

Scaling Multimedia Conferencing

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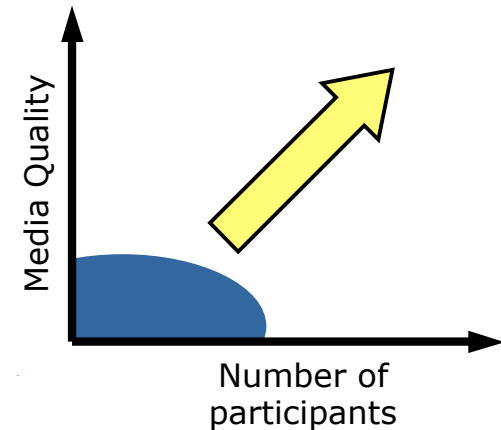


Talk Outline

- Aims and objectives
- Scaling media quality
 - UltraGrid
- Scaling routing and conference size
 - The Digital Amphitheatre
 - The Orta peer-to-peer overlay
- Discussion points for SUMOVER

Research Objectives

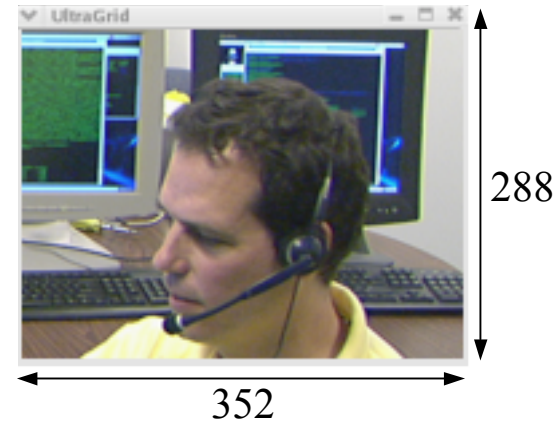
- To scale Internet multimedia conferencing
 - ...to studio quality
 - ...to large interactive sessions
- Focus on novel architectures through innovative use of standard protocols on high performance networks using commercial off-the-shelf hardware
- Drive standards development
 - Primarily IETF
 - Also interactions with ITU, MPEG and SMPTE
- Develop systems that can be safely deployed in the public Internet



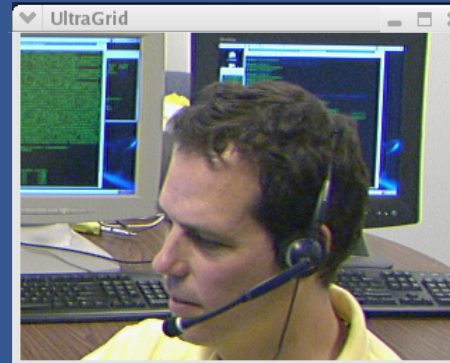
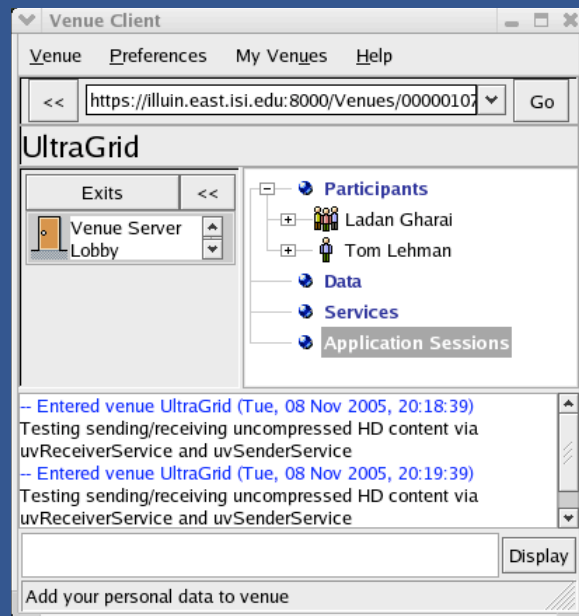
Scaling Media Quality

- Given advances in system power, network bandwidth and video cameras, why are video conferencing environments so limited?

– Why are we stuck with CIF images...?



Why do conferencing systems look like this?



Tue Nov 08
8:37 PM

Venue Client

Venue Preferences My Venues Help

<< Go

UltraGrid

Exits <<

Venue Server Lobby

Participants

- Ladan Gharai
- Tom Lehman

Data

Services

Application Sessions

-- Entered venue UltraGrid (Tue, 08 Nov 2005, 20:18:39)
Testing sending/receiving uncompressed HD content via uvReceiverService and uvSenderService

-- Entered venue UltraGrid (Tue, 08 Nov 2005, 20:19:39)
Testing sending/receiving uncompressed HD content via uvReceiverService and uvSenderService

Display

Add your personal data to venue

RAT v4.2.23: UltraGrid

Listen	256.0 kb/s	Talk	256.0 kb/s
Speaker	Vol 52	Microphone	Gain 52

Tom Lehman

Ladan Gharai

"UltraGrid"

Address: 224.100.100.100 Port: 5004 TTL: 3

Options... About... Quit

...and not like this?



UltraGrid: Aims and Objectives

- To explore the problems inherent in delivering high definition video over IP
 - Related to the protocols
 - Related to the network
 - Related to the end-system
- To push the limits of:
 - Image resolution, frame rate and quality
 - Network capacity
 - End system capacity
- To demonstrate the ability of IP networks to support high quality, high rate, media

UltraGrid: Aims and Objectives

To build a prototype system using:

- standard protocols
- commodity networks
- commodity end systems

RTP over UDP/IP

- Custom payload format
- Best effort delivery
- No additional QoS
- Derived from rat code

Internet2 or other lambda networks

- OC-48 or higher
- Competing with other IP traffic

Local area using 10 gigabit Ethernet

- Hoped to use OC-48 interfaces, but performance is poor

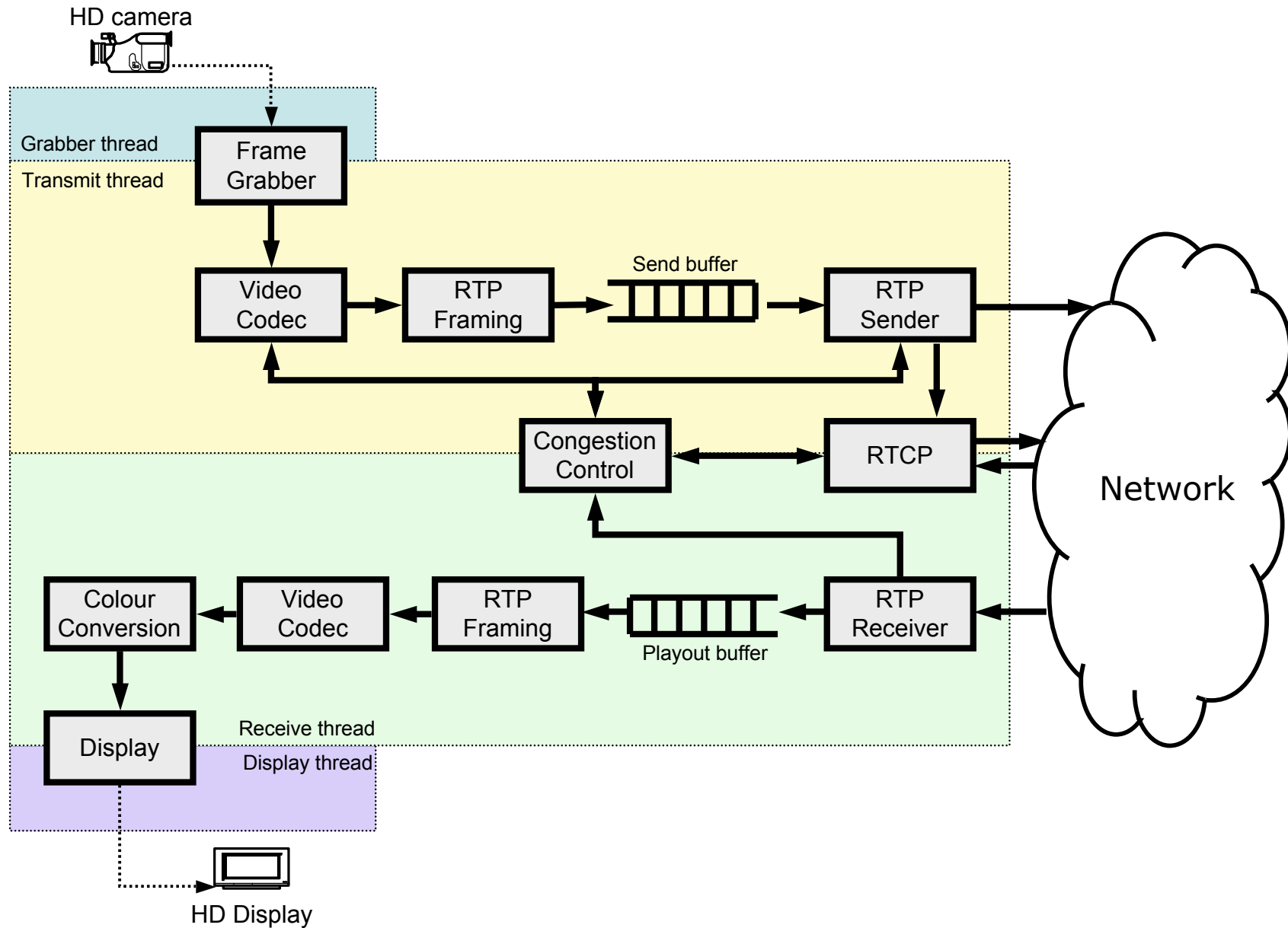
PC or similar workstation

HDTV capture and display

- Highest quality video capture equipment commercially available

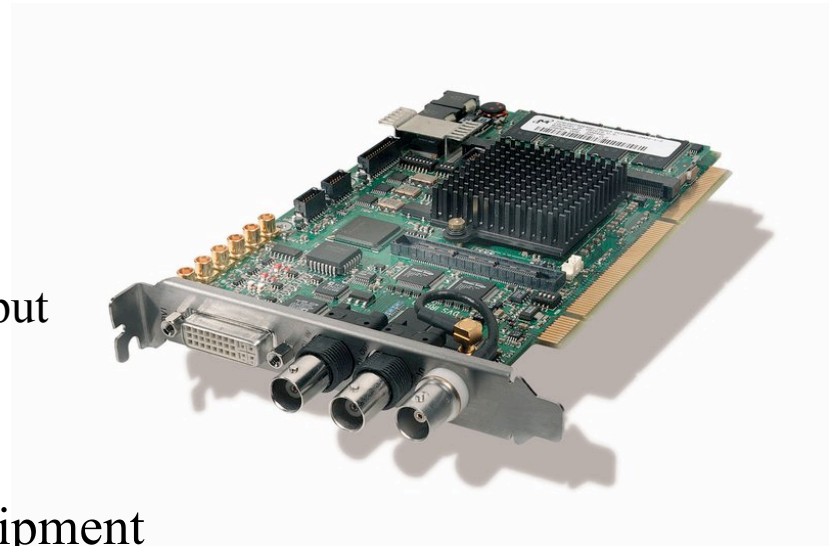
...to prove beyond doubt that IP networks can support high quality media

UltraGrid: Software Architecture



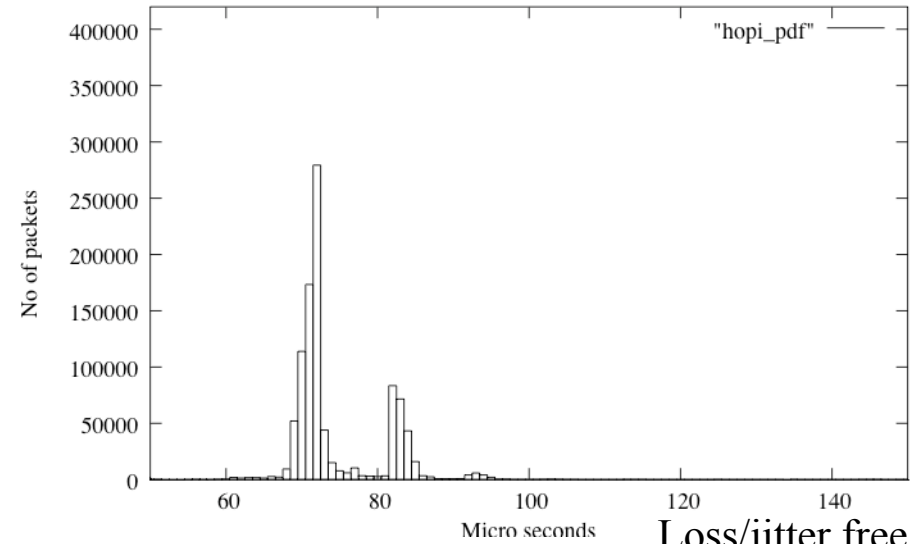
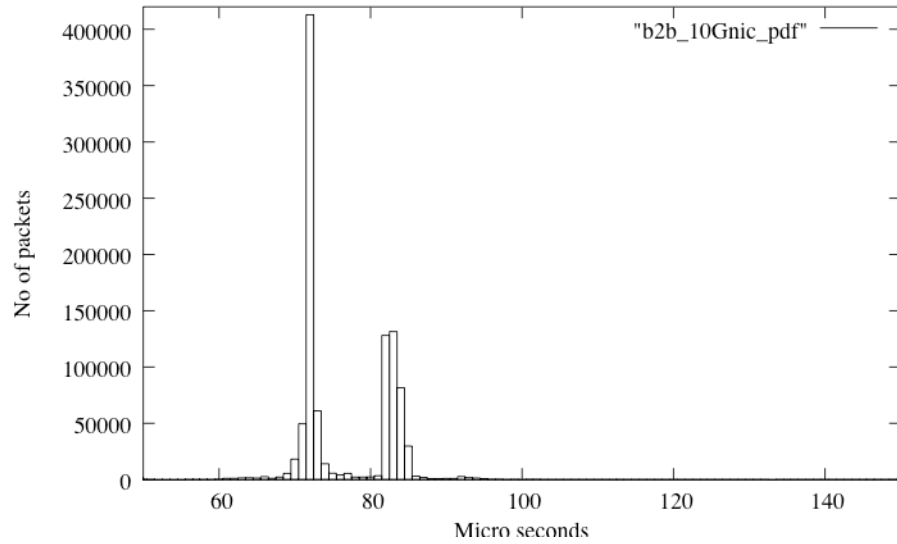
UltraGrid: Media Formats and Equipment

- Sender side equipment
 - Dual Xeon EM64T workstation
 - Red Hat Fedora Core 3/Linux 2.6
 - Chelsio T110 10 Gigabit Ethernet
 - DVS Centaurus HDTV capture card
 - 100Mhz/PCI-X card
 - SMPTE-292M video capture, DVI output
 - Standard and HDTV video
 - Thomson LDK-6000 HDTV camera
 - Approx. \$50k – professional grade equipment
- Display on standard high-end PC
 - 10 Gigabit Ethernet only unusual equipment



- Captures HDTV 1280×720 @ 60fps
- Transmits uncompressed video in RTP over UDP/IP at 1.2Gbps

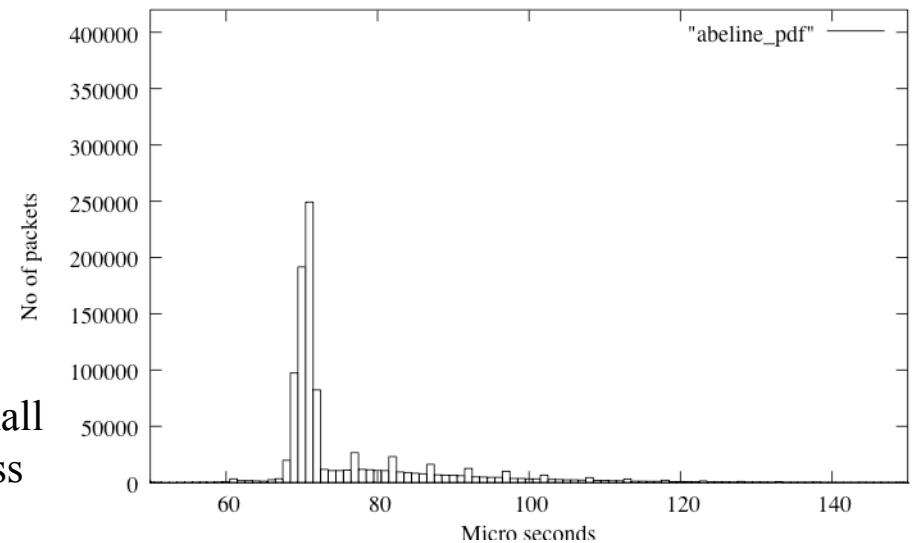
UltraGrid: Performance



Loss/jitter free

Inter-packet spacing: Seattle → Washington DC
...over Internet2 Hybrid Optical/Packet Infrastructure (HOPI)

...over Abilene



Significant jitter; small amount of packet loss

UltraGrid: Congestion Control

- Modern IP networks can be engineered to be loss-free at gigabit rates, but expensive to guarantee
- High rate video requires congestion control for safe deployment
- Ongoing development to integrate TFRC into UltraGrid
 - Motion JPEG + DV initially, moving on to Motion JPEG + HDTV
 - Two independent, compatible, TFRC implementations
 - ISI-East: <http://macc.east.isi.edu/> integrating with iperf
 - Glasgow: integrating with UltraGrid (TFRC code available on request)
 - Integration with UltraGrid + DV in progress
 - Expect public release of code early in 2006

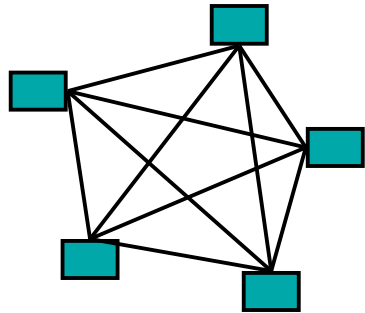
UltraGrid: Status

- UltraGrid project website: <http://ultragrid.dcs.gla.ac.uk/>
 - Latest release available for download
 - Derived from RAT + common library, with extensive modifications
 - Rewrote RTP code to account for TFRC; tight integration with playout and sending buffers
 - Mailing list subscription information
- Public demonstrations
 - Super Computing 2002: ISI-East → Baltimore
 - Super Computing 2004: ISI-East → Pittsburgh
 - iGrid 2005: San Diego → Masaryk Univ. and Louisiana State University
 - Demonstration by CESNET/Louisiana State
 - Super Computing 2005: ISI-East to Seattle

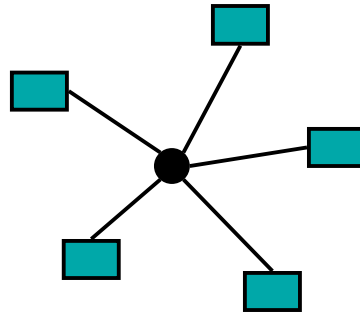
Scaling to Large Interactive Sessions

- How to support...
 - groups with 10s (100s?) of participants
 - rich interaction between participants
 - varying participant roles (audience; speaker; chair; question)
 - rights and responsibilities

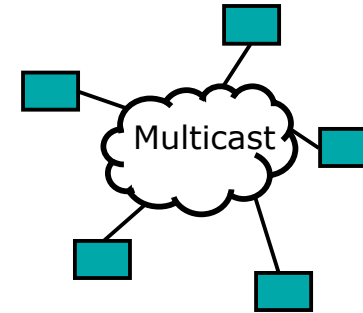
- Typical solutions:



Too much load on end systems; fate sharing problems



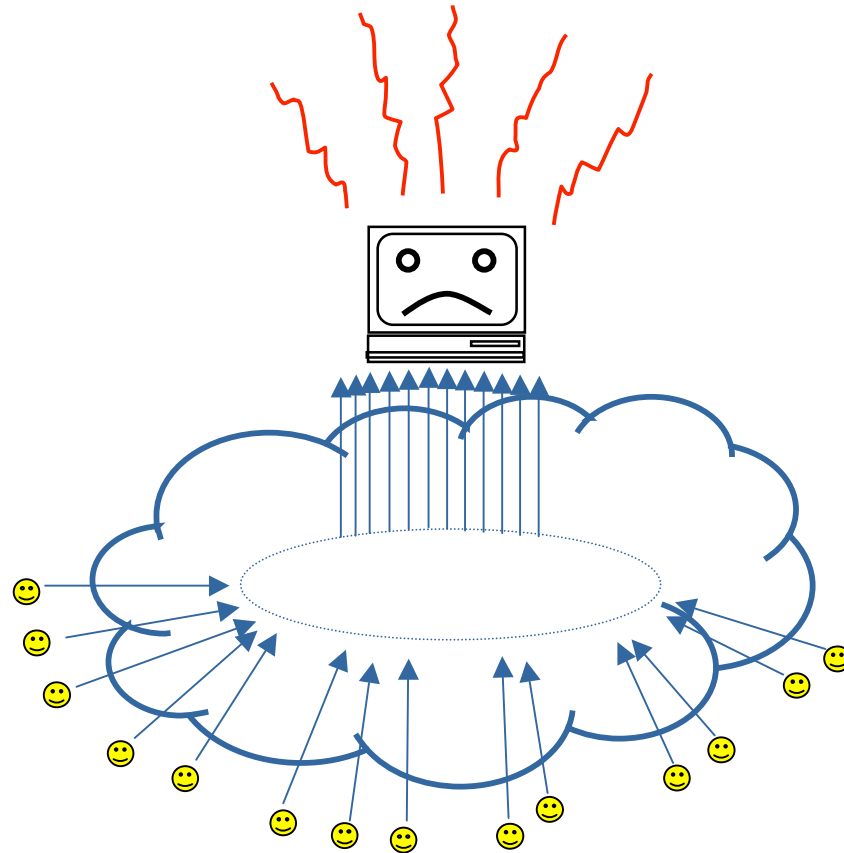
Too much load on server; central point of failure



Insufficient control over routing when participants change roles; hard to deploy

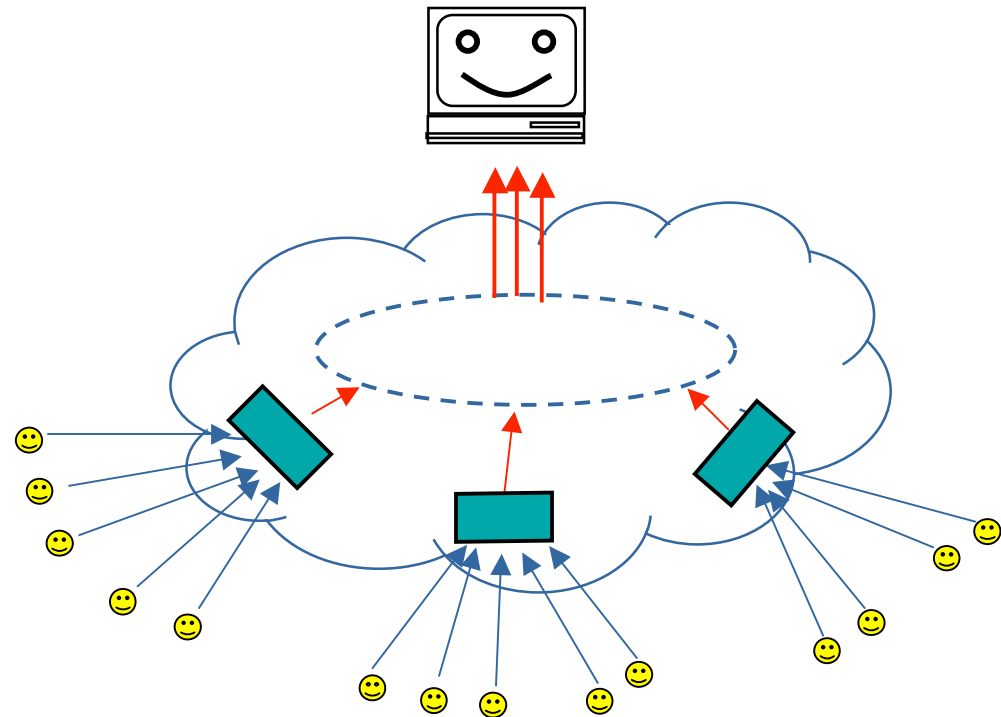
Scaling to Large Interactive Sessions

- Want to distribute the load; spread processing and control routing



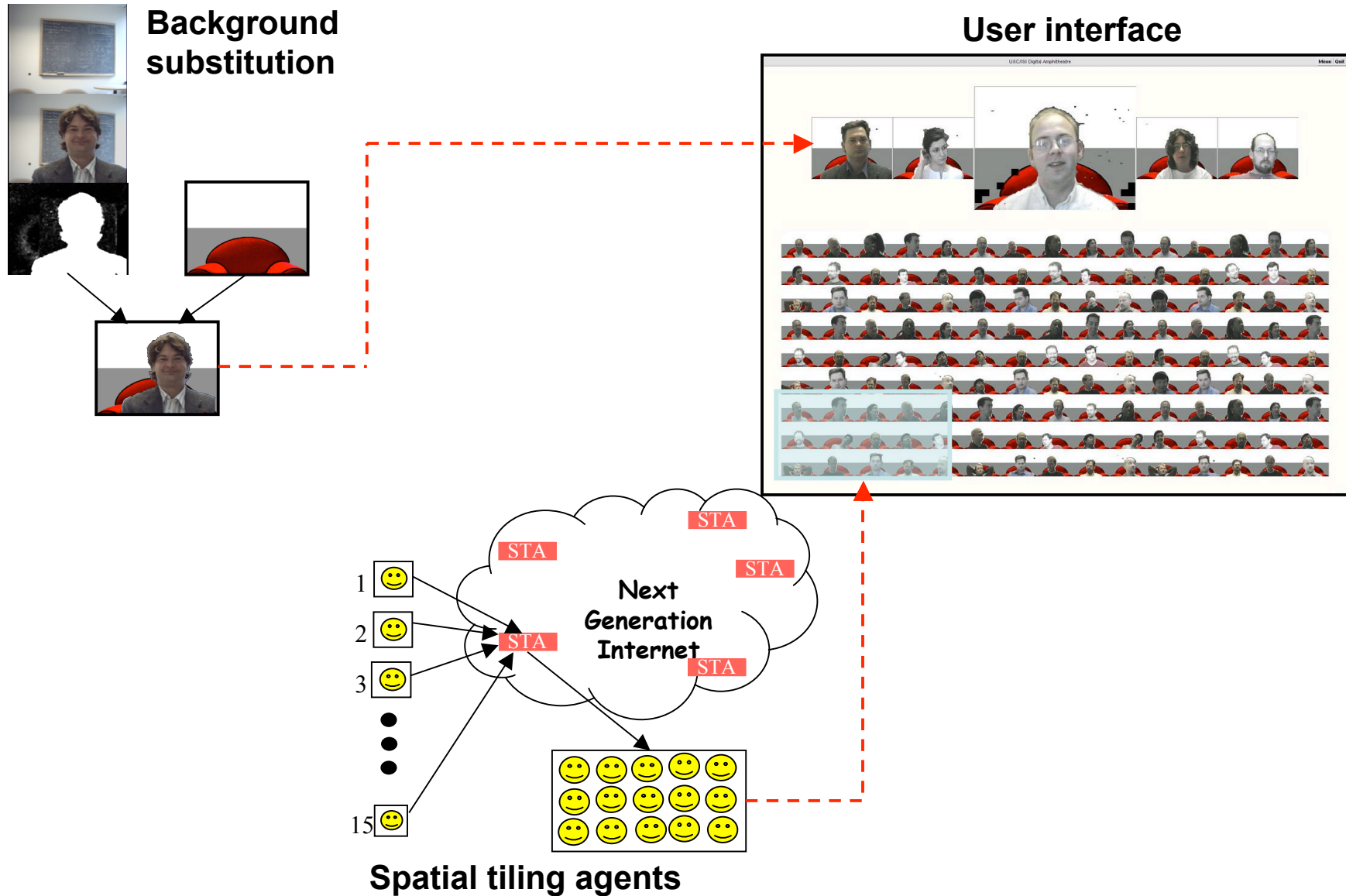
Scaling to Large Interactive Sessions

- Want to distribute the load; spread processing and control routing
- Accept that changing the network is difficult; keep end-to-end principle in mind
- Has to be deployable from the edges:
 - application level multicast
 - peer-to-peer
 - agents



Digital Amphitheatre
Orta peer-to-peer overlay

The Digital Amphitheatre

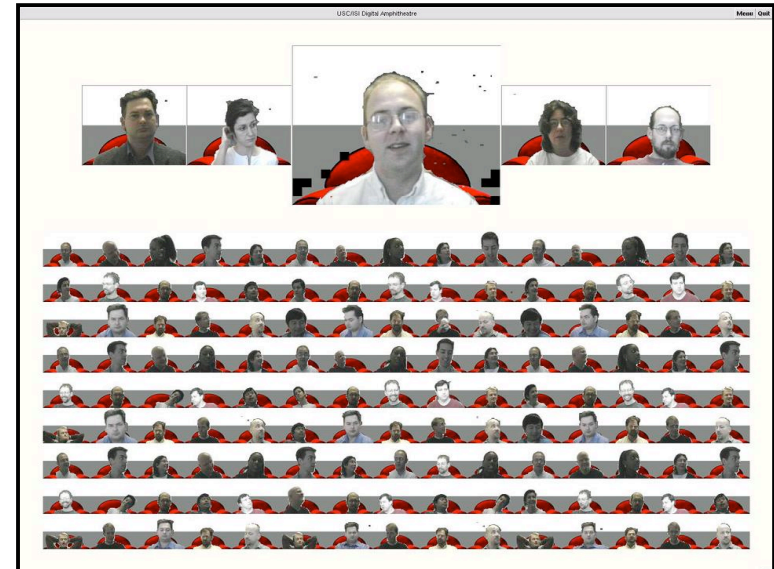


The Digital Amphitheatre

- Seamless display of multiple participants

- Distributed algorithm: key aspects implemented by agents within the network
 - Background substitution at source
 - Spatial tiling agents within network
- Information rich, scaleable, uncluttered

- Distributed algorithms
⇒ load sharing



- Lessons learned:

- Robust background substitution reduces clutter; improves user experience
- In-network processing to reduce load unimportant
- In-network control and overlay routing useful

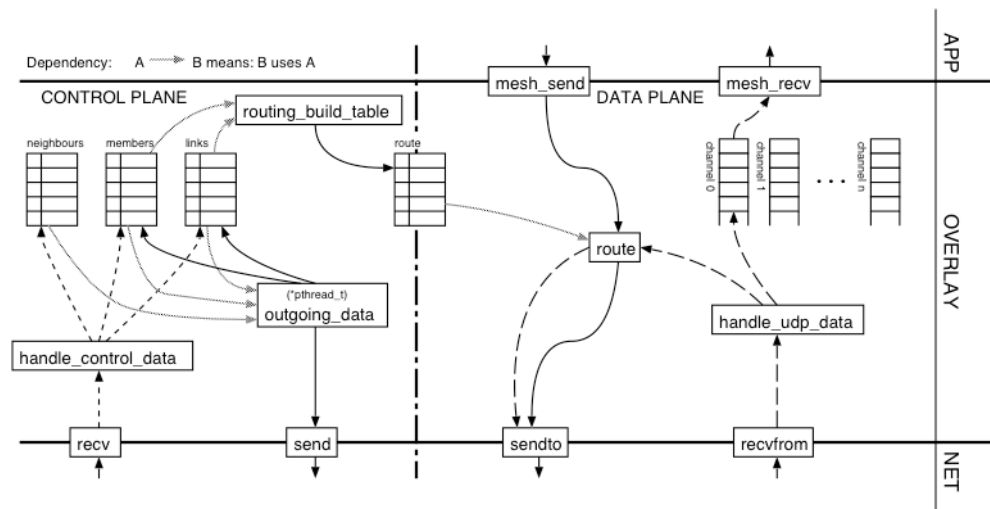
The Orta Peer-to-Peer Overlay

- Problems with IP multicast
 - Deployment limited; limited control over routing; security issues

⇒ Application level peer-to-peer multicast overlay: Orta

- Build well connected unstructured mesh of all peers; robust connectivity
- Link-state shortest path routing over mesh for media data
 - Like Narada but faster convergence; rapid join; incremental routing optimisation

- API similar to `net_udp.c` in common library; easy to integrate into rat
 - IP multicast-like API to application; works with O(dozen) participants
- Initial tests show promise experiments ongoing



From: Stephen Strowes MSc thesis

Further Information

- UltraGrid project website: <http://ultragrid.dcs.gla.ac.uk/>
 - Latest release available for download
 - Mailing list subscription information
- The Digital Amphitheatre: <http://nmaa.east.isi.edu/da/>
- Orta peer-to-peer overlay: <http://orta.sourceforge.net/>
 - Source code download
 - Detailed protocol description + testing results

Input to SUMOVER and the Mbone Toolset

- UltraGrid as a possible alternative to vic?
- Components that could be integrated:
 - Orta peer-to-peer overlay
 - Prototype running within rat now
 - TFRC API + library implementations
 - HDTV frame grabber code
 - Not sure useful without rest of UltraGrid?
- Issues to consider:
 - Modularity of the toolset
 - Standard API for networking?
 - Standard API for playout and/or sending buffers?
 - Standard API for audio and video codecs?
 - Desire to allow experimentation vs. production quality code