

Lessons Learned from International Real-Time Streaming of 4K Digital Video

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PFLDnet 2006

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Laboratories

1

Who am I?

- Name
 - Takashi Shimizu
- Affiliation
 - NTT Network Innovation Laboratories
- Research
 - Flow-based IP Traffic Control
 - MXQ (MaXimal Queueing) [1999]
 - Controls mis-behaving TCP/UDP flows
 - 10Gb/s Implementation: Caspian Networks [2003]



International Real-Time Streaming of 4K at iGrid 2005



iGrid 2005

GLOBAL LAMBDA INT

iGrid Workshop: 26-29 September 2005
GLIF Meeting: 29-30 September 2005
Calit2, University of California, San Diego, CA

Organizers
Keio Univ
UCSD
NTT
UIC
PII

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News Releases

World's First International Real-time Streaming of 4K Digital Cinema over Gigabit IP Optical Fiber Network

San Diego, CA and Tokyo, Japan, September 26, 2005 - In a demonstration that could foretell the future of videoconferencing deployment, scientists from around the world meeting at iGrid 2005 in San Diego were treated to the world's first real-time, intern (SHD) 4K digital video. 4K images have roughly 4,000 horizontal pixels offering approximately four times the resolution of the most times that of a standard broadcast TV signal.

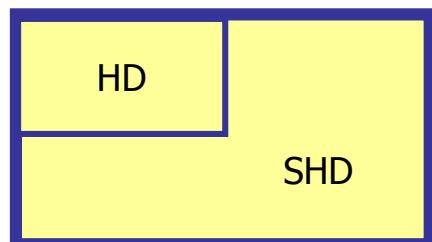
http://www.igrid2005.org/media/press_09.26.05_cinema.html

3

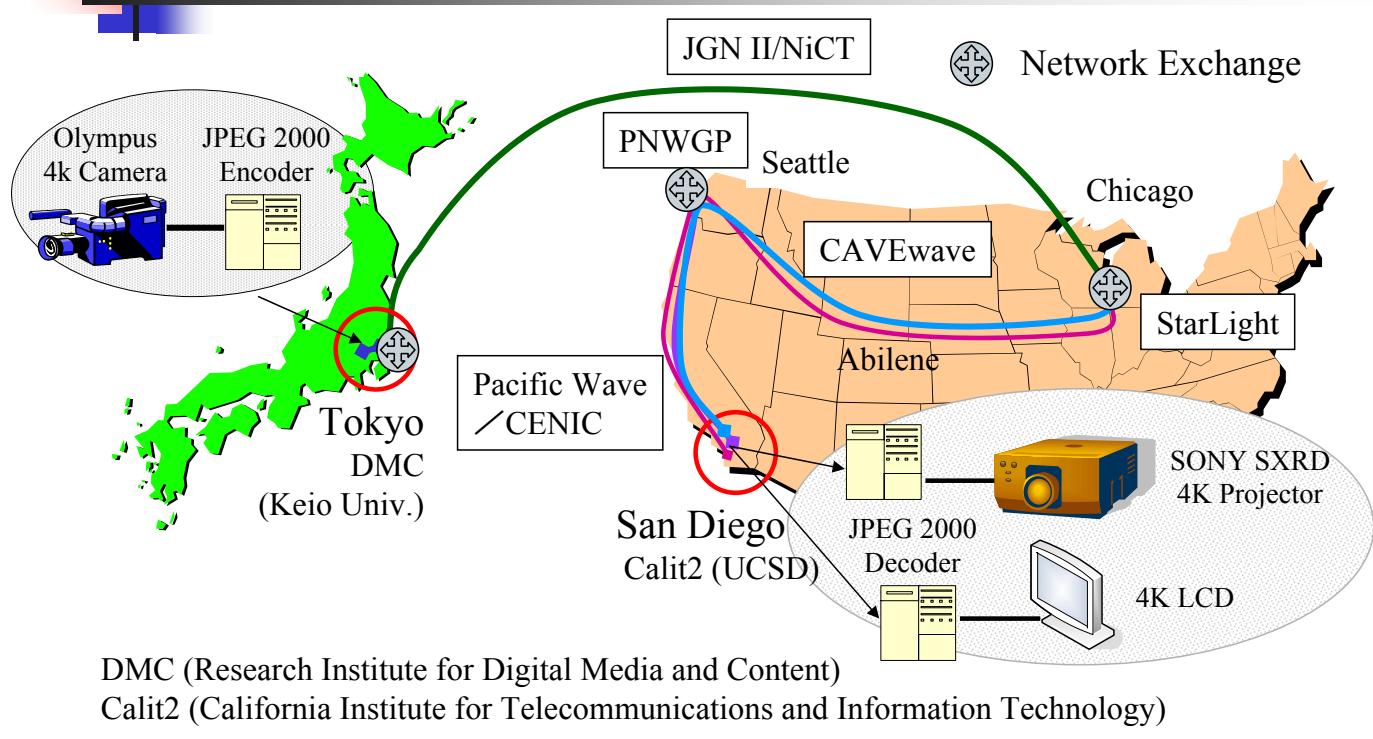


What is 4K Digital Video

- 4K = Super High Definition (SHD)
 - 4096x2160: 8Mpixels
 - 8 or 10 bit x 3 (RGB)
 - 24 or 30 frame/sec
 - Data Rate = 6.4 or 8 Gb/s
- Defined as
 - the optimum resolution for theatrical presentations
- JPEG 2000 Compression
 - Intra Frame Algorithm, compression ratio ~ 1/15
 - Compressed Data Rate = 400 ~ 600 Mb/s
 - Allow the use of common 1 gigabit ethernet

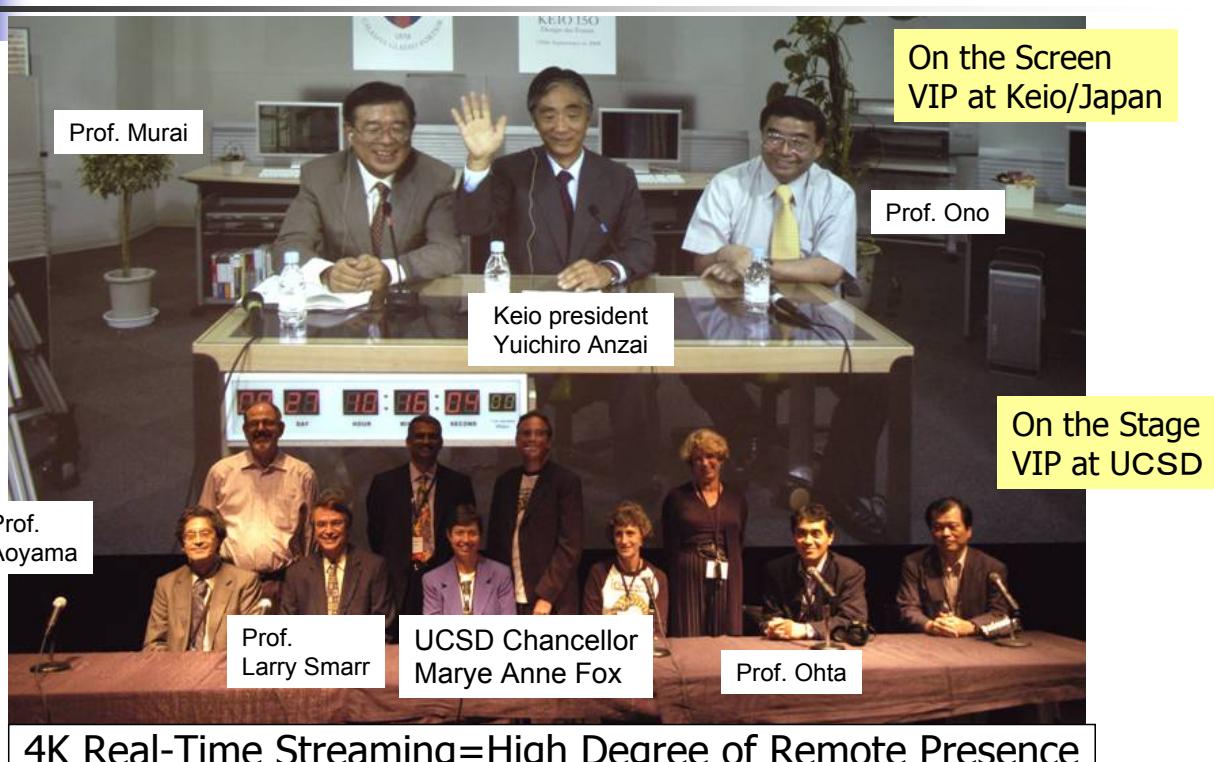


Overall System



5

4K Tele-Presence VIP Session (UCSD and Keio Univ.)



6

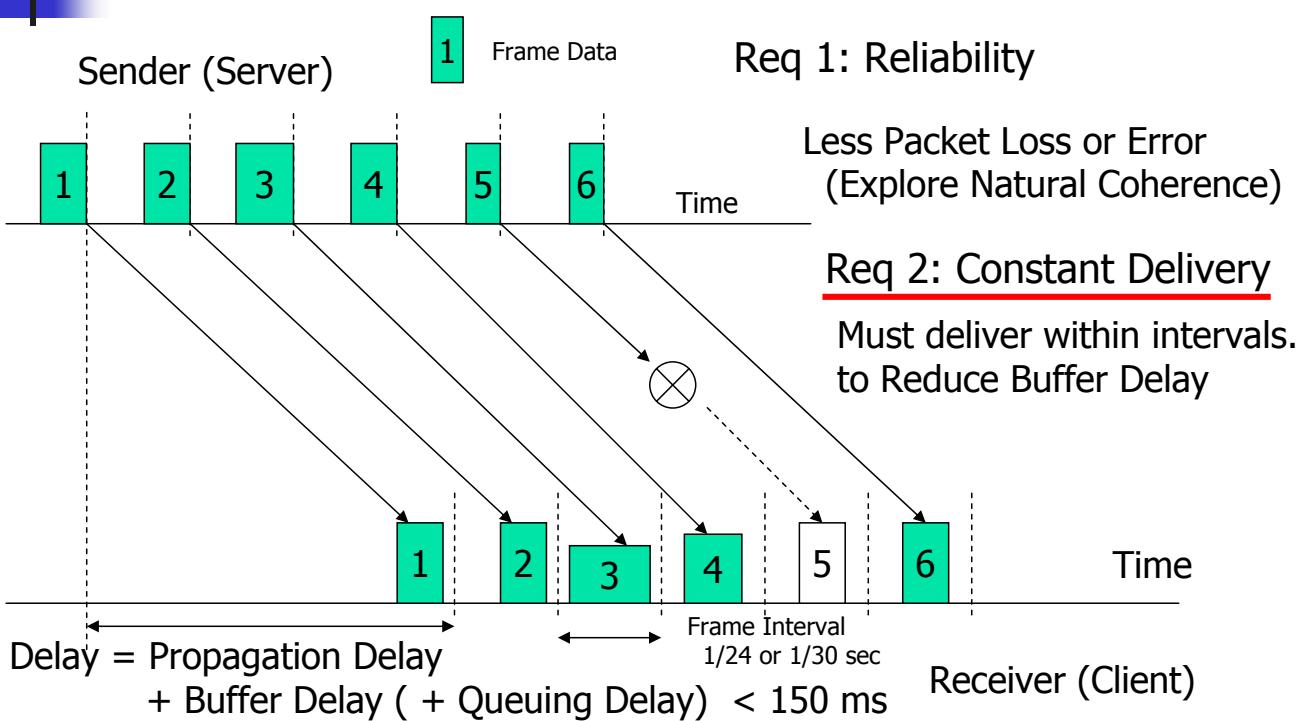
4K Distance Learning Lecture on the Guttenberg Bible



Live Steaming from Keio to UCSD

Life Size Image of the Professor and Objects. Little Camera Work

Requirements for Interactivity



Transport Design: ARQ vs FEC

- ARQ (use of TCP)
 - Improve reliability
 - Increase the worst-case delay
 - OK for short RTT, but NG for Long RTT
- FEC (use of UDP)
 - Shorter Delay
 - Intolerant for unpredicted packet loss
 - How we design redundancy ?
 - Packet Loss or Error Model
 - Algorithms

Our Design Choice

- Internet2 2002: Pre-Recorded
 - Chicago → Los Angeles (~3000 km)
 - Multiple TCPs
 - Packet pacing
 - Asynchronous Socket
- iGrid 2005: Real-Time and Interactive
 - Tokyo → Chicago → San Diego (~15000km)
 - Use of UDP
 - Packet-level FEC + Interleaving

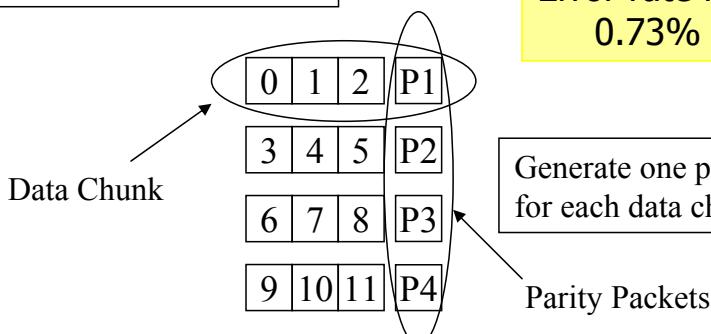
Packet-Level FEC

Horizontal Parity + Interleaving

0	1	2	3	4	5	6	7	8	9	10	11
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Divide compressed data
with the size of UDP payload

14% parity data
243 recovered video frames
18 lost video frames
35777 video frames in total.
Error rate improvement
0.73% → 0.05%.



Generate one parity packet
for each data chunk.

Parity Packets

0	3	6	9	1	4	7	10	2	5	8	11	P1	P2	P3	P4
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Generated packets are transmitted in interleaved fashion

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11

Jumbo Frame vs Fragmentation

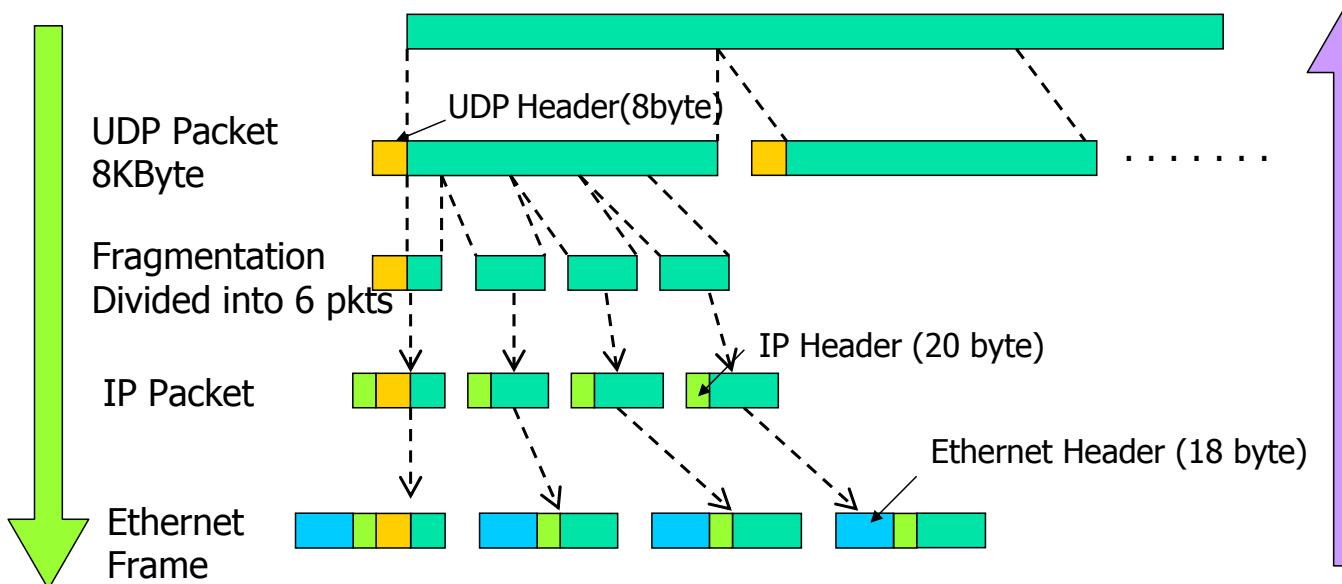
- Jumbo Frame
 - An Major Tool for Improving Throughput
 - Might cause operational problems
- Fragmentation
 - Higher Compatibility
 - Performance Issues
- Our Approach
 - Do not use Jumbo Frame and do fragmentation
 - We found no performance degradation
 - Most bottleneck is Socket Read/Write

Details of Transmission

Encoder

One frame data compressed with JPEG 2000 2.5MByte

Decoder

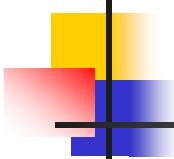


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13

Concluding Remark

- International Real-Time Streaming
 - Challenge for Interactivity under Long RTT
 - Tele-Presence + Distance Learning
- ARQ vs FEC
 - Use Packet-Level FEC for interactivity
 - My interest: Other solutions to address this?
- Jumbo Frame
 - No Jumbo Frame
 - Fragmentation worked fine.

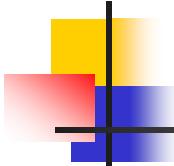


Organizers

- DMC (Research Institute for Digital Media and Content), Keio University
- Calit2 (California Institute for Telecommunications and Information Technology), University of California, San Diego
- NTT Network Innovation Laboratories
- EVL (Electronic Visualization Laboratory), University of Illinois at Chicago
- Pacific Interface Inc.

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15



Contributors

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Digital Cinema Consortium of Japan
National Institute of Information and Communications Technology (Japan)
Olympus Corporation, Toppan, Sony Electronics, Inc.,
Silicon Graphics, Inc., SGI Japan, ASTRODESIGN, Mitsubishi Electric,
Yamaha Corporation of America
University of Illinois Urbana Champagne National Center for Supercomputer Applications
University of Southern California School of Cinema-TV
San Diego State University
Tokyo University of Technology Creative Lab
Tatsunoko Production Co., Ltd., The Pixel Farm, DALSA, Miranda,
BAPS Swaminarayan Sanstha, Skywalker Sound, a Lucasfilm Ltd. Company
San Francisco State University Institute for Next Generation Internet,
Youth Radio, JGN2/NICT, CAVEwave, Paci-ficWave, CENIC, StarLight,
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