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

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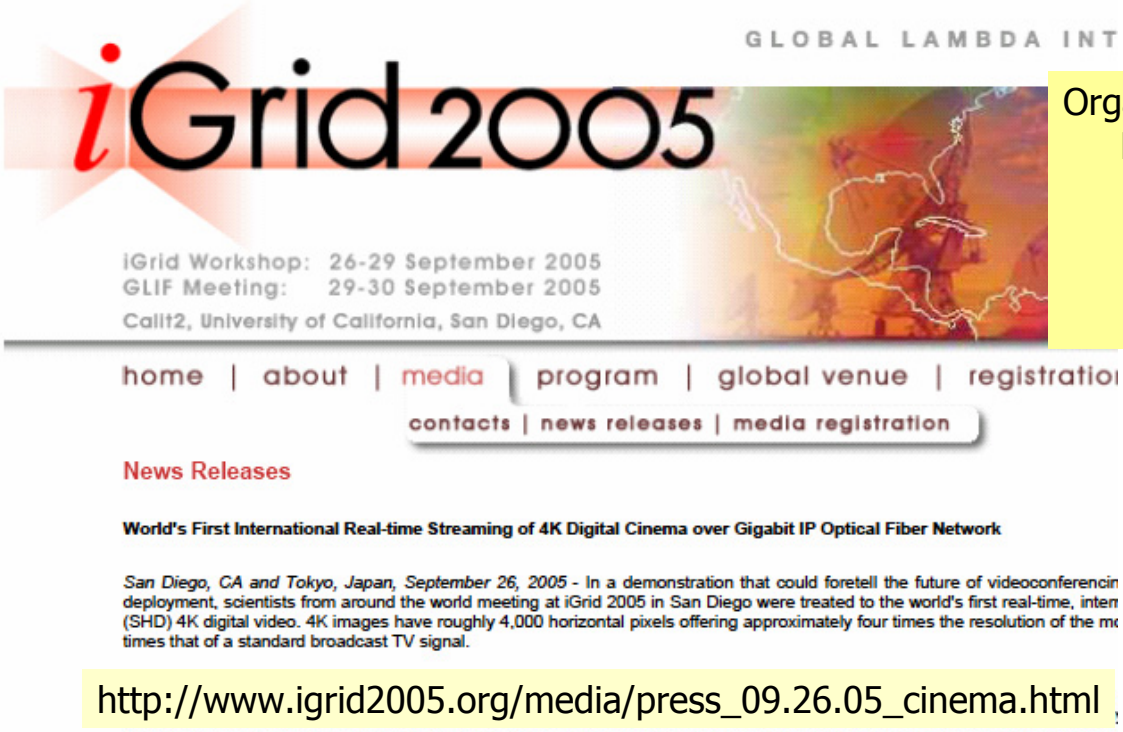
Who am I?

- 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

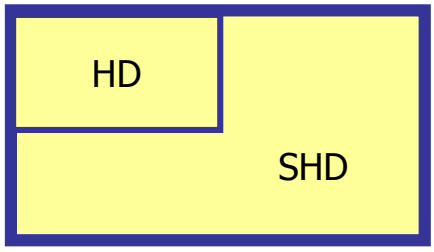


Organizers
Keio Univ
UCSD
NTT
UIC
PII

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

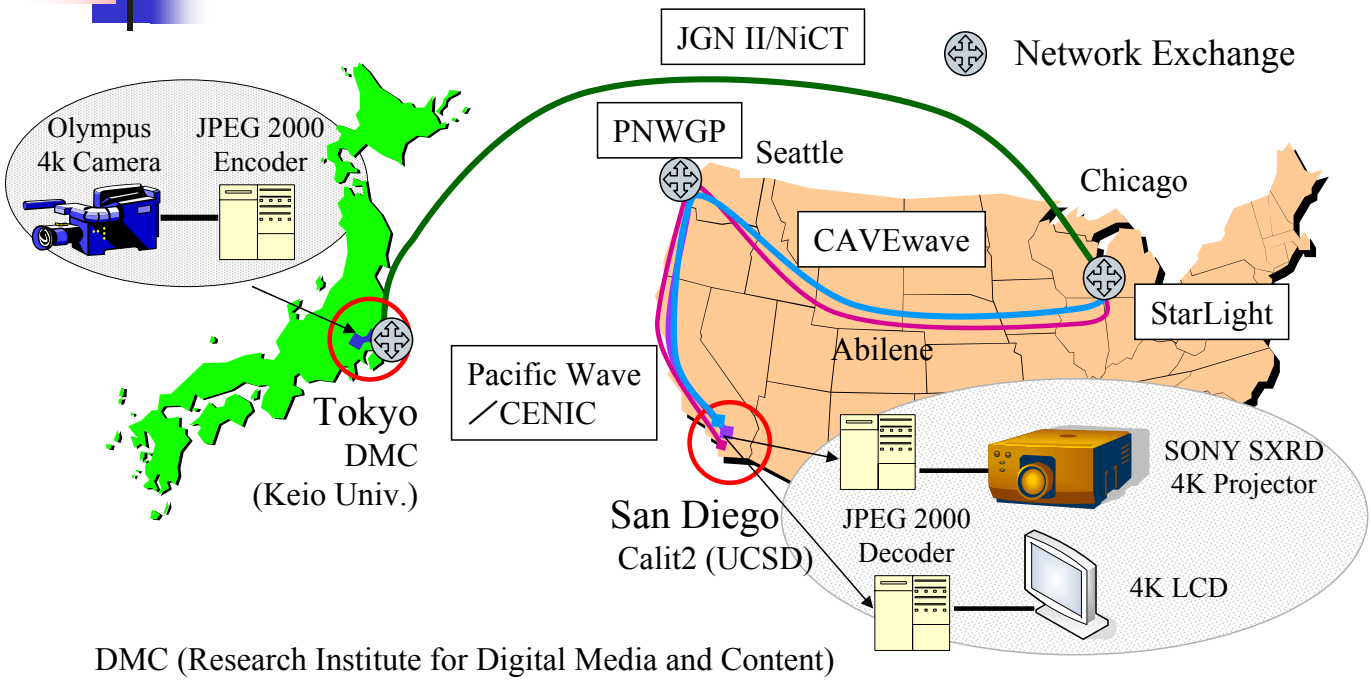
What is 4K Digital Video

- 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



DMC (Research Institute for Digital Media and Content)
Calit2 (California Institute for Telecommunications and Information Technology)

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

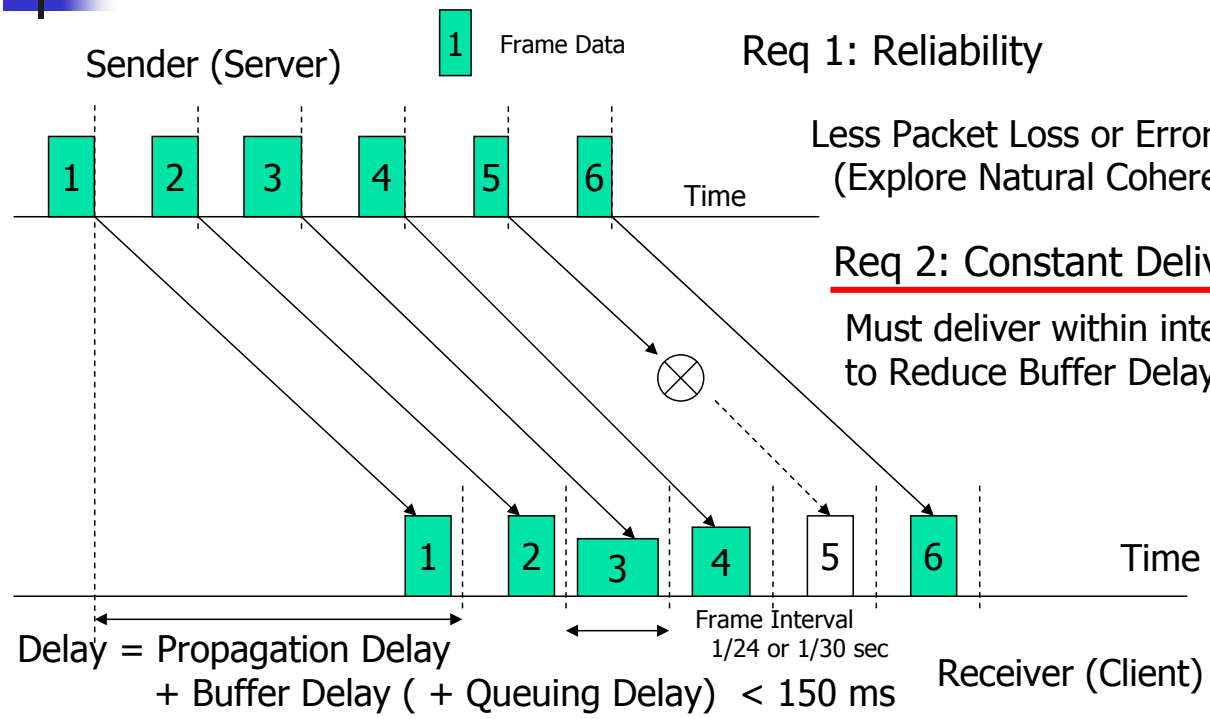
4K Real-Time Streaming=High Degree of Remote Presence

4K Distance Learning
Lecture on the Guttenberg Bible

Keio Professor Toshiyuki Takamiya

Live Steaming from Keio to UCSD
Life Size Image of the Professor and Objects. Little Camera Work

Requirements for Interactivity



NTT

Transport Design: ARQ vs FEC

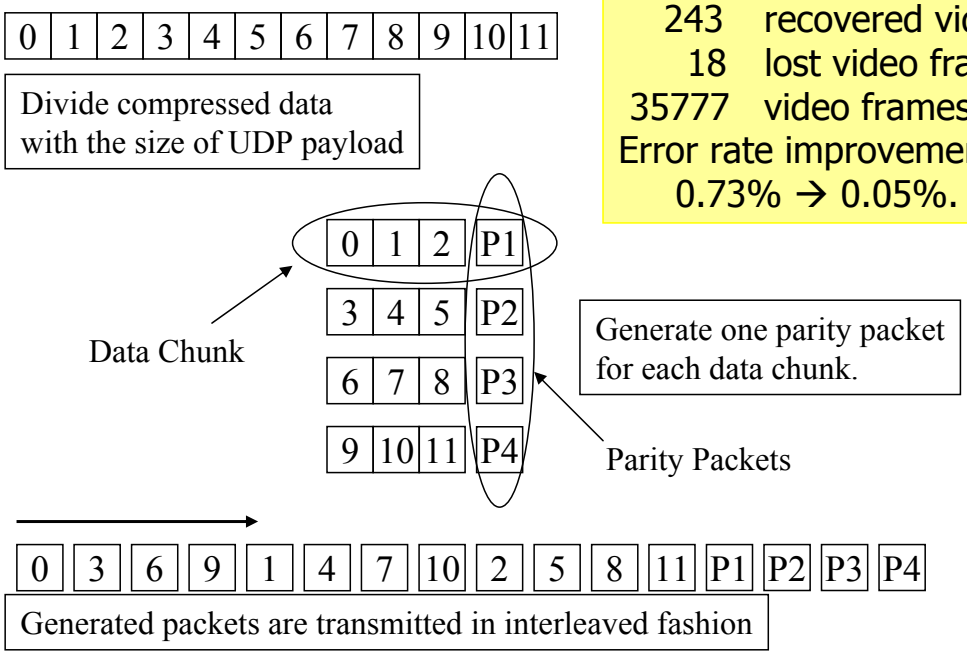
- ARQ (use of TCP)
  - Improve reliability
  - Increase the worst-case delay
    - OK for short RTT, but NG for Long RTT
- FEC (use of UDP)
  - Shorter Delay
  - Intolerant for unpredicted packet loss
  - How we design redundancy ?
    - Packet Loss or Error Model
    - Algorithms

NTT

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

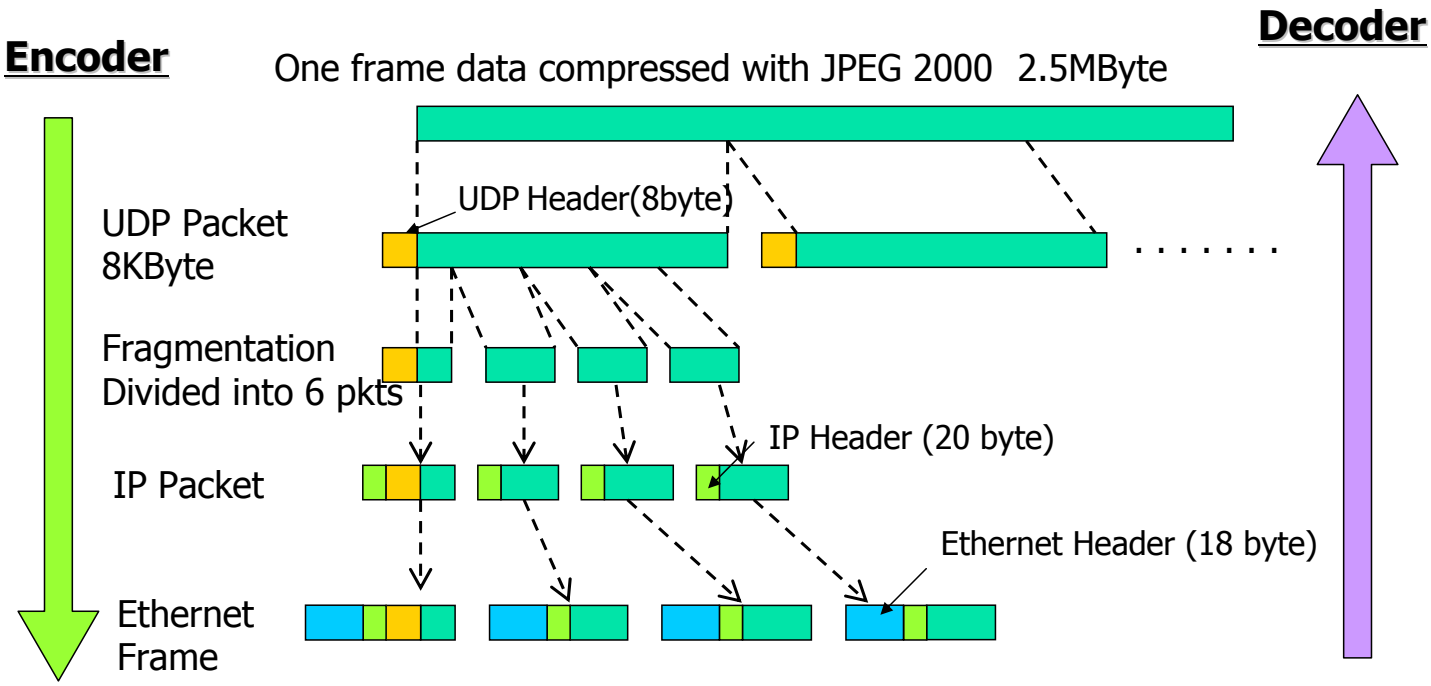


14% parity data
243 recovered video frames
18 lost video frames
35777 video frames in total.
Error rate improvement
0.73% → 0.05%.

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



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.

Contributors

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Yamaha Corporation of America
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University of Southern California School of Cinema-TV
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