CineGrid @ GLIF 2008

Building a New User Community for Very High Quality Media Applications On Very High Speed Networks

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CineGrid Founding Members

- Cisco Systems
- Keio University DMC
- Lucasfilm Ltd.
- NTT Network Innovation Laboratories
- Pacific Interface Inc.
- Ryerson University/Rogers Communications Centre
- San Francisco State University/INGI
- Sony Electronics America
- University of Amsterdam
- University of California San Diego/Calit2/CRCA
- University of Illinois at Urbana-Champaign/NCSA
- University of Illinois Chicago/EVL
- University of Southern California, School of Cinematic Arts
- University of Washington/Research Channel

CineGrid Institutional Members

- California Academy of Sciences
- Cinepost, ACE Prague
- Dark Strand
- i2CAT
- JVC America
- Korea Advanced Institute of Science and Technology (KAIST)
- Louisiana State University, Center for Com and Tech
- Mechdyne
- Meyer Sound Laboratories
- Nortel Networks
- Renaissance Computing Initiative (RENCI)
- SARA
- Sharp Corporation Japan
- Sharp Labs USA
- Swedish Royal Institute of Technology
- Tohoku University/Kawamata Lab
- Waag Society

CineGrid Network/Exchange Members

- CANARIE
- CENIC
- CESNET
- CzechLight
- Internet 2
- JANET
- Japan Gigabit Network 2
- National LambdaRail
- NetherLight
- Pacific Wave
- Pacific North West GigaPOP
- StarLight
- SURFnet
- WIDE

Current Media Industry Practice

- Typical workflow in digital cinematography is file based transfer between specific systems (camera, editing, color grading, FX) via local SAN.
- Files are typically transferred over long distances using hard-drives physically transported, or some limited use of WAN <1Gbps between a few key locales (eg. LA-London)
- Higher image qualities and decentralized production/post trends are creating file transfer bottlenecks at many points in the workflow.

Moving Big Data Objects Globally

- **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**
  - 4K RGB x 24 FPS x 10bit/color: ~ 48MB/Frame uncompressed *(ideal)*
  - 6:1 ~ 20:1 shooting ratios => 48TB ~ 160TB digital camera originals
- **Digital Dailies**
  - HD compressed MPEG-2 @ 25 ~ 50 Mb/s
- **Digital Post-production and Visual Effects**
  - Gigabytes - Terabytes to Select Sites Depending on Project
- **Digital Motion Picture Distribution**
  - Film Printing in Regions
    - Features ~ 8TB
    - Trailers ~ 200GB
  - Digital Cinema Package to Theatres
    - Features ~ 100 - 300GB per DCP
    - Trailers ~ 2 - 4GB per DCP
  - Web Download to Consumers
    - Features ~ 1.3GB
    - TV Shows ~ 600MB

Real-World Example

- Prague-based CineGrid member CINEPOST went to LA carrying 7TB to finalize VFX deliverables under contract deadline.
- Upon arival in LA, CINEPOST discovered the data format of 2TB (from 7TB) was incompatible with the LA system.
- CINEPOST had 5 days to complete their work.
  - Resending data via Fedex/DHL from Prague to LA required 2 days, plus copying from SAN to 1394 HDD in Prague and then from HDD to SAN in LA.
  - Resending data via hand-carry would cost price of RT airplane ticket Prague-New York - LA, plus copying time at both ends.

Real World Schedule

- 7:00 (10pm) Receive call in Prague describing problem in LA
- 7:30 (10:30pm) CINEPOST in Prague started to re-format data into transmission format
- 10:30 (1:30am) Checked network connection within Prague
- 11:00 (2am) First TB ready for sending from CINEPOST
- 13:00 (4am) Second TB ready for sending from CINEPOST
- 16:00 (7am) Checked the connection CINEPOST - CZLight in Prague -> Starlight in Chicago -> UCSD/Calit2 in San Diego
- 16:30 (7:30am) Got positive response from UCSD willing to cooperate
- 18:00 (9:00am) Team at San Diego ready to start file transfer
- 18:30 (9:30am) Started to work on netconfig @ San Diego
- 19:00 (10am) Started to transfer data files using multiple FTP sessions with tuned network stack – jumbo frames, TCP window)
- 21:00 (12pm) Started to transfer data files using RBUDP (needed to compile it on production Mac)
- 5:00 (8pm) Finished file transfer to UCSD
- 6:30 (9:30pm) Finished download to local disks at UCSD
- 7:00 (10pm) Data left San Diego to LA via hand-carry

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Quick recap

- 24 hour project with no advance warning
- Only 8 hours of network activity!
- Production machines in Prague were connected to CESNET so link to UCSD via GLIF/CineGrid feasible with no-notice
- Final destination in LA was not on net, CineGrid member in LA (USC) was not available, so transferred to closest CineGrid member in San Diego
- Key to success was trust among CineGrid members who agreed to cooperate to solve problem.

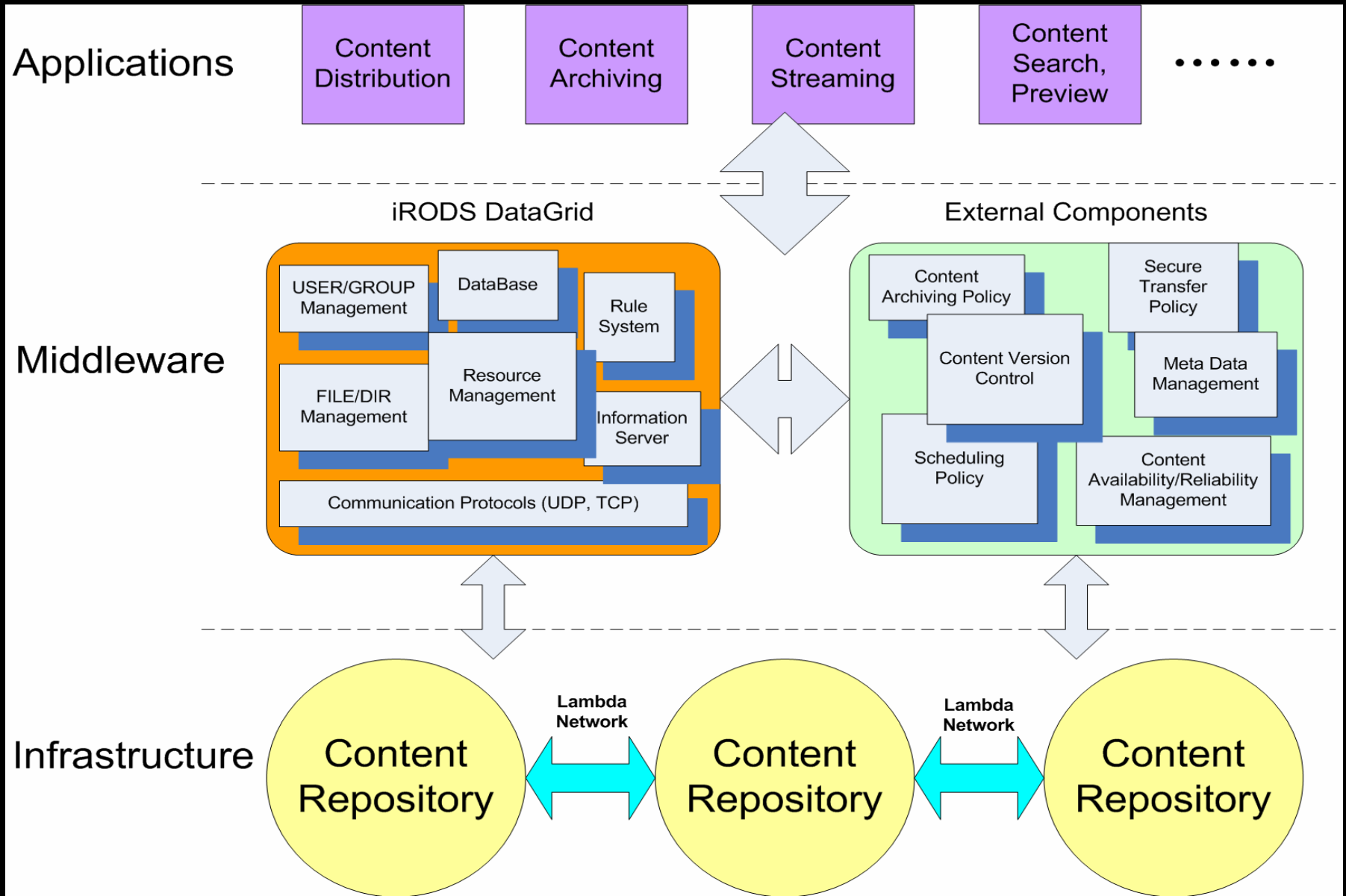
Lessons learned

- Need trusted store-and-forward service
- Need “external hard drive” service at ends
- Need for federated ad-hoc lambda end-to-end build/tear-down services
- Need a “standard” description of the elements required to implement services
  - (where are participating CineGrid members, contact e-mail, IP addresses of servers, storage capacity, supported protocols …)

CineGrid Exchange

- CineGrid Exchange collects high quality digital media assets, including (but not limited to) 4K, 2K, HD, mono & stereo, still & motion pictures; plus audio with various channel counts. Future addition of 8K, gigapixel, high FPS.
- CineGrid Exchange first three digital repositories already on GLIF: more to be added as offered by members
  - UCSD/Calit2 in San Diego
  - UvA in Amsterdam
  - Keio/DMC in Tokyo
- CineGrid has written permissions to make Exchange media accessible to CineGrid members via fast network access.
- CineGrid Exchange will support member-driven testbeds for networked digital media asset management, transcoding, distribution and preservation experiments.

CineGrid Exchange Architecture



CineGrid Exchange Repositories Linked by Networks

San Diego @ UCSD/Calit2 *(56 TB with 10Gbps connectivity)*
Amsterdam @ UvA *(20 TB with 10Gbps connectivity)*
Tokyo @ Keio/DMC *(8 TB with 10 Gbps connectivity)*
Total length = 21,000 km

Integrating File Transfer for CineGrid Exchange

- FTP: most common protocol
- UDT: UDP-based Data Transfer
- RBUDP: Reliable Blast UDP appears fastest for CineGrid Exchange
- Integrated RBUDP into iRODS to support more efficient workflows
  - Convert RBUDP protocol from C++ to C
  - Integrate RBUDP into iRODS communication library
  - Adapt RBUDP functions to iRODS's communication model
  - Test RBUDP + iRODS performance (ongoing)
- Future developments for fast(er) file transfer capabilities
  - Make RBUDP multi-threading capable
  - Reduce RBUDP per file ACK to increase throughput for small files
  - Accelerate disk-to-disk media file transfer via 10 Gbps network

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CineGrid Exchange Data Transfer Experiments "4K Digital Camera Originals"

- Live performance of "Magic Lanterns" at AMPAS shot using Dalsa 4K digital cinema cameras connected to purpose-built CODEX field recorder, then copied to external Ciprico disk slower than real-time
- Camera data transferred via network from Los Angeles to CineGrid Exchange in San Diego ~ 100 miles
  - RAW frame size: 16MB
  - RAW data rate: 3.2 Gbps
  - Data volume: 11 TB
  - Network: 1Gbps VLAN over CENIC
- Transfer Speeds Measured: Disk to Disk via network
  - Parallel FTP (MTU 1500) = 160 Mbps
  - Parallel FTP (MTU 9000) = 216 Mbps
  - Parallel FTP + FastSoft (MTU 1500) = 272 Mbps
  - RBUDP (MTU 9000) = 336 Mbps *[RAM to RAM = 930 Mbps]*

CineGrid Exchange Data Transfer Experiments

Network Capacity	1Gbps	10Gbps	10Gbps	10Gbps
Average Media File Size	2.2 GB	1 GB	1 GB	1 GB
Media Data Volume	2.2 TB	1 TB	1 TB	1 TB
Media Source	Tokyo	San Diego	Amsterdam	Amsterdam
Media Destination	San Diego	Tokyo	San Diego	Tokyo
Disk read speed	4.9Gbps	5.4Gbps	5.3Gbps	5.3Gbps
Disk write speed	3.8Gbps	3.6Gbps	3.5Gbps	3.6Gbps
Network speed (iperf)	750Mbps	6.4Gbps	6Gbps	6Gbps
Disk-2-Disk XFR speed (iRODS+RBUDP)	650Mbps	1.2Gbps	1.2Gbps	1.05Gbps

CineGrid Projects: 2008-2009

- CineGrid Exchange (UCSD/Calit2, Keio/DMC, UvA)
- GreenLight Project (UCSD/Calit2)
- Magic Lanterns (AMPAS/STC, UCSD/Calit2, USC/SCA)
- Alternate Endings (USC/SCA, UCSD/Calit2)
- CineGrid Audio Studio (UCSD/Calit2, Lucasfilm)
- VizCasting (UIC/EVL, Sharp Labs, others)
- Two-Way 4K (NTT, Keio/DMC, UCSD/Calit2, UIC/EVL)
- Photonic Multicasting (CESNET, StarLight, UW)
- Future of the Story (USC/SCA, Keio/DMC)
- And many more…. *Your Project Here !*

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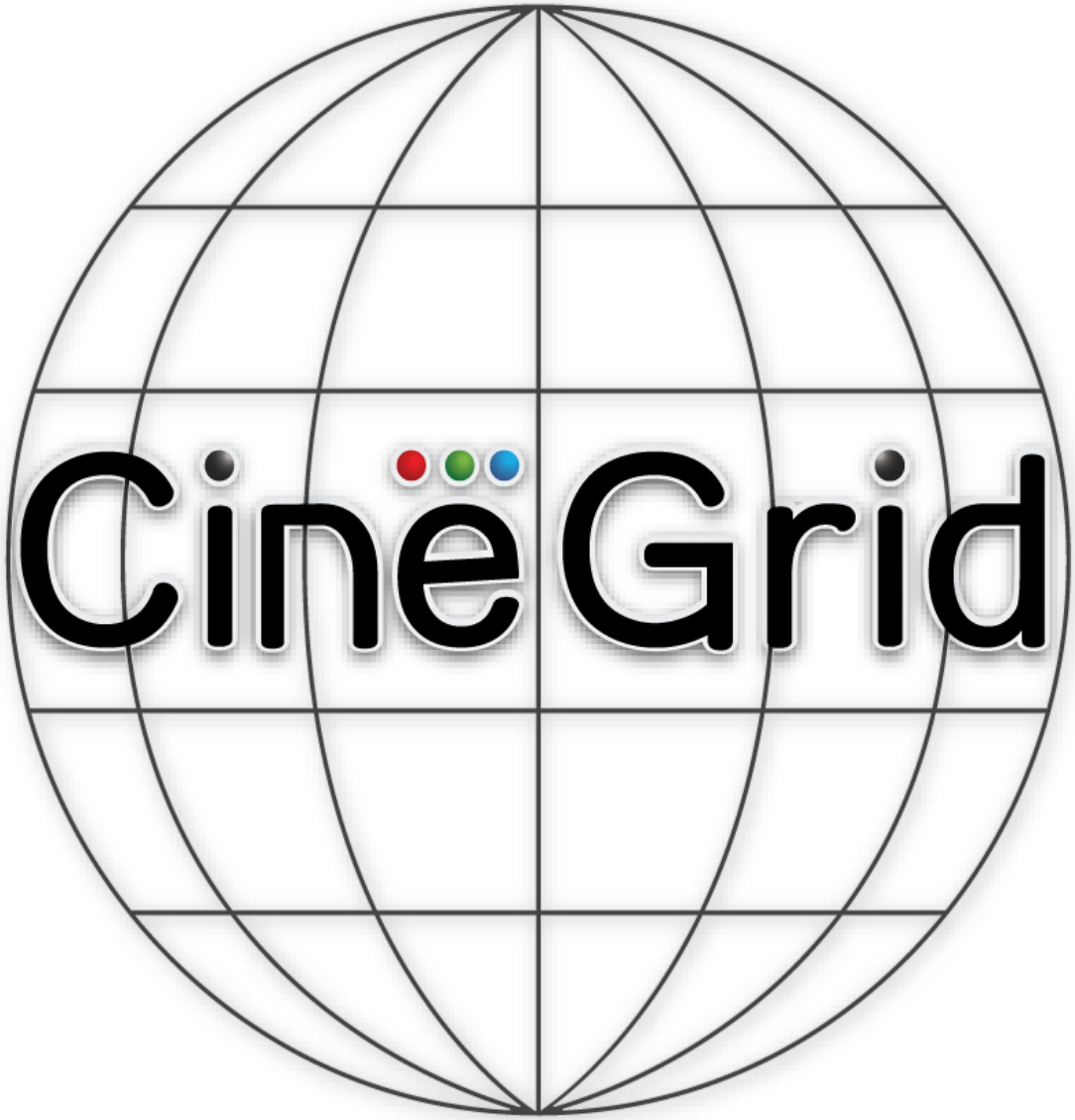
CineGrid International Workshop 2007 @ UCSD/Calit2 in San Diego

Save the Date: December 7-10, 2008



www.cinegrid.org