Full rate Uncompressed HDTV Transport: Experiences and Implementation

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Outline

- Goals
- The UltraGrid System
- Beyond 1 Gbps
- Deployment and Experiments
- Summary

Goals

- develop next generation ultra-high quality video conferencing tool

- develop a platform for research on:
  - Real-time high performance transport protocols
  - Congestion control algorithms for media applications
  - Audio and video codecs

Approach

- use a modular layered architecture, that facilitates:
  - adding new audio and video codecs
  - experimenting with new transport protocols

- build a system that can be replicated and built by other researchers:
  - Use hardware that is commercially available
  - All audio and video codecs are open source
  - Use standard protocols:
    - Real-time Transport Protocol (RTP)
    - Custom payload formats and profiles where necessary
  - Software available for download

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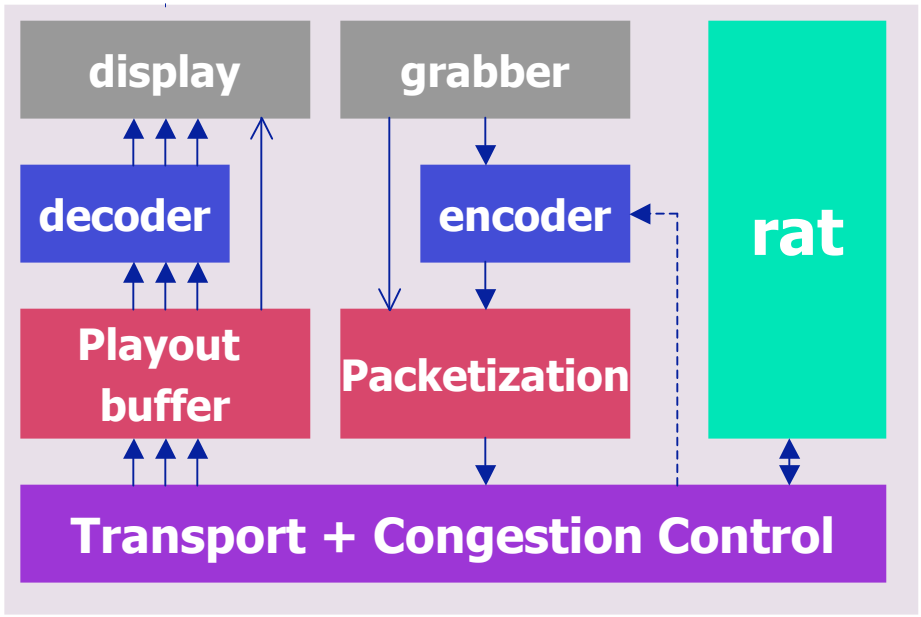
UltraGrid: Architectural Overview



UltraGrid Node

- Codec Support:
  - M-JPEG, RFC 2435
  - DV, RFC 3189
  - H.261, RFC 2032
- Transport protocols:
  - RTP/RTCP
  - RFC 3550
- Congestion Control:
  - TCP Friendly Rate Control (TFRC)
  - RFC 3448

Congestion control

- RFC 3448: IETF standard document for TFRC
  - defines the mechanism of congestion control
  - does not describe how TFRC interacts with the transport layer
  - TFRC can be used with different transports: I.e: UDP, RTP

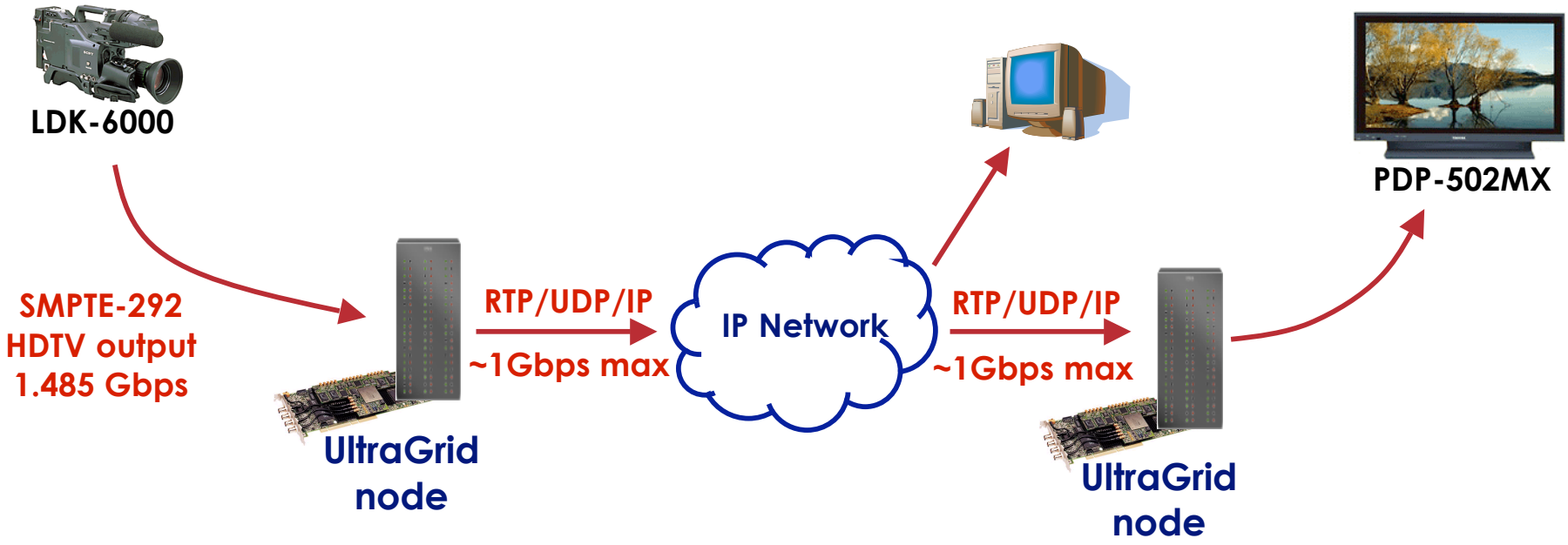
- The `RTP Profile for TCP Friendly Rate Control' detail the interactions of TFRC with RTP/RTCP: draft-ietf-avt-tfrc-profile-03.txt
  - format of data packet
  - format of RTCP feedback packets
  - timing of RTCP packets

AccessGrid

Completed the integration with AccessGrid:

- Use the Node Manager to add the services:
  - UltraGrid Receiver
  - UltraGrid Sender
- Created as part of the UltraGrid:
  - uvReceiverService.zip
  - uvSenderService.zip

Uncompressed Video Transport @ ~1 Gbps



- Successful tests @ ~1 Gbps were conducted over SuperNet:
  - research wide area network which overlays on a commercial ISP network
  - OC-48 shared with commercial IP traffic; no QoS support
  - 10 hop path between ISI-east & ISI-west with 132ms RTT

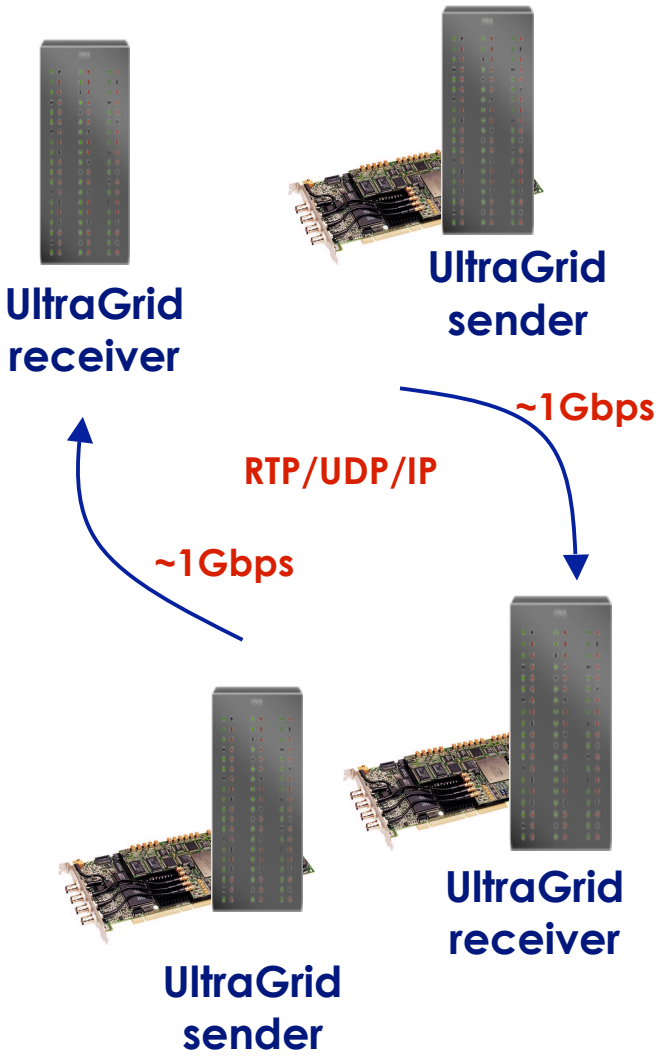
The UltraGrid node

Hardware Instantiation:

- HDstation HDTV capture card from DVS
- Gigabit Ethernet
- Transmitter and receiver hosted on separate PCs
  - Dell PowerEdge 2500 servers
  - 1.2GHz PIII Xeon/Dual processor
  - 64 bit PCI bus
  - Linux 2.4

Software display capability:

- requires xvideo extensions support by OS and video card



System Limitations

- Why < 1 Gbps?
  - ➔ the only limitation is the Gigabit Ethernet NIC
    - 64 bit PCI (theoretically) 4Mbps throughput
    - HDstation HDTV capture is capable of processing full rate HDTV

- Video is down sampled at the sender:
  - ➔ Color is down sampled from 10bits to 8bits
  - ➔ Auxiliary data removed

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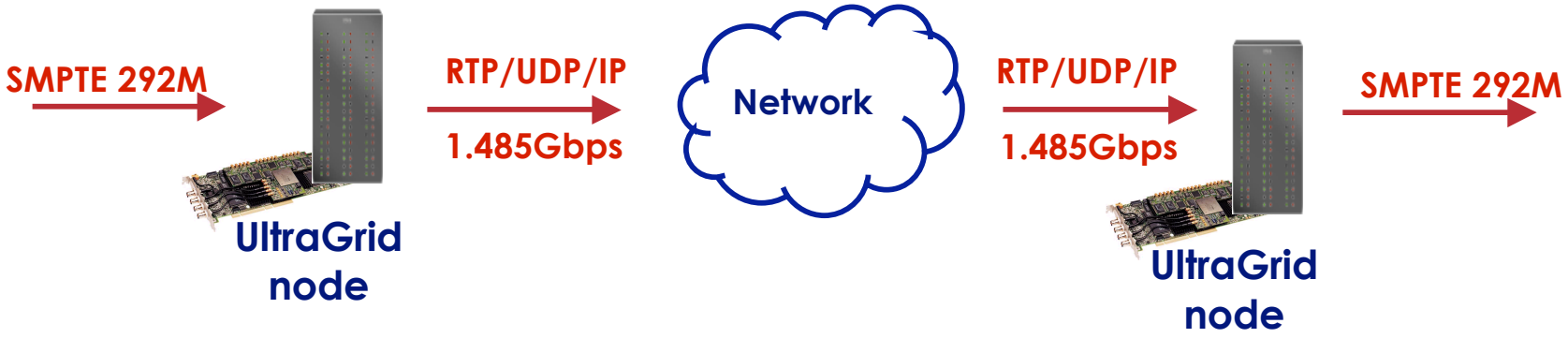
Motivation

- Experience true HDTV video quality teleconferencing

- Build a complete SMPTE292M-over-IP system:
  - ➔ HDTV distribution and editing purposes

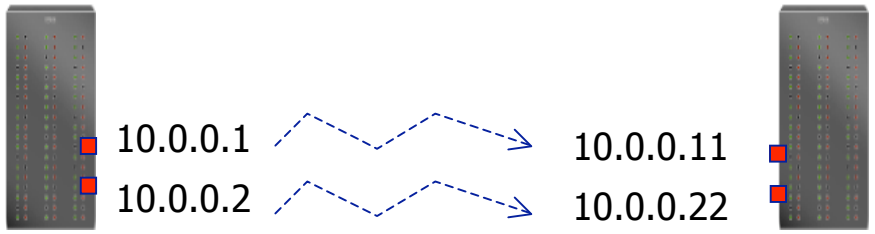


Beyond 1 Gbps

- limitation: Gigabit Ethernet

- Solutions:
  1. 2 Gigabit Ethernet NICs
     - Added complexity for the application
     - Inexpensive $
     - Connects to switch or router at 1G
  2. 10 Gigabit Ethernet NIC
     - Application is oblivious to data rate
     - Expensive $$$
     - Connects to switch or router at 10G

The 2 NIC system



- Sender:
  - ➔ application splits data between to outgoing interfaces and sends to two different IP addresses.
- Receiver:
  - ➔ Application receives data from the two interfaces and reassembles into data

- Potential hazards:
  - ➔ the two flows compete against each other bandwidth
  - ➔ increased percentage of out-of-order packets

The (new) UltraGrid node

- 10 Gigabit Ethernet NIC:
  - T110 10GbE from Chelsio: http://www.chelsio.com/
  - 133Mhz/PCI-X
- HDTV capture card:
  - Centaurus HDTV capture card from www.dvs.de
    - same SDK as HDstation
    - 100Mhz/PCI-X
- Dual Xeon EM64T Power Station
  - SuperMicro mother board
  - 5 programmable PCI-X slots
  - 32bit Fedora Core3 - Linux 2.6 Kernel

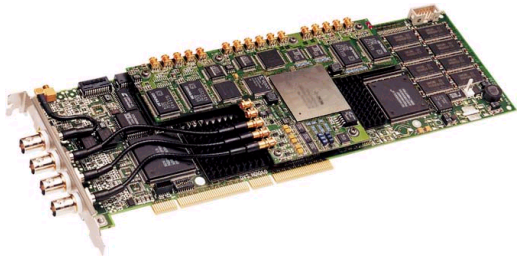
The Centaurus vs. HDstation Card

Centaurus HDTV capture Card: www.dvs.de

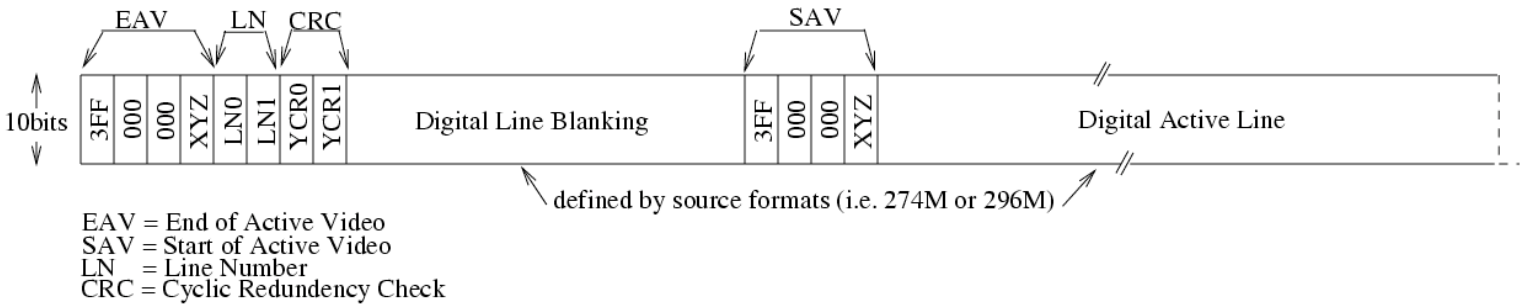
- Linux 2.4, 2.6 Kernels
- 100Mhz/PCI-X card
- Supports common SD, HD and 2K format:
  - HSDL: 2048x1556@ 15psF,18psF
  - 2K: 2048x1556@ 24p,24psF,48i
- Price: $9000K

Hdstation HDTV capture card: www.dvs.de

- Linux 2.4 Kernel
- 64 bit PCI card
- Supports common SD and HD formats
- Price: $15000k



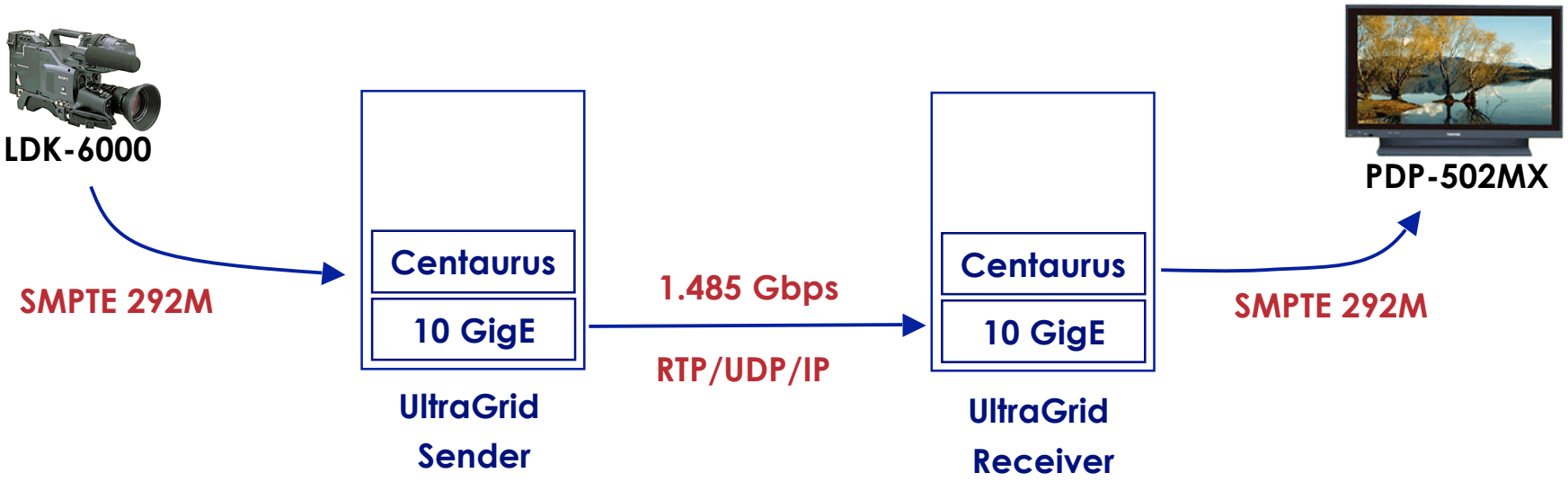
Software modifications



- Both capture cards operate in 10bit or 8bit mode

- Update code to operate in 10bit mode
  - ➔ packetization must operate in 10bit mode
  - ➔ packetization is based on draft-ietf-avt-uncomp-video-06.txt
    - Supports range of formats including standard & high definition video
    - Interlaced and progressive
    - RGB, RGBA, BGR, BGRA, YUV
    - Various color sub-sampling: 4:4:4, 4:2:2, 4:2:0, 4:1:1

Lab Tests



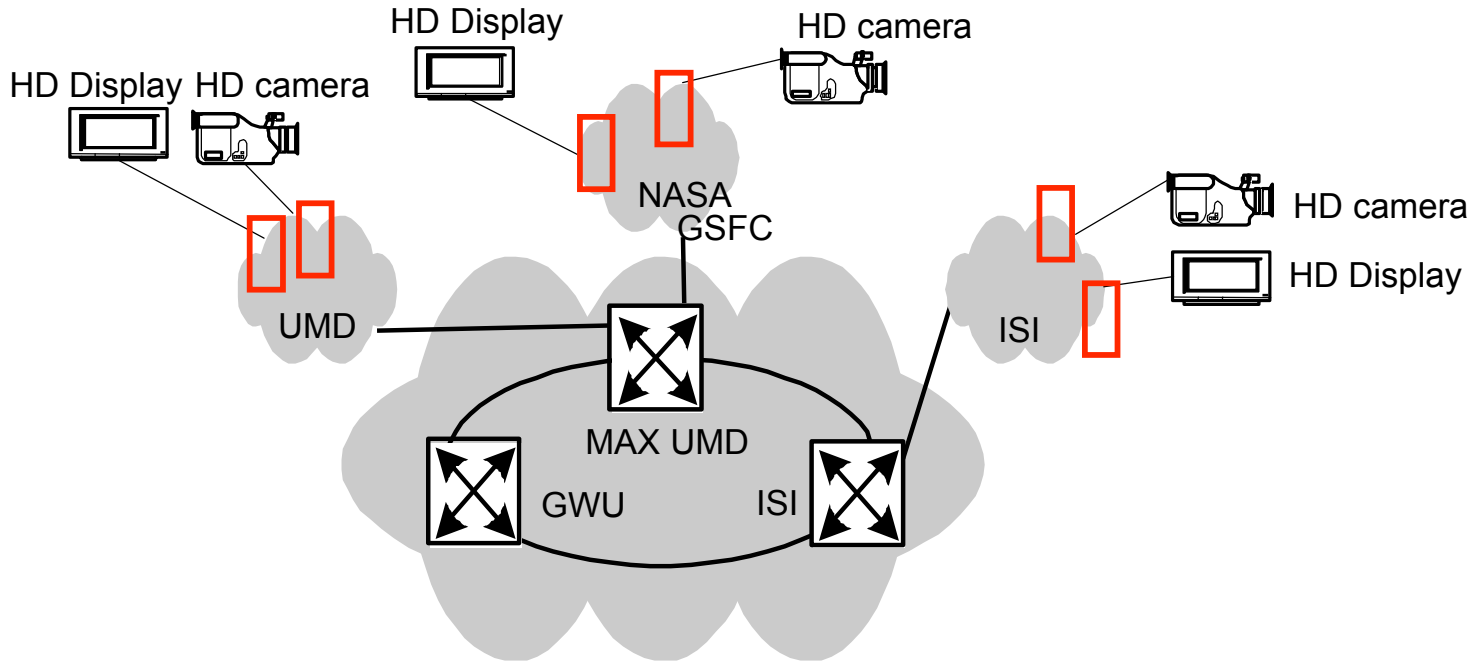
- connect two system back to back and test send and receive capabilities

Metropolitan Area Deployment

- In collaboration with DRAGON network:
  - Dynamic Resource Allocation via GMPLS Optical Networks
  - is conducting research and developing technologies to enable dynamic provisioning of network resources on an interdoman basis across heterogeneous network technologies
  - Local instantiation of experimental infrastructure in the Washington D.C. metropolitan
  - network infrastructure: hybrid best effort packet and circuit switched

http://dragon.east.isi.edu/

Metropolitan Area Deployment



- UltraGrid instantiations at:
  - University of Maryland (UMD), Mid-Atlantic Crossroads(MAX)
  - NASA Goddard Space Flight Center (GSFC)
  - Information Sciences Institute (ISI)

Cost?

PC system	$5500
Centaurus Card.....	$ 9,000
Single-link HD/SD PCI-X board	
Centaurus-Audio08	$ 1,000
10 GigE NIC	$2500
Total cost	$18000

Software is free :)

Summary

- Scaling up to full rate uncompressed HDTV over IP presents an interesting engineering challenge, but few new fundamental problems

- UltraGrid provides a platform for research and experimentation:
  - Real-time high performance transport protocols
  - Congestion control for media applications

- A `visual' demonstrator applications for new technologies:
  - Demonstrator application for DRAGON project at SuperComputing 2004

Further Information…

http://ultragrid.east.isi.edu/

http://macc.east.isi.edu/

http://dragon.east.isi.edu/