CineGrid Networking

Cees de Laat

University of Amsterdam

Contents

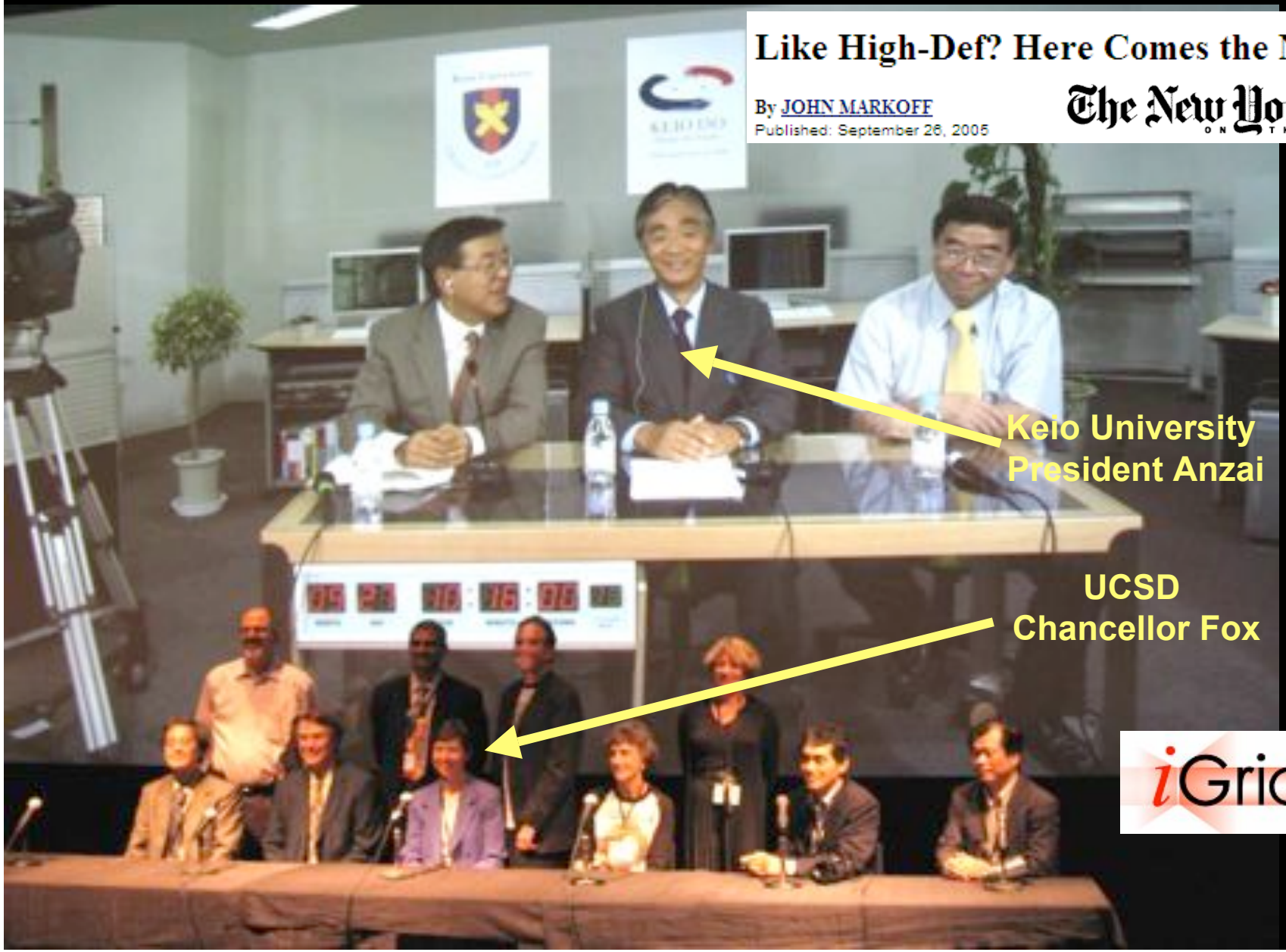
1. Use cases CineGrid & Networks
2. Formats - Numbers - Bits
3. Global Lambda Integrated Facility
4. A LightPath
5. Transport Protocol issues
6. End System Issues
7. Network Storage
8. Q/A

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

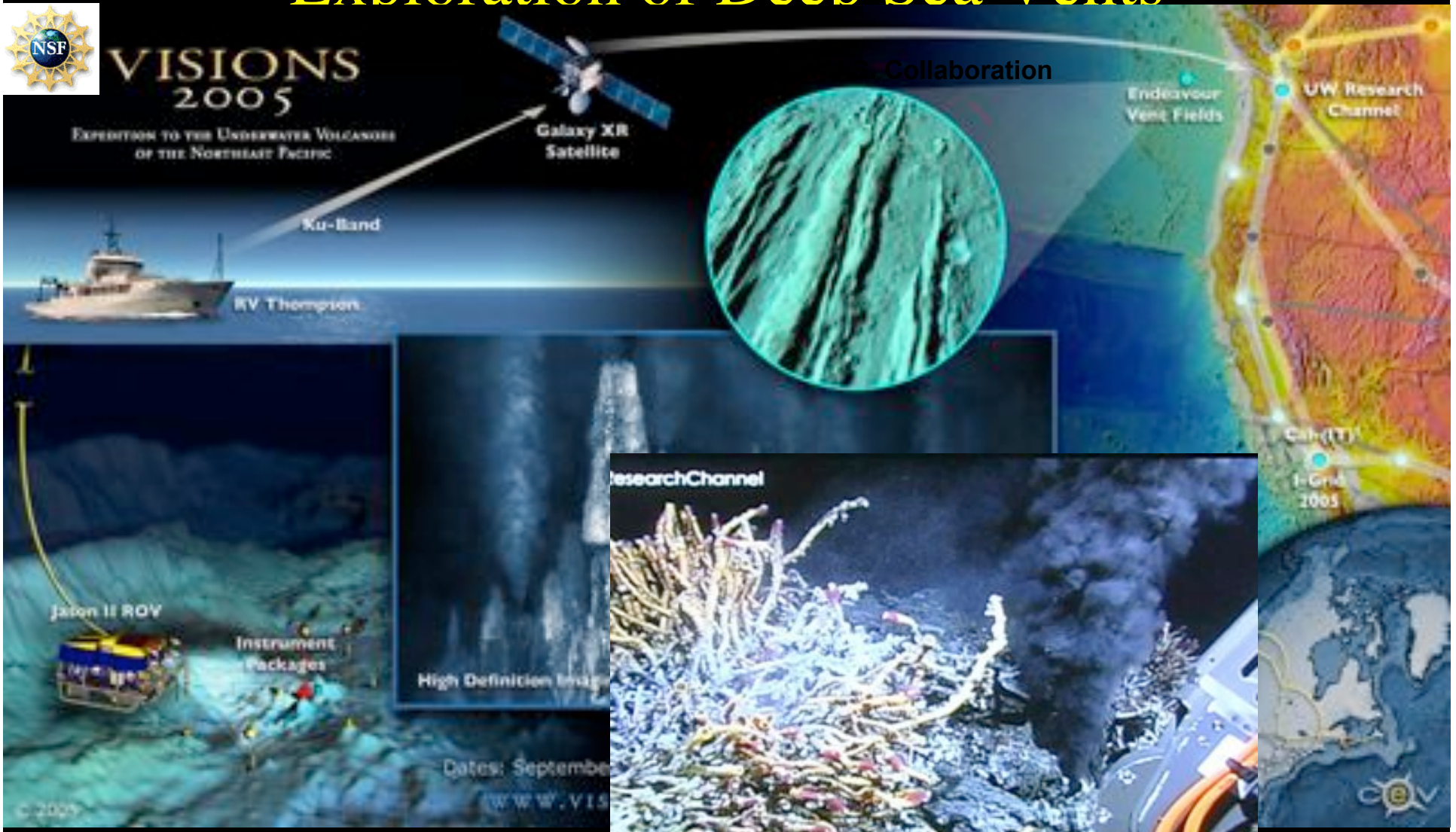
Used 1Gbps Dedicated

Sony NTT SGI

iGrid 2005

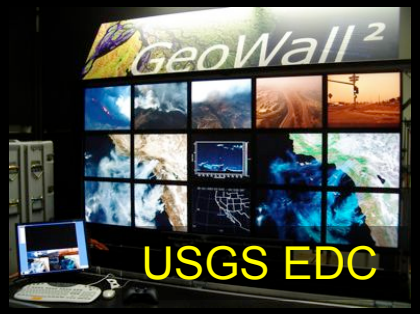
CineGrid@SARA

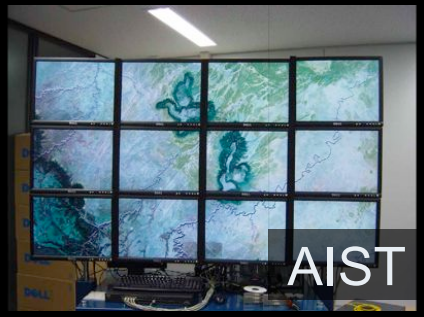
First Remote Interactive High Definition Video Exploration of Deep Sea Vents

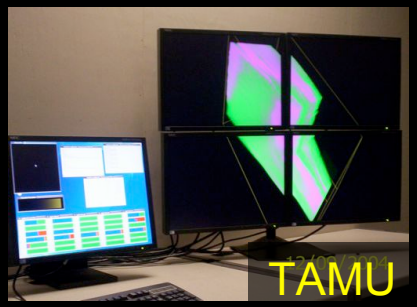


Source John Delaney & Deborah Kelley, UWash

US and International OptIPortal Sites







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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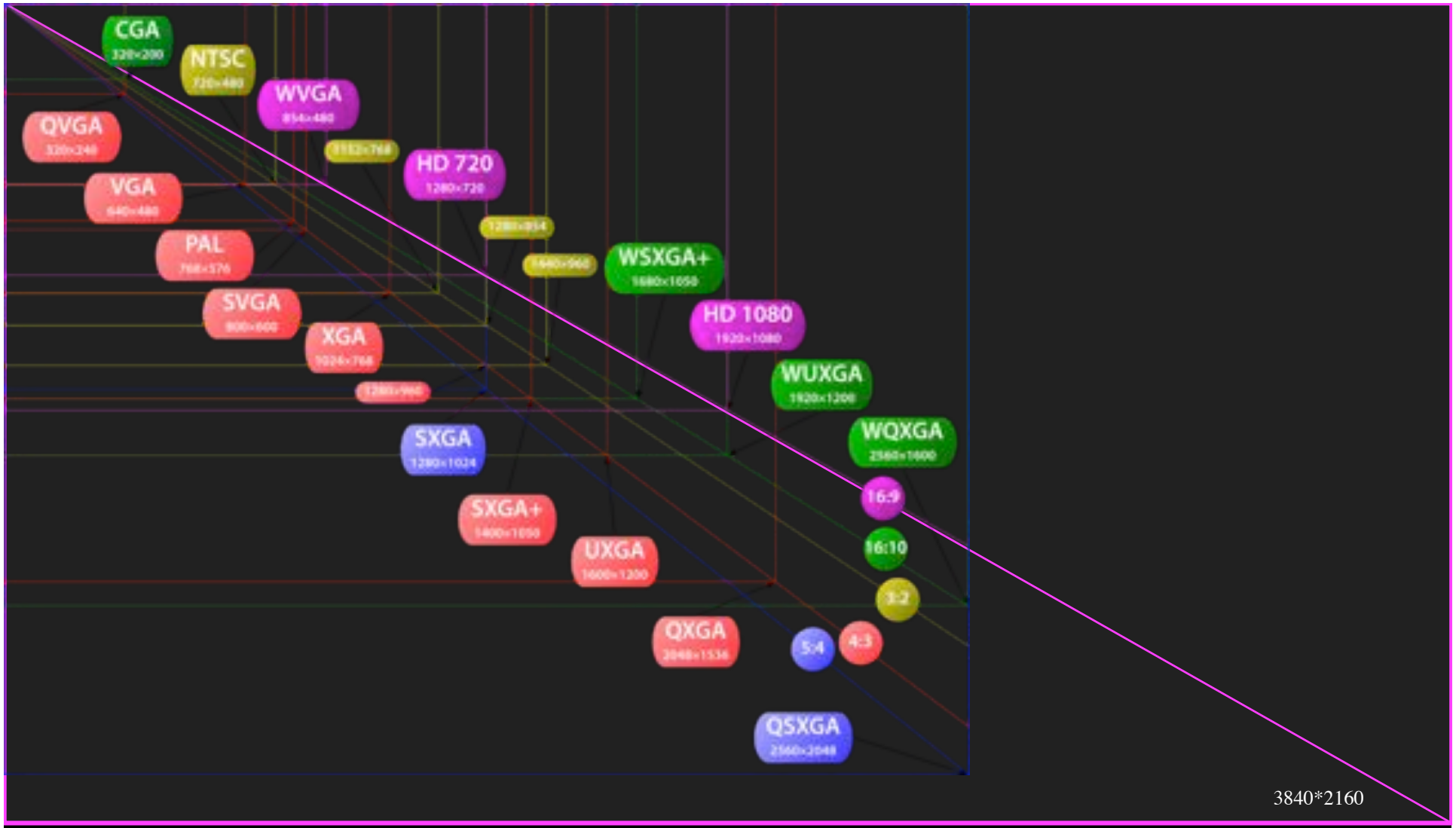

Formats - Numbers - Bits

Format - Numbers - Bits (examples!)

Format	X	Y	Rate	Color bits/pix	Frame pix	Frame MByte	Flow MByt/s	Stream Gbit/s
720p HD	1280	720	60	24	921600	2.8	170	1.3
1080p HD	1920	1080	30	24	2073600	6.2	190	1.5
2k	2048	1080	24/48	36	2211840	10	240 480	1.2 2.4
SHD	3840	2160	30	24	8294400	25	750	6.0
4k	4096	2160	24	36	8847360	40	960	7.6

Note: this is excluding sound!
Note: these are raw uncompressed data rates!

Formats - Numbers - Bits

- Formats:
  - uncompressed unreadable (UMF) — 3/4 GBytesec
  - compressed unreadable (jpeg2000) — 300 - 700 Mbit/s
  - uncompressed readable (eg TIFF) — 1.2 GB/s, 4.3 TB/h
  - compressed readable (eg DXT) — 300 - 800 Mbit/s
- Do not compress away the science!
- Storage
  - Holland festival taking uncompressed about 12 TByte

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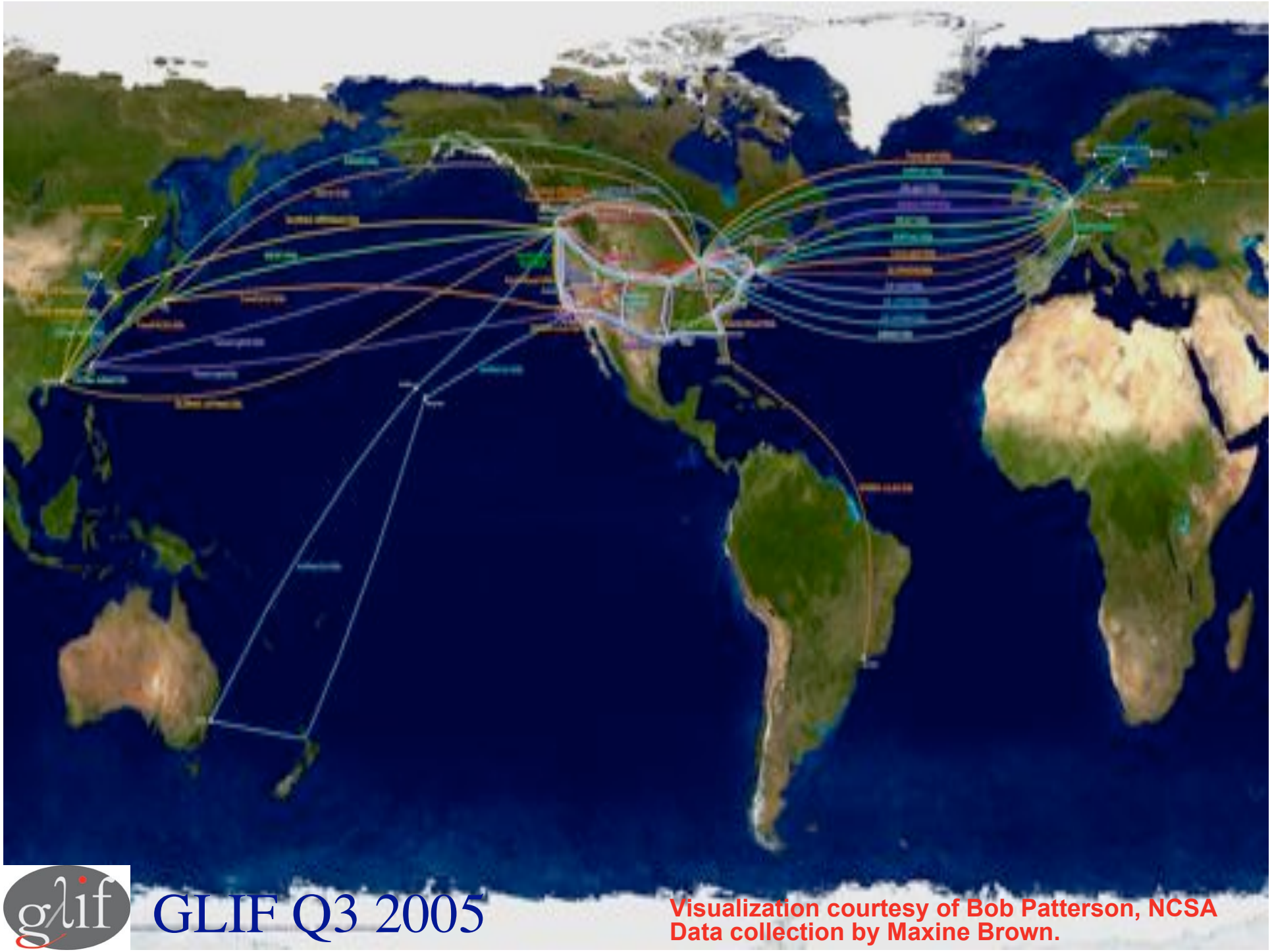
GLIF Mission Statement

- **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 Q3 2005

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

Calit2 is Partnering with CENIC to Connect California Industries and Researchers Into CineGrid

Partnering with SFSU's Institute for Next Generation Internet

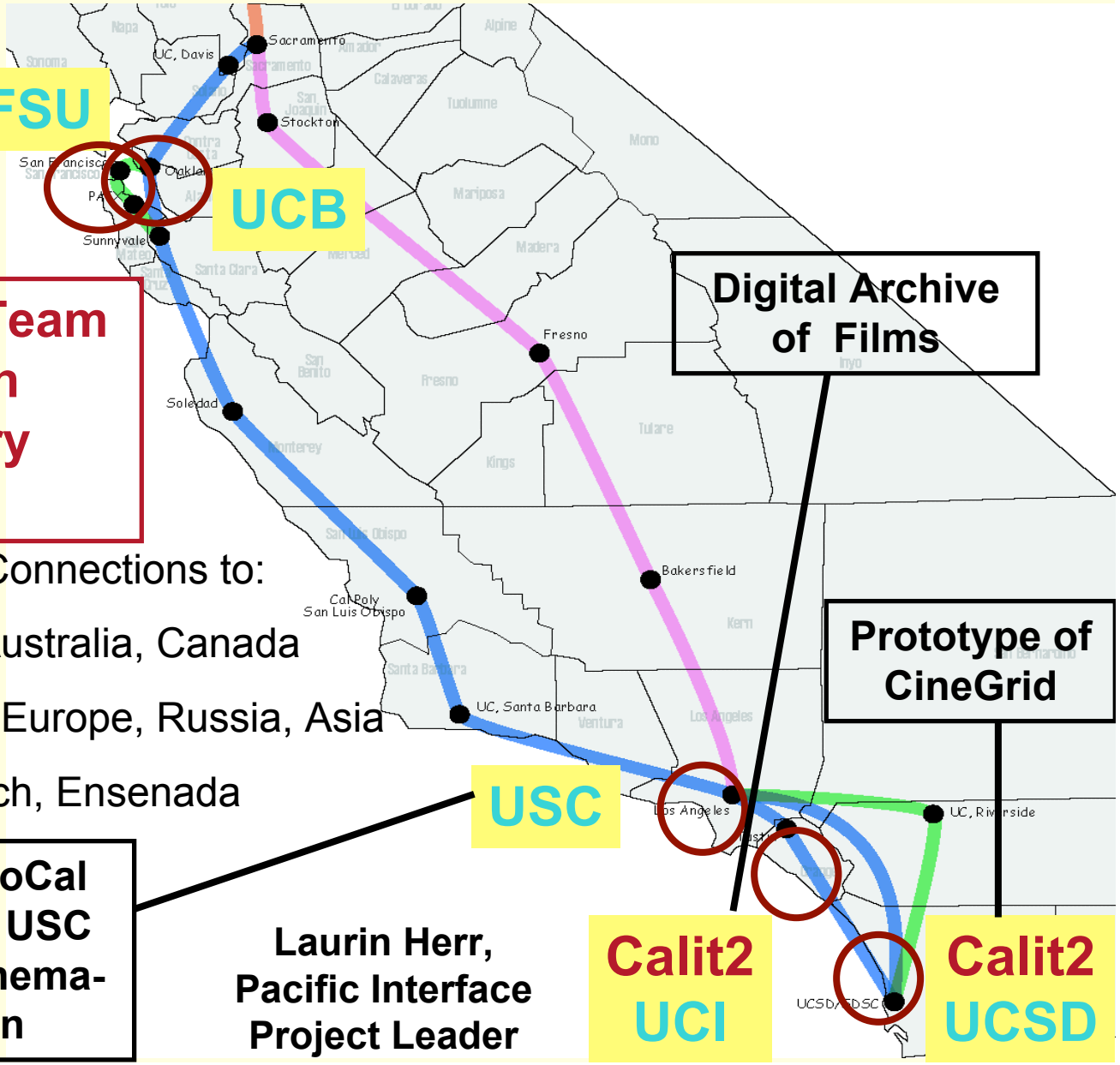
Calit2's CineGrid Team is Working with Cinema Industry in LA and SF

In addition, 1Gb and 10Gb Connections to:

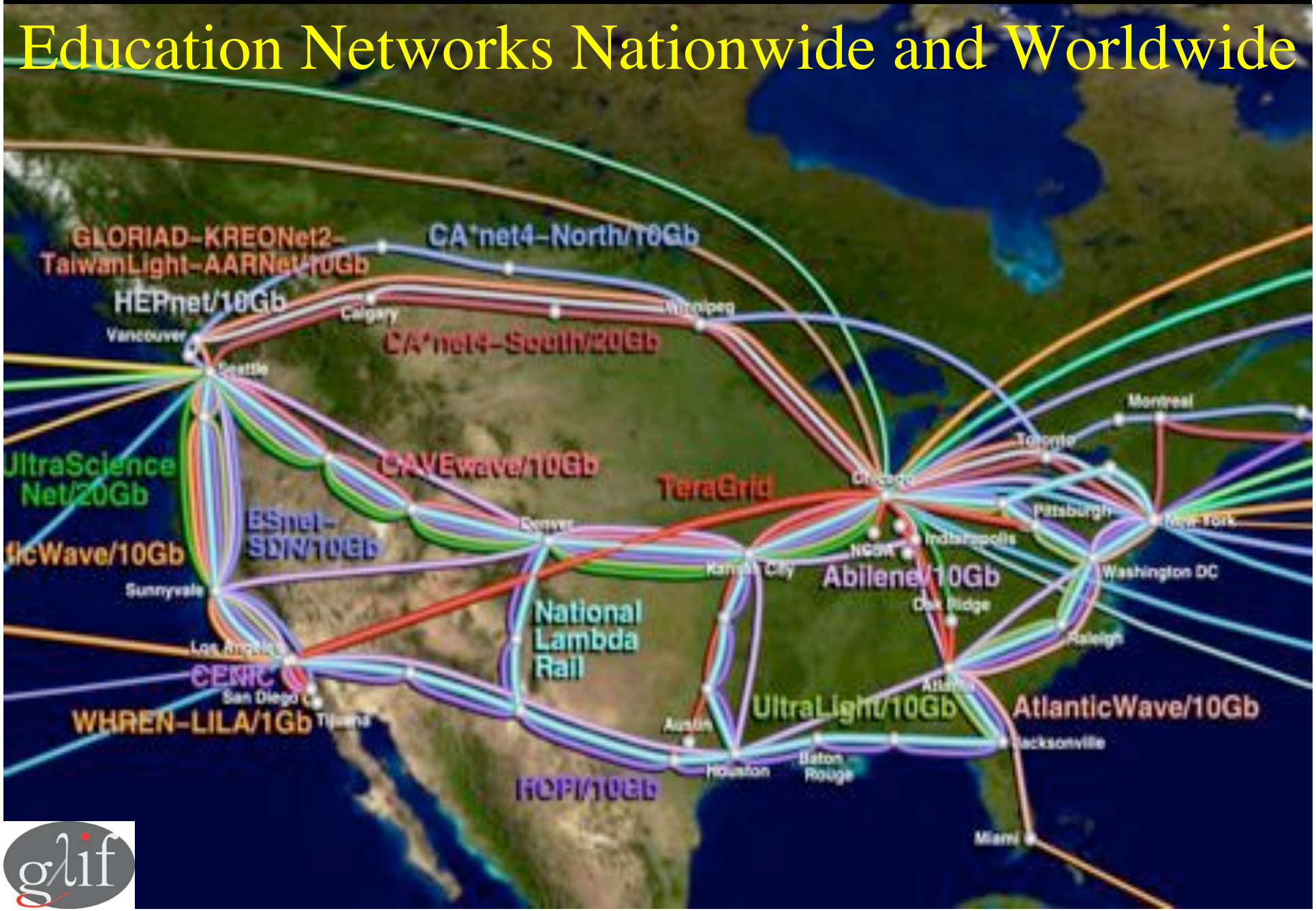
- Seattle then to Asia, Australia, Canada
- Chicago, Amsterdam, Europe, Russia, Asia
- Tijuana, Rosarita Beach, Ensenada

Extending SoCal OptIPuter to USC School of Cinema-Television

Laurin Herr, Pacific Interface Project Leader



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



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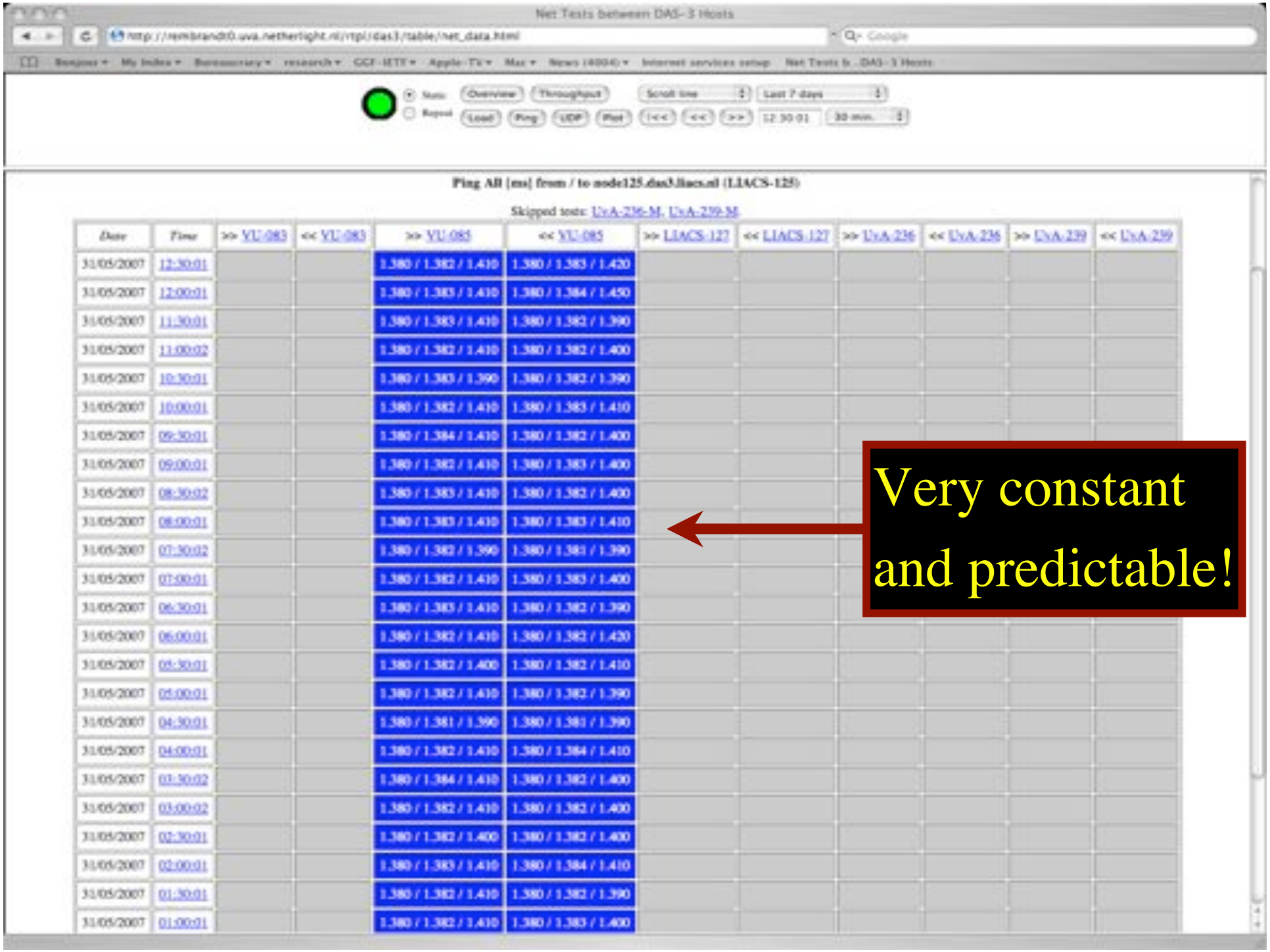
What is a LightPath

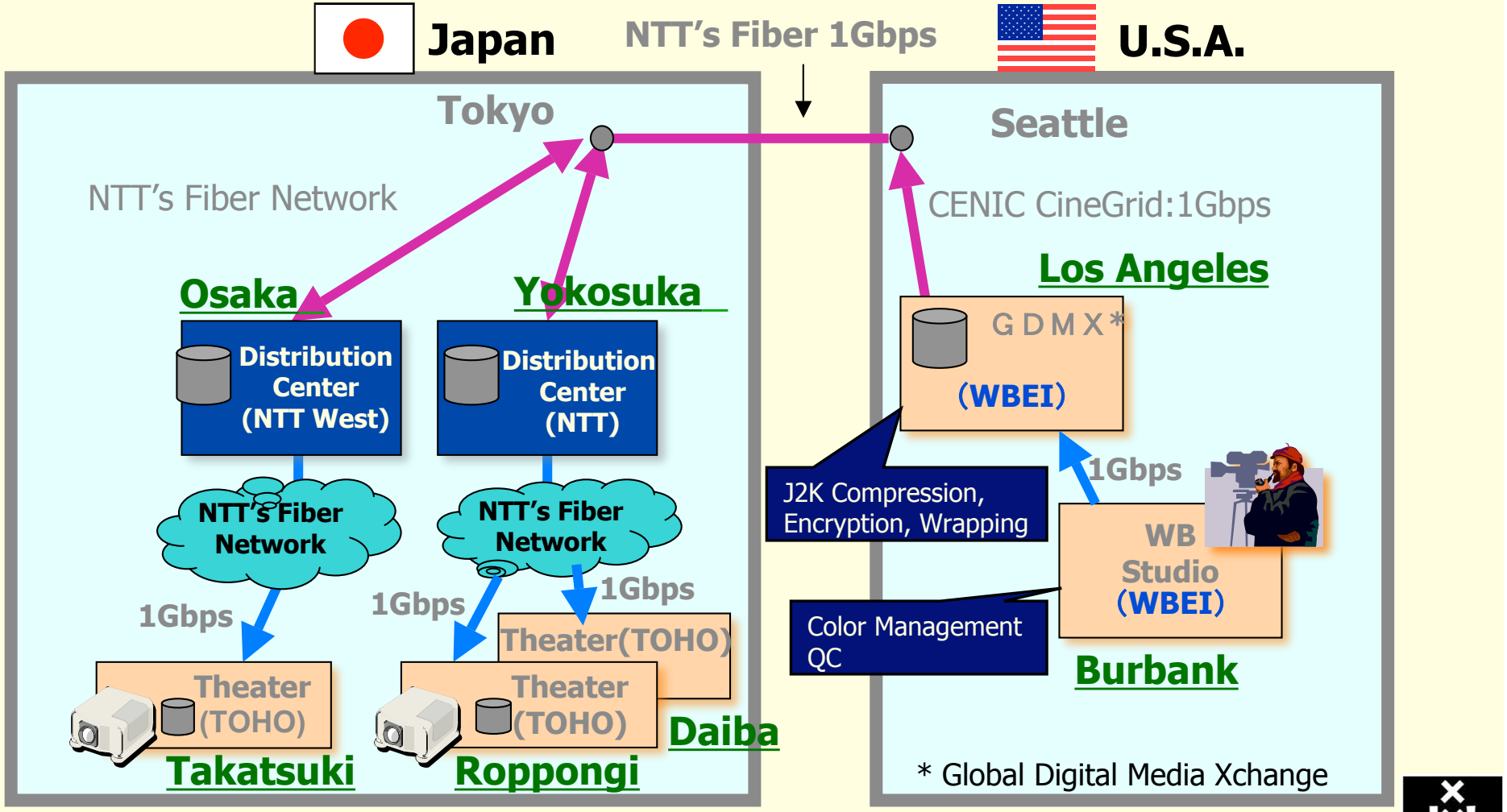
- A LightPath is a circuit like connection that connects end systems to each other. This uses usually the same infrastructure as the Internet, but a LightPath gets dedicated resources next to Internet.
- A LightPath can be a combination of:
  - A color in a fiber (Lambda)
  - Sonet/sdh circuit in a sonet 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!

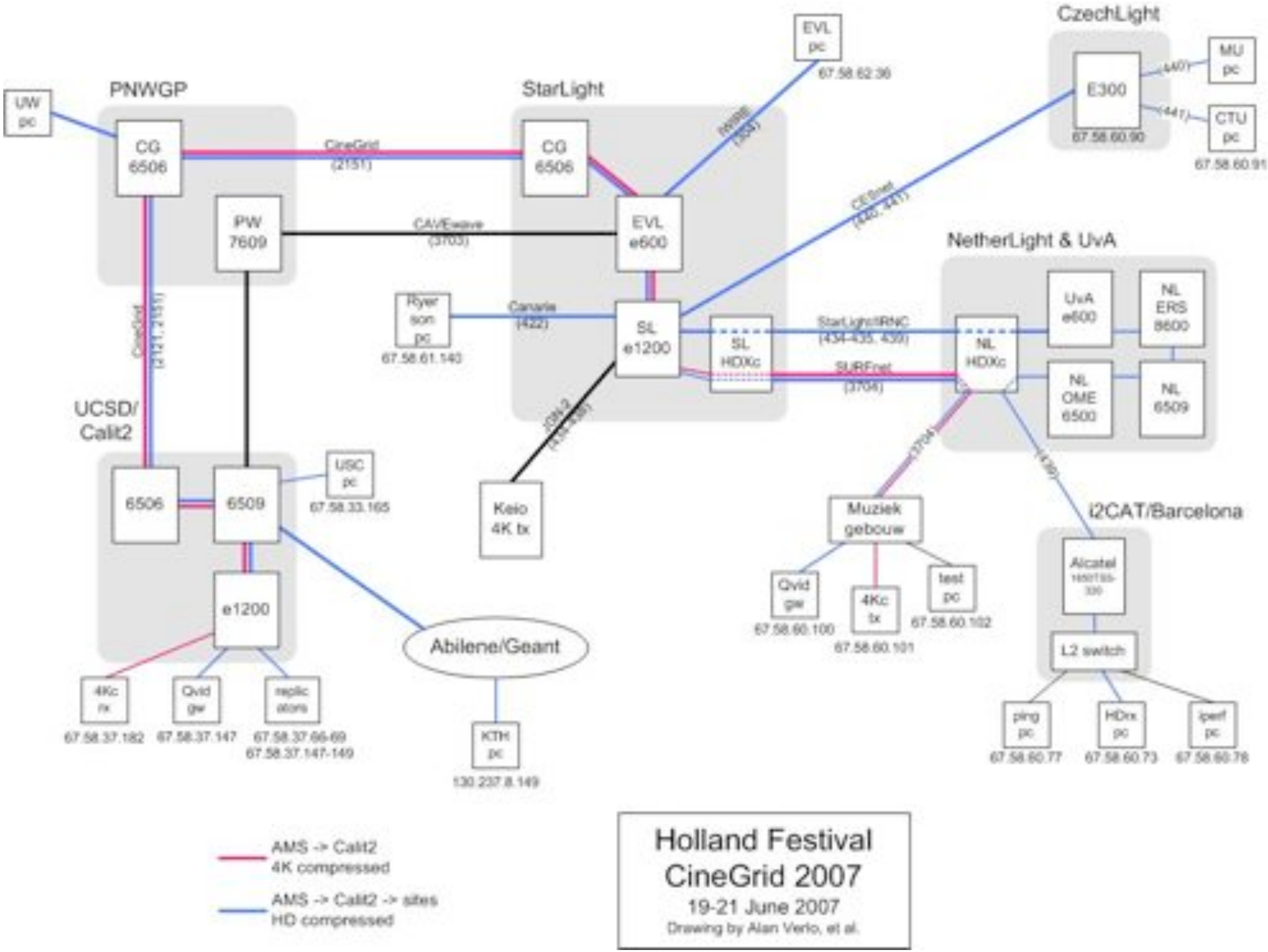


Date	Time	>> VU-083	<< VU-083	>> VU-085	<< VU-085	>> LIACS-127	<< LIACS-127	>> UvA-236	<< UvA-236	>> UvA-239	<< UvA-239
31/05/2007	12:30:01			1.380 / 1.382 / 1.410	1.380 / 1.383 / 1.420						
31/05/2007	12:00:01			1.380 / 1.383 / 1.410	1.380 / 1.384 / 1.450						
31/05/2007	11:30:01			1.380 / 1.383 / 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						
31/05/2007	08:00:01			1.380 / 1.383 / 1.410	1.380 / 1.383 / 1.410						
31/05/2007	07:30:02			1.380 / 1.382 / 1.390	1.380 / 1.383 / 1.390						
31/05/2007	07:00:01			1.380 / 1.382 / 1.410	1.380 / 1.383 / 1.400						
31/05/2007	06:30:01			1.380 / 1.383 / 1.410	1.380 / 1.382 / 1.390						
31/05/2007	06:00:01			1.380 / 1.382 / 1.410	1.380 / 1.382 / 1.420						
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						

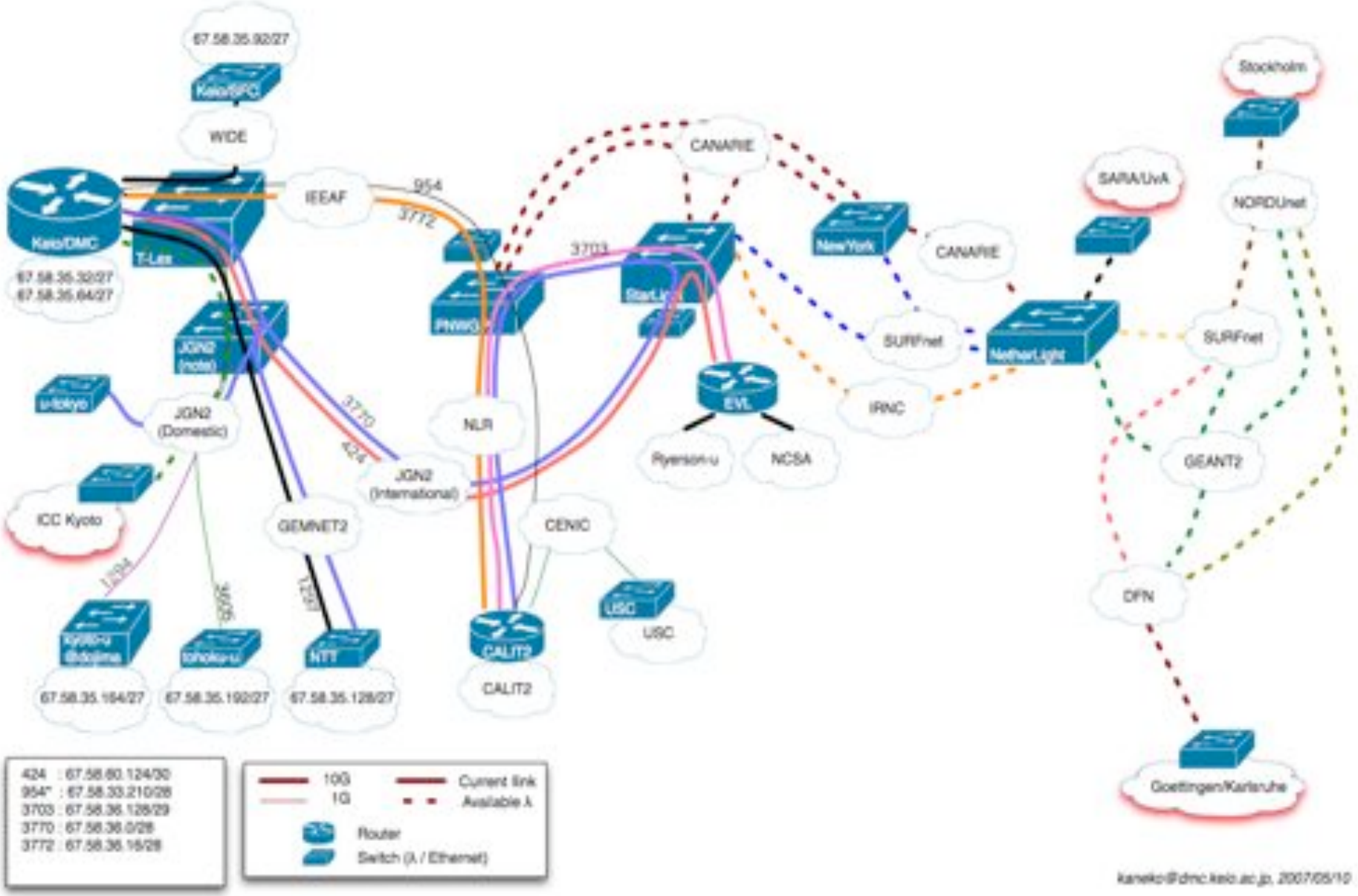
Network for “4K Pure Cinema” Trial

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.




PNWGP
UW pc
CG 6506
PW 7609
CineGrid (2151)
CineGrid (2121, 2151)
StarLight
CG 6506
EVL pc
67.58.62.36
EVL e600
SL e1200
SL HDXc
Ryerson pc
67.58.61.143
Canarie (422)
CAVEwave (3703)
Keio 4K tx
UCSD/ Calit2
6506
6509
USC pc
67.58.33.165
e1200
4Kc rx
67.58.37.182
Qvid gw
67.58.37.147
replic ators
67.58.37.66-69
67.58.37.147-149
Abilene/Geant
KTH pc
130.237.8.149
CzechLight
E300
67.58.60.90
MU pc
CTU pc
67.58.60.91
CESnet (440, 441)
NetherLight & UvA
NL HDXc
UvA e600
NL ERS 8600
NL OME 6500
NL 6509
StarLight/IRNC (434-435, 439)
SURFnet (3704)
Muziek gebouw
Qvid gw
67.58.60.100
4Kc tx
67.58.60.101
test pc
67.58.60.102
i2CAT/Barcelona
Alcatel
L2 switch
ping pc
67.58.60.77
HDrx pc
67.58.60.73
iperf pc
67.58.60.78
AMS -> Calit2
4K compressed
AMS -> Calit2 -> sites
HD compressed
Holland Festival
CineGrid 2007
19-21 June 2007
Drawing by Alan Verlo, et al.

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

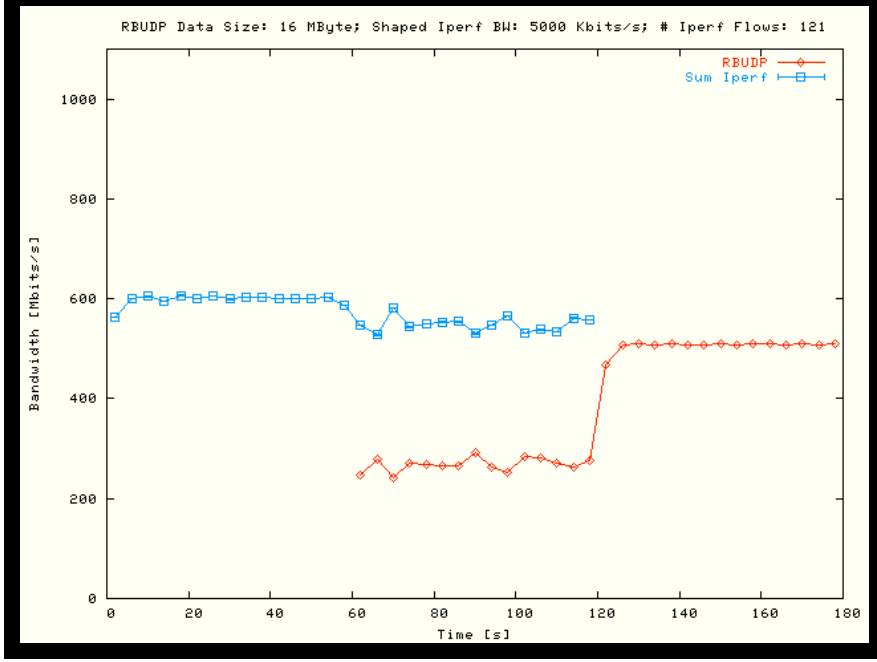
RTT	100 Mbit/s	1 Gbit/s	10 Gbit/s
1	12.5 kB	125 kB	1.25 MB
2	25 kB	250 kB	2.5 MB
5	62.5 kB	615 kB	6.15 MB
10	125 kB	1.25 MB	12.5 MB
20	250 kB	2.5 MB	25 MB
50	625 kB	6.25 MB	62.5 MB
100	1.25 MB	12.5 MB	125 MB
200	2.5 MB	25 MB	250 MB
500	6.25 MB	62.5 MB	625 MB
1000	12.5 MB	125 MB	1250 MB

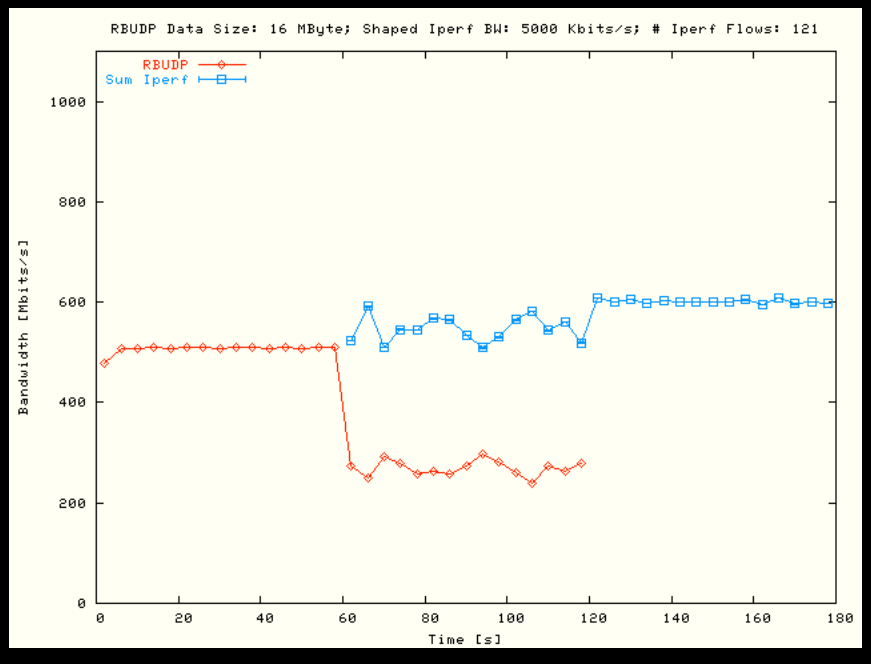
TCP Tuning (if not auto-tuning)

- 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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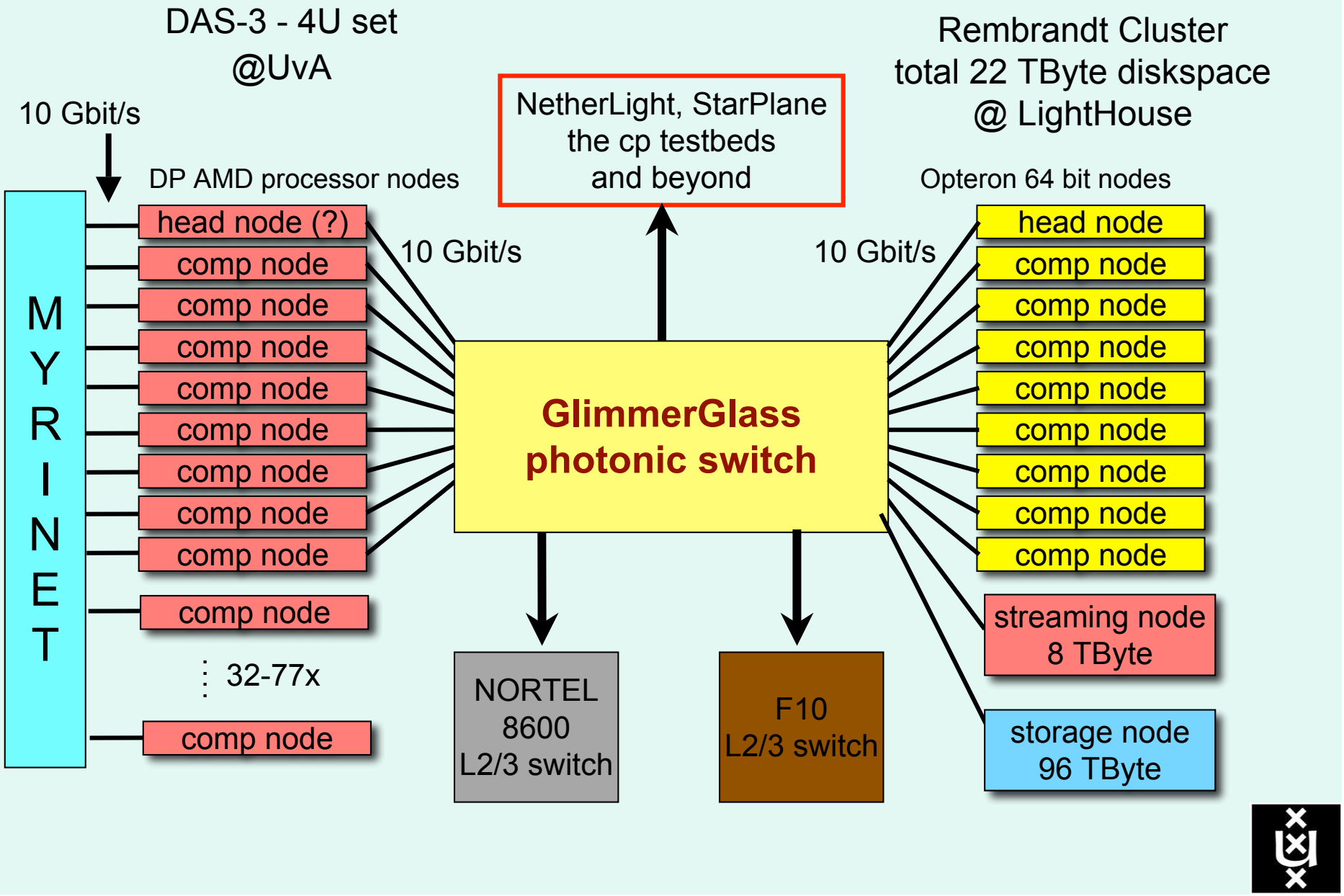
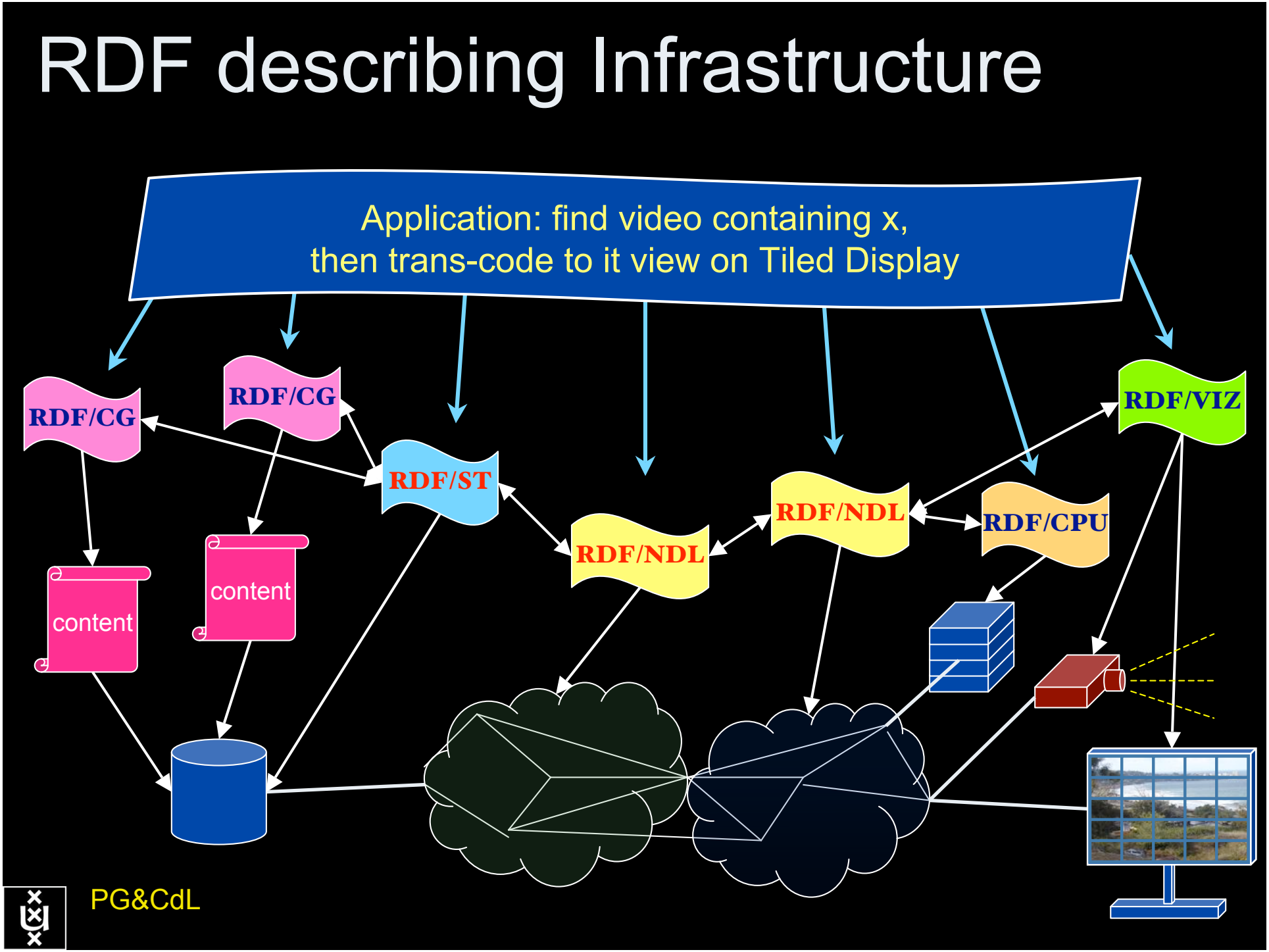
Amsterdam CineGrid S/F node



RDF describing Infrastructure



PG&CdL

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Questions ?

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