHZ mode
  - PCI-Express
    - 2.5 Gbit/s per lane, 4, 8, 16 lanes
- Memory organization
- CPU cache
  - Effect when things go out of cache (small windows, etc.)
- CPU core
  - Takes 1 core to handle network (affinity may help)
- Disk raid subsystem
  - raid0 twice as fast as raid5
  - One disk does typically 40 MB/s write, 60 MB/s read

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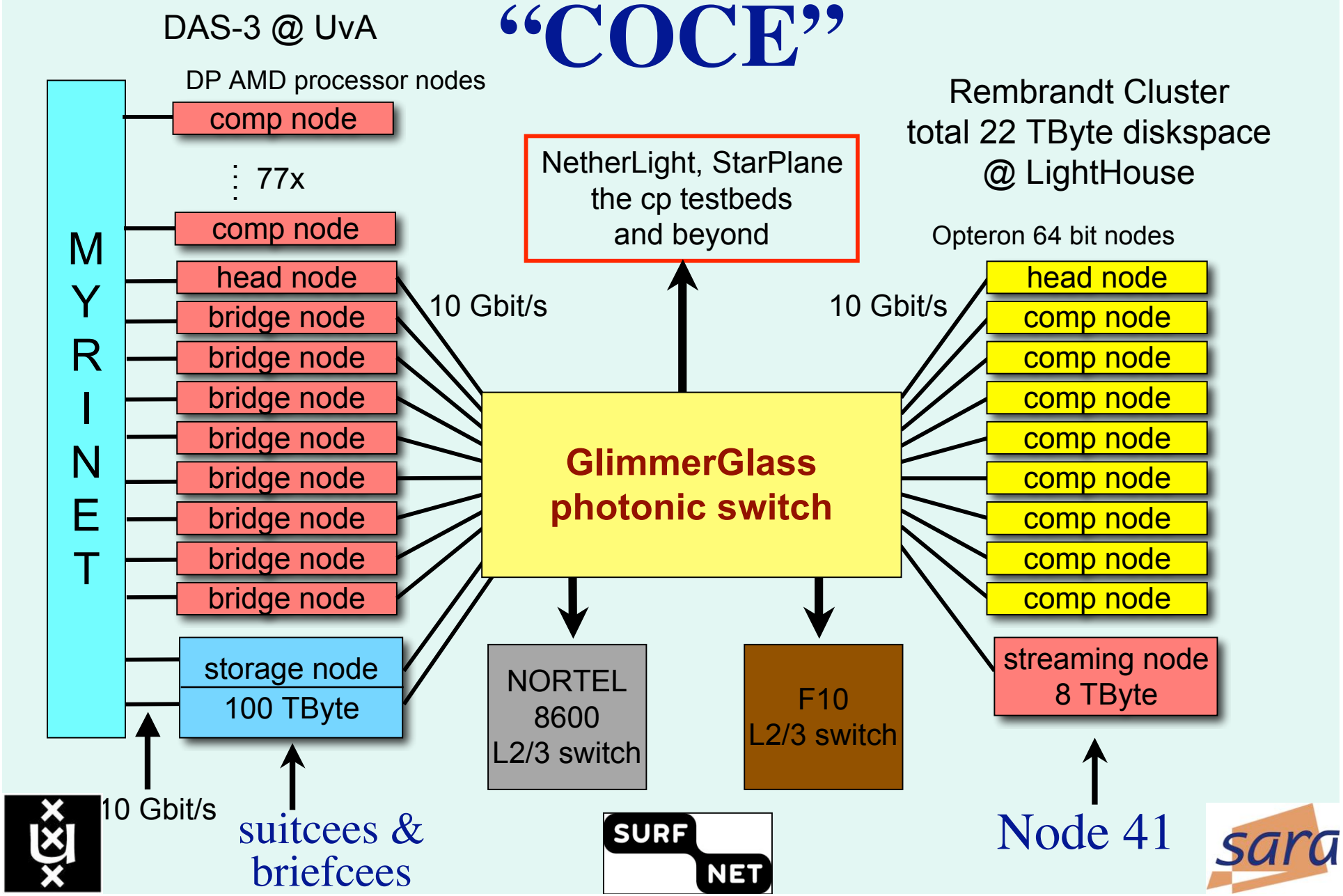
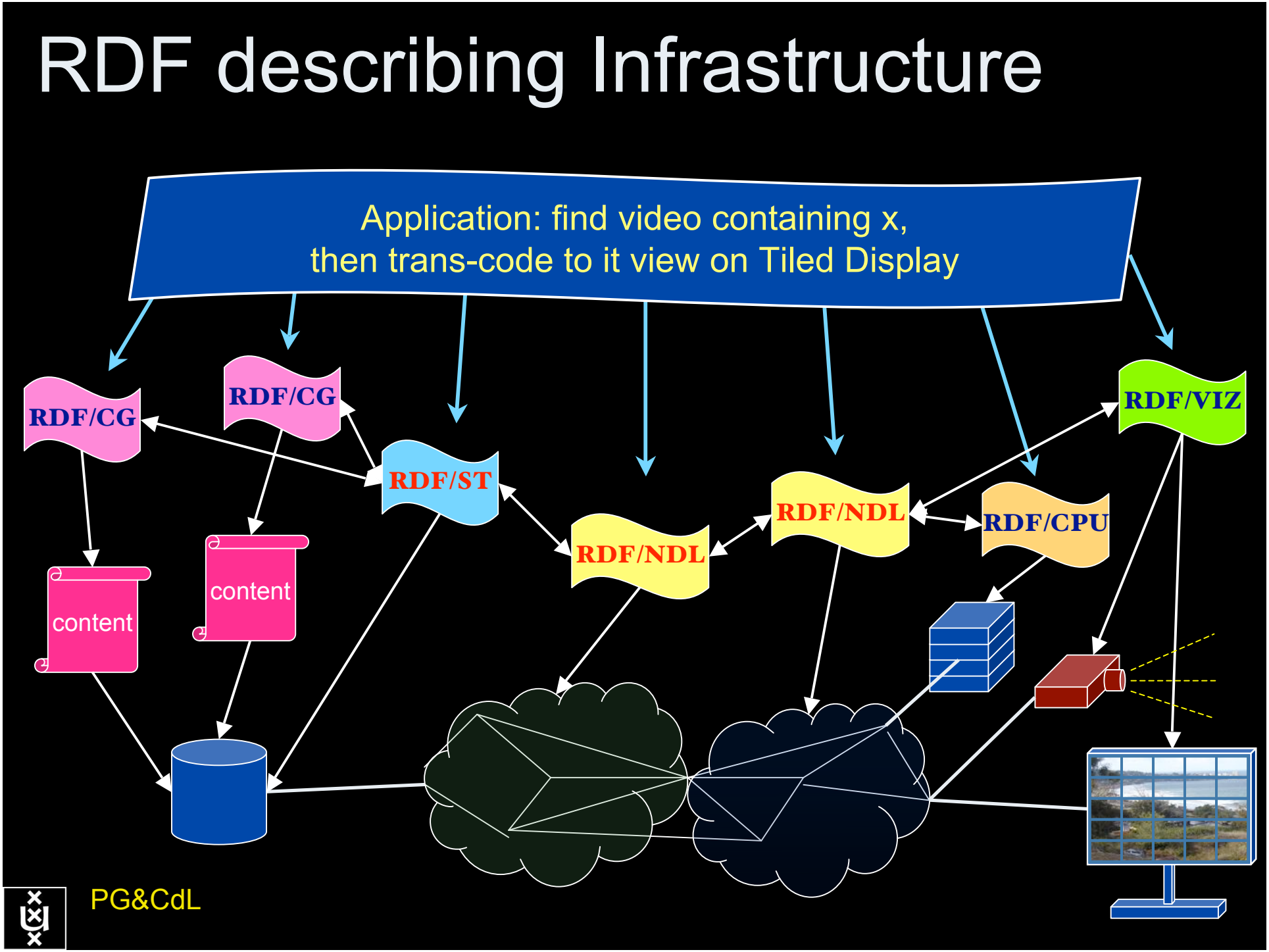
CineGrid Exchanges

- The Cinegrid community has 3 main exchanges
  - located in:
    - Tokyo at Keio University/DMC
    - Amsterdam at University of Amsterdam
    - San Diego at CALIT2
  - implemented as store and forward servers
  - connected by 10 Gbit/s lightpaths
  - capacities 20 - 100 TByte
  - for persisent store of content for experiments
  - streaming, workflows, processing, dubbing, etc.

Amsterdam CineGrid S/F node "COCE"



RDF describing Infrastructure



PG&CdL

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www.cinegrid.org
www.science.uva.nl/~delaat

Questions?