Advanced Visualization and Collaboration Research over High-Speed Networks

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Overview

- A bit of history on the Electronic Visualization Laboratory
- New Displays
- Networking
- SAGE

New Displays

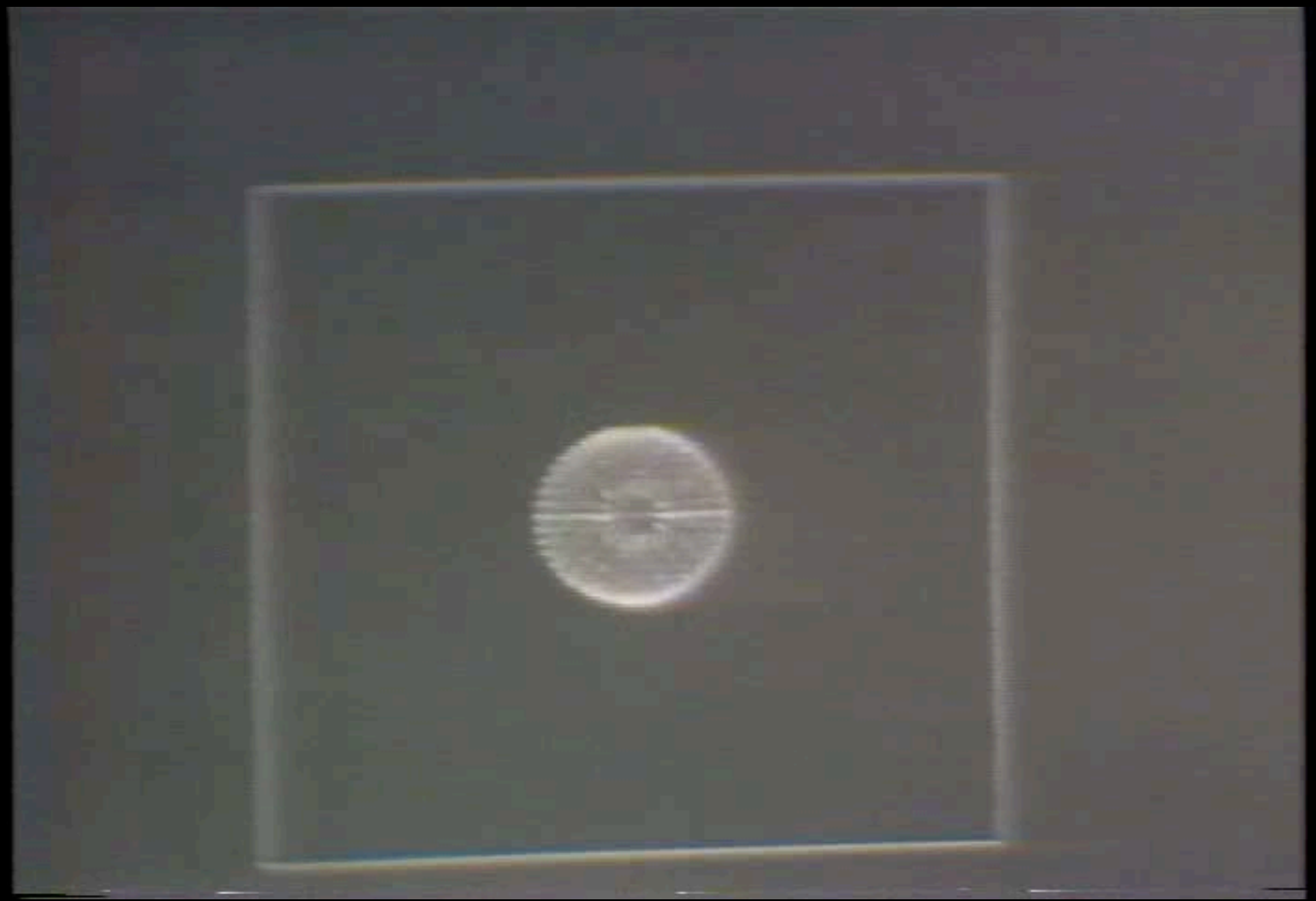
A long time ago…

- Established in 1973 by Tom DeFanti and Dan Sandin
- Interdisciplinary collaboration in Computer Science and Art
- Co-directors: Tom DeFanti, Dan Sandin, **Jason Leigh**
  - 10 full time staff
  - 40 graduate students (20 funded), Art and CS
  - Students in CS, ECE, Art+Design
- Real-time Computer Science + Art → Networked Scientific Visualization, Computer Graphics and Tele-immersive Virtual Environments → Lightpaths and LambdaGrids

Electronic Visualization Laboratory

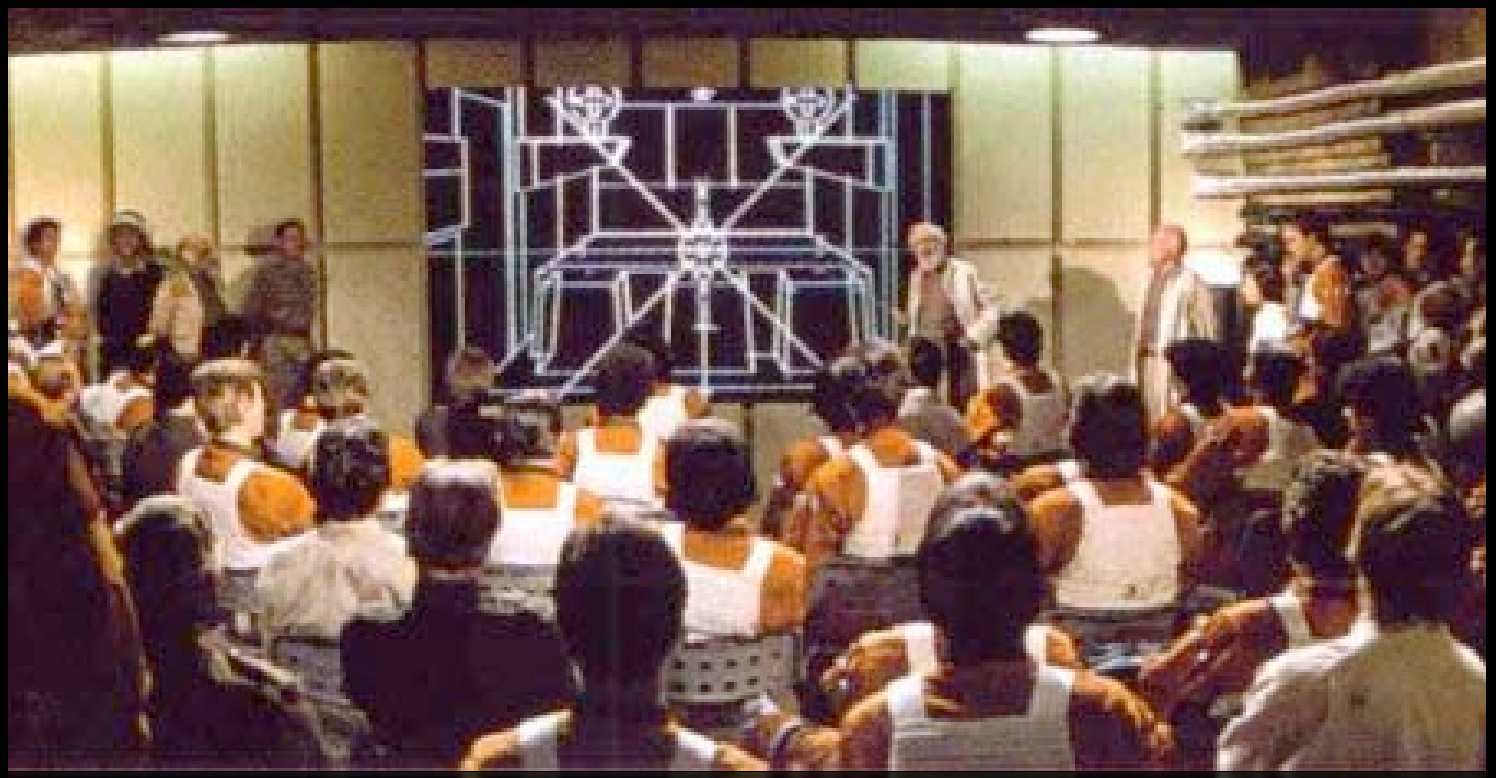
- Research in:
  - Advanced display systems
  - Visualization and virtual reality software
  - Advanced networking protocols
  - Collaboration and human/computer interaction
- Funding mainly NSF, ONR, NIH. Also NTT, General Motors

Early work



... in a laboratory far, far away…

- Created Computer Graphics for a movie in 1976



Star Wars

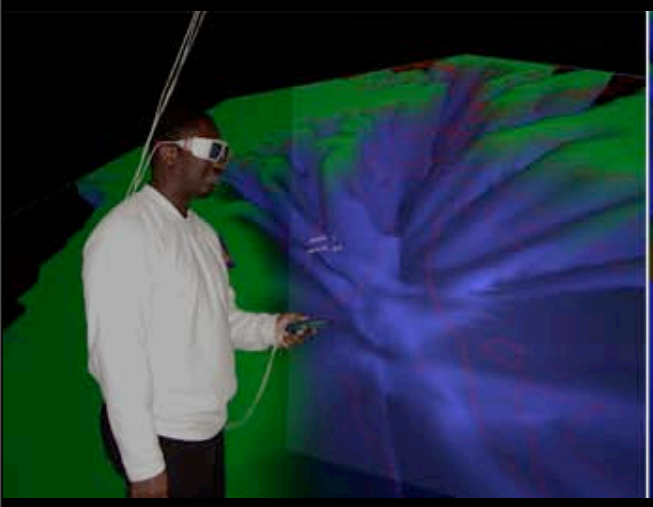
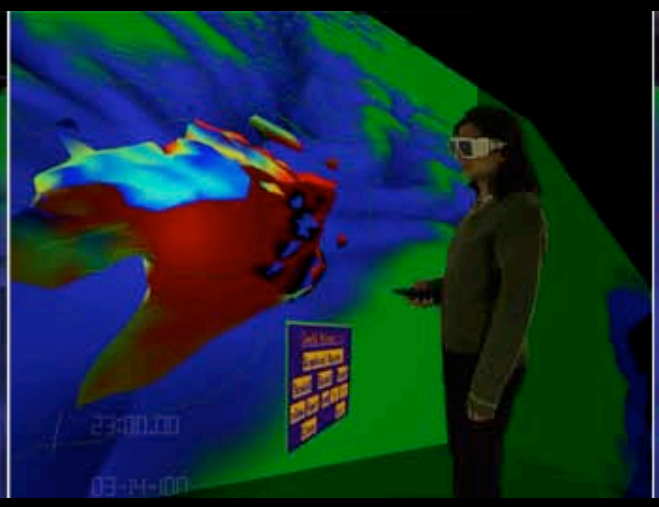
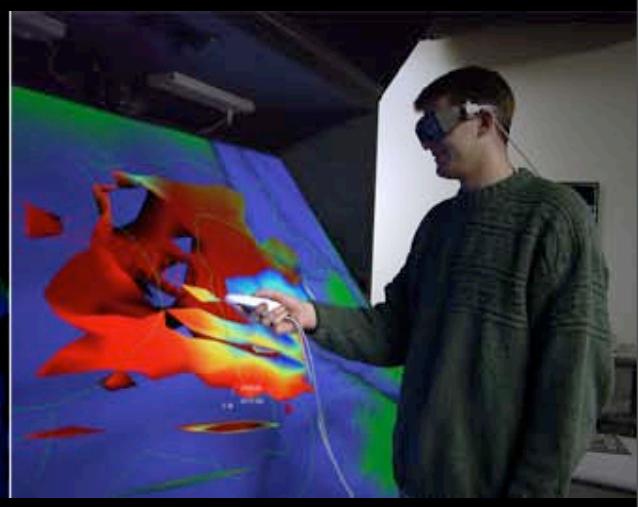
Making of Star Wars

- Larry Cuba's "Death Star"
- EVL (then called the Circle Graphics Habitat) at the University of Illinois at Chicago Circle
- Dept. of Chemistry computer

Virtual Reality Devices

- Created several Projection-based Virtual Reality devices:
  - CAVE in 1992
  - ImmersaDesk in 1995
  - PARIS in 2003

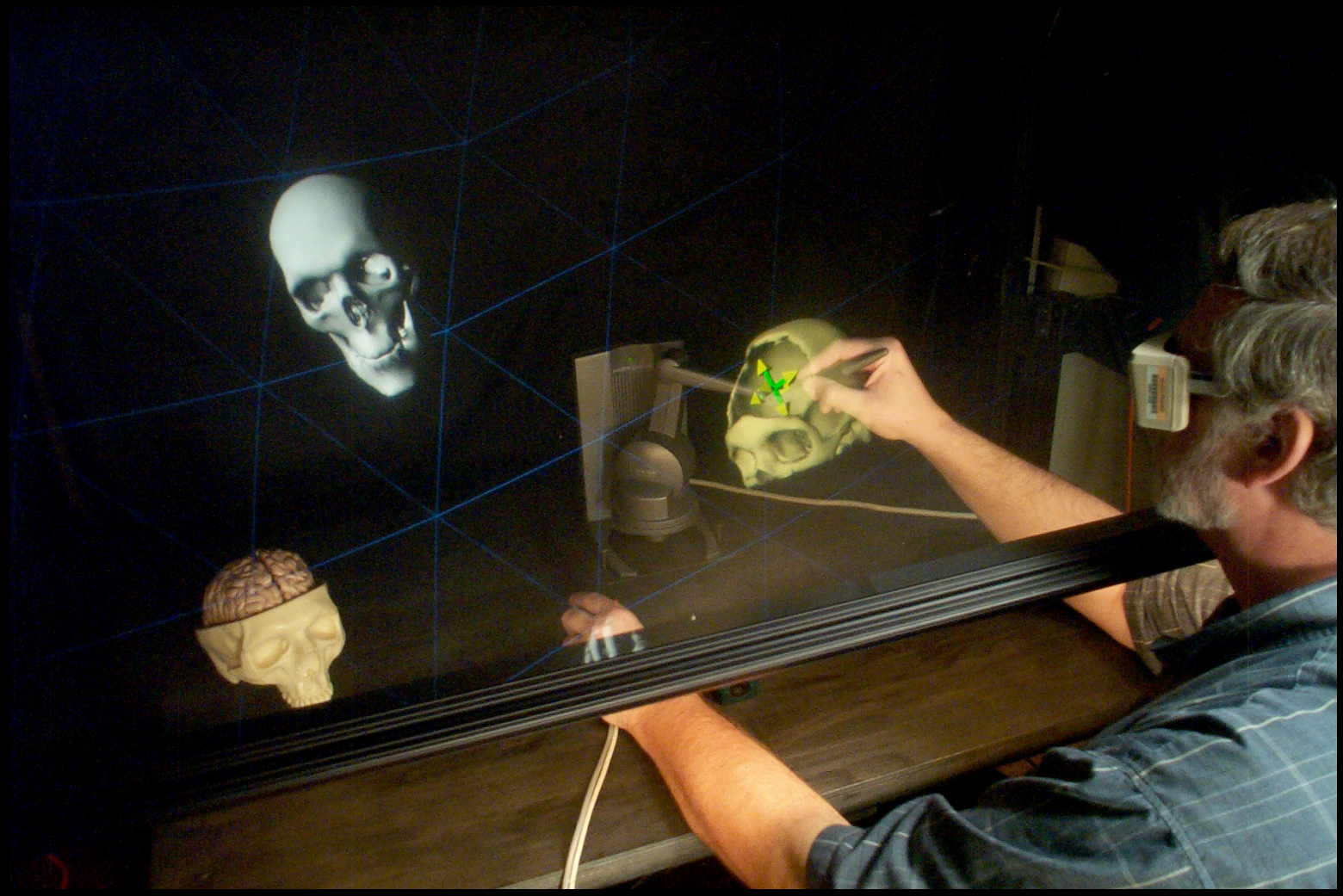
- We like big screens and shared experiences

CAVE - 1992

Immersadesk - 1995

PARIS - 2003

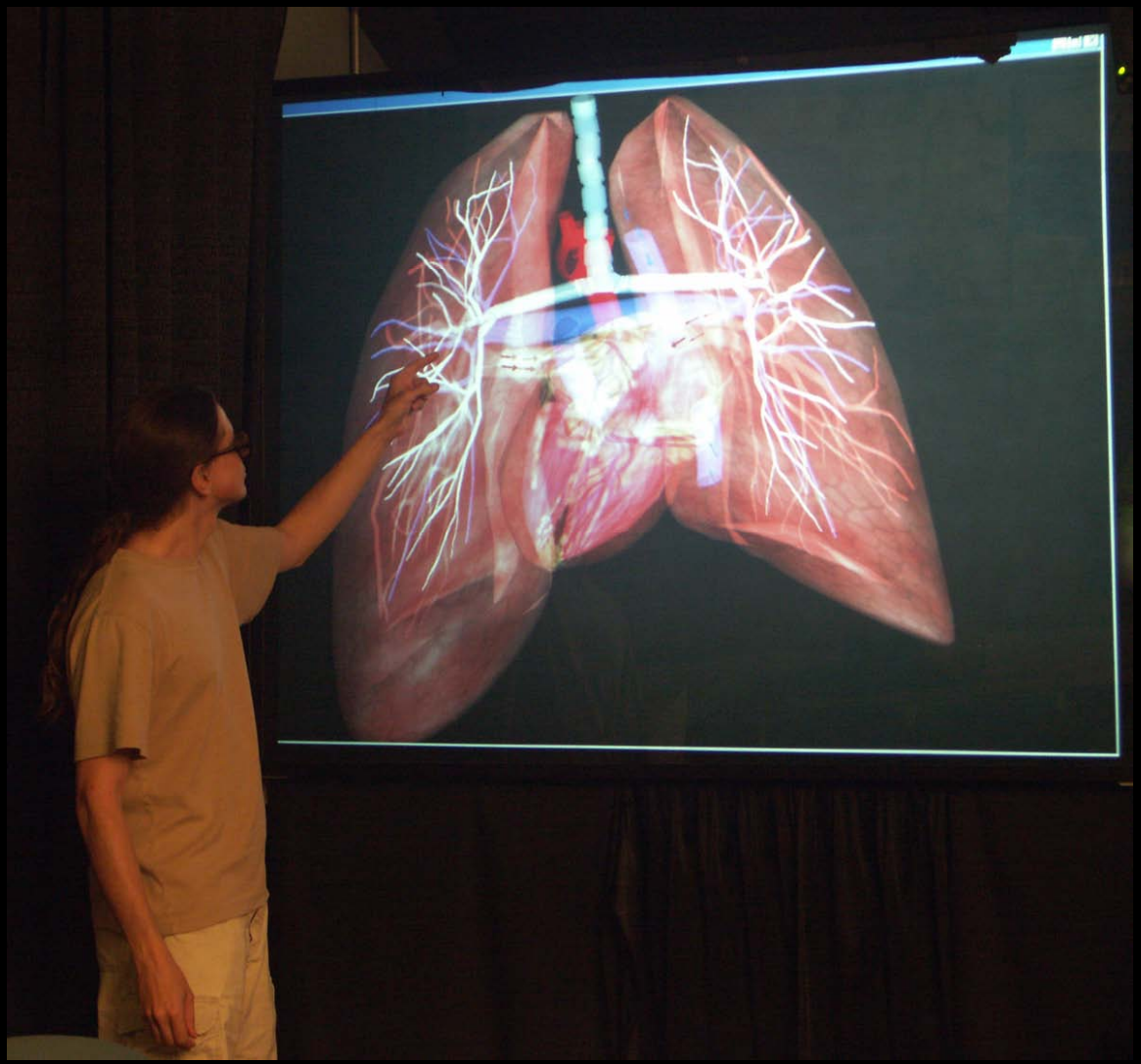


Newer Devices

- In the 90s you needed a very powerful computer to do good visualization work, very often an SGI machine (graphics supercomputer)
- These cost a lot of money

- Graphics power of desktop PCs has increased dramatically thanks to the videogame industry allowing us to create new devices based on commodity hardware

The GeoWall



Birth of the GeoWall

- Question came in 2000 from Paul Morin at the University of Minnesota who is working in the Earth Sciences
- Earth Science data is 3D and time-dependent
- Shared experience is best
- Traditional material often gets in the way of learning
- But CAVEs and IDesks are way too expensive

GeoWall Goals

- Stereo Projection for the office, lab and classroom
- For research and education

- Off-the-shelf hardware

- Passive stereo (like in 3D movies in the 1980's) with 20+ people viewing at a time

- No head tracking -> not VR

- Total cost under $10,000
- Small and Portable

U of Minnesota

How It Works

- Many PC Graphics cards have 2 output connectors - Allows you to have one wide desktop spread over 2 displays.
- Draw left eye view on one display, and right eye view on the other display

- Filters in front of projectors polarize the light that reaches the screen
- Viewers wear lightweight glasses with filters so the right eye sees only the right-eye image and the left eye sees only the left-eye image

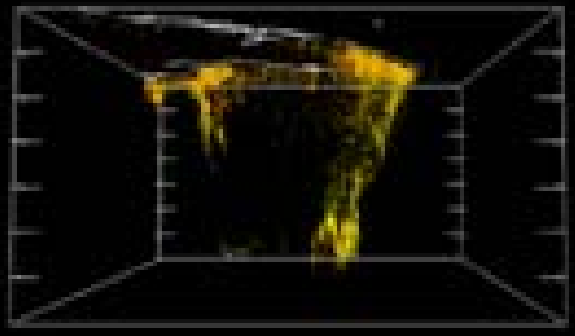
Lincoln Elementary, Oak Park

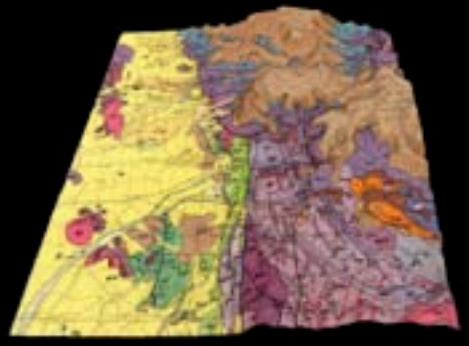
GeoWall Consortium

- Key factor in the success
- Group of individuals at various Universities, Government Agencies, Schools, Museums, and Companies around the country working on the project
- Want to share experiences and Open Source software
- Want to make the hardware, software, and teaching materials more widely available and easier to work with
- Other members include Adler Planetarium, Science Museum of Minnesota, Jet Propulsion Laboratory, Scripps Institute, US Geological Survey

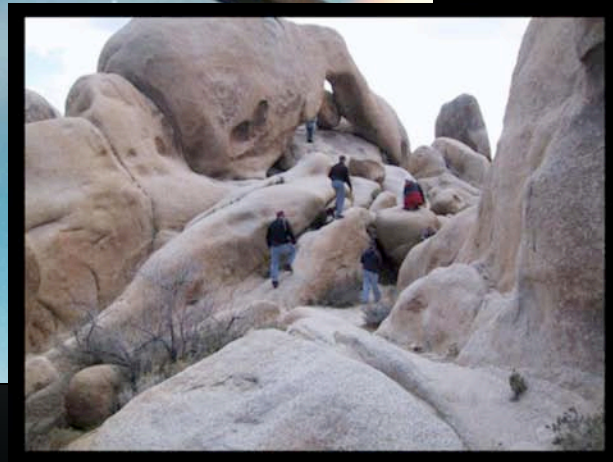
GeoWall at U of Minnesota Geology Dept.

- Each discipline has critical skills or assessments serving as 'gate-keepers' for progress in that field
- In earth science, visualization and map interpretation is critical restriction curtailing students' ability to access and explore course concepts
- Students who are not innately predisposed to understanding maps find it difficult to understand much of the course content and methodology





Example of Content



Need for Resolution

- Previous Displays
  - Immersive VR
  - Off-the-Shelf stereo

- Need for more resolution !

Need for Resolution

- The earth is 3D, highly detailed, and changing in time. The GeoWall was important in dealing with 3D data, but it does not do as well when dealing with the needs of high resolution and time

- To address the need of high-resolution we developed the GeoWall-2 in 2003

GeoWall2

- 5x3 LCD tiles, 1600x1200 per tile, 8000x3600 pixels
- ~30 Mpixels total
- Driven by 10 Linux PCs
- Shows detail and context at same time
- One road case for display, another for the PCs

GeoWall2: LCDs plus Computers

Looking for Correlations

- Tile displays are also good for viewing and manipulating multiple related images at the same time to look for correlations

A Variety of Sizes, Shapes, and Uses

Tiled displays

Tiled Displays

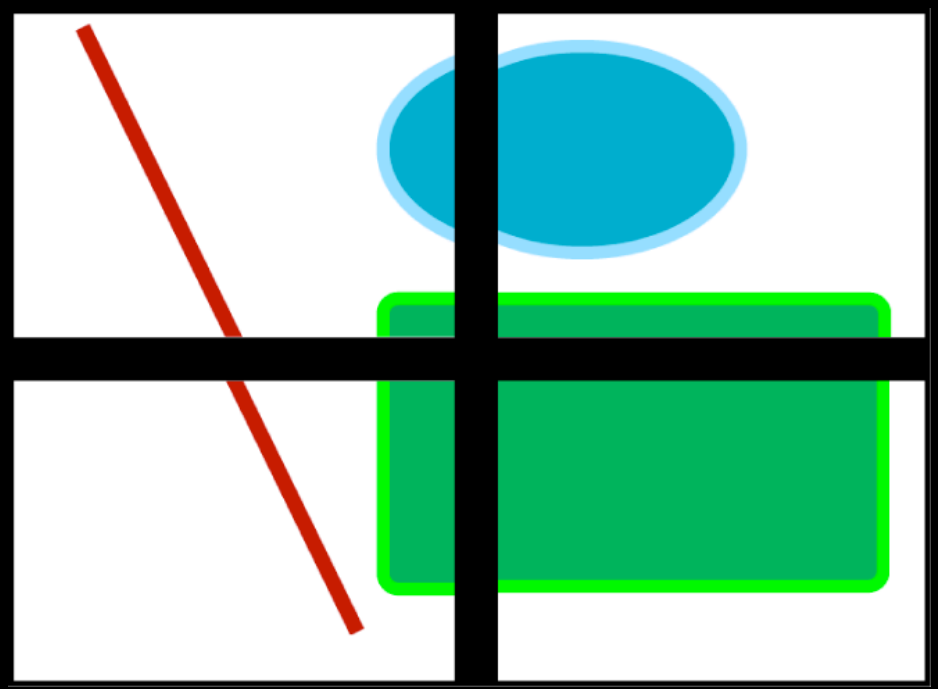
- Why not use multiple projectors?
- You could, and all software supports their use, but ...
- The advantages of projectors are:
  - Big images
  - Seamless
- The disadvantages of projectors are:
  - Hard to align and color balance
  - Large throw distances even when using mirrors
  - Bulb replacement costs are high ($400+ per bulb)
  - Much shorter lifespan compared to LCDs (2,000 hours compared to 20,000 hours-50,000 hours)

- LCDs allow us to leave the display on all the time, to improve casual usage of the display

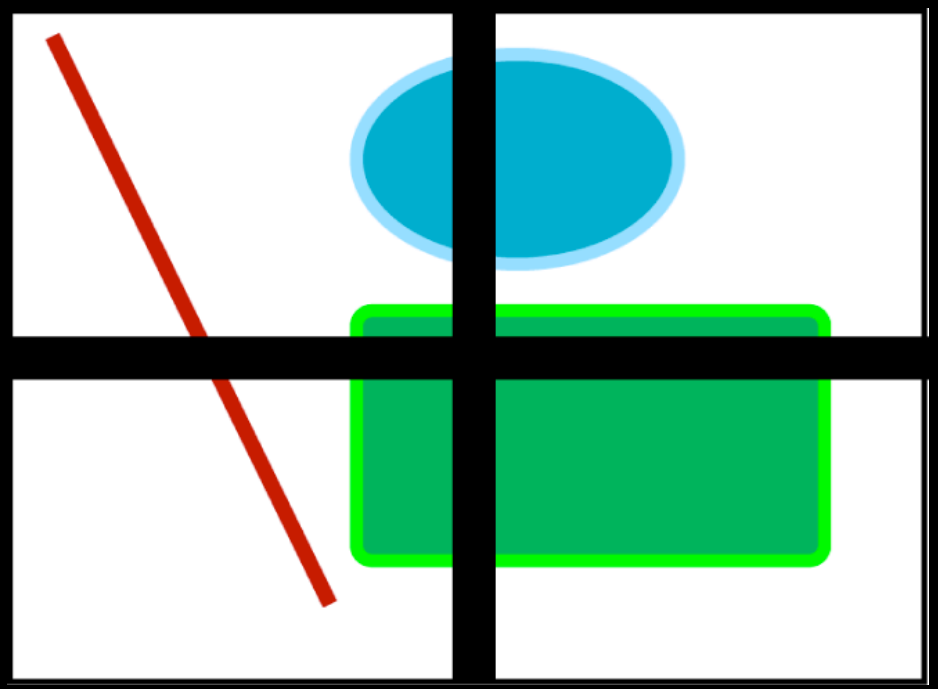
Tiled Displays

- What about the borders?
- For the scientists, the borders quickly disappear as the users begin interacting with their data in a more effective way they have never been able to before
- Helped greatly through ‘window-pane’ metaphor where computer graphics continue ‘underneath’ the borders
- Users can treat the large high-resolution display as a familiar window with multiple panes of glass

Border Management



Without



With

Tiled Displays

- Typically we are running 2 displays per node off of one graphics card
- Why so many cluster nodes?
- You can put several graphics cards into each computer
- Modern PCs (even a shuttle) can now drive 4 apple / dell 30” monitors using a pair of GeForce 7900 GTX cards
- 16 megapixel display for $15,000

Large High-Resolution Screens

- Statistics always questionable but from www.w3schools.com

  July 2005 25% 800 x 600 (0.5 megapixels)
  55% 1024 x 768 (0.8 megapixels)
  14% higher

- 1600 x 1200 (1.9 megapixel) 20” are $600
- 1920 x 1200 (2.3 megapixel) 23” or 24” are $900 - $1,200
- 2560 x 1600 (4.0 megapixel) 30” are $2,000 - $2,500

- Still don’t have the resolution of IBM’s T221 that had 3840 x 2400 pixels (9 megapixels) in 22” but it also cost $9,000

Large High-Resolution Screens

- The coming of HD - new high-definition DVDs are 1920x1080p - LCD displays: 37” at $1,500, 45” at $3,000
- Handhelds increasing in resolution (OLED at 1200 dpi)
- In terms of getting content onto these displays:
  - 8 and 9 megapixel still cameras now under $400
  - HD video cameras now under $1,500

Tiled Displays

- Number of nodes (computers) is very important
- Managing a single PC with multiple displays as a single large desktop is doable for a Geoscientist, Bioscientist or Astronomer
- Managing a cluster of PCs can be intimidating and requires specialized help

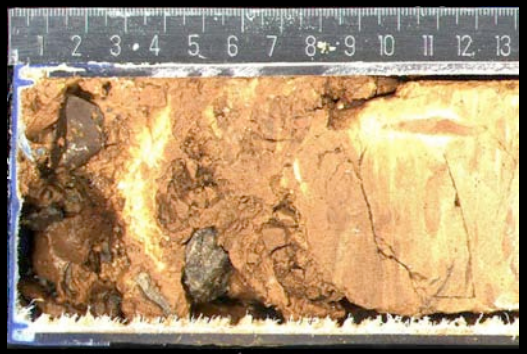
- So we are trying to develop a variety of solutions
  - Personal display for the office
  - Larger shared display in the lab

Three Types of Displays

- CoreWall
- LambdaTable
- LambdaVision

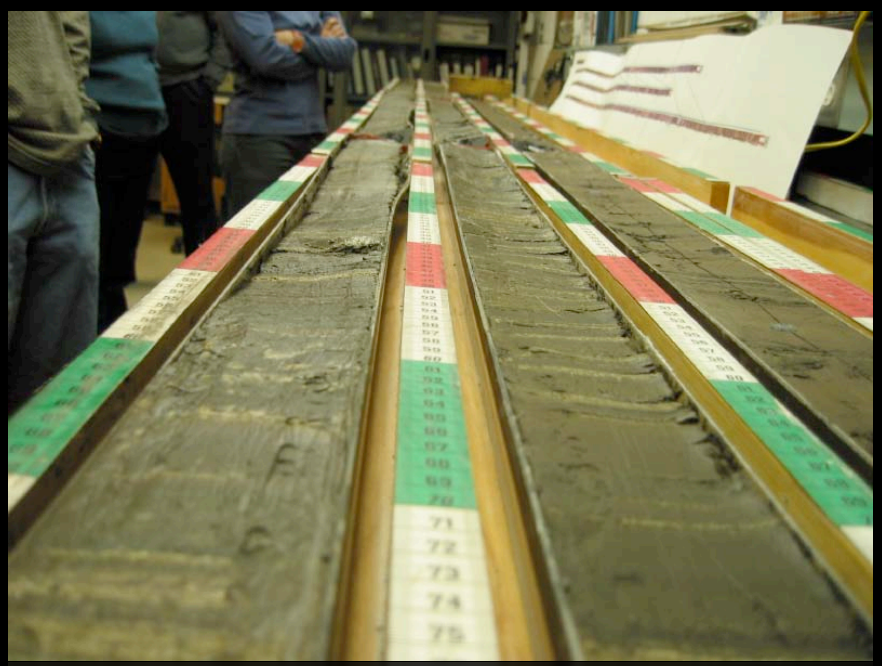
CoreWall

- Data fusion environment for description of sediment cores
- Ocean, lake, antarctic cores
- Integrated Ocean Drilling Program
  - Multiple countries, multiple vessels
  - Recover up to thousands of meters per expedition
- Antarctic Drilling (ANDRILL)
  - Drill thru ice, to get to ocean floor, 1km expected



CoreWall

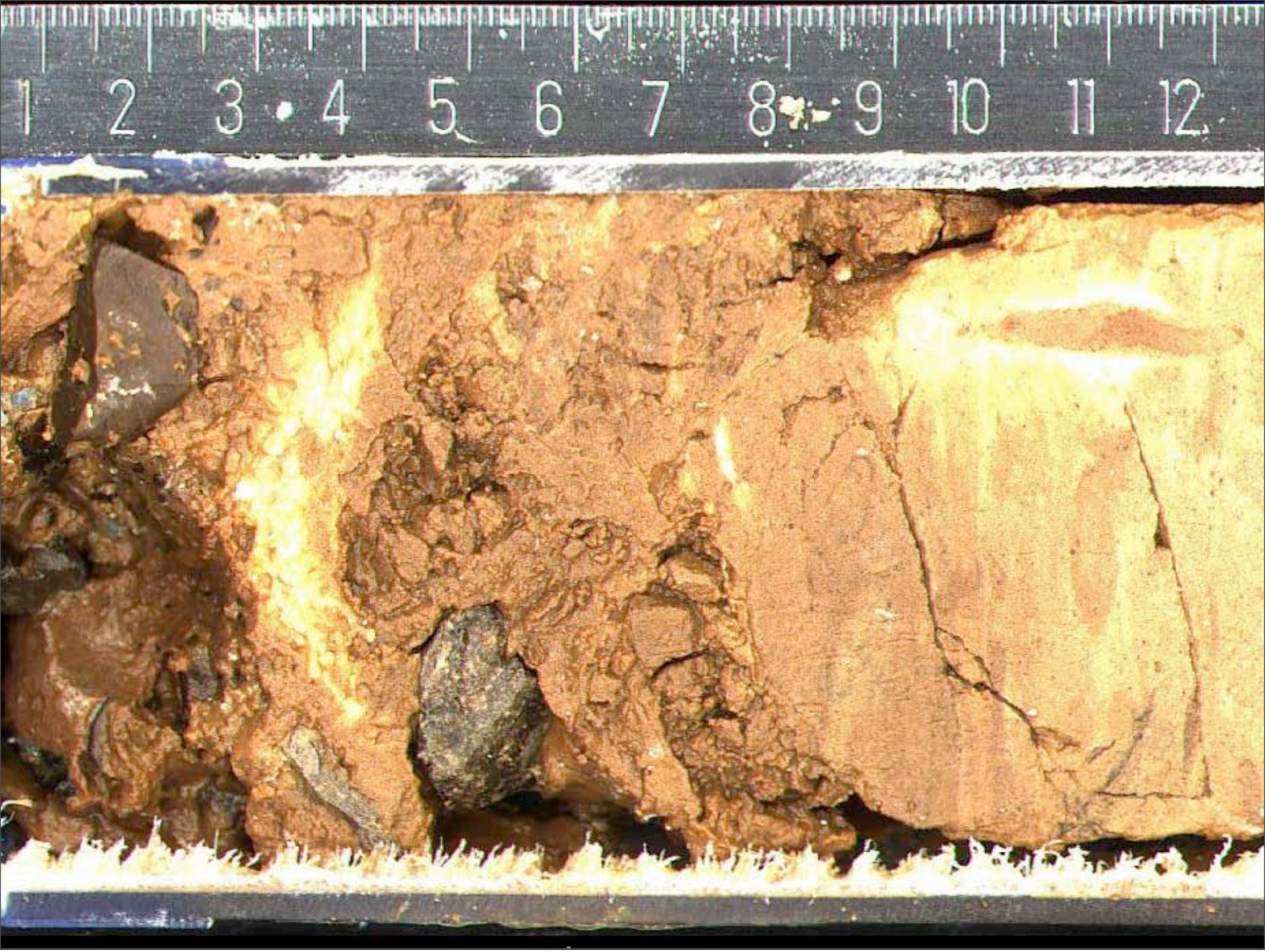
- Cores are brought up, sliced in half, and scanned
- Large amounts of data that is expensive to get to, hard to visualize
- Want to display sections from one or more cores along with discrete data streams and nested images, and be able to make annotations



CoreWall

- Imagery of these cores is taken at 10-40 pixels per mm
- High-resolution displays are needed to visualize the core in at multiple levels of detail
- Researchers prefer to look at imagery of the core rather than the core itself - guaranteed lighting conditions

- Lots of other data collected and then graphed next to the core imagery to help interpret the core


1 2 3 4 5 6 7 8 9 10 11 12

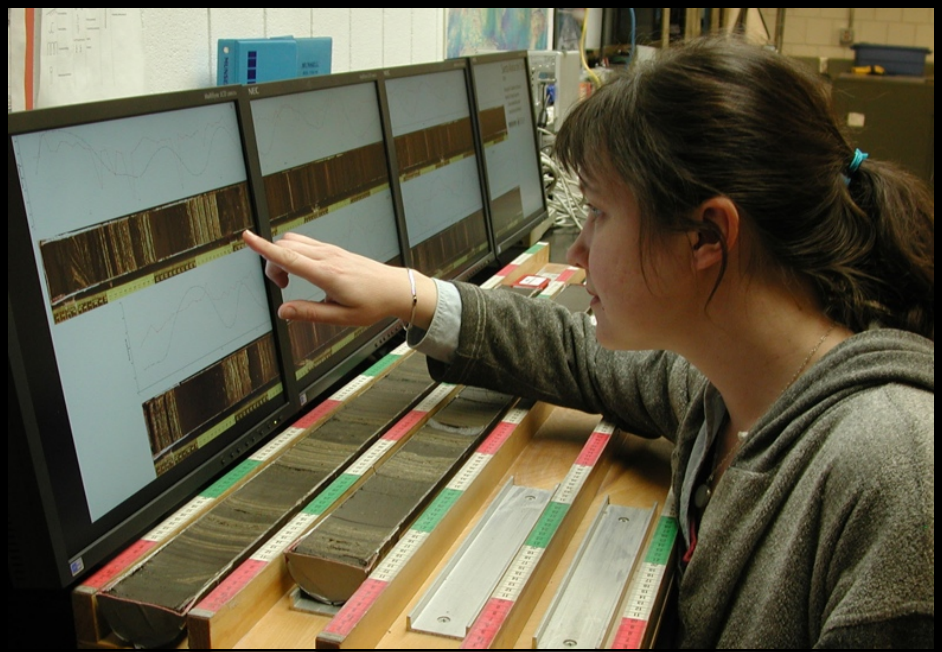
CoreWall

- GeoScientists want to use this to:
  - Help plan where to drill
  - Quickly change drilling priorities while out in the field (on the ship, on the ice, etc)
  - Show new people what they will see at a familiar site
  - Share core data more easily

- Want to use it to give their students a better experience
  - Show cores in detail during lecture - ones they have collected or cores showing famous events
  - Let students do their own core description in the labs

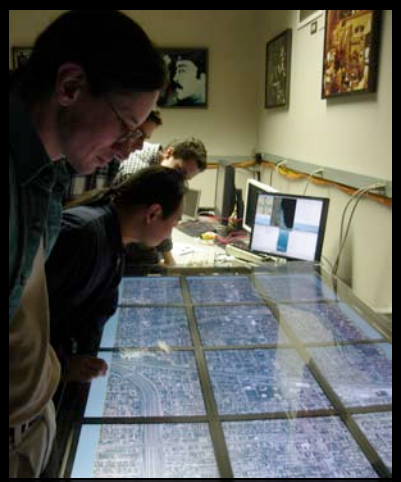
CoreWall

- Want to display sections from multiple cores along with discrete data streams and related images
- 1PC, 2 to 6 LCD screens
- Funded 2006 - 2008 by the National Science Foundation



LambdaTable

- Turned the original GeoWall 2 display into a table
- Our focus is on working with a high-resolution table
- Allows us to investigate camera-tracked physical icons, overlays, rotatable text, and lots of user interface issues

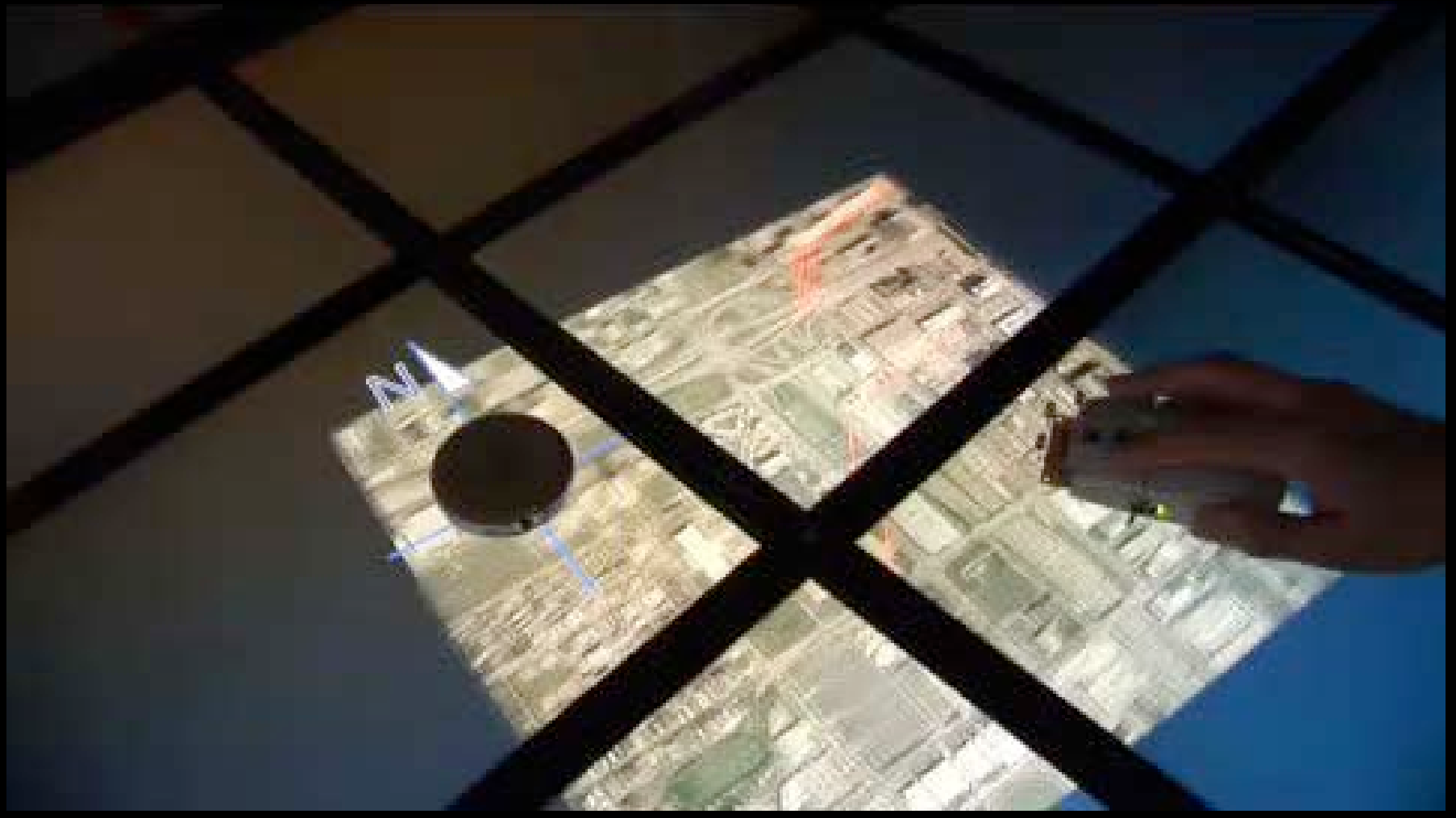


LambdaTable

- Why not use a single projected table / large plasma panel / big LCD as the table?
- A single projector or plasma panel limits the available resolution to roughly 1600x1200 pixels for a 50” diagonal display, which is basically a typical desktop monitor spread over a larger area
- Higher resolution displays like the apple/dell 30” LCD are still only 2560x1600

- Our next generation table make use of 30” LCD displays
  - 3x2 tiled display
  - 25 Mpixels
  - 3 PCs for display, 3 PCs for tracking

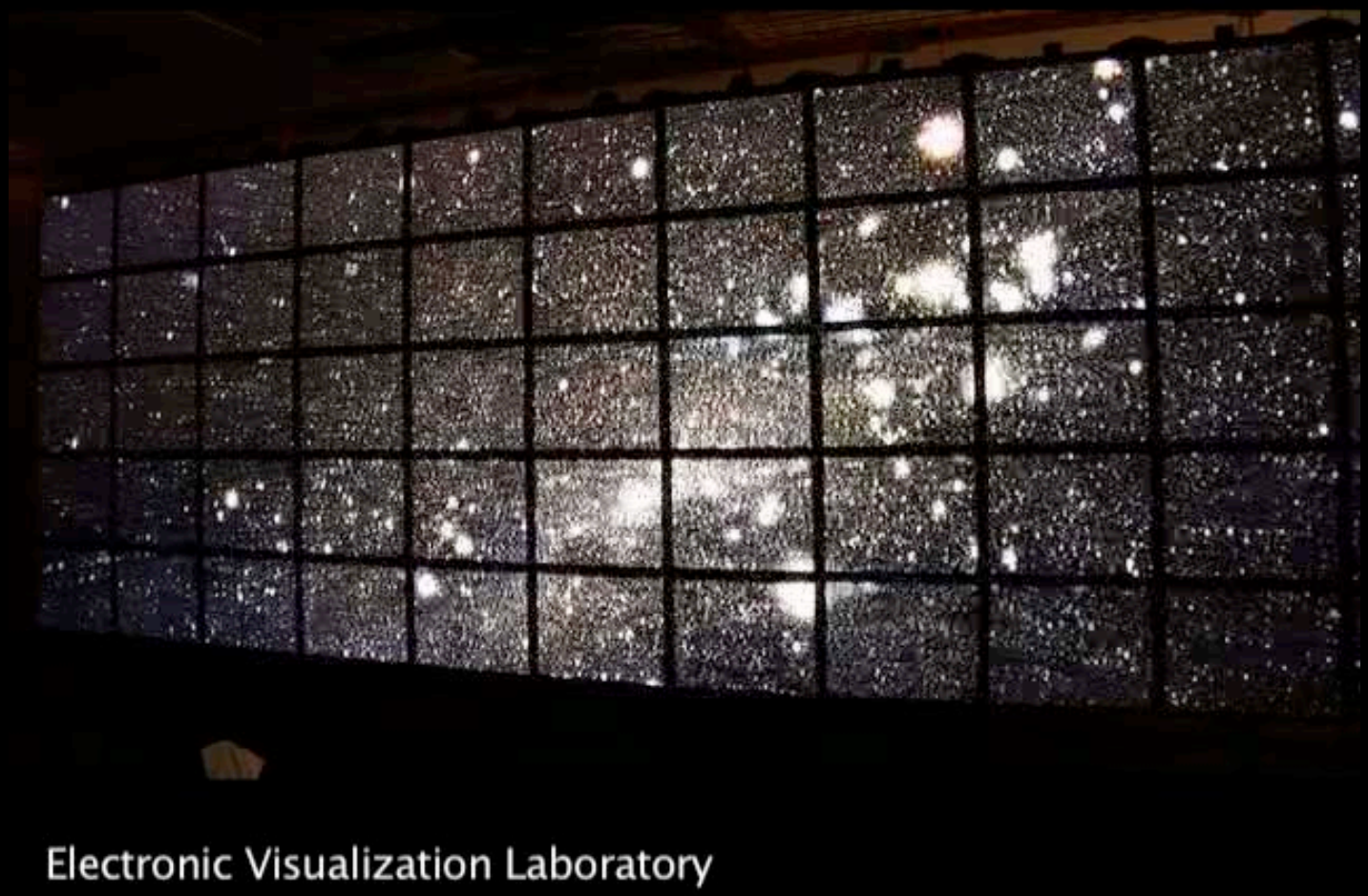
LambdaTable



LambdaVision

- 55 (11x5) tiled display at EVL, 30 Computers
- 100 Mpixels

Video Clip

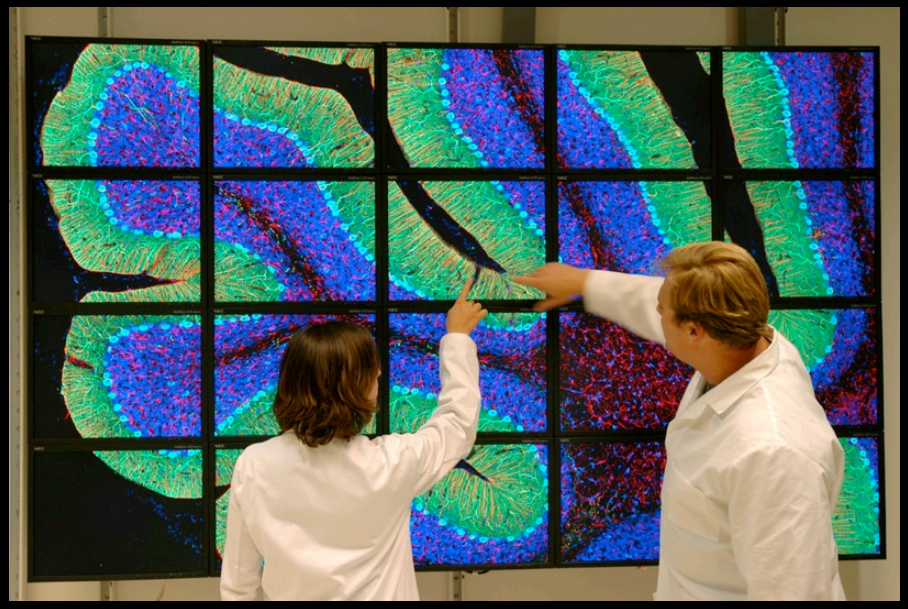


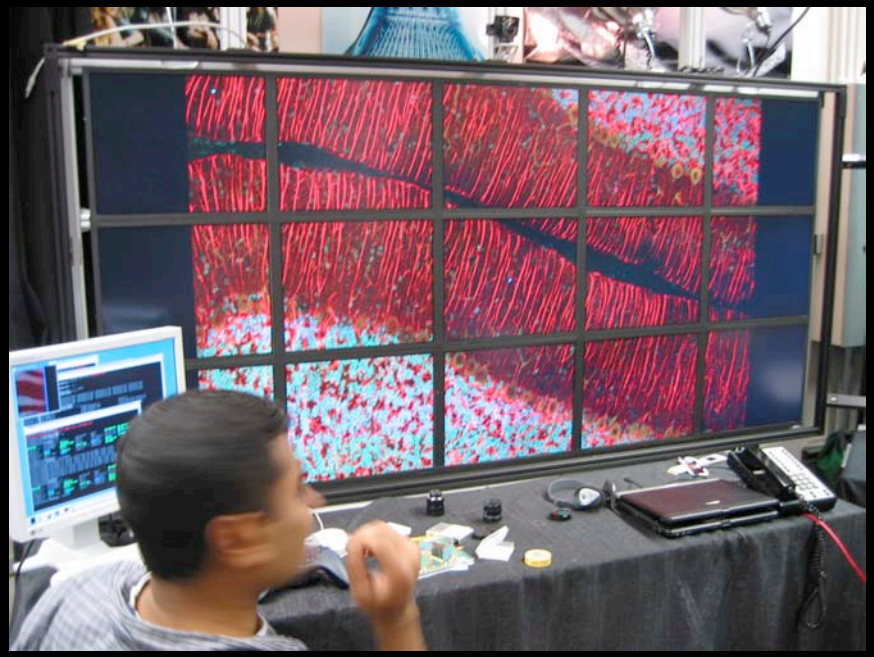
Scientific Needs: Large Amount of Data and the Ability to Perform Data Fusion

- US Geological Survey
  - National Map Mission
  - 51TB (51,000 GB) of aerial photos
  - 133 cities in US at 1/3 meter resolution
  - 365,000 * 365,000 pixels in each map

Scientific Needs: Large Amount of Data and the Ability to Perform Data Fusion

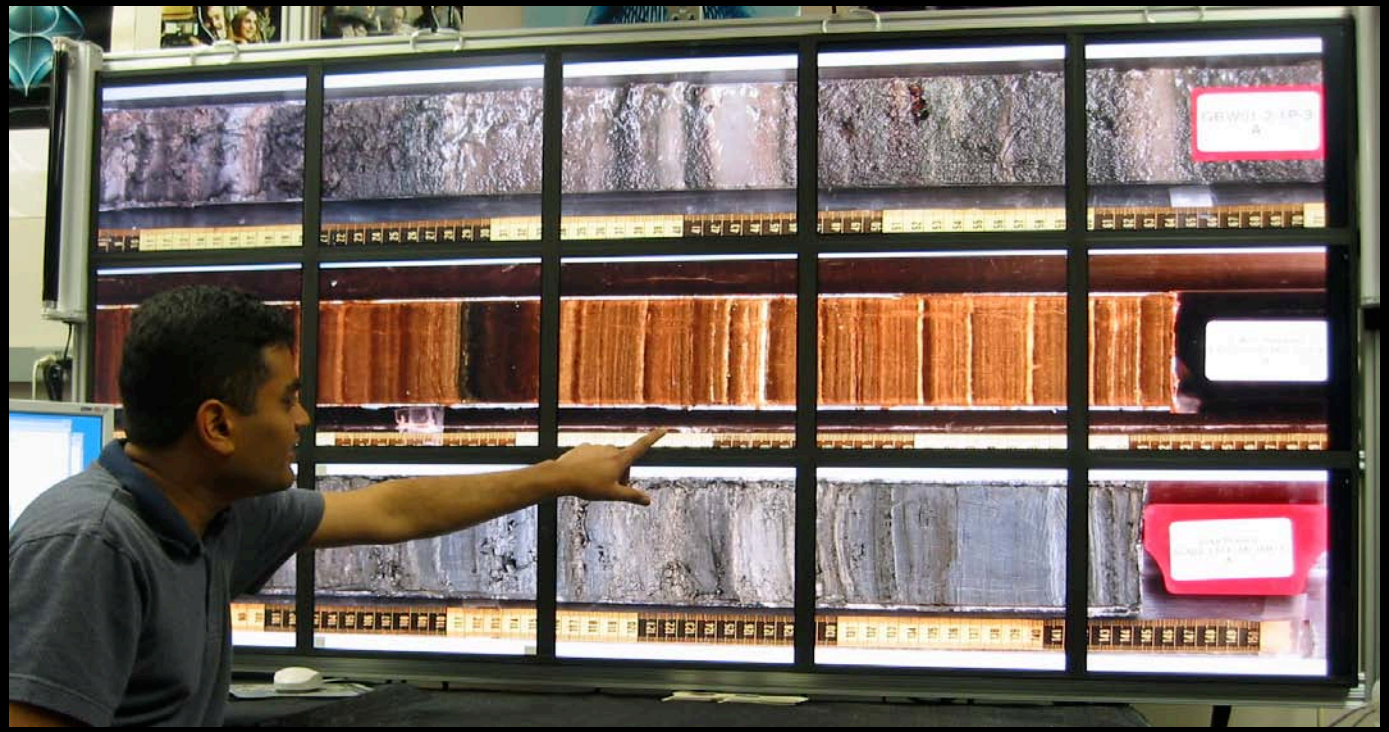
- NCMIR (Microscopy)
  - Rat Brain Mapping
  - Montage of 43,200 images
  - Each image 4,000 x 4,000 pixels





Scientific Needs: Large Amount of Data and the Ability to Perform Data Fusion

- Core Lab (Geology)
  - 300 km of core samples
  - scanning at 1200dpi



Expanding International Community of Users

Expanding International Community of Users

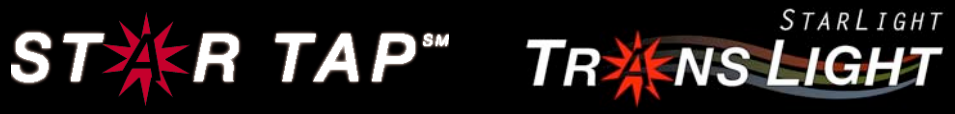
Networking

- EVL has been a long-time user of networks
- Tele-immersion
  - Connected VR CAVEs environments in 90s
  - Remote presence

- StarLight facility in downtown Chicago
  - 1x and 10x gigabit interconnection for research and science
  - Free of politics and carrier troubles

Networking in Chicago

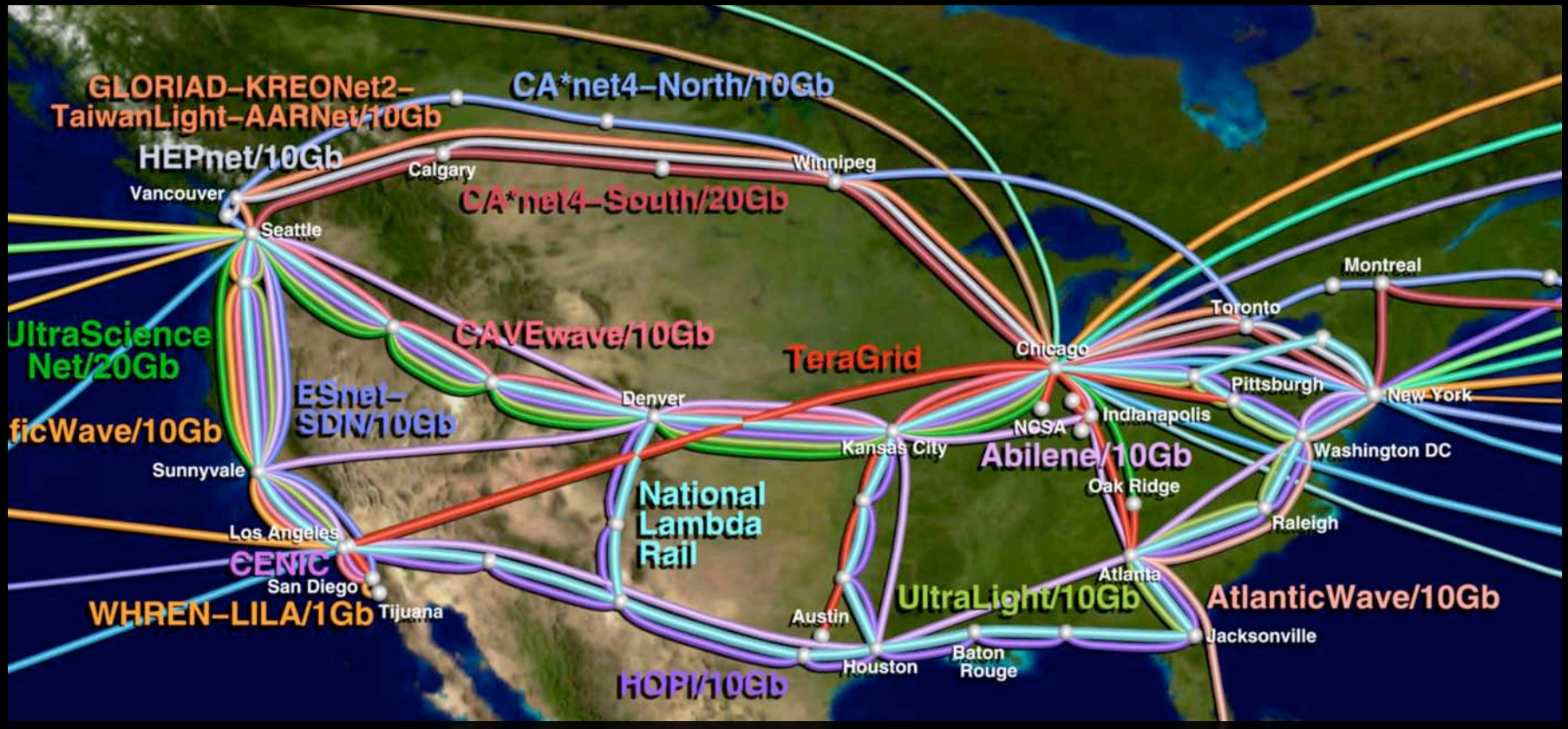
- 1997 STAR TAP
  - NSF supported STAR TAP − a persistent infrastructure to facilitate the long-term interconnection and interoperability of advanced international networking
- 2000 StarLight
  - NSF funded StarLight, the optical STAR TAP
- 2005 IRNC
  - NSF funded International Research Connections Program



TransLight/StarLight

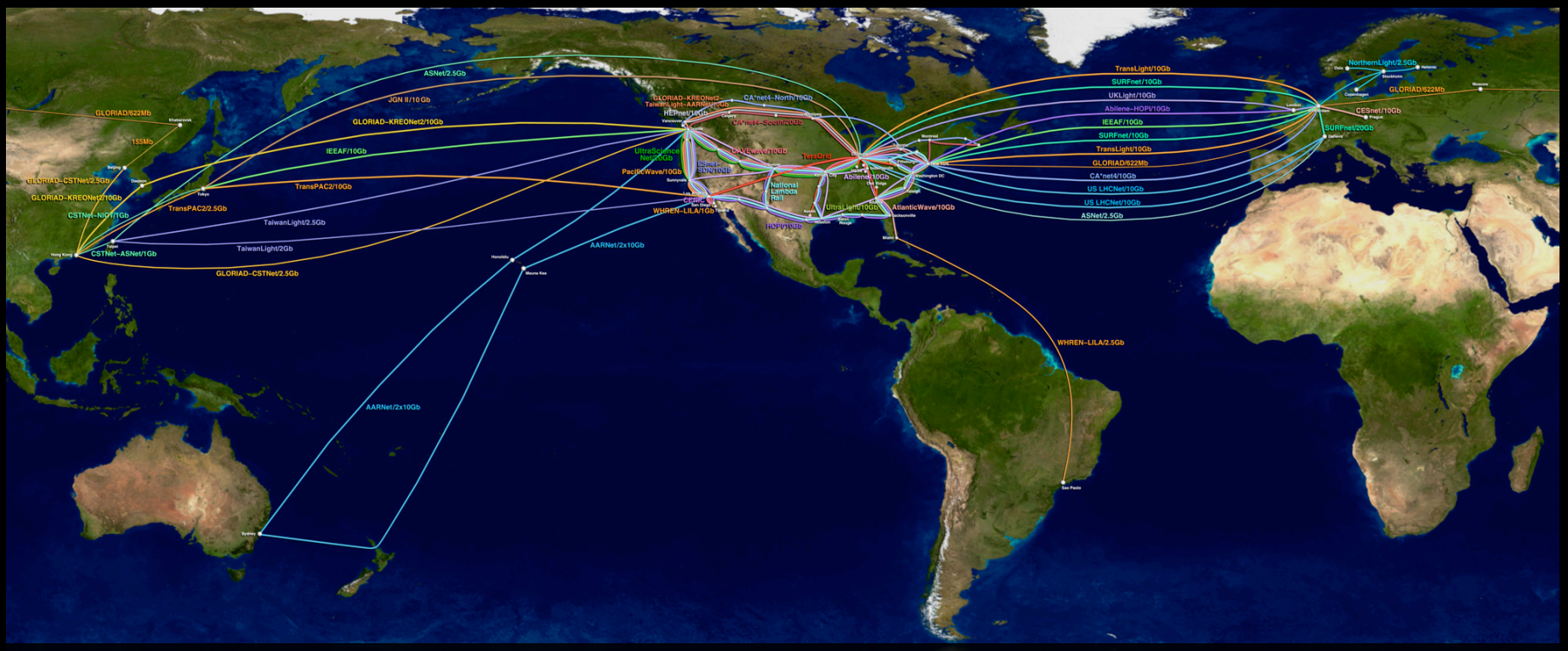
- TransLight/StarLight works with US and European research and education networks:
  - To implement strategies to best serve production science
  - To identify and to best serve pre-production data-intensive e-science applications requiring deterministic, not best-effort, networks
    - Guaranteed Bandwidth (data movement)
    - Guaranteed Latency (visualization/ collaboration, data analysis)
    - Guaranteed Scheduling (remote instruments)

Networks Peering in Chicago



Global Lambda Integrated Facility

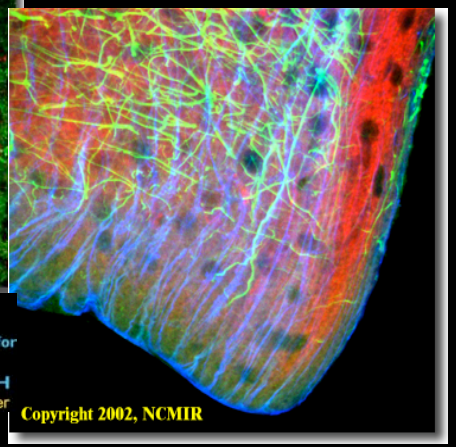
GLIF is a consortium of institutions, organizations, consortia and country National Research & Education Networks who voluntarily share optical networking resources and expertise to develop the Global LambdaGrid for the advancement of scientific collaboration and discovery



OptIPuter: Removing Bandwidth as an Obstacle In Data-Intensive e-Science

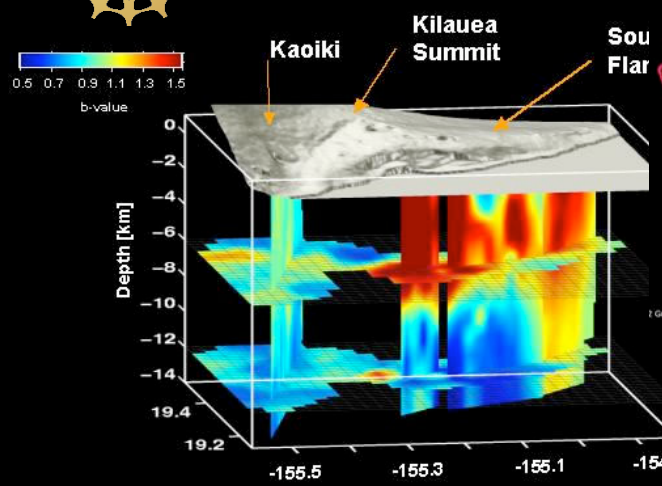
- OptIPuter is an NSF-funded award to develop cyberinfrastructure to enable the real-time collaboration and visualization of very-large time-varying volumetric datasets for the geosciences and biosciences
- OptIPuter is examining a new model of computing whereby ultra-high-speed networks form the backplane of a global computer

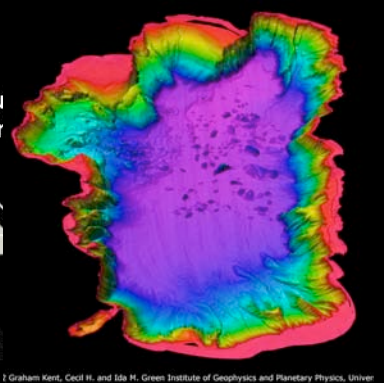
NIH Biomedical Informatics Research Network



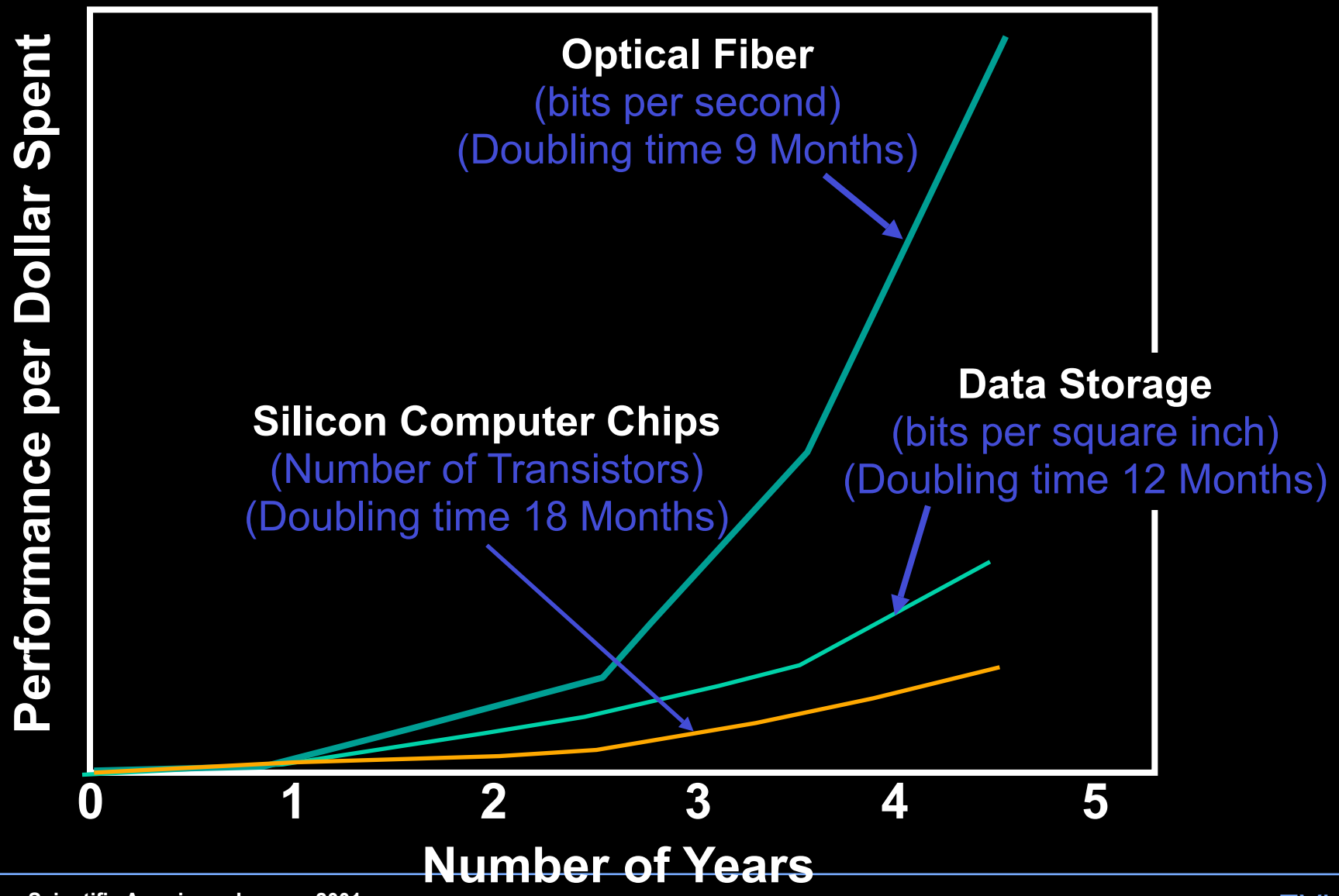
NCMIR
NATIONAL CENTER for MICROSCOPY and IMAGING RESEARCH
at San Diego, an NIH supported resource center

NSF EarthScope and ORION



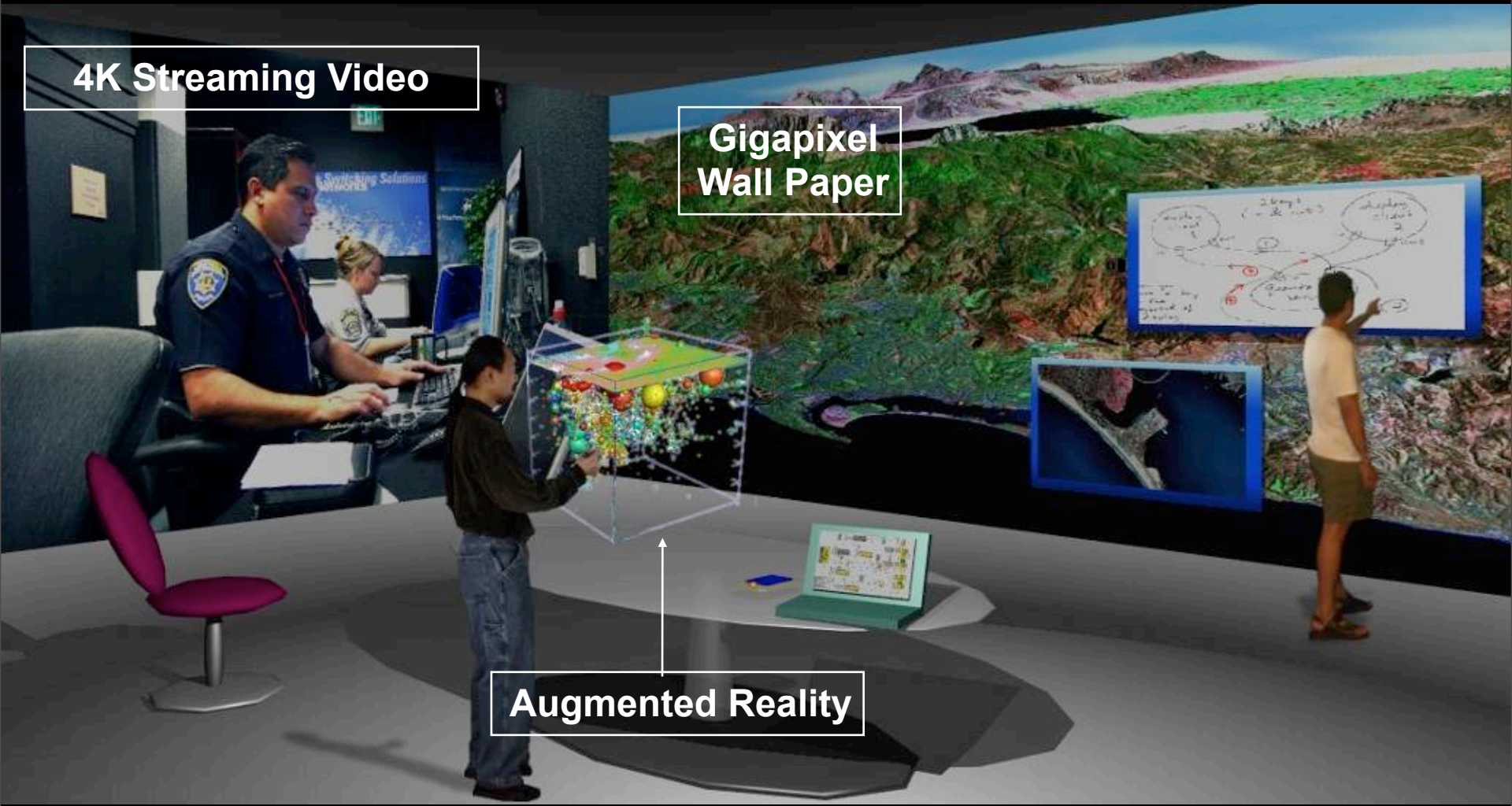


Optical Networks as a Driver



Scientific American, January 2001

A Vision for the Next Decade: Gigapixel Terabit/sec Networked Displays



1 GigaPixel x 3 Bytes/pixel x 8 bits/byte x 30 frames/sec ~ 1 Terabit/sec!

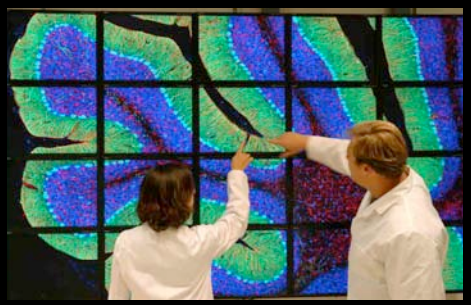
Source: Jason Leigh, UIC/EVL

evl www.evl.uic.edu/cavern/optiputer

STARLIGHT TRANS LIGHT OptIPuter glif NSF

The OptIPuter
Enabling Users with Gigabyte Data Objects

- Interactive analysis and visualization of hundreds of megapixel 2D images or 3D objects requires
  - Deterministic networks
  - Hardware that is bandwidth matched to networks
  - Scalable visualization displays
  - Scalable adaptive graphics environments



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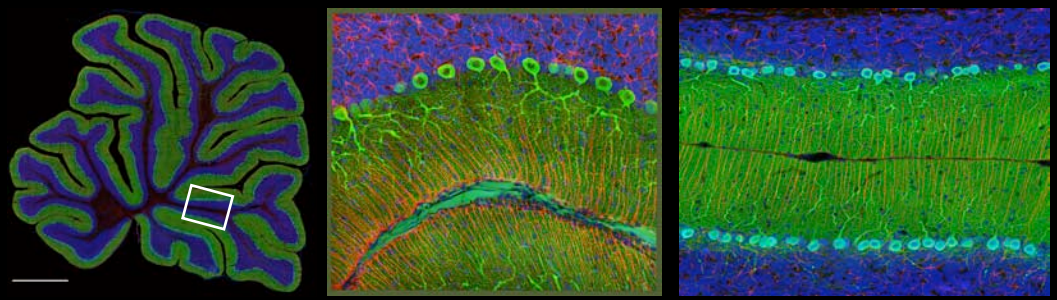


OptIPuter Partners

- UCSD
- University of Illinois at Chicago
- University of California-Irvine
- San Diego State Univ
- University of Southern California
- NCSA
- Northwestern
- Texas A&M
- University of Michigan
- Purdue University
- USGS
- NASA
- CANARIE, Canada
- CRC, Canada
- SARA, Netherlands
- Univ of Amsterdam, Netherlands
- KISTI, Korea
- AIST, Japan

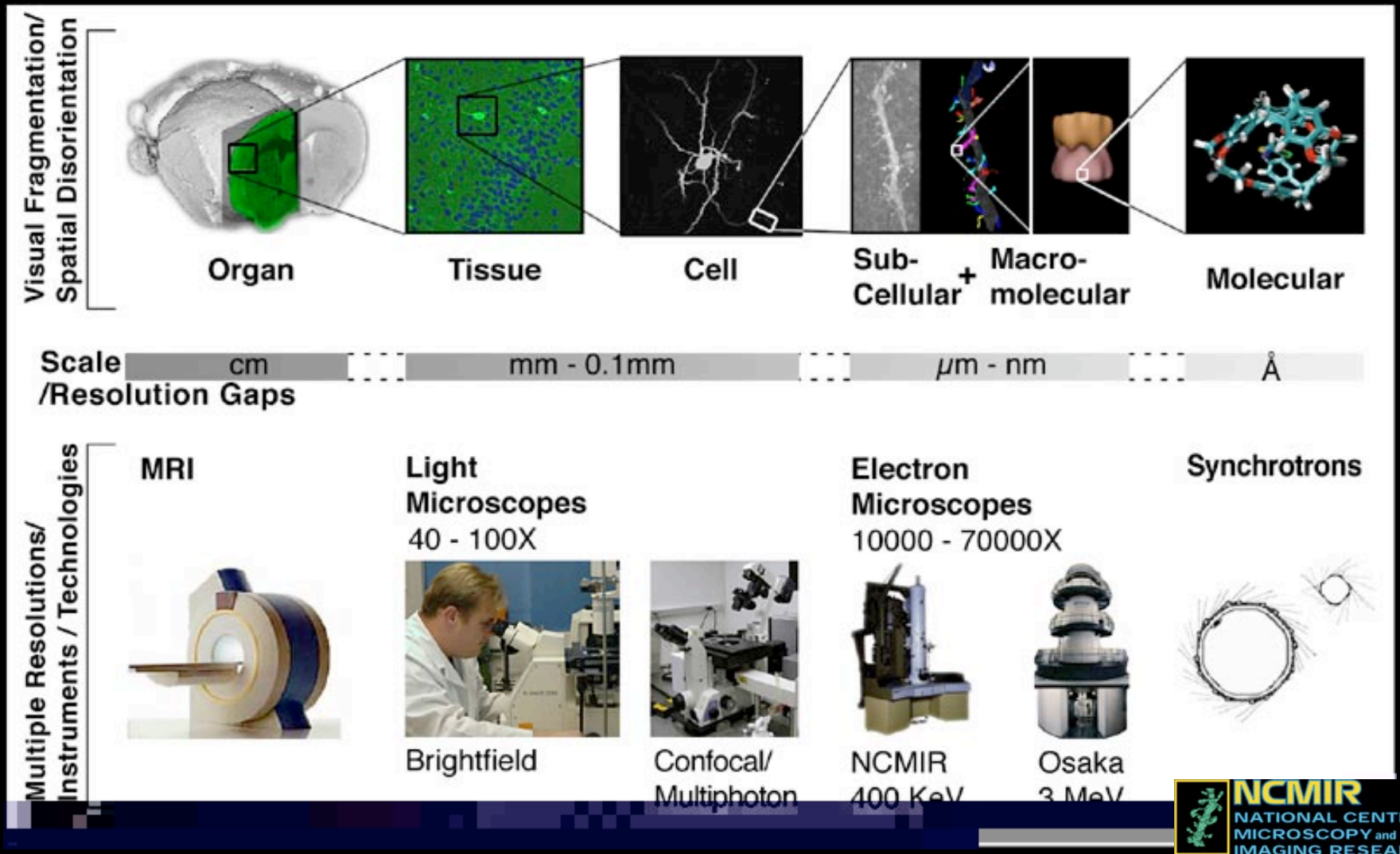
http://ncmir.ucsd.edu
www.optiputer.net

evl

STARLIGHT TRANS LIGHT OptIPuter glif NSF

The OptIPuter

BioScience Multi-Scale Correlated Microscopy Experiment

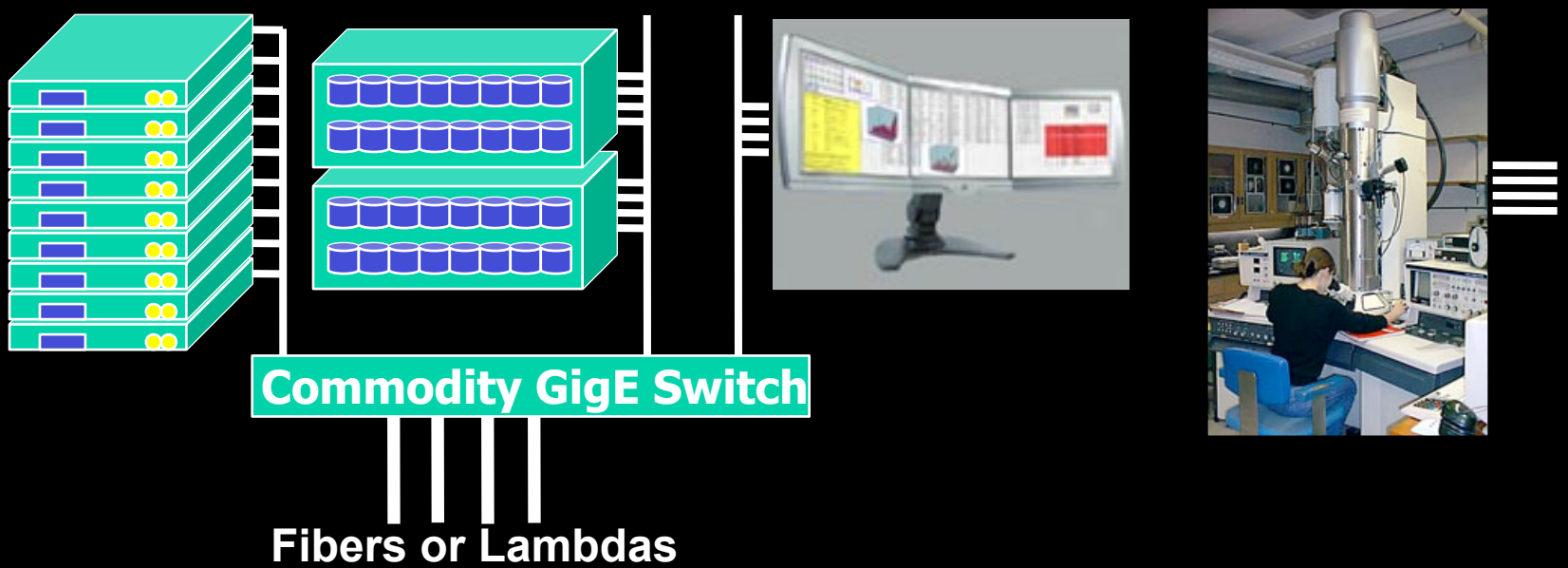


Source: NCMIR

http://ncmir.ucsd.edu

The OptIPuter Is About Architecture
Bandwidth Matching the Clusters to the Network

- **Hardware:** clusters of computers that act as giant storage, compute or visualization peripherals, in which each node of each cluster is attached at 1 or 10GigE to a *backplane* of ultra-high-speed networks
- **Software:** Advanced middleware and application toolkits are being developed for light path management, data management and mining, visualization, and collaboration



The OptIPuter Enables Persistent Collaboration Spaces

21st Century PCs with 10Gbps Network Connections

- Tiled-display "LambdaVision" installations at OptIPuter partner sites
- Unified software

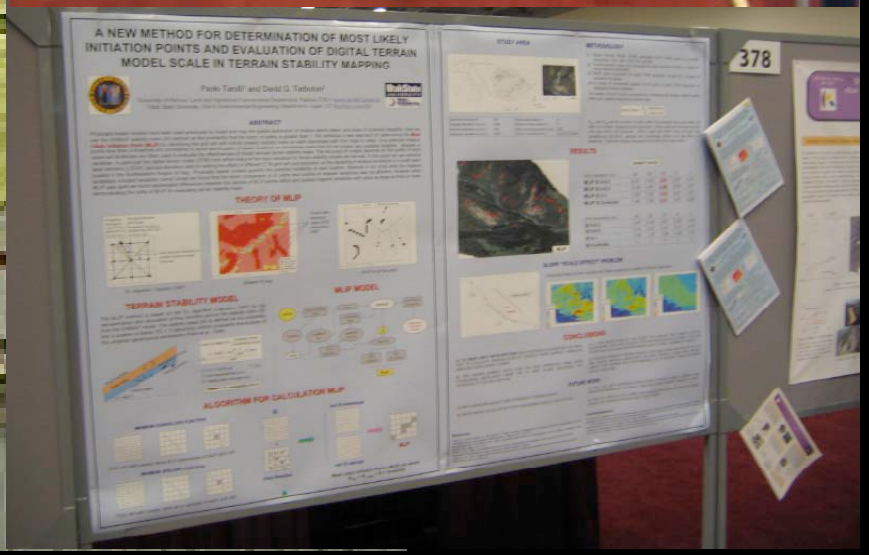
The OptIPuter
10GE CAVEwave on the National LambdaRail

The OptIPuter exploits a new world in which the central architectural element is optical networking – creating *supernetworks*

CAVEwave™ is the University of Illinois at Chicago (UIC) Electronic Visualization Laboratory's very own 10 Gigabit wavelength on the NLR infrastructure, connected to the University of Washington in Seattle and UCSD in San Diego, enabling OptIPuter experiments. It was recently extended to the DC area to connect with NASA GSFC and Venter Institute

Multiple Datasets and Multiple Users

Motivation for Multiple Simultaneous Visuals



Motivation for Collaboration

- Olson & Olson – Michigan
- Study of 9 project rooms

- Comparison of these groups with norm showed performance well above corporate average (doubling for software design case)

Collaboration Spaces

- Various groups doing work in this area including Fraunhofer with iLand and standford with iRoom
- Recent Chi 2006 Workshop - Information Visualization and Interaction Techniques for Collaboration across Multiple Displays

- How can we amplify these benefits and support distributed teams using modern collaboration technology?
- Makes use of optical networks to link the various collaborators to each other and to the shared data sets that they are working on

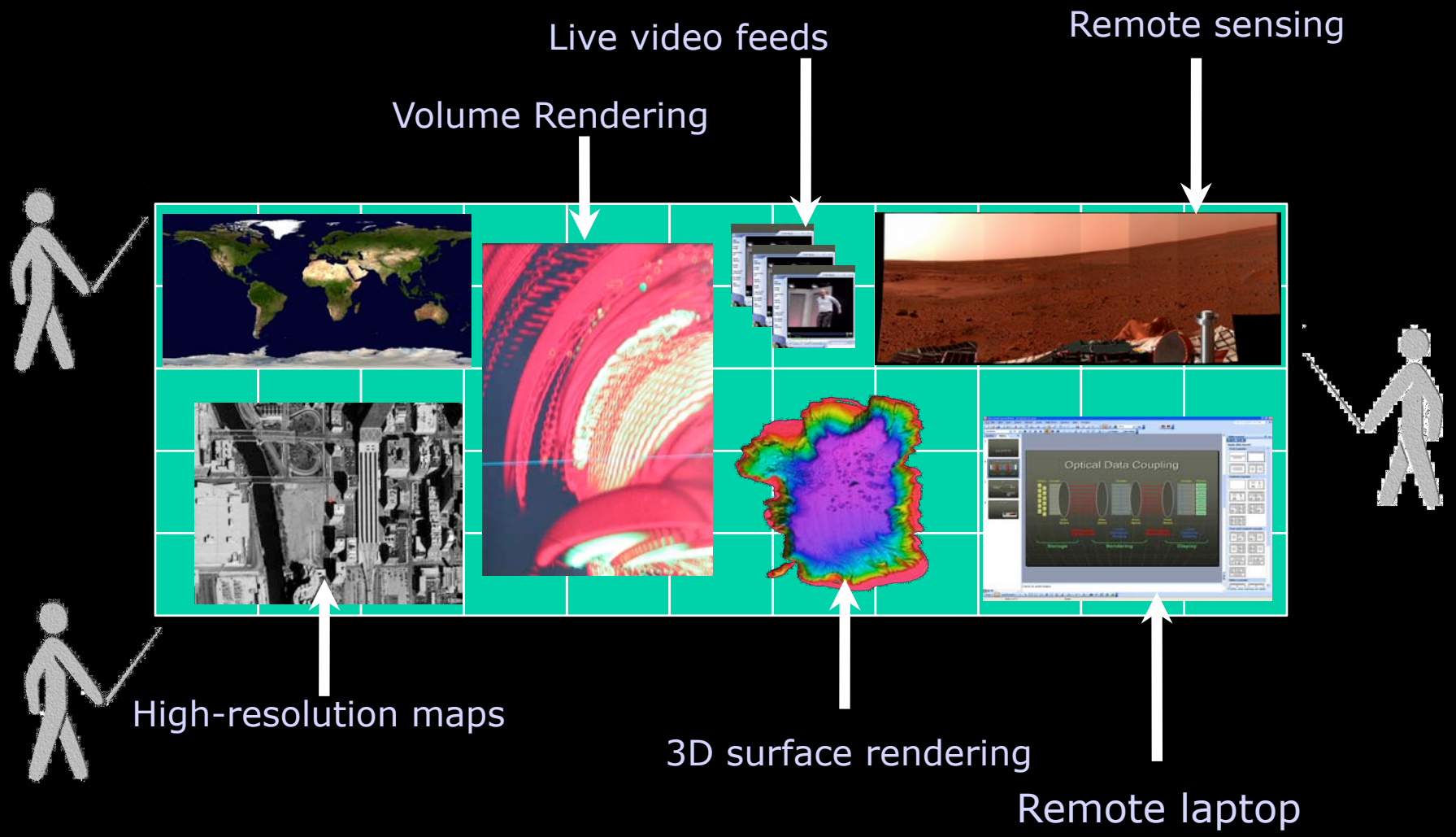
The Continuum

- Developing software to seamlessly integrate these technologies to allow effortless use by distributed groups
- Preparing for the time when the walls and furniture themselves are high-resolution displays

So What's the Problem?

- Building the display is pretty straightforward but the software side is much harder
  - accessing data
  - rendering the data to the screens
  - juxtaposing multiple related datasets
  - interacting with the data
  - collaborating with others
  - keeping track of the state of the collaboration
  - easily outputting the results of the collaboration to more traditional media

Managing Multiple Applications with SAGE



SAGE

SAGE Requirements

- To see heterogeneous high-resolution datasets at a time
- To resize and reposition visualization windows on tiled displays
- To share remote visualization resources
- Collaboration on high-resolution display environment

New Approach

- Displays as frame buffers on the network
- Network as a bus between
  - Storage
  - Computing
  - Display resources
- Bridge between network and display
  - Small PCs
  - Gigabit and DVI
- “GigE rather than DVI to the display”

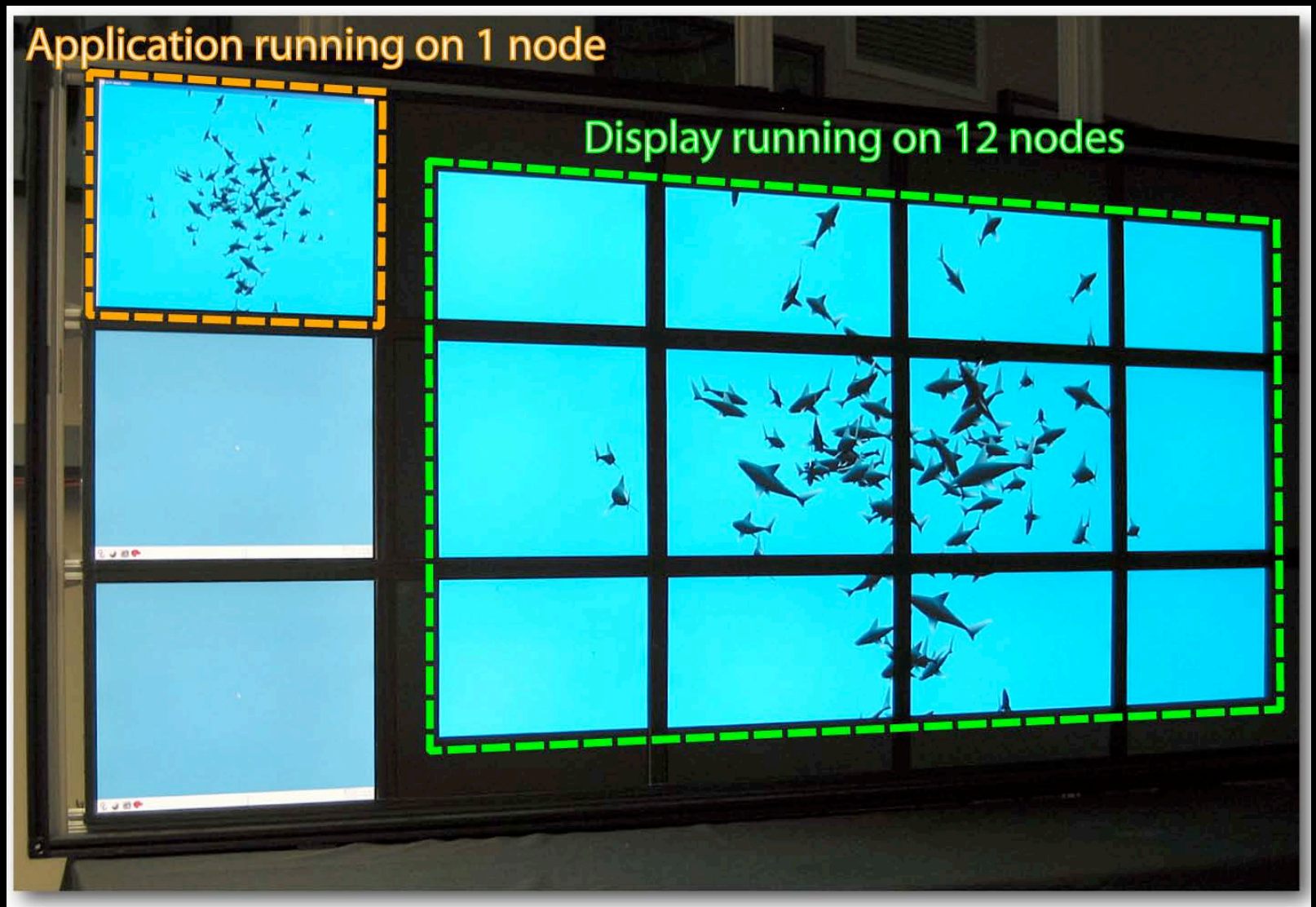
SAGE: Scalable Adaptive Graphics Environment

- Imagine
  - Display everywhere
  - Unlimited Bandwidth
- Decoupling rendering and display
- Visualization
  - Scalable in term of data size
  - Scalable in term of resolution

SAGE Steps

- Capture the pixels
- Partitioning of the images
- Routing the pixels
- Layout on the display
- User interaction

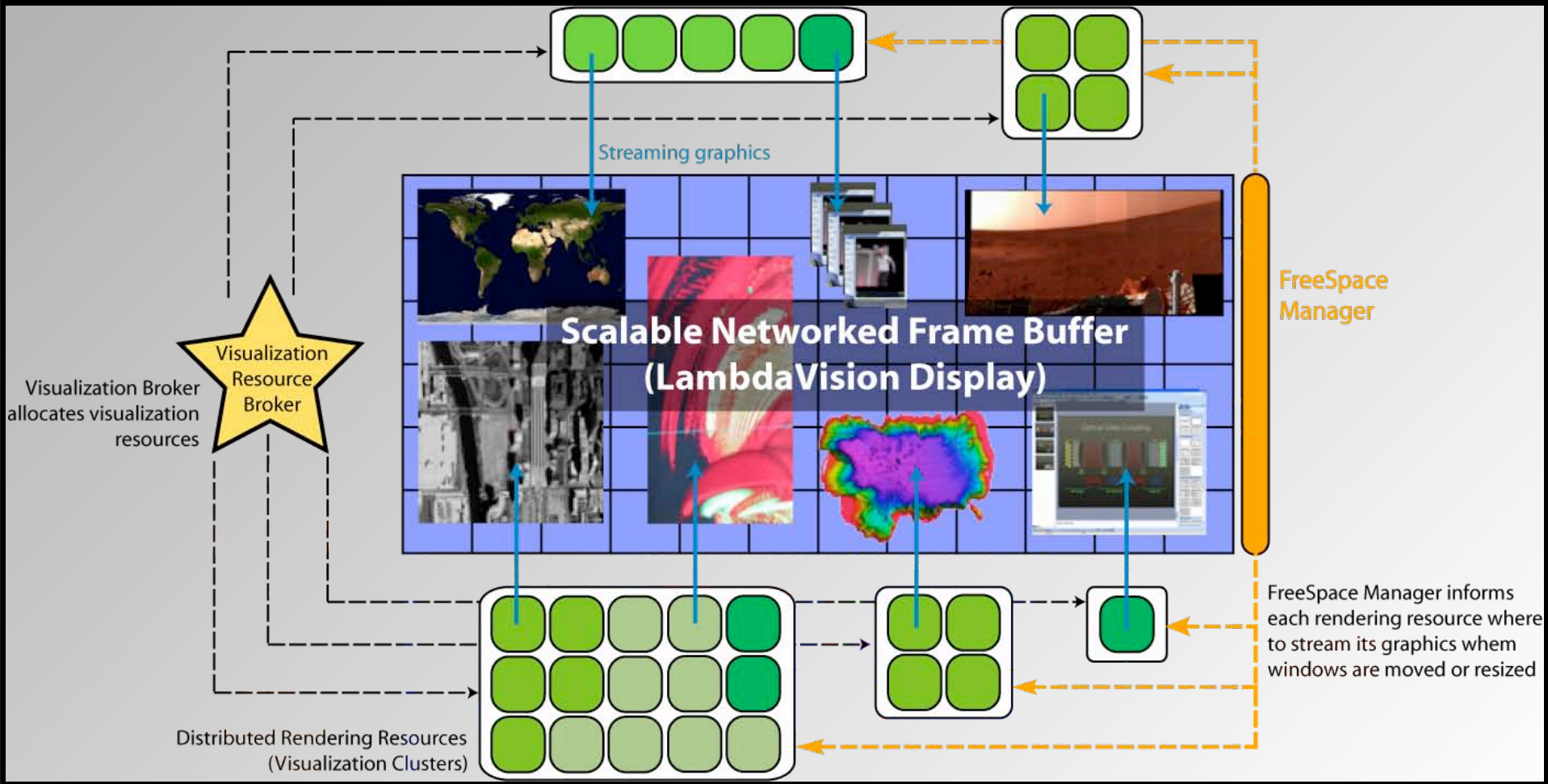
Result



SAGE Primitives

- Now
  - Everything is pixel
  - RGB uncompressed
- Future
  - Color + depth
  - Compression
  - Screen updates
  - 3D primitives
    - Polygons, 2D and 3D textures, …

SAGE : to Manage Content on Tiled Displays



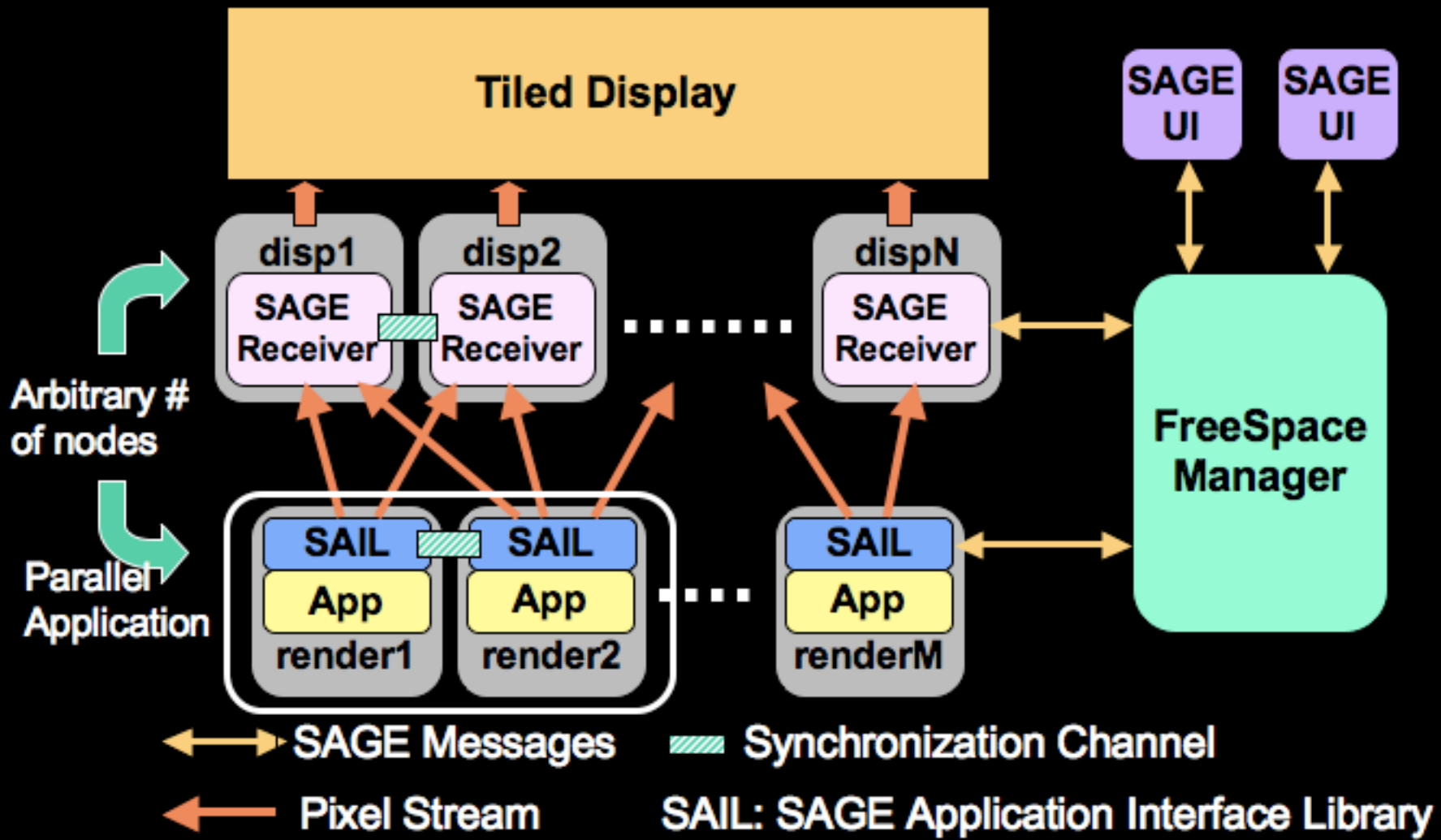
Research Questions

- What is the most appropriate graphics streaming architecture for scalable display environment?
- How to dynamically reconfigure graphics streams to support window move and resizing?
- Is the proposed architecture scalable in performance and resolution?
- How big is the latency of graphics streaming over wide area networks (WAN)?

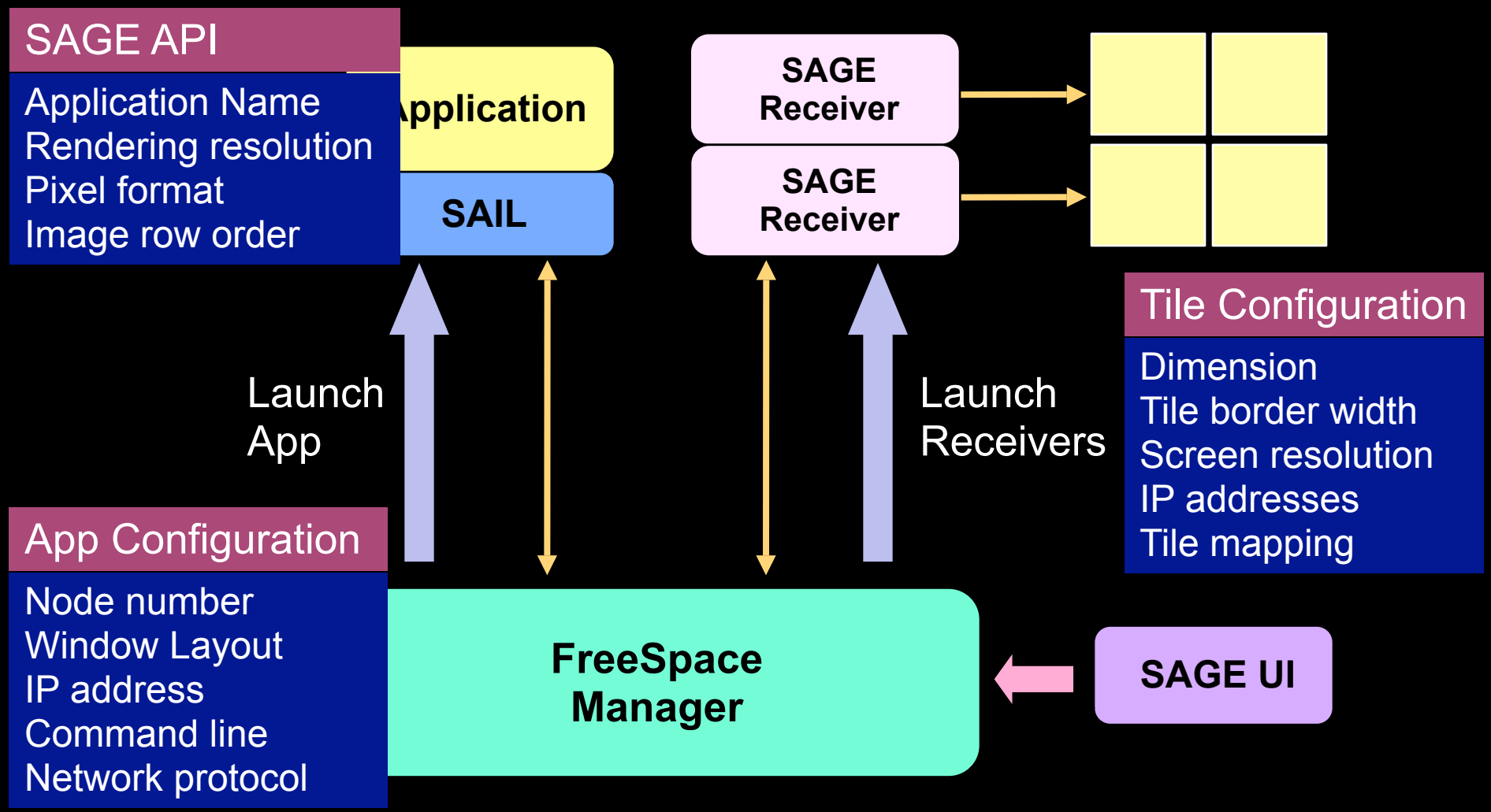
Comparison with Other Approaches

	SAGE	SGE	XDMX	Chromium	WireGL	TeraVision
Multi-tasking (multiple windows)	Y	Y	Y	-	-	-
Window reposition and resizing	Y	Y	Y	-	-	-
Display-rendering decoupling	Y	Y	-	-	-	Y
High-performance WAN support	Y	-	-	-	-	Y
Scalable parallel application support	Y	Y	-	Y	-	-
Scalable image multicasting	Y	-	-	-	-	-

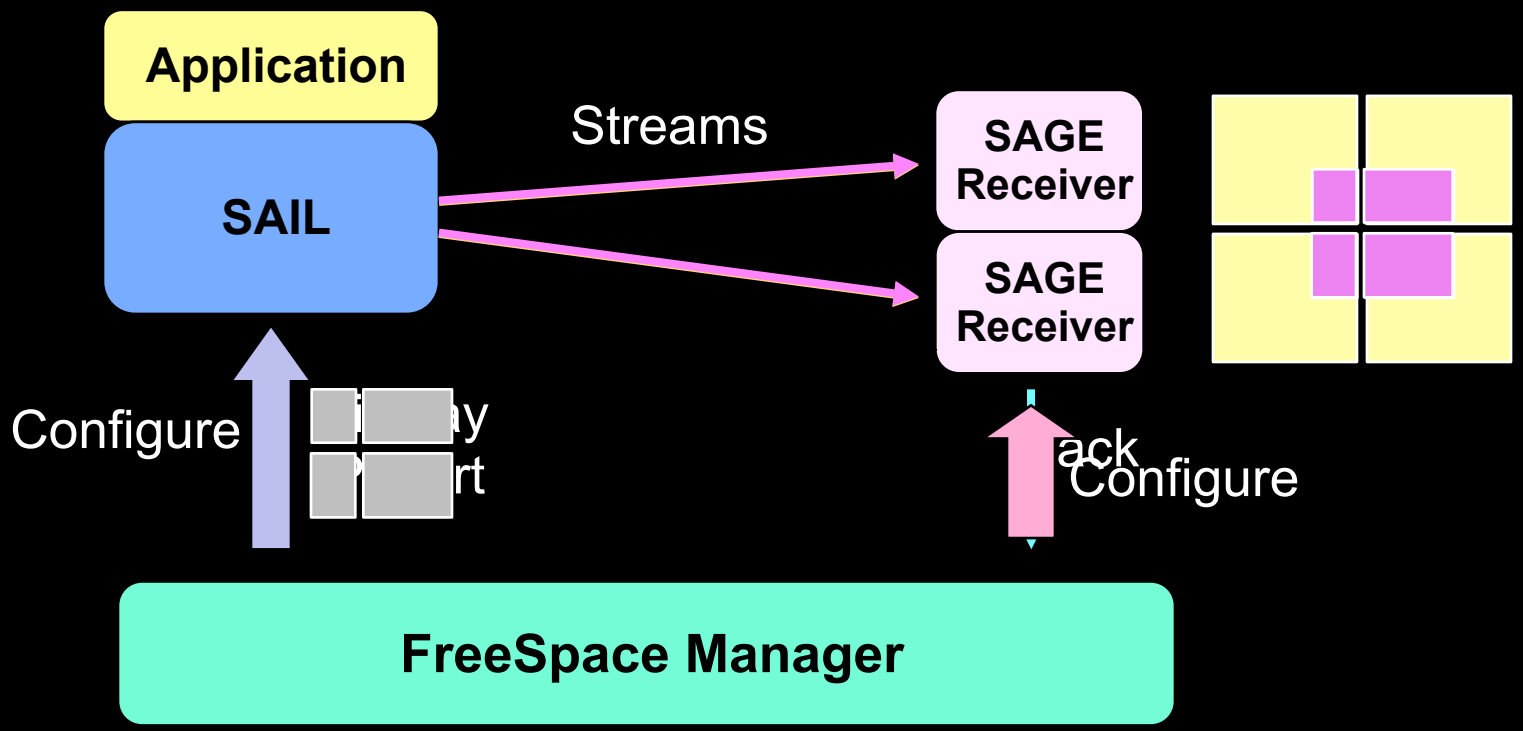
SAGE Architecture



Execution Procedure – Launching

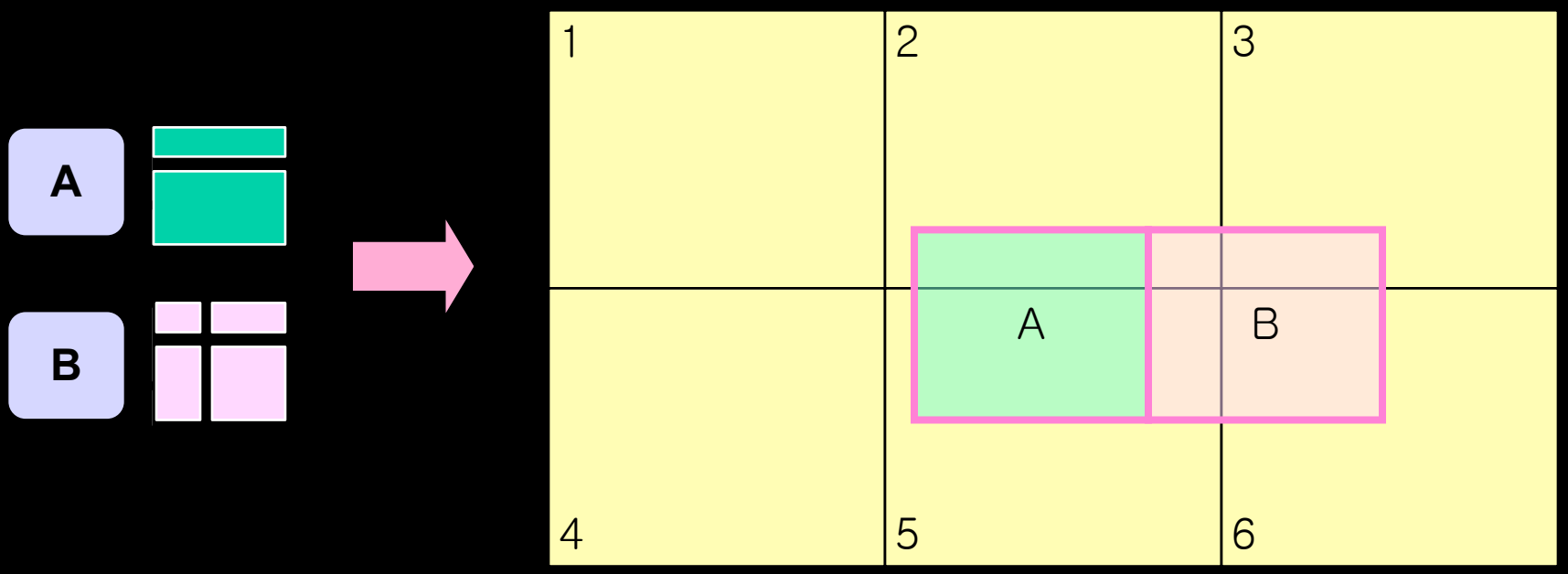


Execution Procedure – Start Streams

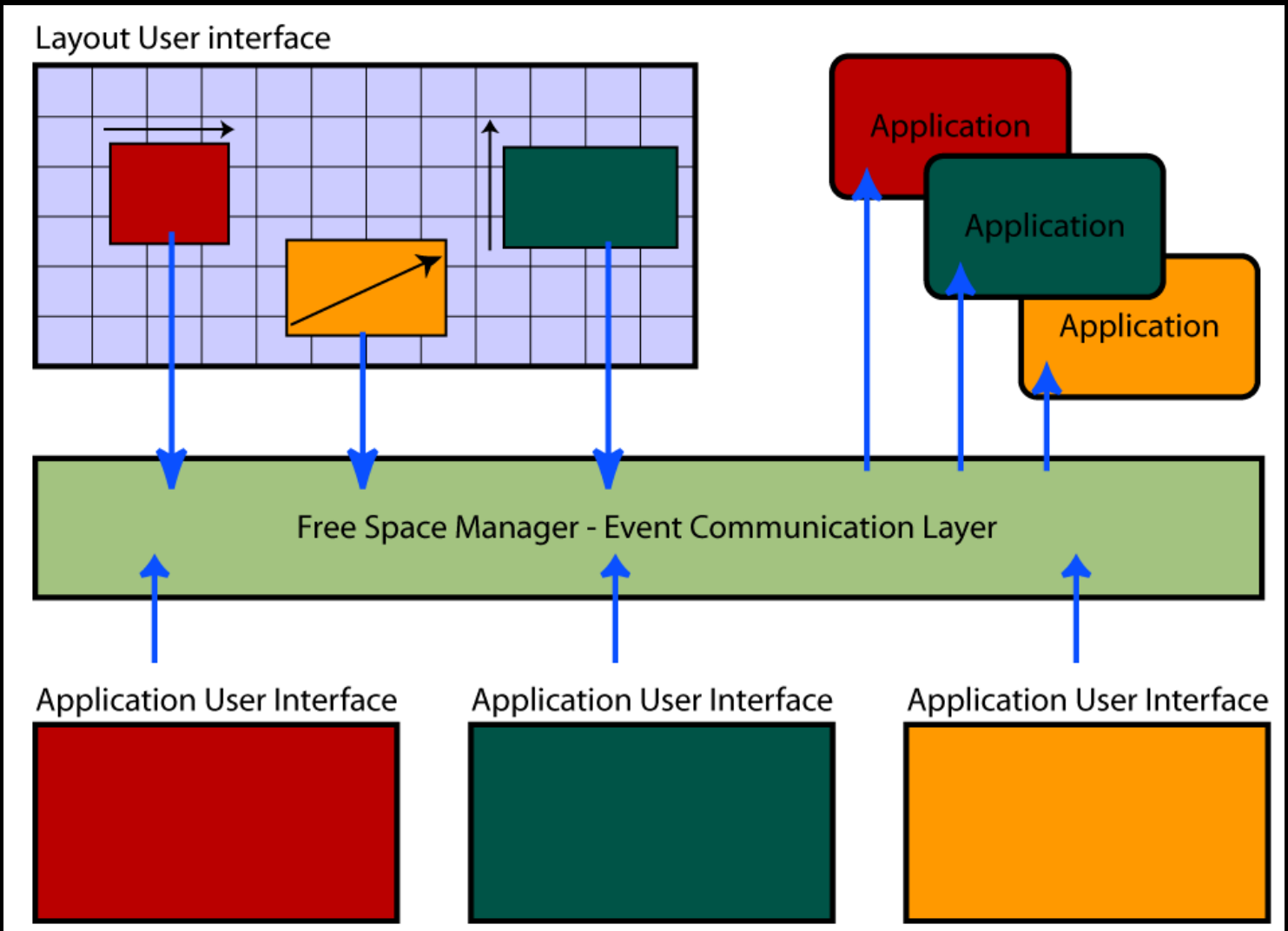


Dynamic Pixel Stream Reconfiguration

- Resume pixel streams

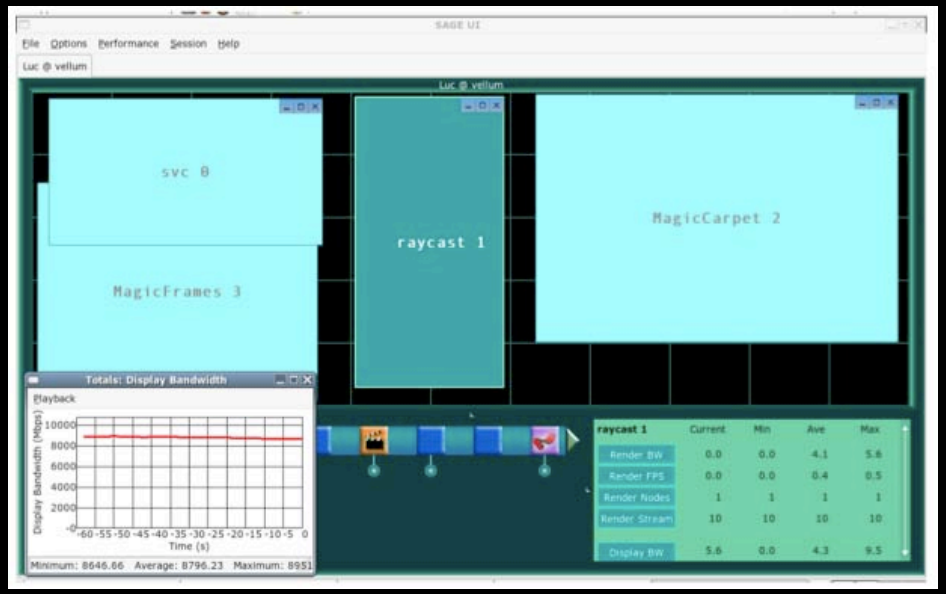


Application Model

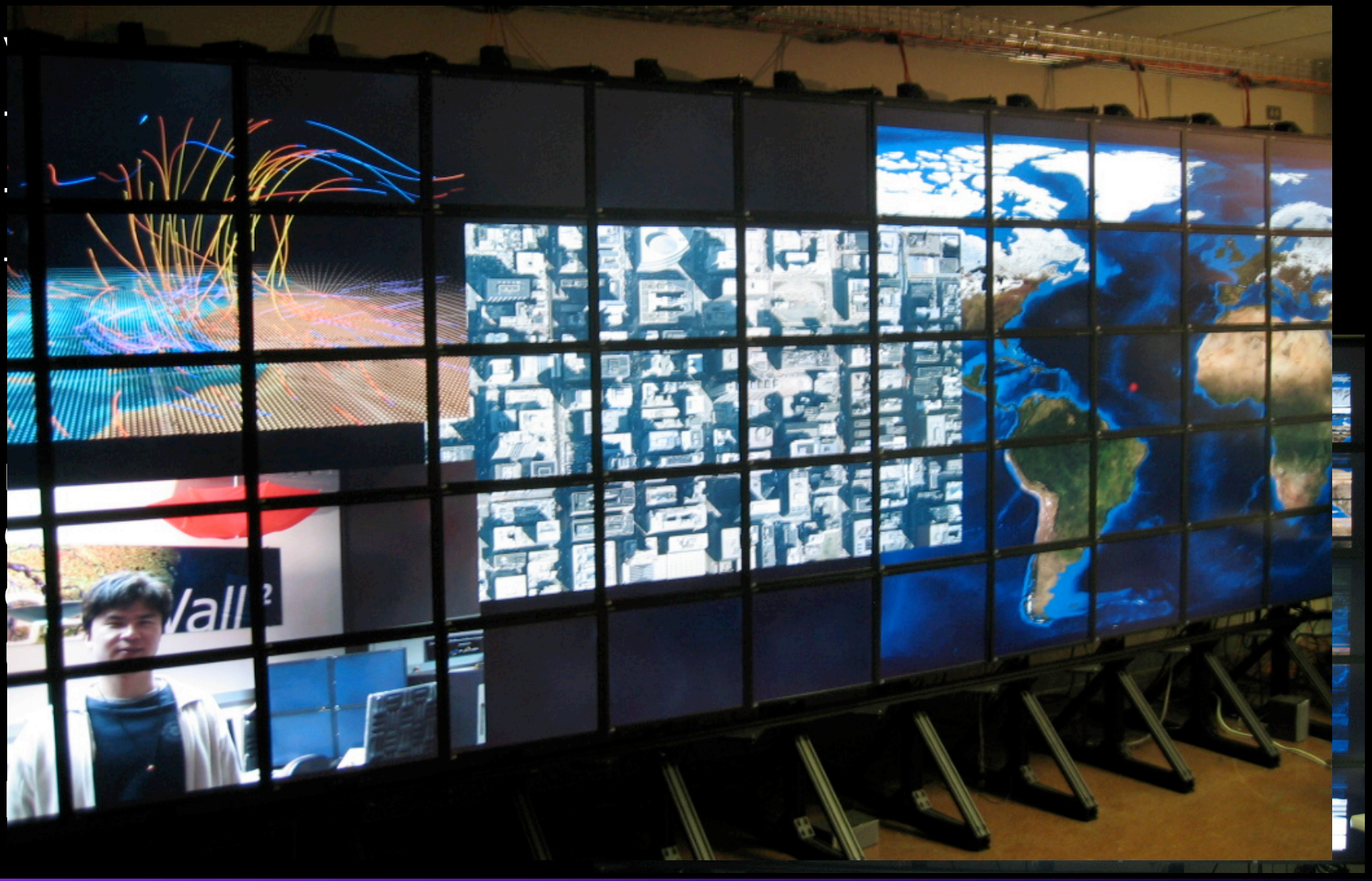


SAGE User Interface

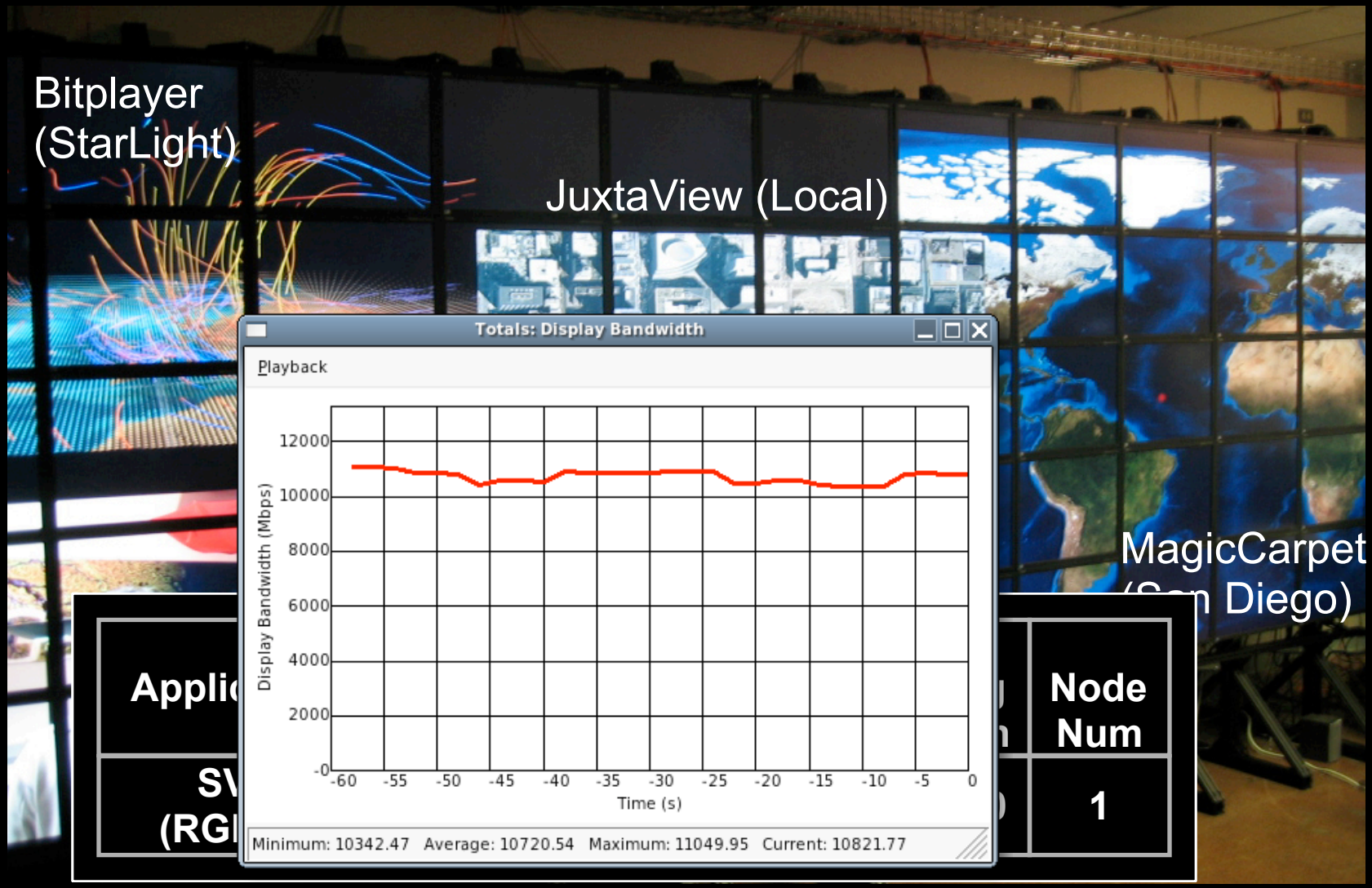
- Creation of a simple user interface that provides interaction with SAGE
- Replaces the command line SAGE user interface
- SAGE UI:
  - All of the SAGE applications appear in the launcher area
  - Dynamic configuration of the SAGE display
  - Operations: resize, move, z-ordering, start, kill
- Application performance monitoring information



Network Streaming Protocol



Multi-Application Test



Video Clip

Video

Performance

- Dynamic pixel stream reconfiguration:
  - multiple applications
  - window move and resize
- Experimental results showed low latency, high throughput and scalability of SAGE on local and wide area networks.
- 12 rendering nodes, 1GigE, LAN, UDP:

  11.2Gbps, no packet loss
- 10 rendering nodes, 10Gbps WAN, UDP:

  9.0Gbps, at most 1% packet loss
- Wide-area distributed visualization is now feasible at ultra-high resolutions while maintaining interactivity.

Building and Programming

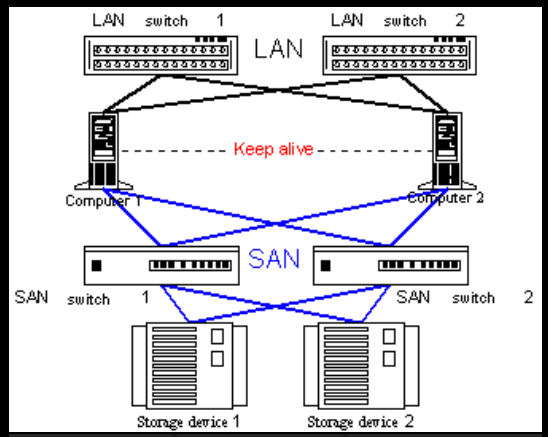
- LambdaVision
  - 17-foot-wide by 6-foot-high wall
  - 55 LCD panels
  - 1600x1200
  - 21 inch
  - 32-node cluster
  - AMD Opteron 64bit
  - 4GB RAM, NVIDIA Quadro3000, several NICs
  - 1.5TB storage per node
  - DVI over fiber cables
  - **17600 x 6000 pixels : 105 Megapixel**

Software for Tiled Displays

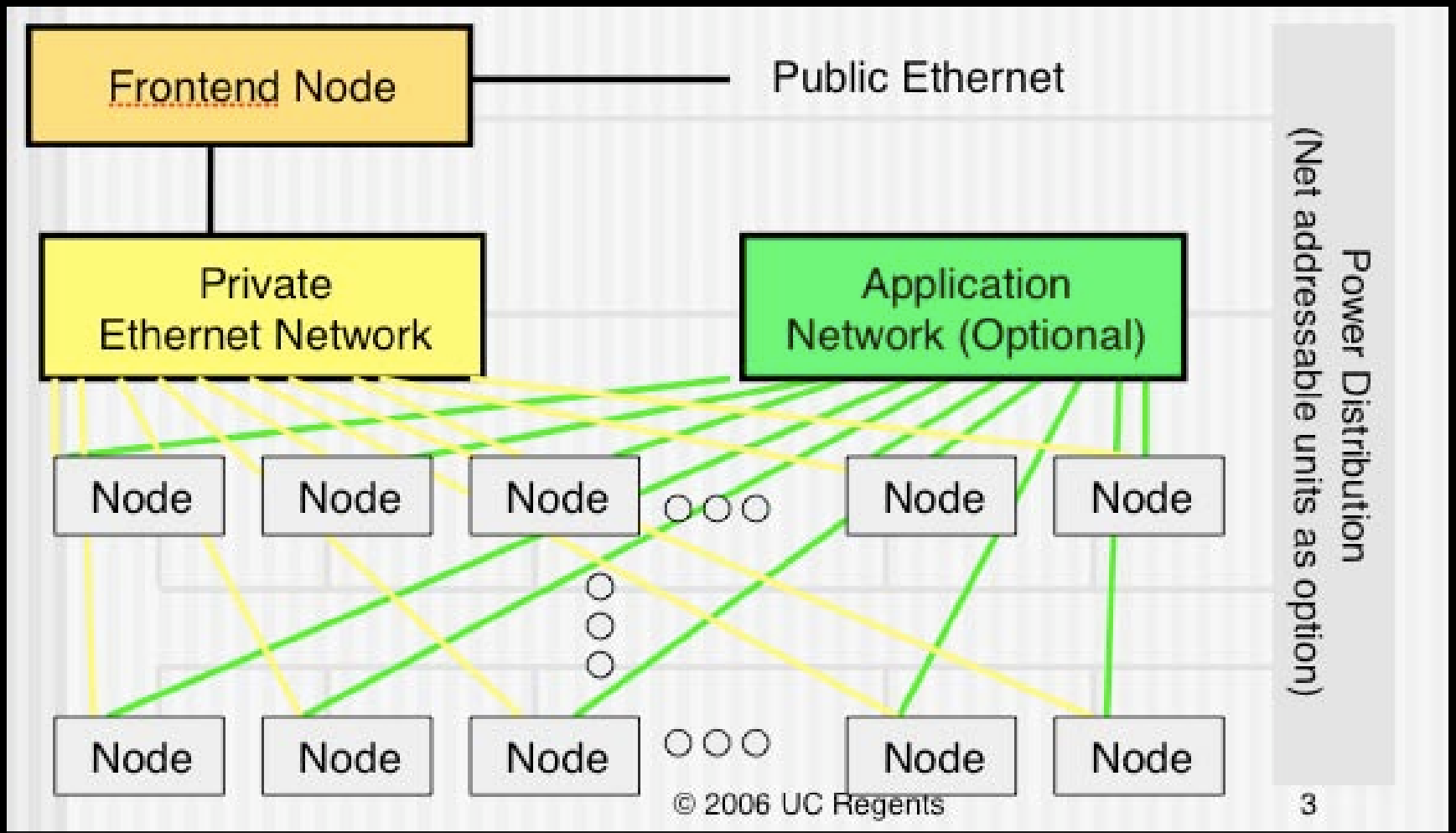
- Building Visualization Clusters using Rocks
- SDSC work with help of EVL
- Rocks distribution
  - Linux for cluster
  - Add ‘viz’ packages

Types of Clusters

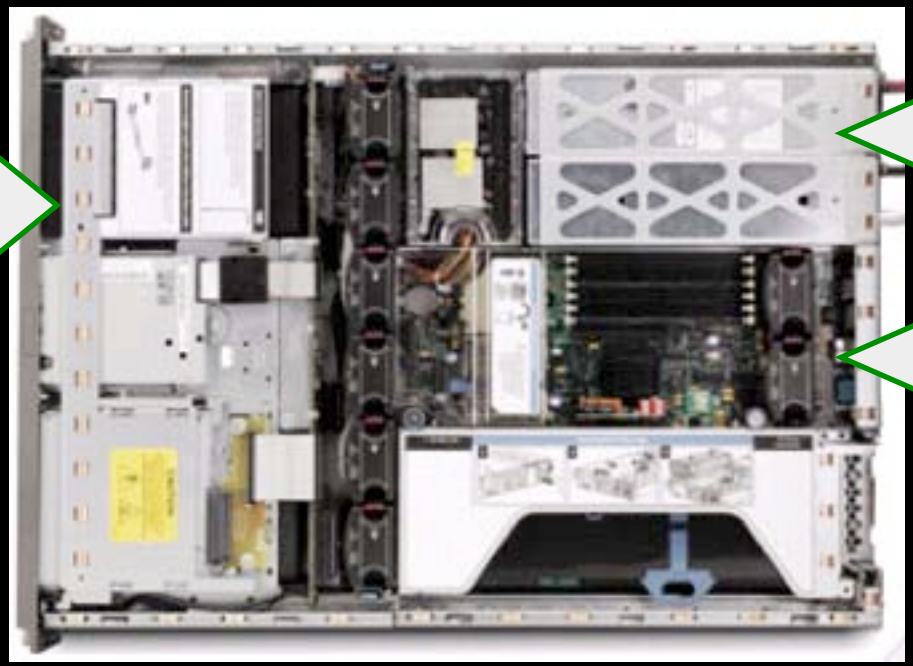
- Highly Available (HA)
  - Generally small, less than 8 nodes
  - Redundant components
  - Multiple communication paths
  - This is not Rocks
- Visualization Clusters
  - Each node drives a display
  - OpenGL machines
  - This is not core Rocks
  - But, there is a Viz Roll
- Computing (HPC Clusters)
  - AKA Beowulf
  - This is the core of Rocks



Definition: HPC Cluster Architecture



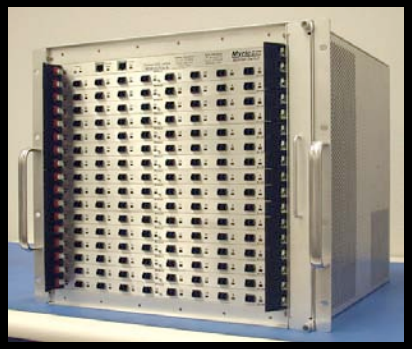
Minimum Components



i386 (Pentium/Athlon)
x86_64 (Opteron/EM64T)
ia64 (Itanium) server

Optional Components

- High-performance network
  - Myrinet
  - Infiniband (Infinicon or Voltaire)
- Network-addressable power distribution unit
- Keyboard/video/mouse network not required



The Dark Side of Clusters

- Clusters are phenomenal price/performance computational engines …
  - Can be hard to manage without experience
  - High-performance I/O is still unsolved
  - Finding out where something has failed increases at least linearly as cluster size increases
- Not cost-effective if every cluster "burns" a person just for care and feeding
- Programming environment could be vastly improved
- Technology is changing very rapidly. Scaling up is becoming commonplace (128-256 nodes)

The Top 2 Most Critical Problems

- The largest problem in clusters is *software skew*
  - When software configuration on some nodes is different than on others
  - Small differences (minor version numbers on libraries) can cripple a parallel program
- The second most important problem is adequate job control of the parallel process
  - Signal propagation
  - Cleanup

Rocks (open source clustering distribution)
www.rocksclusters.org

- Technology transfer of commodity clustering to application scientists
  - “make clusters easy”
  - Scientists can build their own supercomputers and migrate up to national centers as needed
- Rocks is a cluster on a CD
  - Red Enterprise Hat Linux (opensource and free)
  - Clustering software (PBS, SGE, Ganglia, NMI)
  - Highly programmatic software configuration management
- Core software technology for several campus projects
  - BIRN
  - Center for Theoretical Biological Physics
  - EOL
  - GEON
  - NBCR
  - OptIPuter
- First Software release Nov, 2000
- Supports x86, Opteron/EM64T, and Itanium
- RedHat/CentOS 4.x

Philosophy

- System Administration is hard and expensive
- All nodes are 100% automatically configured
  - Zero “hand” configuration
  - This includes site-specific configuration
- Has to run on heterogeneous standard high volume components
  - Use components that offer the best price/ performance

Philosophy - continued

- Optimize for installation
  - Get the system up quickly
  - In a consistent state
  - Build supercomputers in hours not months
- Manage through re-installation
  - No support for on-the-fly system patching
- Do not spend time trying to issue system consistency
  - Just re-install

Rocks Basic Approach

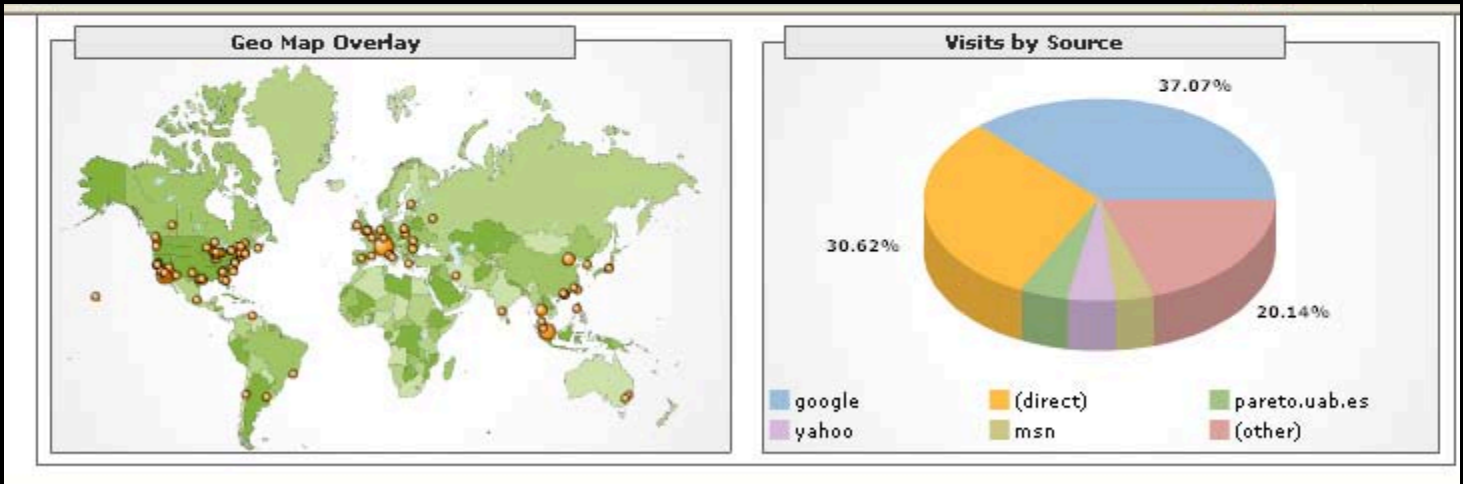
- Install a frontend
  1. Insert Rocks Base CD
  2. Insert Roll CDs (optional components)
  3. Answer 7 screens of configuration data
  4. Drink coffee (takes about 30 minutes to install)
- Install compute nodes:
  1. Login to frontend
  2. Execute insert-ethers
  3. Boot compute node with Rocks Base CD (or PXE)
  4. Insert-ethers discovers nodes
  5. Goto step 3
- Add user accounts
- Start computing

Optional Rolls

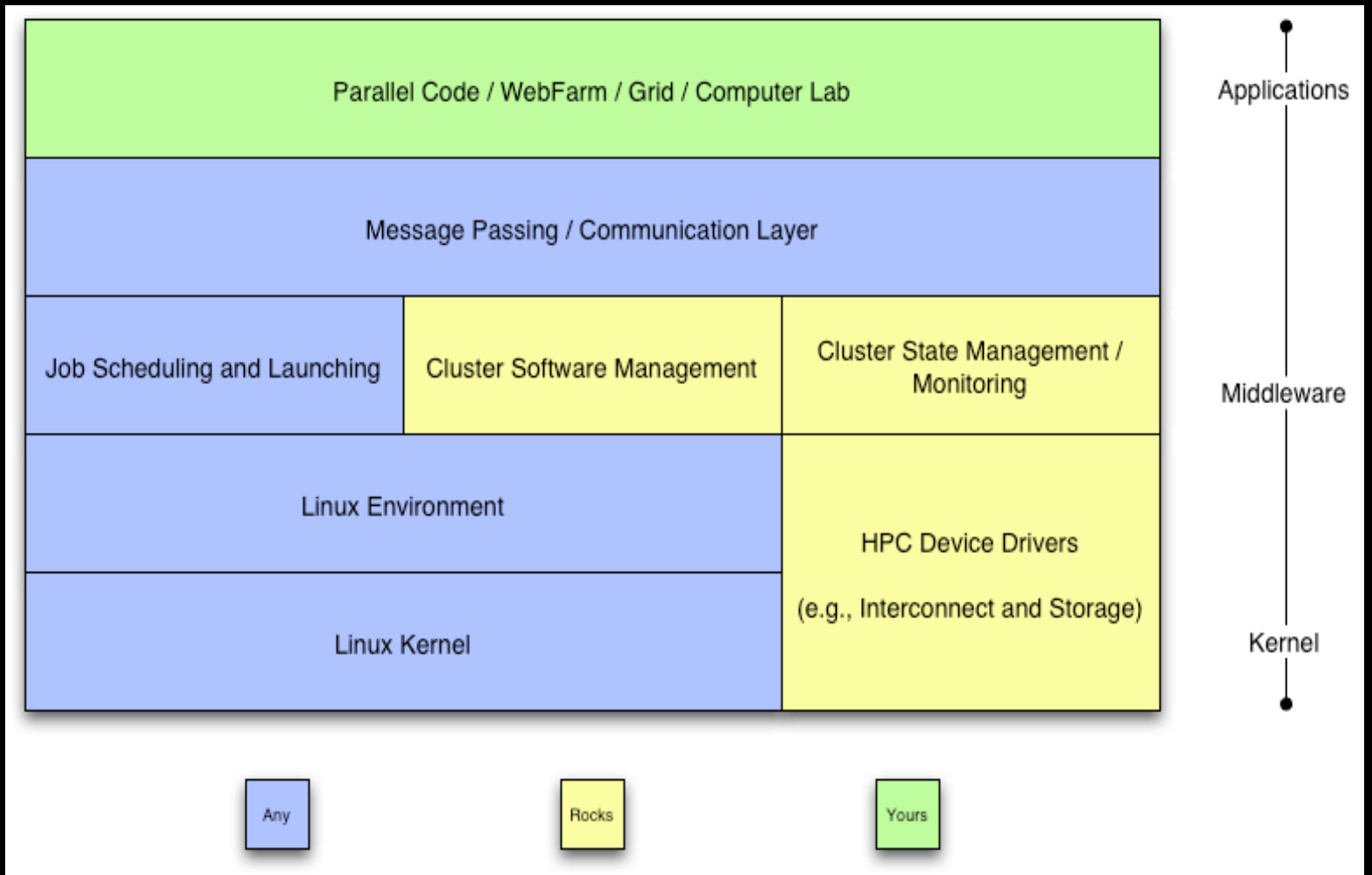
- Condor
- Grid (based on NMI R4)
- Intel (compilers)
- Java
- SCE (developed in Thailand)
- Sun Grid Engine
- PBS (developed in Norway)
- Area51 (security monitoring tools)
- Many Others …

User Base

- > 1300 Users on the Discussion List
- 5 Continents
- **University**, Commercial, Hobbyist



Cluster Software Stack



Viz Roll

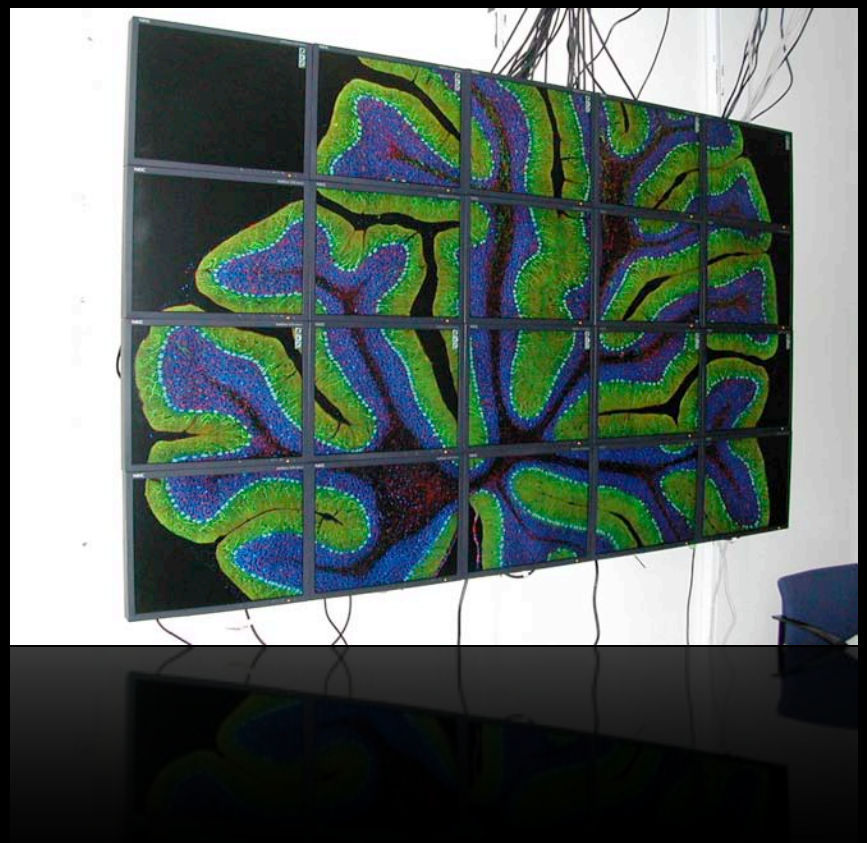
- Adding graphics and visualization to compute clusters

Early Work: NCSA

- LCD Cluster
  - Custom framing
  - One PC / tile
  - Portable
  - SC 2001 Demo
- NCSA Software
  - Pixel Blaster
  - Display Wall In-A-Box
  - OSCAR based
  - Never fully released

NCMIR

- Using Rocks
- Hand configured a visualization cluster
- “Administered the machine to the point of instability” - David Lee
- Automation is needed



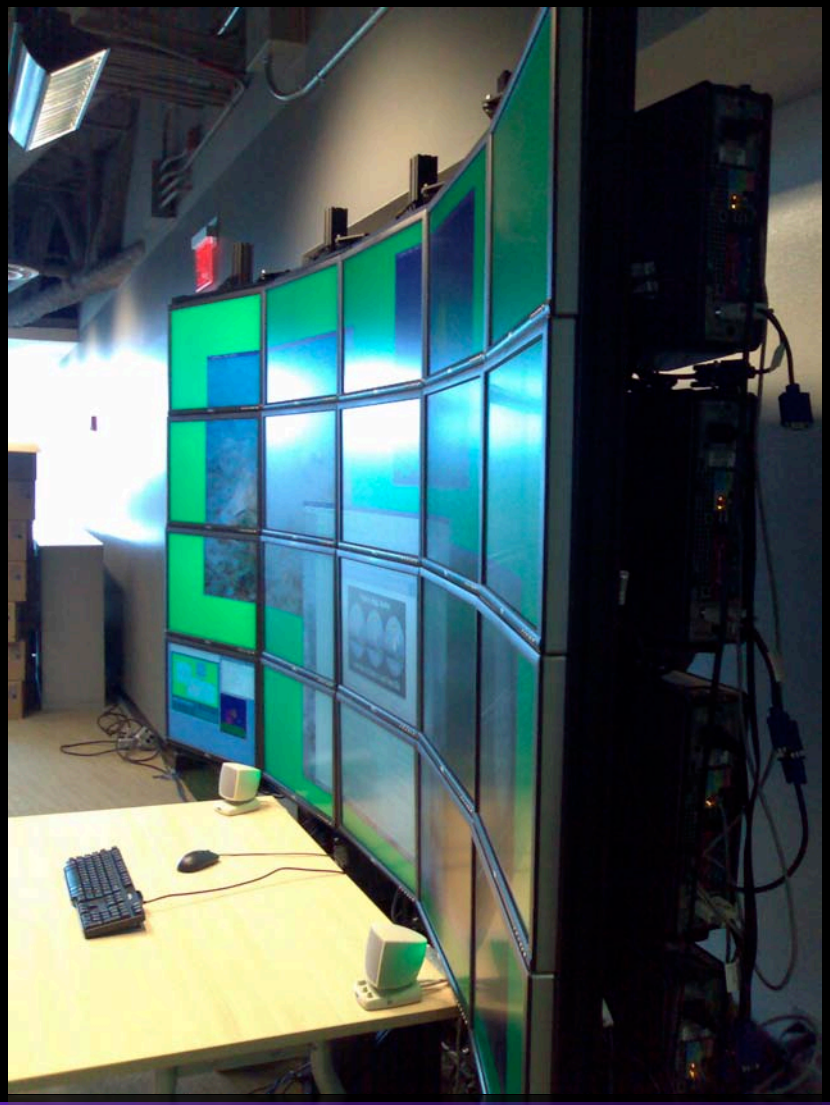
COTS Vis: GeoWall

- LCD Clusters
  - One PC / tile
  - Gigabit Ethernet
  - Optional Stereo Glasses
  - Portable
  - Commercial Frame (Reason)
- Applications
  - Large remote sensing
  - Volume Rendering
  - Seismic Interpretation
  - Brain mapping (NCMIR)
- SAGE - Electronic Visualization Lab
  - Jason Leigh (UIC)

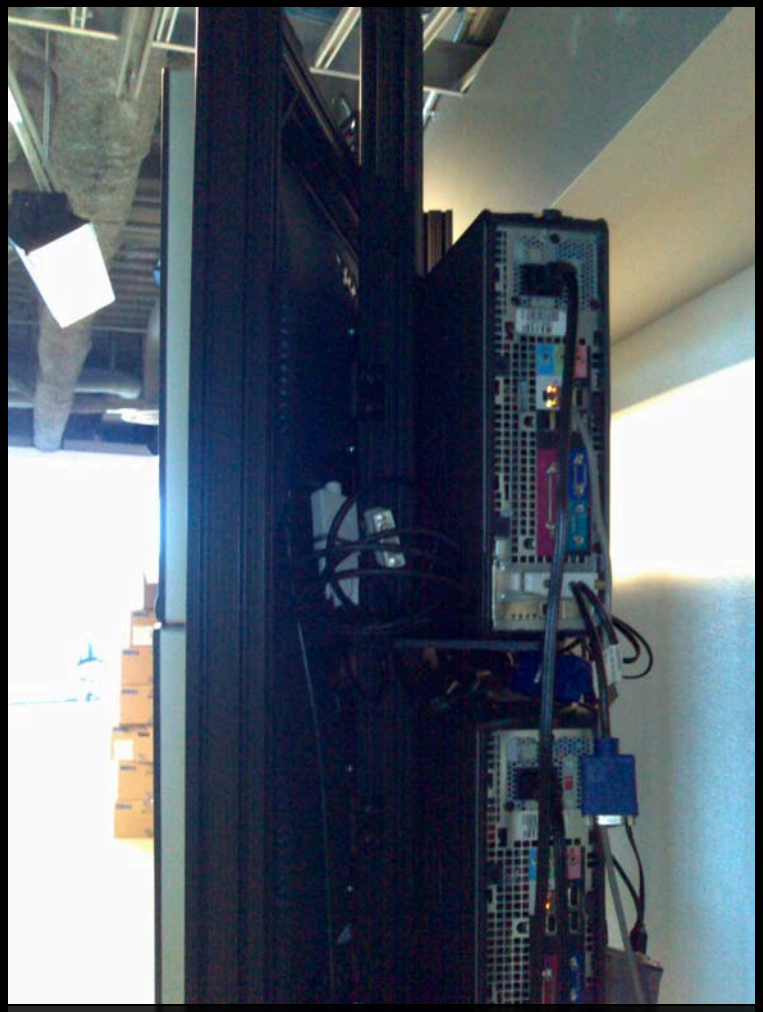
One Node per Display

OptIPortal Running SAGE

OptIPortal



Nodes Behind the Wall



Light System: ‘Dell’ HD Components

- 15x HD displays (1920x1200, $1000)
- 15x OptiPlex 620 (P4 2.8Ghz, small, $850)
- 1x high-end workstation with display
- 1x GigE switch
- 35 MPixel == $33K

Scaling up...

Width	Height	Total	Mpixels	Price
1	1	1	1.9	$9,546
2	2	4	7.7	$14,643
3	2	6	11.5	$18,041
4	3	12	23.0	$28,235
5	3	15	28.8	$33,332
5	5	25	48.0	$50,322
7	5	35	67.2	$67,312
11	5	55	105.6	$101,292
9	7	63	121.0	$114,884
11	7	77	147.8	$138,670
13	11	143	274.6	$250,804

Program a SAGE application

- SAGE object
- Initialization phase
- Streaming phase
- Event processing

Program a SAGE application

- SAGE object:
  - Headers for SAGE
    - #include "sail.h"
    - #include "misc.h"
  - Pixel buffer
    - unsigned char *rgbBuffer = 0;
  - SAGE information
    - sail sageInf; // sail object

Program a SAGE application

- **Initialization phase**
- sageRect imageMap;
- imageMap.left = 0.0;
- imageMap.right = 1.0;
- imageMap.bottom = 0.0;
- imageMap.top = 1.0;

- sailConfig scfg;
- scfg.cfgFile = strdup("sage.conf");
- scfg.appName = strdup("atlantis");
- scfg.rank = 0;

- scfg.resX = 1024;
- scfg.resY = 768;
- scfg.imageMap = imageMap;
- scfg.colorDepth = 24;
- scfg.pixFmt = TVPIXFMT_888;
- scfg.rowOrd = BOTTOM_TO_TOP;

- **sageInf.init(scfg);**

Program a SAGE application

- Streaming phase
  - Copy pixel data into "*rgbBuffer*"
  - **sageInf.swapBuffer(rgbBuffer);**
- That's it !!

Program a SAGE application

- Event processing

```
sageMessage msg;
if (sageInf.checkMsg(msg, false) > 0) {
        switch (msg.getCode()) {
            case APP_QUIT : {
                exit(1);
                break;
            }
        }
}
```

SAGE Configuration

- Various configuration files
  - Tiling information: *stdtile.conf*
  - Application configuration: *sage.conf*
  - Master configuration: *fsManager.conf*

SAGE Configuration

- Tiling information: *stdtile.conf*
  - *TileDisplay*
  - *Dimensions 2 1*
  - *Mullions 0.625 0.625 0.625 0.625*
  - *Resolution 1280 1024*
  - *PPI 90*
  - *Machines 2*

  - *DisplayNode*
  - *Name localhost1*
  - *IP 127.0.0.1*
  - *Monitors 1 (0,0)*

  - *DisplayNode*
  - *Name localhost2*
  - *IP 127.0.0.2*
  - *Monitors 1 (1,0)*

SAGE Configuration

- Application configuration: *sage.conf*
  - *appList*
  - ***render*** *{*
    - *configName local*
    - *nodeNum 1*
    - *Init 100 100 1000 1000*
    - *exec 127.0.0.1 render 0 127.0.0.1*
    - *nwProtocol tvTcpModule.so*
  - *}*
  - ***tileConfiguration*** *stdtile.conf*
  - *receiverBaseSyncPort 12000*
  - *receiverBufNum 20*
  - *receiverStreamPort 21000*
  - *fullScreen 0*
  - *sailBaseSyncPort 11000*

SAGE Configuration

- Master configuration: *fsManager.conf*

  - *fsManager local 127.0.0.1 131.193.78.204*
  - *systemPort 20002*
  - *uiPort 20001*
  - *trackPort 20003*
  - *conManager 131.193.48.235 15556*

SAGE Applications

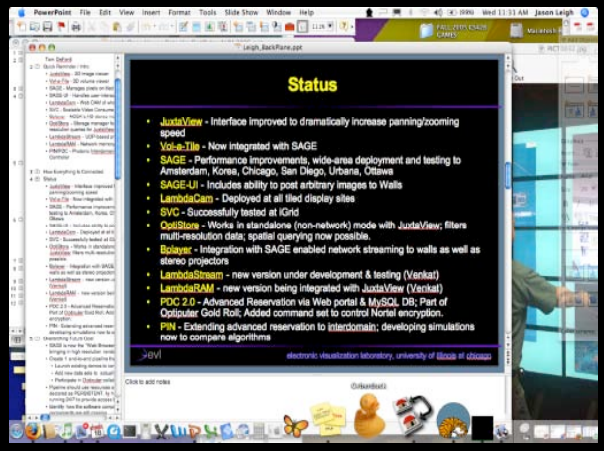
- ImageViewer
- VNC
- Movie players: mplayer and VLC
- JuxtaView and MagicCartpet
- Bitplayer: HD animation
- SVC: Live HD video
- ... develop your own...

SAGE Applications

- **ImageViewer**
  - Reads most of the common image file formats (JPEG, PNG, TIFFF, ...)
  - “Drag and drop” feature from SAGE UI
  - Works for small and moderate file sizes
  - Can start many instances (lightweight)

SAGE Applications

- **VNC**
  - Remote desktop / desktop sharing tool
  - Compatible with standard VNC server
  - Share you Windows, Linux, or MacOSX desktop
  - Can be launched from SAGE UI
  - First step towards collaboration

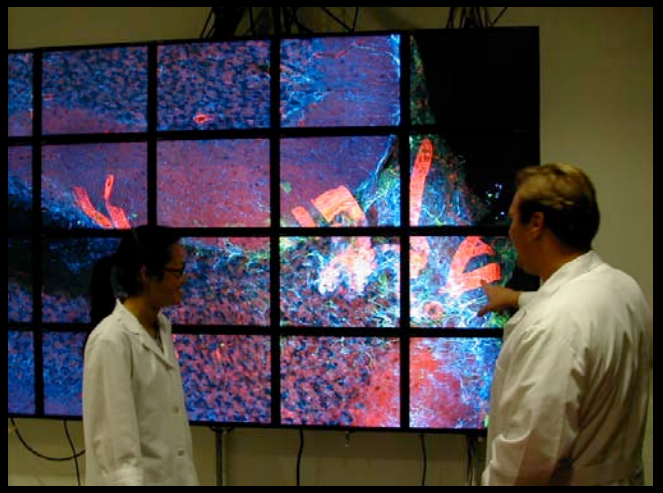


SAGE Applications

- **Movie players: mplayer and VLC**
  - Plugins for Linux movie players
  - Display modules only added
  - Plays most of the movie formats (mpeg, mp4, mov, avi, ...)
  - Managed by the SAGE UI
  - Can start several instances

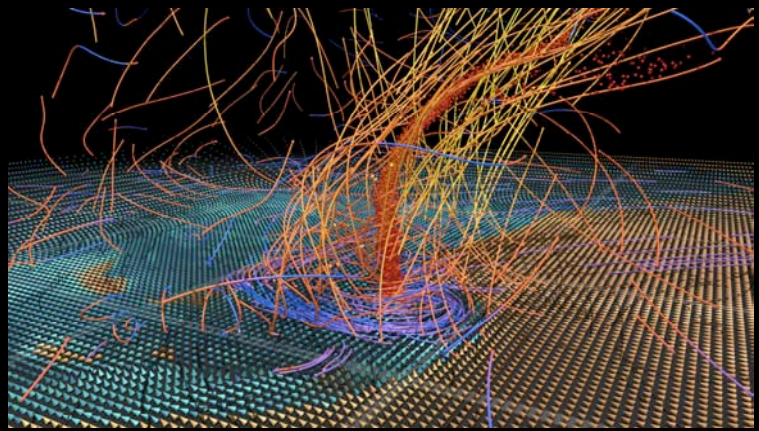
SAGE Applications

- **JuxtaView and MagicCartpet**
  - High-resolution image viewer
  - Works with large mosaic of images
    - ex: aerial photograpy or microscopy
  - Parallel applications
  - Juxtaview: software rendering
  - MagicCarpet: hardware rendering



SAGE Applications

- **Bitplayer: HD animation**
  - Developed by NCSA initially
  - Read uncompressed animations
    - read frame by frame
  - No size limitation
    - common: 1920x1080 HD
    - testing: 4K SHD, 3840x2160
  - Very demanding for the storage performance

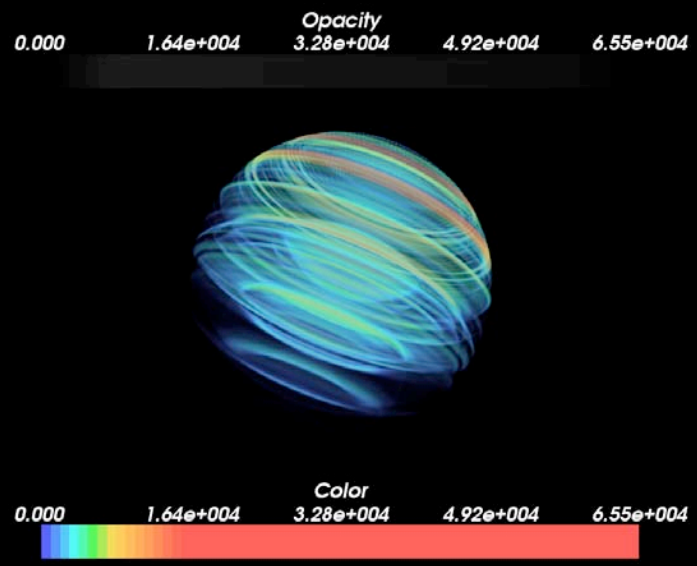


SAGE Applications

- **SVC: Live HD video**
  - Streams live HD video from HDV camera
  - 1440 x 1080 resolution
  - MPEG2 codecs, decompressed
  - YUV transport pixel format: 16bits per pixels
  - Streams also audio
  - High-latency: 1s to 2s

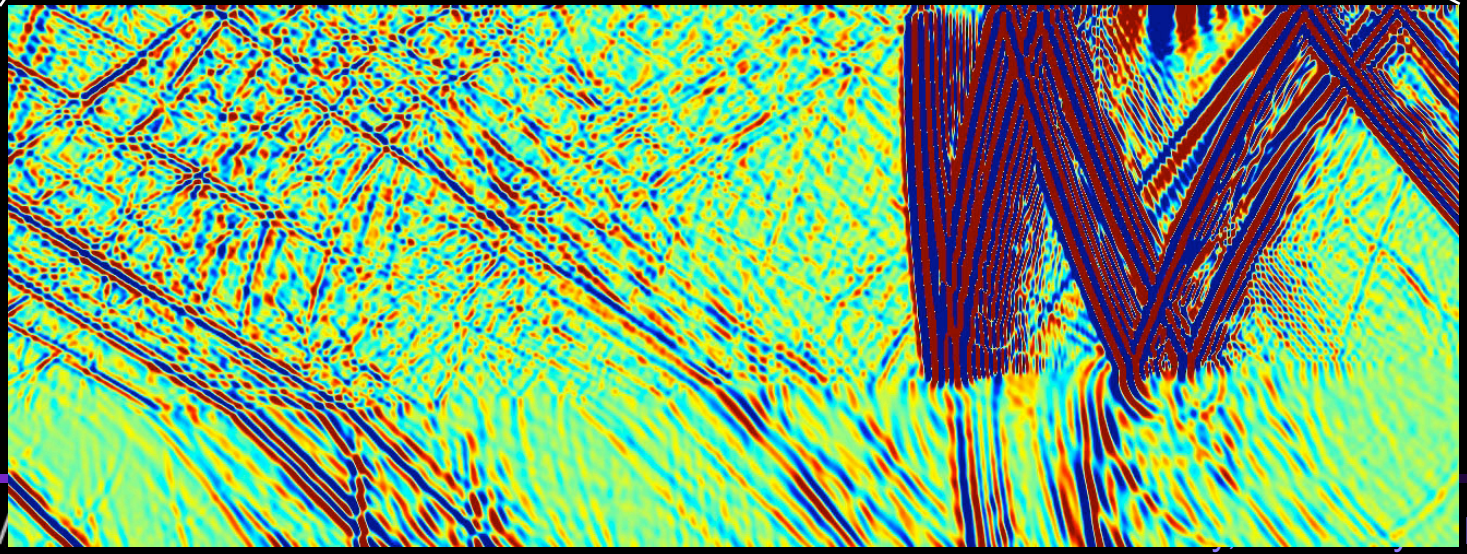
Scenario 1: Visualize the output

- Images, animations, or videos produced at one site
- Load
  - Images: ‘imageviewer’ application
  - Movies: ‘mplayer’ / VLC plugin
  - Animation: `bitplayer’ NCSA format
- Stream
- Display



Example: SDSC/Geon

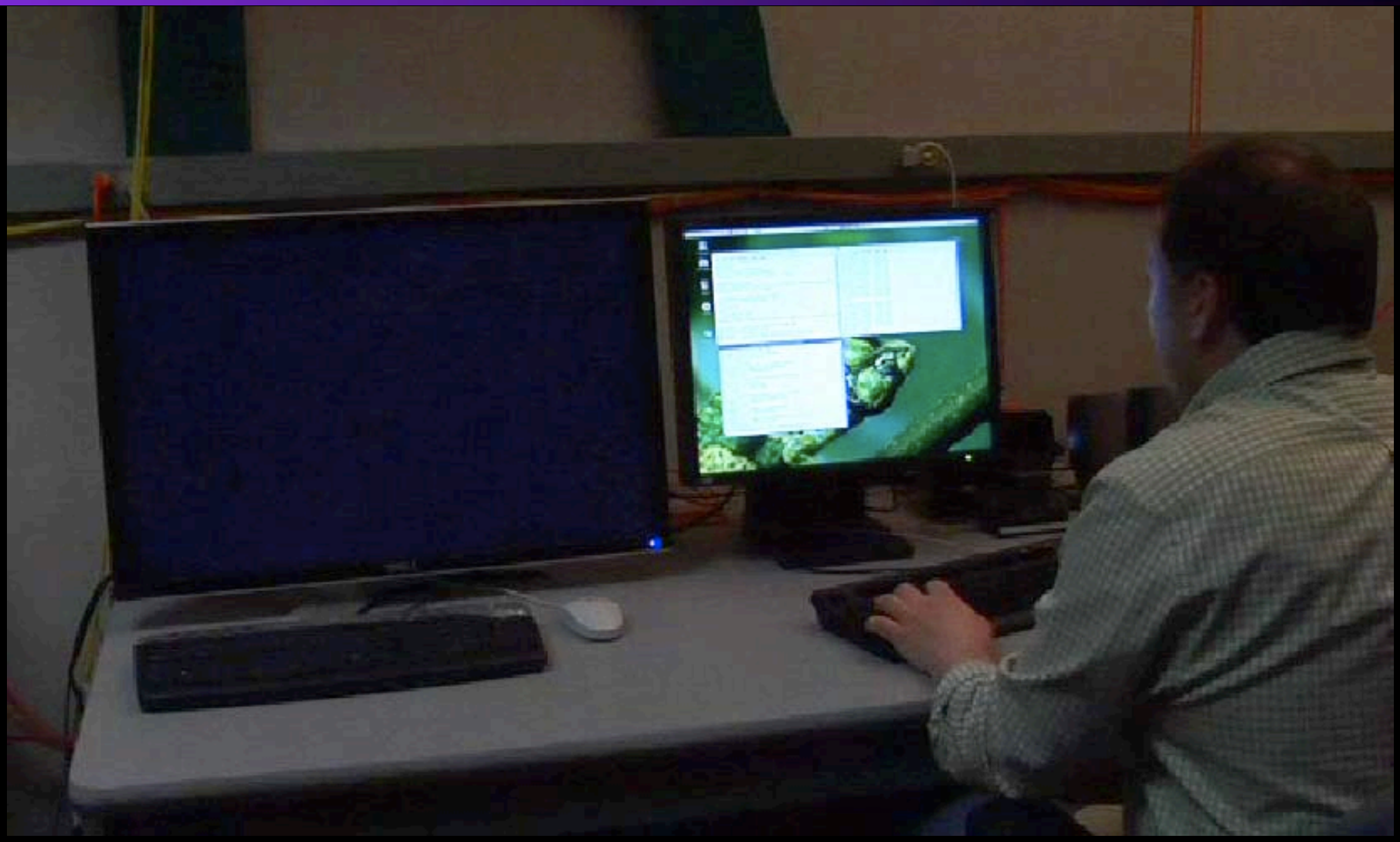
- Images at 8874x2000 pixels, 400 frames



Scenario 2: OpenGL application

- OpenGL hardware rendering application
- Capture pixels
  - No application modification
  - Dynamic loading of a new OpenGL library
  - À la Chromium
- Stream
- Display

Paraview + Live HD video



Paraview + Live HD video

Scenario 3: Application modification

- Application produces pixel buffers
- Stream
- Display

Initialization

```
sailConfig scfg;
scfg.cfgFile = "sage.conf";
scfg.appName = "myapp”;
scfg.resX = 1024;
scfg.resY = 768;
scfg.colorDepth = 24;
scfg.pixFmt = TVPIXFMT_888;
scfg.rowOrd = TOP_TO_BOTTOM;
sageInf.init(scfg);
```

Streaming

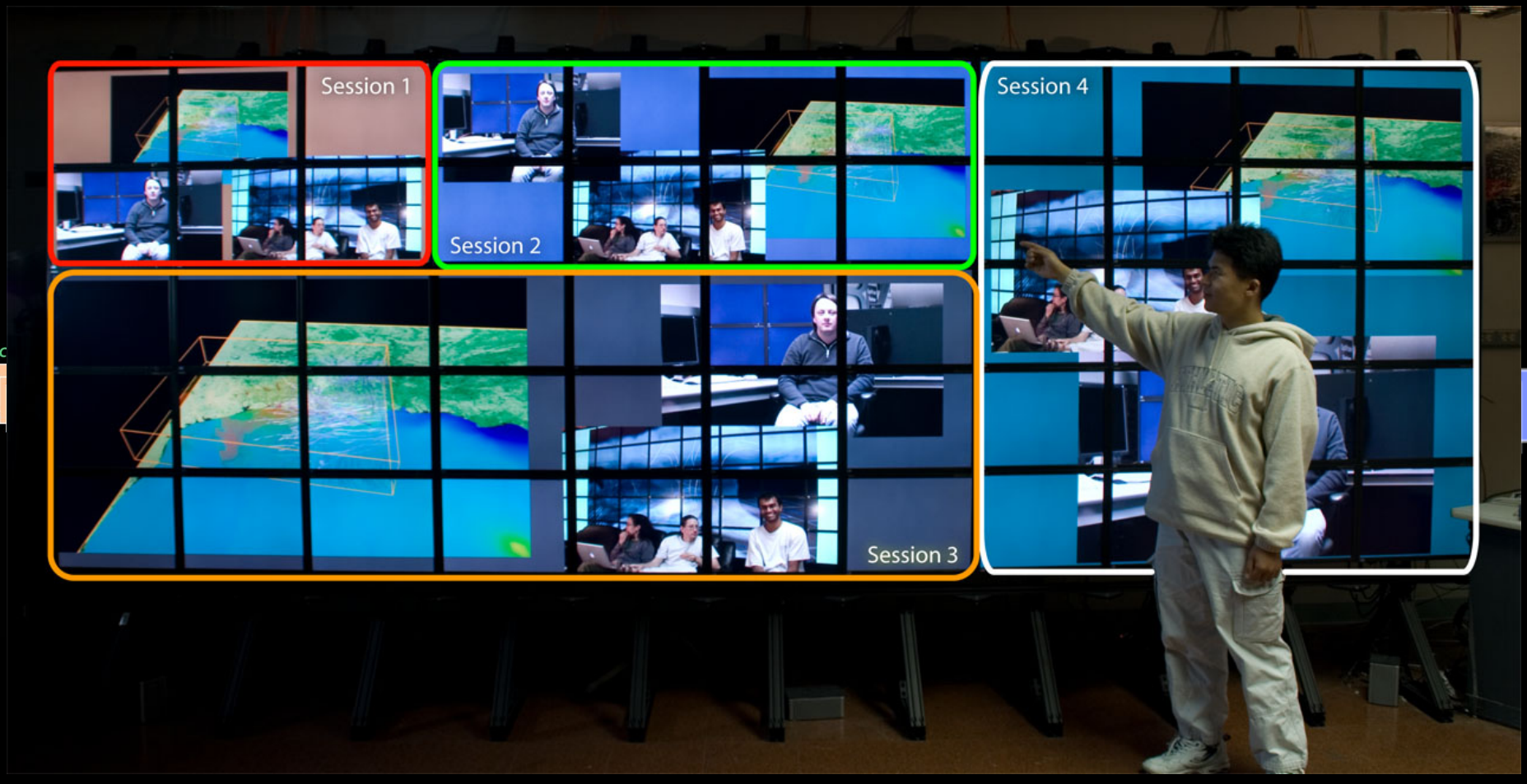
```
memcpy(rgbBuffer, data, size);
or
glReadPixels(..., ..., rgbBuffer);
sageInf.swapBuffer(rgbBuffer);
```

SAGE Streams

	Format	*Bandwidth*
HDV compressed	1080i/720p MPEG2	~ 30 Mbps
HDV uncompressed	1440x1080 RGB16	~ 700 Mbps
HD video	1920x1080 RGB16	~ 1 Gbps
HD animation	1920x1080 RGB24	~ 1.4 Gbps
HD animation stereo	1920x1080 RGB24	~ 2.8 Gbps
SHD animation	3840x2160 RGB24	~ 5 to 6 Gbps

Current Research

- Visualcasting – scalable real-time image multicasting



Scalable VisualCasting for Global Ultra-Definition Collaborative Visualization

- **Motivation:**
  - In time critical situations, high-definition video and ultra-high resolution visualizations need to be distributed in real-time to many collaborating sites to facilitate joint analysis and decision making.
  - Immersive war room environments with potential resolutions on the order of hundreds of megapixels require “multicasting” of visualizations at tens of gigabits per second.
  - This is not possible with current generation of war room technology & telco equipment.

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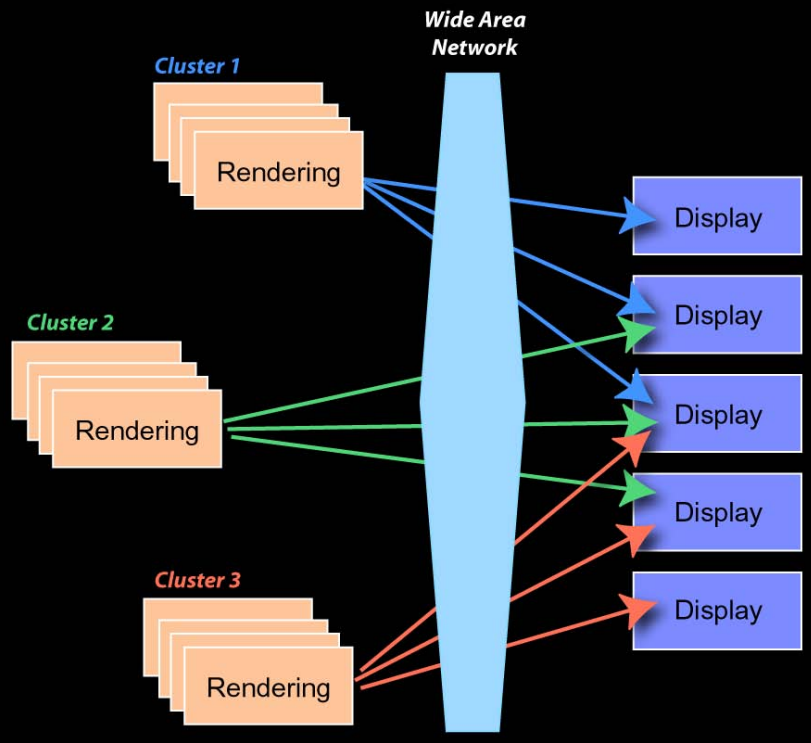
Proposed Solution

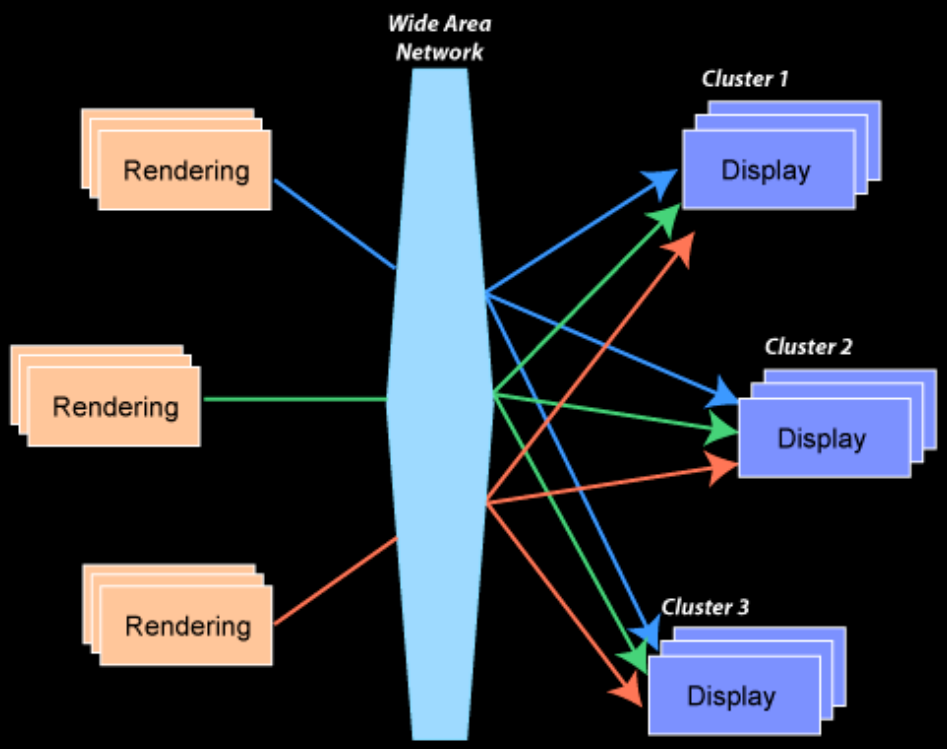
- A fundamental requirement of high-resolution collaborative visualization systems is multicast of visualization.
- Visualcasting: scalable real-time image multicasting service in ultra-high resolution display environment.
- SAGE Bridge: A high-speed bridging system which distributes pixel data received from rendering clusters to each end-point.
- It is deployed on a high-performance PC cluster equipped with 10gigabit network interfaces.
- It incrementally allocates bridge nodes as the number of endpoints increases.
- It considers heterogeneity of endpoints: different display resolution, computing power and network bandwidth.

Current and Proposed Models



Current model

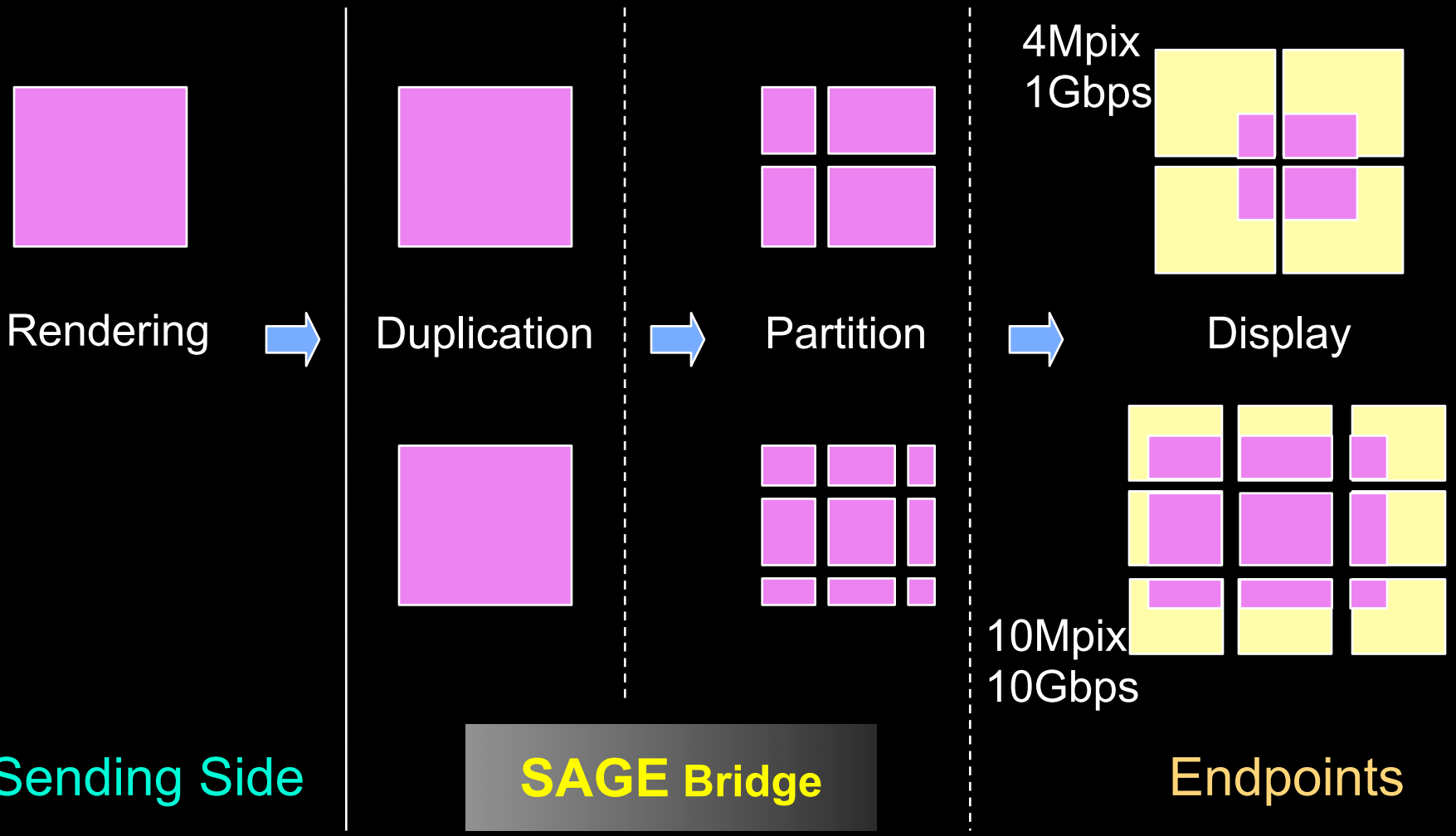
SAGE



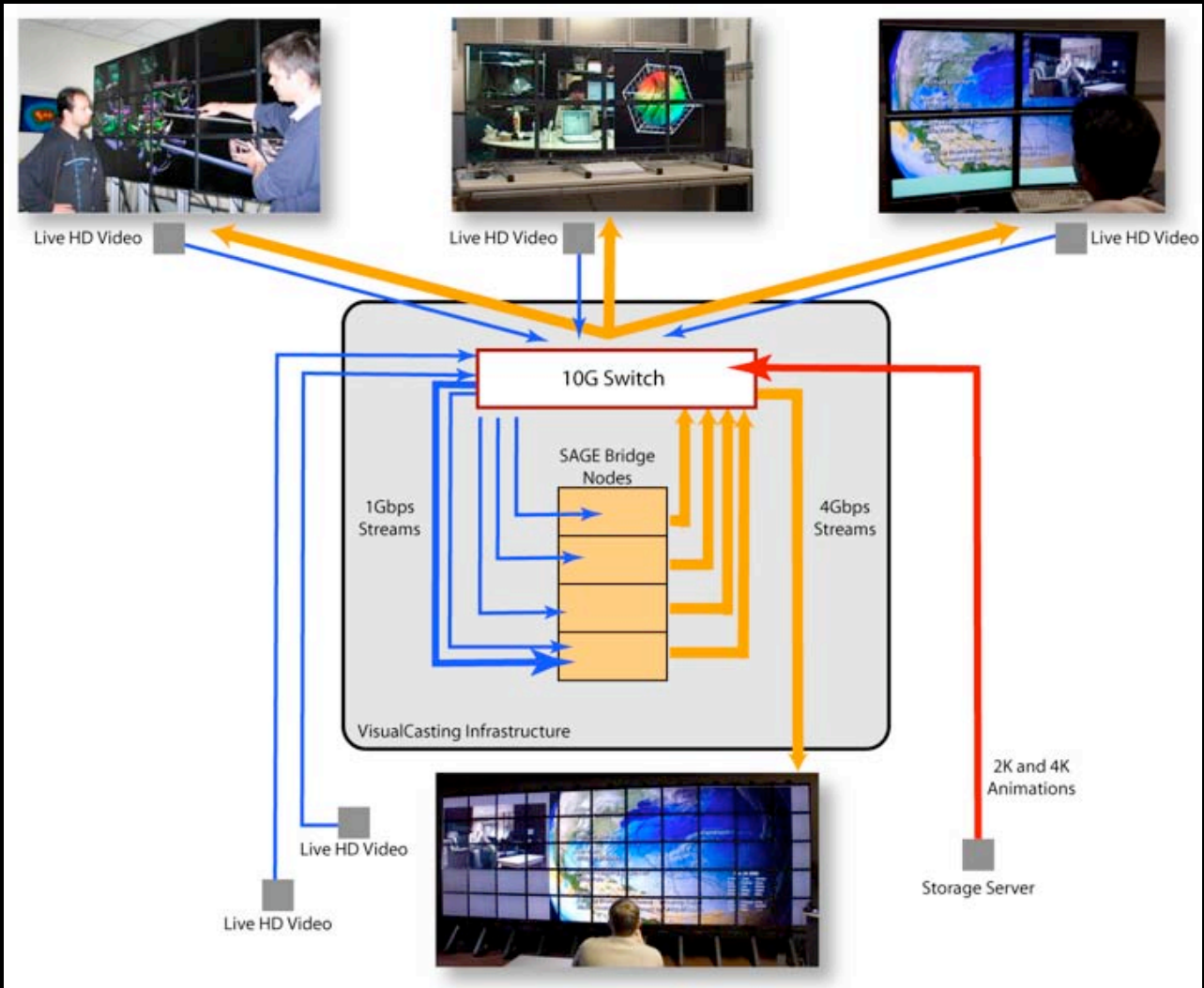
Proposed model

Visualcasting

Introducing SAGE Bridge



VisualCasting at SC06



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VisualCasting at SC06

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Video Clip

evl

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Global Lambda Visualization Facility

Live the Dream: Persistent Connectivity Among GLIF Sites

- **Motivation**
  - Optical networks and LambdaGrids enable large-scale global science collaborations − but interoperable visualization and collaboration tools are missing!
- **Approach**
  - Launched in September 2005, a group of iGrid 2005 Workshop participants who were designing and developing complementary, distributed visualization and collaboration technologies decided to pool expertise, build on each other's successes, and integrate their work into a coherent whole, providing a unique model for international partnerships.

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  - CoreWall - NSF
  - OptIPuter - NSF
  - Collaborative Continuum Displays and Collaboration Studies - ONR

For More Information

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iGrid 2005: September 26-30, 2005, San Diego, California

- **4th community-driven biennial International Grid event attracting 450 participants**
  - An international testbed for participants to collaborate on a global scale
  - To accelerate the use of multi-10Gb international and national networks
  - To advance scientific research
  - To educate decision makers, academicians and industry about hybrid networks
- **49 demonstrations** showcasing global experiments in e-Science and next-generation shared open-source LambdaGrid services
- **20 countries:** Australia, Brazil, Canada, CERN, China, Czech Republic, Germany, Hungary, Italy, Japan, Korea, Mexico, Netherlands, Poland, Russia, Spain, Sweden, Taiwan, UK, USA
- **25 lectures,** panels and master classes as part of a symposium
- **100Gb into the Calit2 building on the UCSD campus**

evl www.igrid2005.org

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