Tiling and Streaming: High-Resolution Displays over High-Speed Networks

Luc Renambot

Research Assistant Professor

Electronic Visualization Laboratory

University of Illinois at Chicago



KAUST Winter Enrichment Program 2010

Electronic Visualization Laboratory

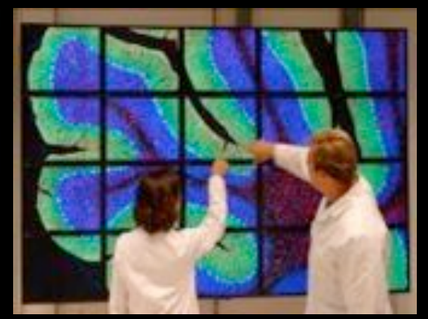


- Established in 1973
- Directors: Jason Leigh, Tom DeFanti, Dan Sandin (emeritus)
- ~ 10 full-time staff
- Interdisciplinary CS, Art, Biomedical, Communications Depts working in partnership with universities, research labs, non-profit orgs and industry.
- Currently ~15 funded students
- Research in:
  - Advanced Display Instruments
  - Visualization and Simulation, Collaboration, Human-Computer Interaction
  - High-Speed Networking
  - International Network Infrastructure



















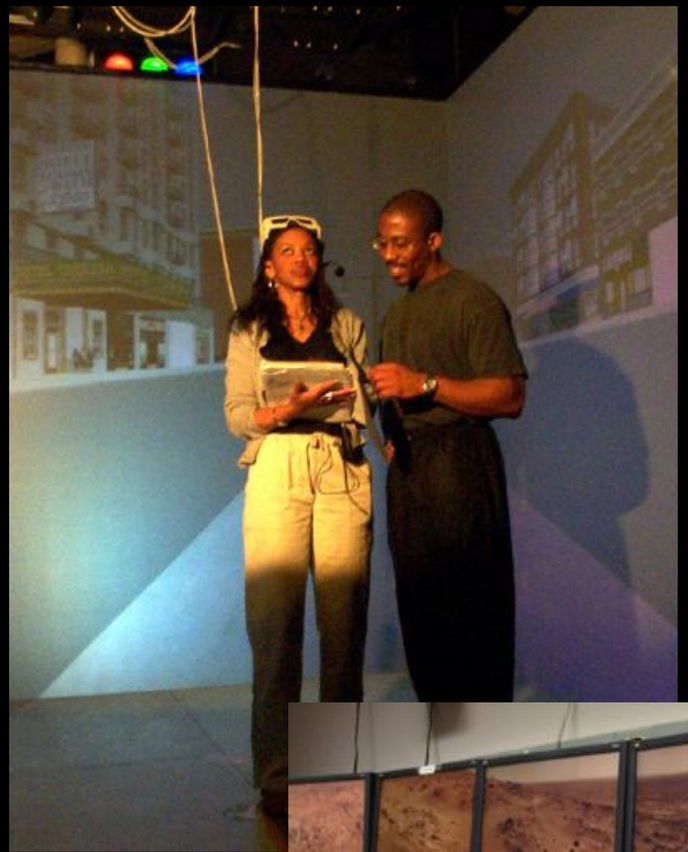








New Display Research









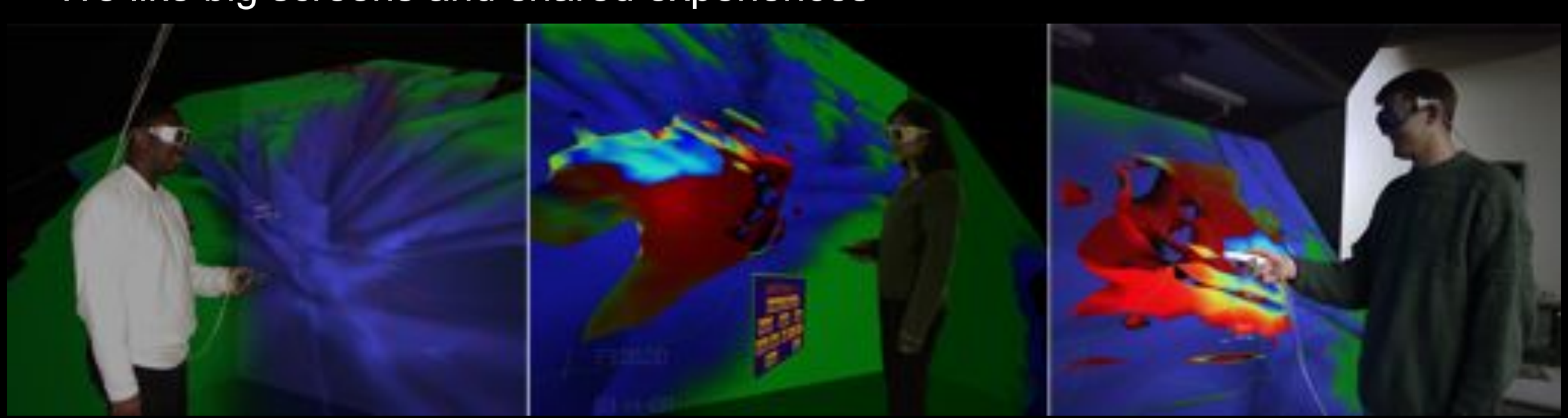




Virtual Reality Devices

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

- We like big screens and shared experiences



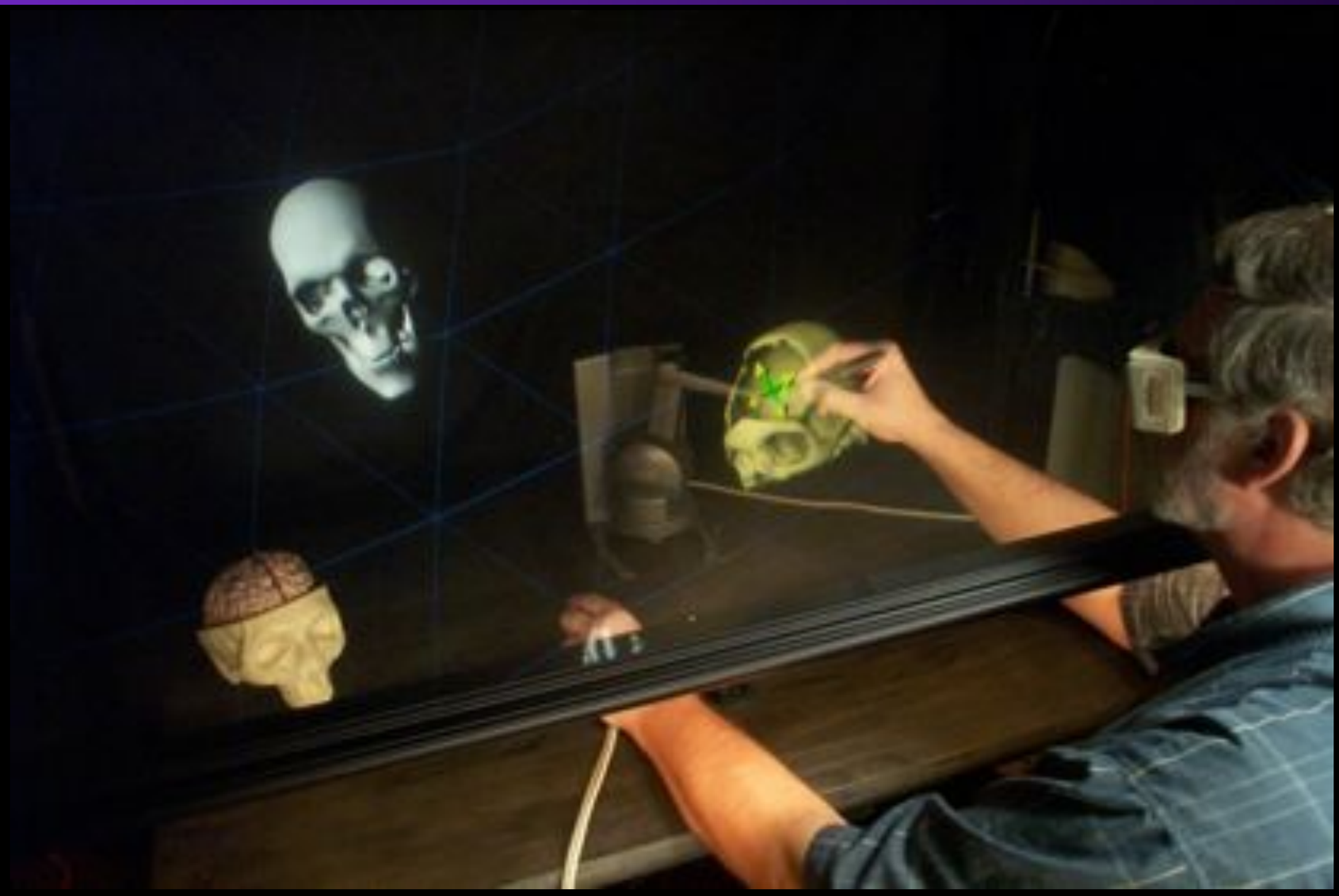
CAVE - 1992



Immersadesk - 1995



PARIS - 2003



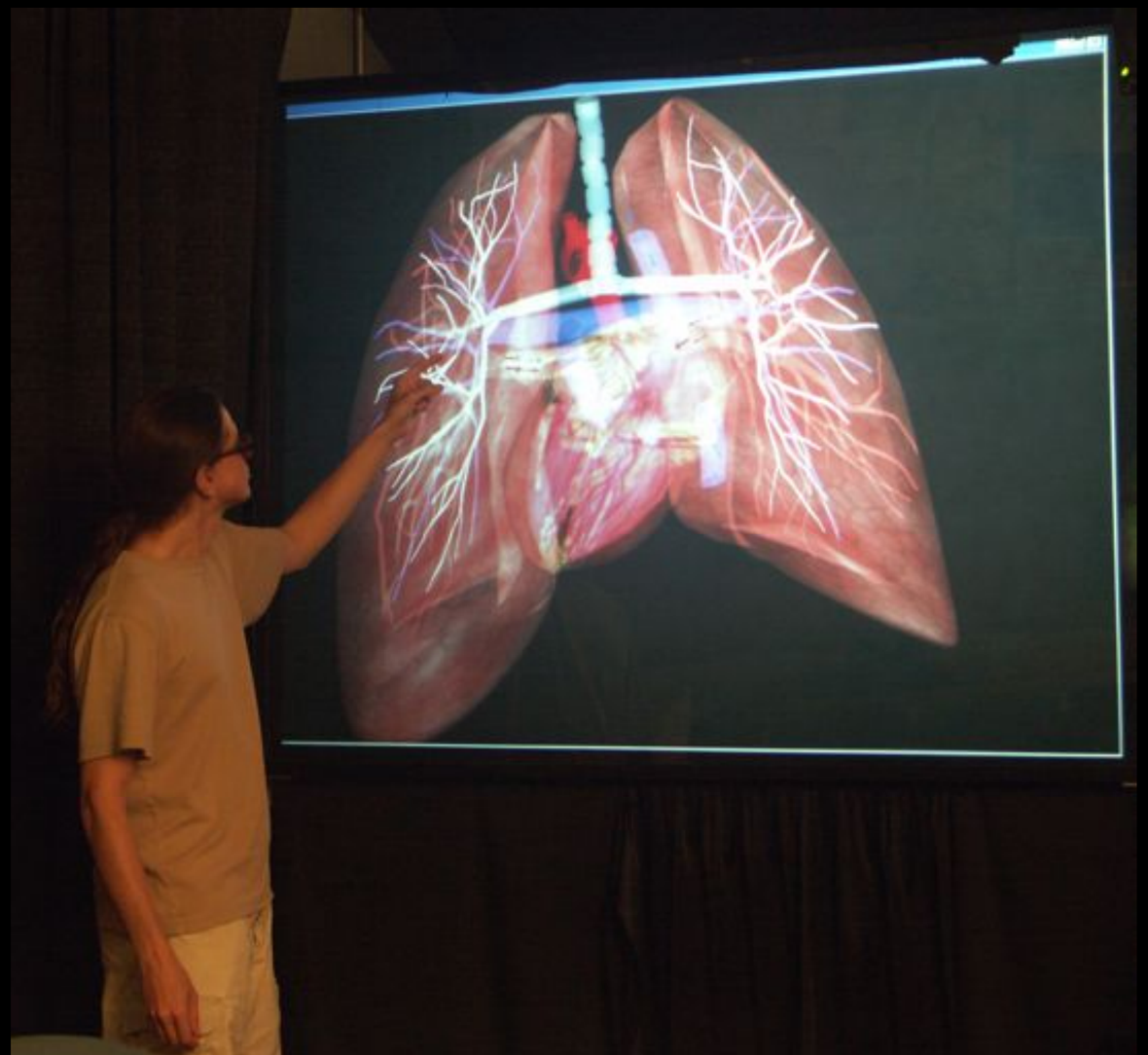
Newer Devices

- 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





GeoWall Project Expands the Window Into Earth Science

An inexpensive system offers a detailed geophysical presentation to hundreds of viewers at a time.

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 with
  20+ people viewing at a time

- No head tracking -> not VR

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



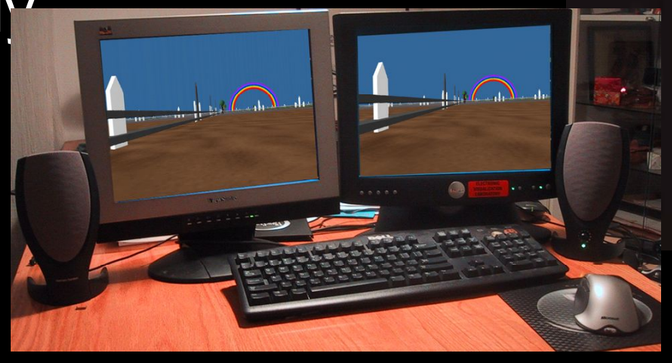
U of Minnesota

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

Motivation

- Scale, Complexity, and Collaboration

Motivation

- Problems today are of much larger scale and complexity than ever before
- These and other problems can only be solved through interdisciplinary collaborations- e.g. Global Climate Change
- There is a need to teach students, not just scientists how to collaborate with people from other disciplines

Where we ultimately see things going…
EVL's 100-Megapixel LambdaVision Wall



University of Illinois at Chicago

www.evl.uic.edu

The Role of Visualization in Science, Engineering & Education

- Vision is the dominant sense for the acquisition of information from our everyday world.
- Nearly 1/3 of your brain is devoted to processing visual information.
- Visualization has 3 main roles in scientific / engineering computing:
  - As an instrument to view and understand complex phenomena (like a microscope)
  - To validate results (like a computational simulation)
  - To explain complex results to a lay audience (such as government / policy makers and the general public, and to inspire the next generation of scientists)

Real World Examples of Managing Scale and Complexity



Will Self, English novelist known for crafting complex narratives with weaving story lines



www.will-self.com/writing-room

Real World Examples of Managing Scale and Complexity

Antarctic Drilling Program
Documenting features is done by hand, on paper







Examples of Managing Scale and Complexity



BMW's Wall of Inspiration

Depicts trends in context of Time, Fashion and Architecture

Examples of Managing Scale and Complexity



BMW's Wall of Inspiration

Depicts trends in context of Time, Fashion and Architecture

Examples of Managing Scale and Complexity



BMW's Wall of Inspiration

Depicts trends in context of Time, Fashion and Architecture

Another Example

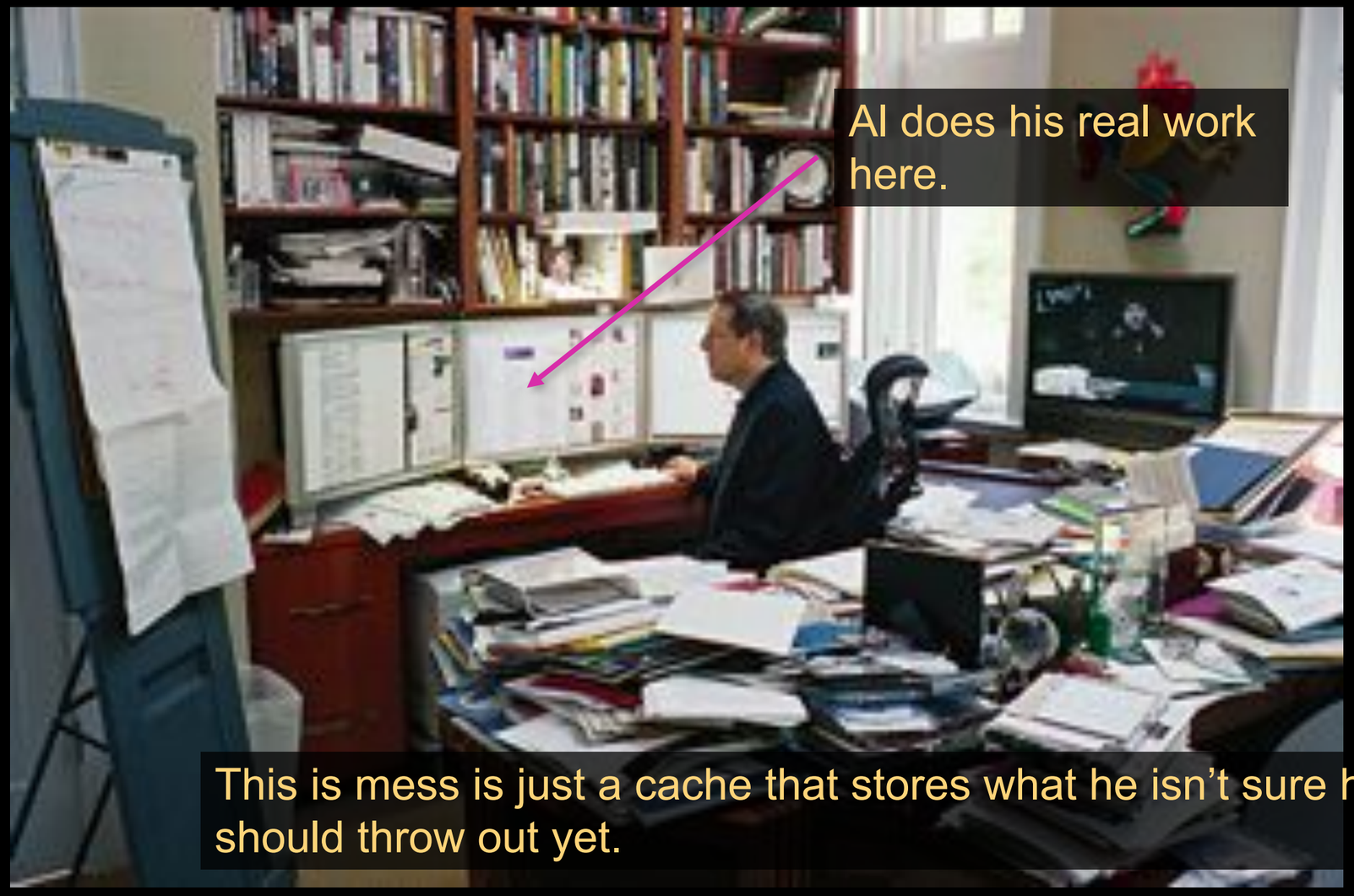


http://www.time.com/time/photogallery/0,29307,1622338_1363003,00.html



http://www.time.com/time/photogallery/0,29307,1622338_1363003,00.html

Another Example



http://www.time.com/time/photogallery/0,29307,1622338_1363003,00.html

Managing Scale and Complexity in Teams



“War” Rooms / Project Rooms





Is it Just Display Size? Or Does Resolution Matter?

	Small Screen	Big Screen
Low Res	1 doc @ a time Pan & zoom Single user / viewer Single point of control	1 doc @ a time Pan & zoom Multi user / viewer Single point of control or turn taking for multi users
High Res	Multi doc @ a time Reduced pan & zoom Enables detail & context Single user / viewer Single point of control	Multi doc @ a time Reduced pan & zoom Enables detail & context Multi viewer Multi control New modalities of interaction (up close and far away)

Is it Just Display Size? Or Does Resolution Matter?

	Small Screen	Big Screen
Low Res	1 doc @ a time Pan & zoom	1 doc @ a time Pan & zoom
High Res	Multi doc @ a time Reduced pan & zoom Enables detail & context Single user / viewer Single point of control	Multi doc @ a time Reduced pan & zoom Enables detail & context Multi viewer Multi control New modalities of interaction (up close and far away)

Large Scale High Resolution Display Spaces enable users to Externalize and Expand their Working Memory-
A powerful weapon against problems of scale and complexity!

Need for Resolution

- Need for more resolution !

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

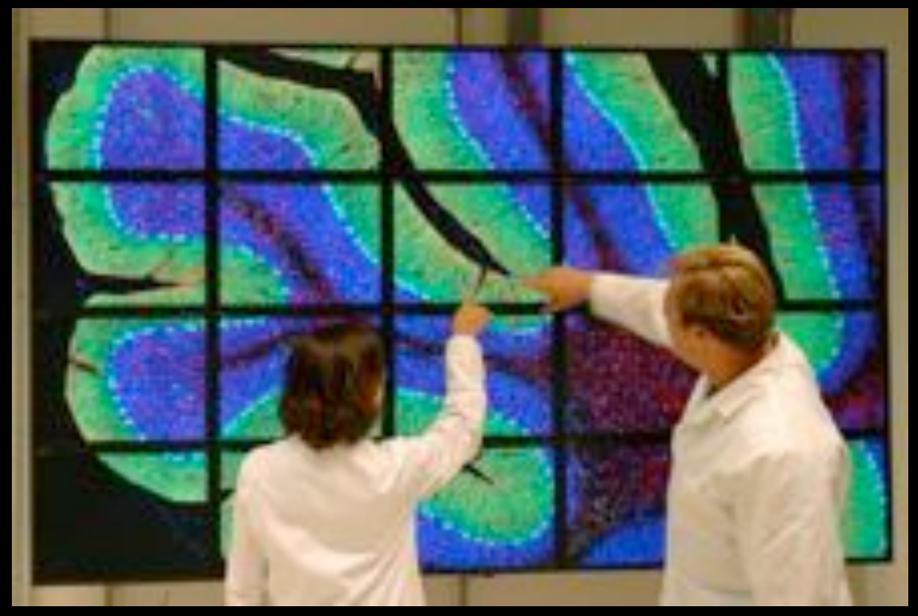
- US Geological Survey
  - National Map Mission
  - 51TB (51,000 GB) of aerial photos
  - 133 cities in US at 1/3 meter resolution
  - 365,000 * 365,000 pixels in each map

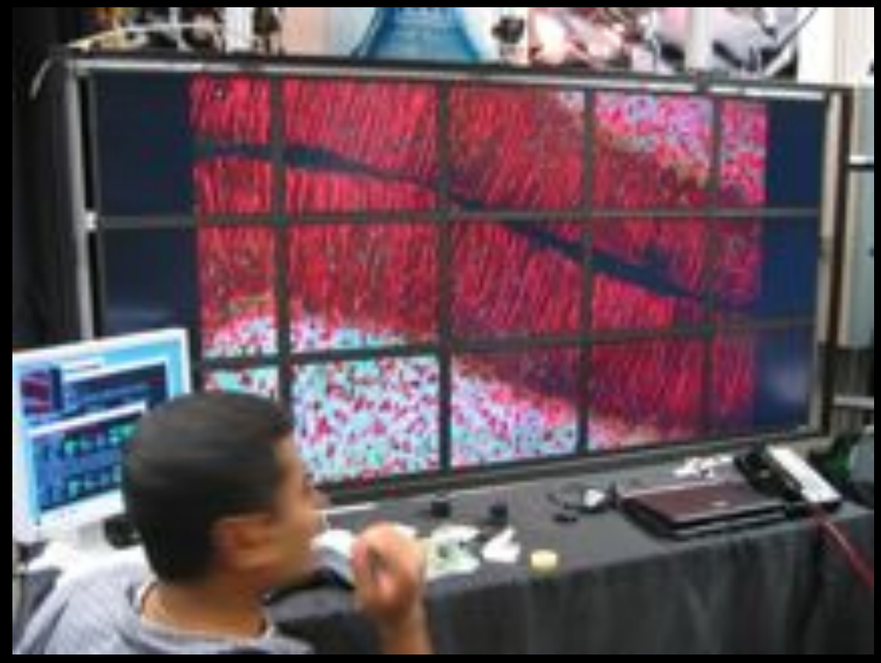




Scientific Needs: Large Amount of Data and the Ability to Perform Data Fusion

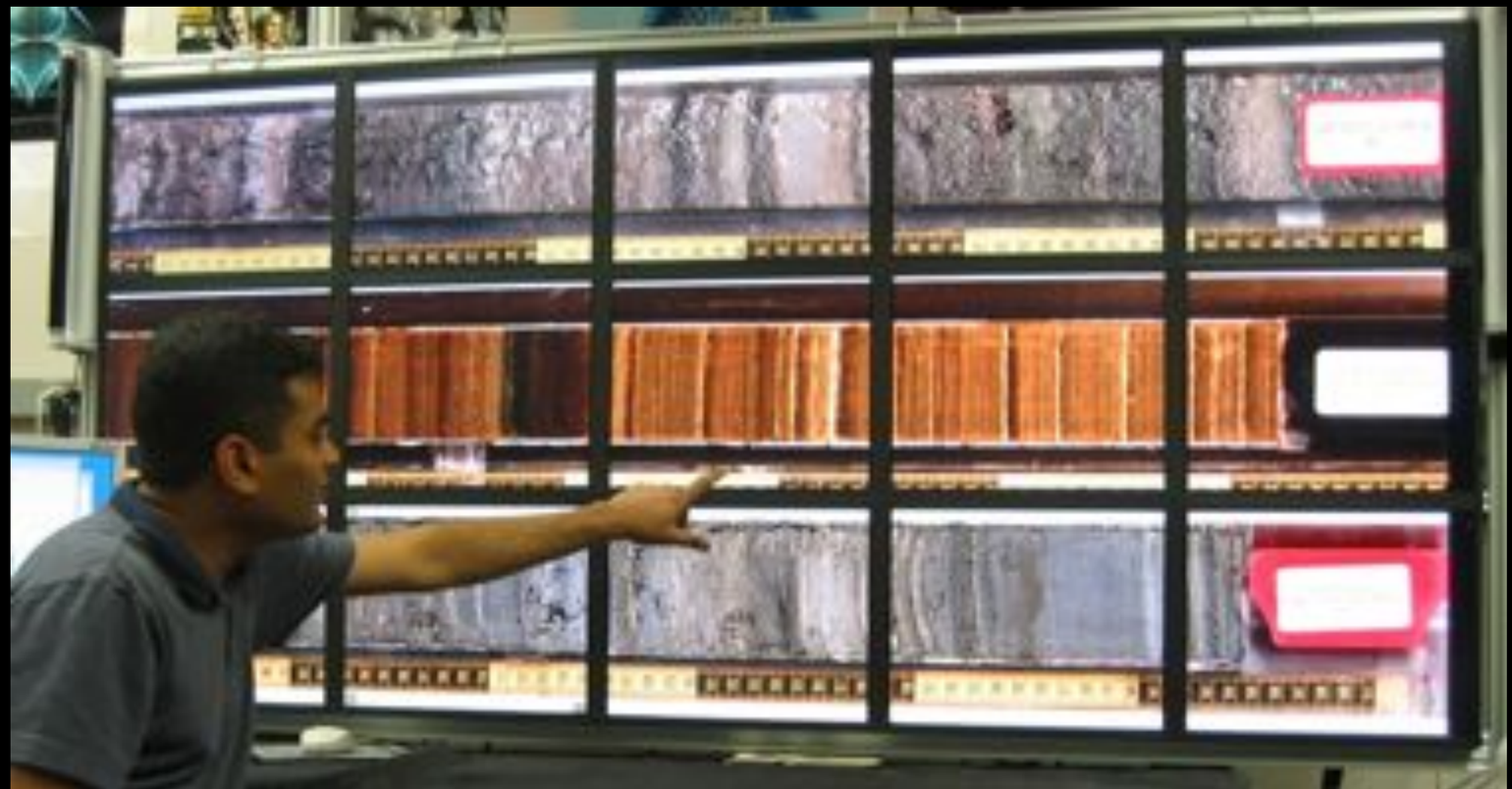
- NCMIR (Microscopy)
  - Rat Brain Mapping
  - Montage of 43,200 images
  - Each image 4,000 x 4,000 pixels





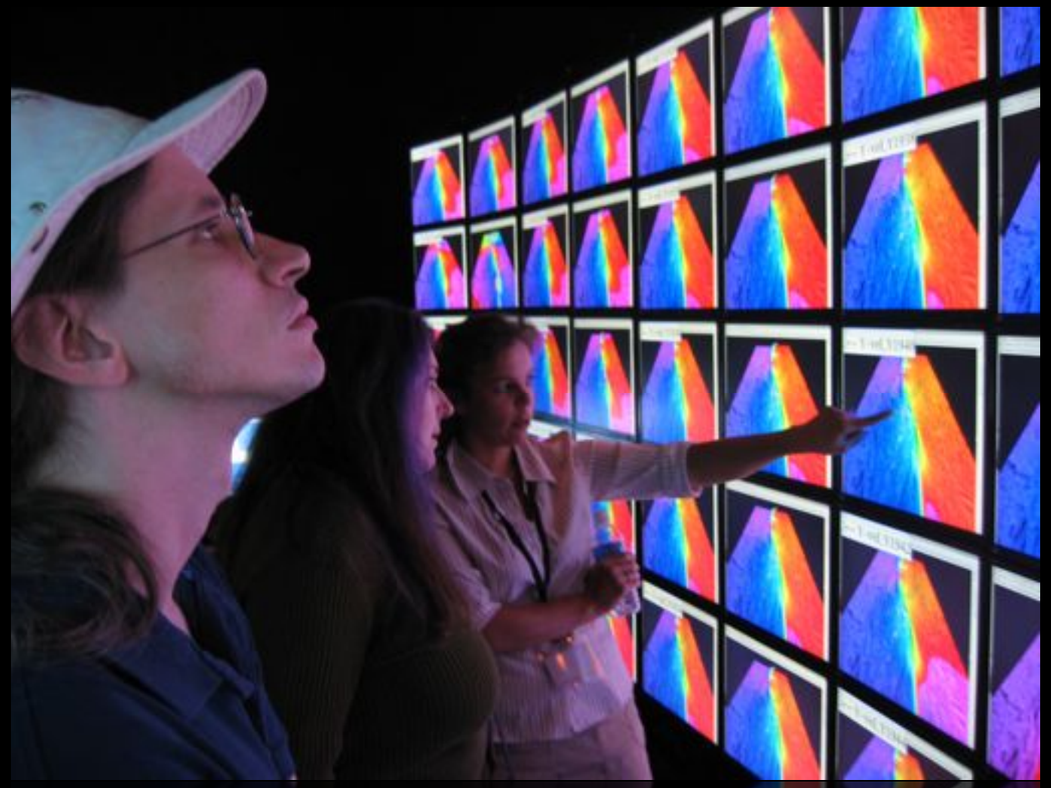
Scientific Needs: Large Amount of Data and the Ability to Perform Data Fusion

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



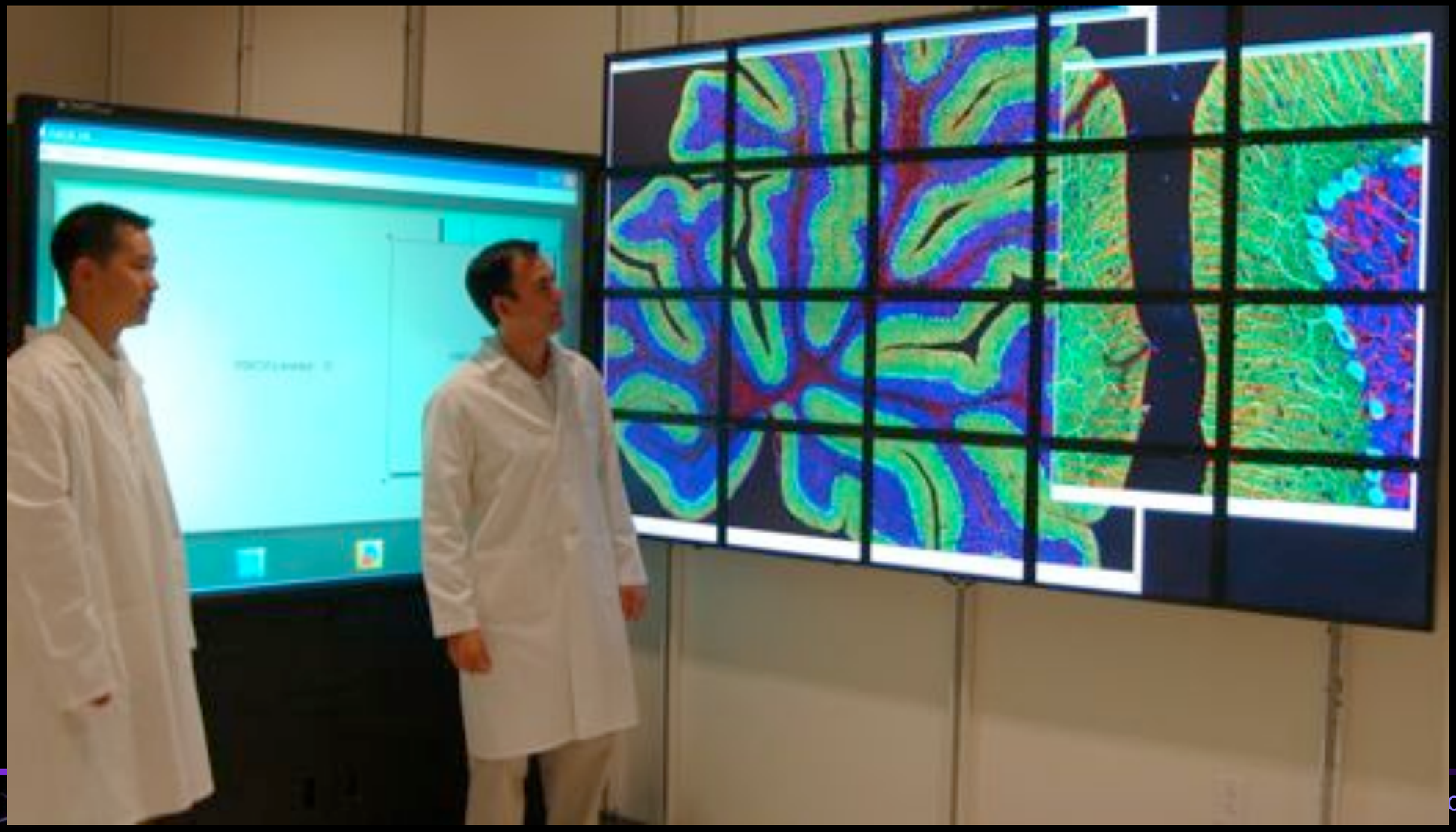
Looking for Correlations

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





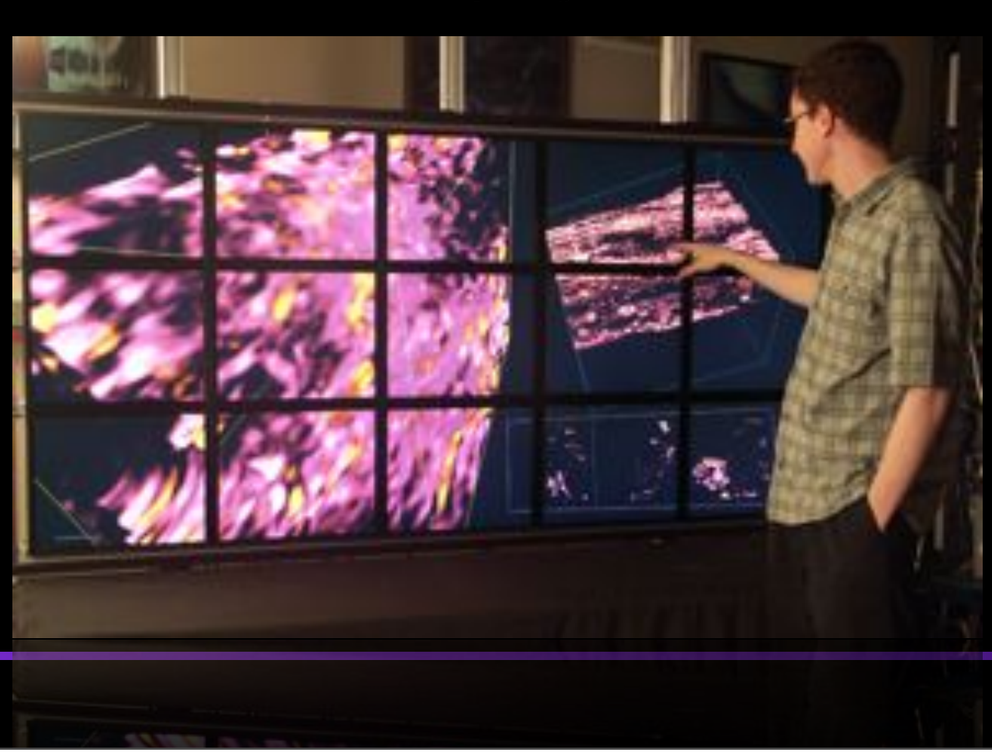
High Resolution Displays Connected to High Speed Networks are Becoming the Lenses



- National Center for Microscopy and Imaging Research
- UC San Diego

8 Years Ago

- 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



GeoWall2: LCDs plus Computers





A Variety of Sizes, Shapes, and Uses



Tiled displays



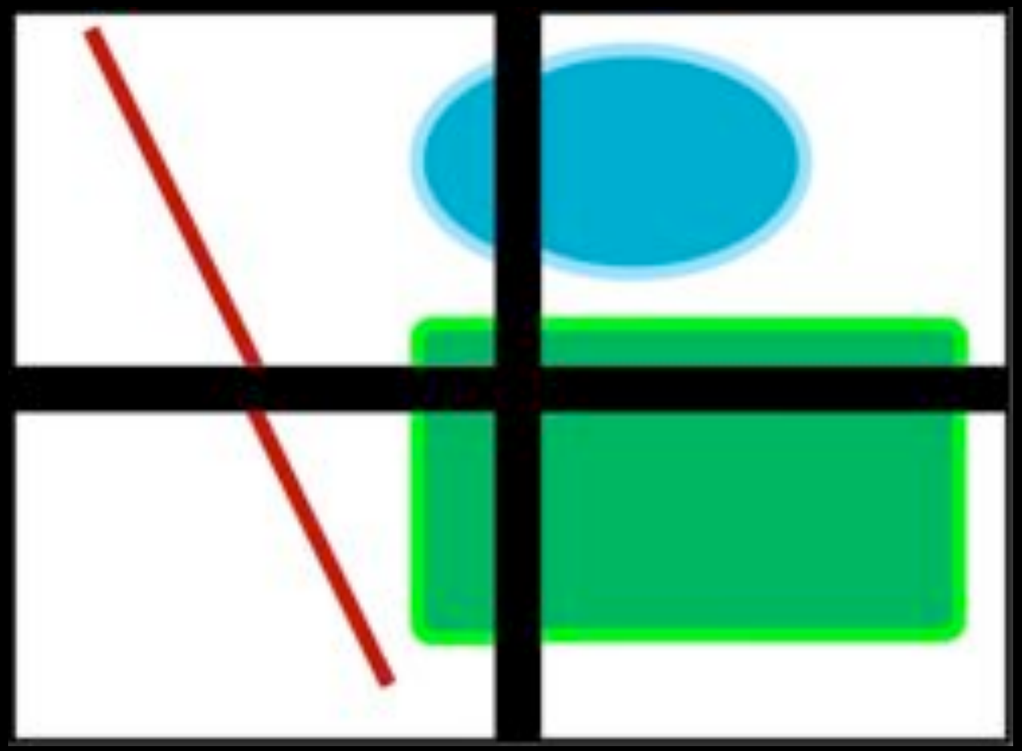
Tiled Displays

- 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 ($500+ per bulb)
  - Much shorter lifespan compared to LCDs (2,000 hours compared to 20,000 hours-50,000 hours)
- LCDs allow to leave the display on all the time, to improve casual usage of the display

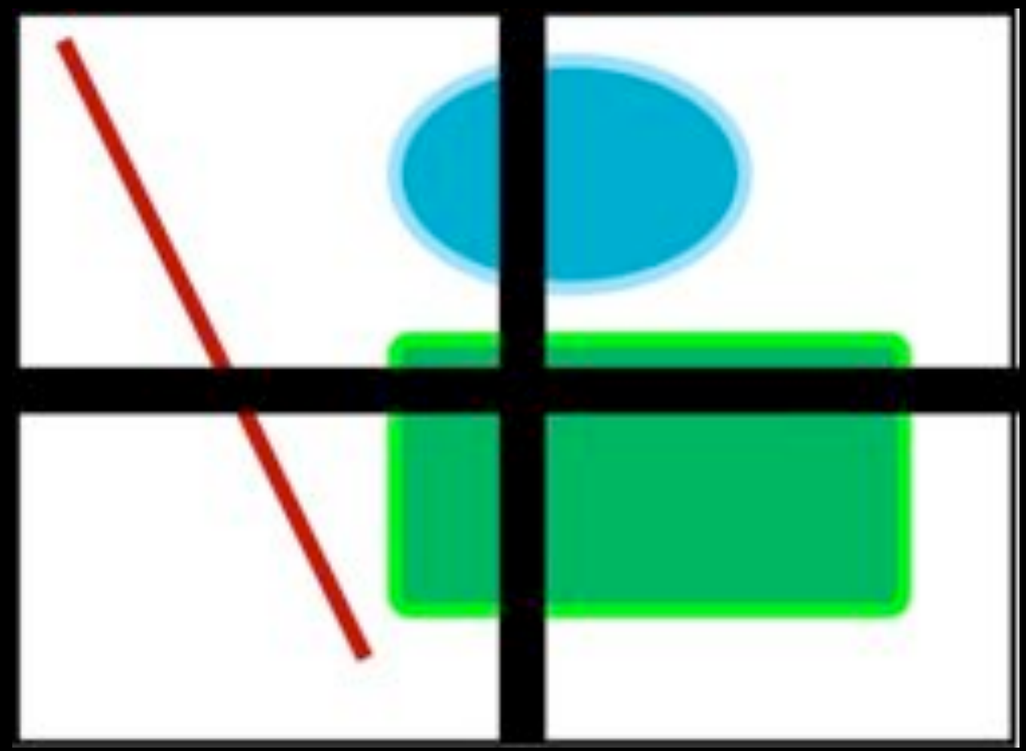
Tiled Displays

- 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
- Borders are getting smaller

Border Management



Without

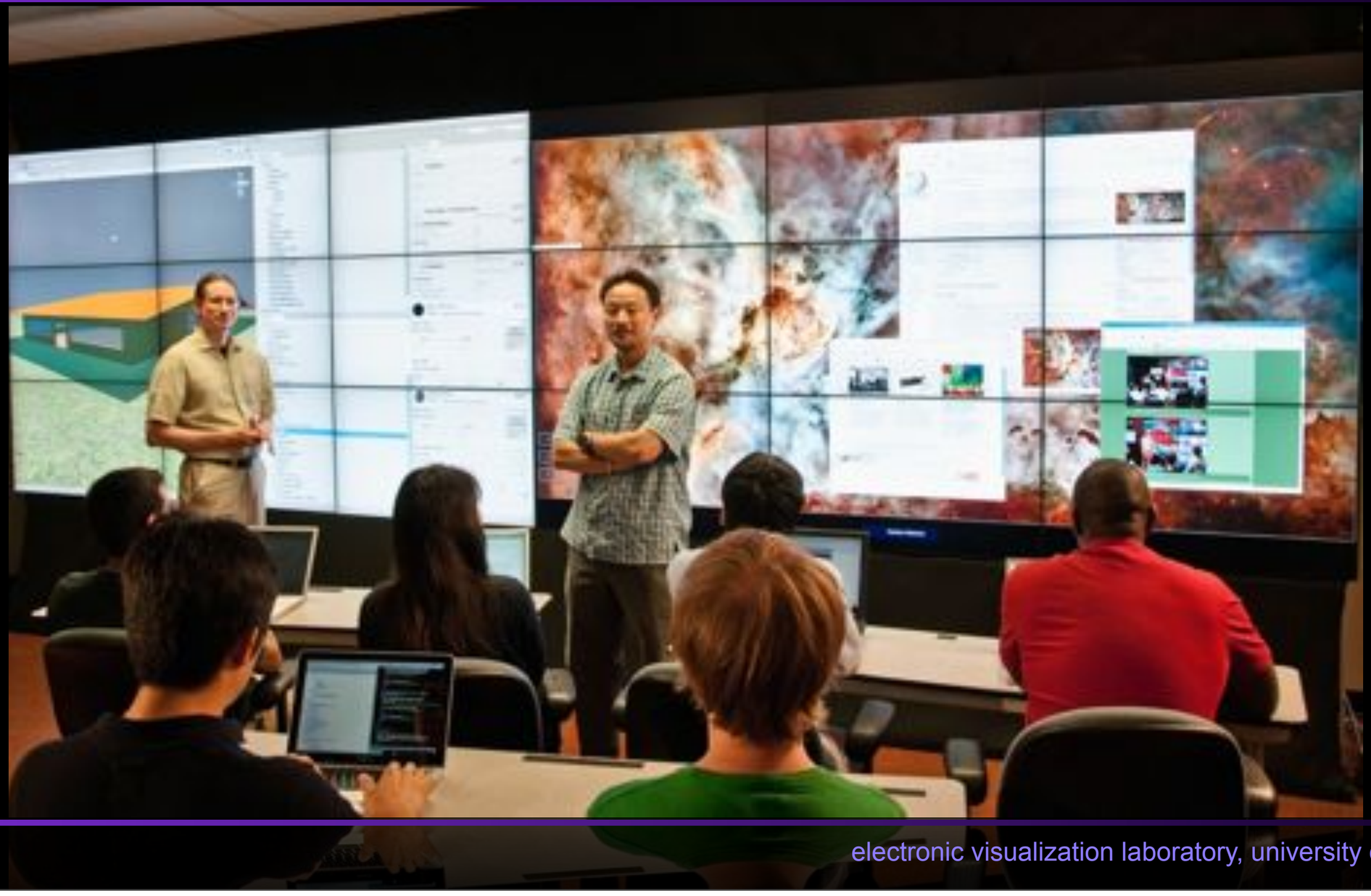


With

Narrow Borders: ‘Showcase’ at KAUST



Narrow Borders: ‘CyberCommons’ at EVL



Three Types of Displays

- LambdaVision

- CoreWall

- LambdaTable

LambdaVision

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

LambdaVision

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



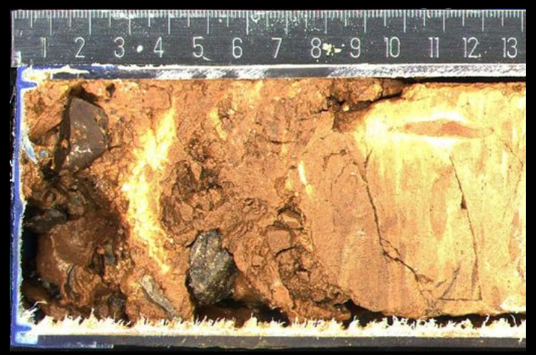
LambdaVision

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



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



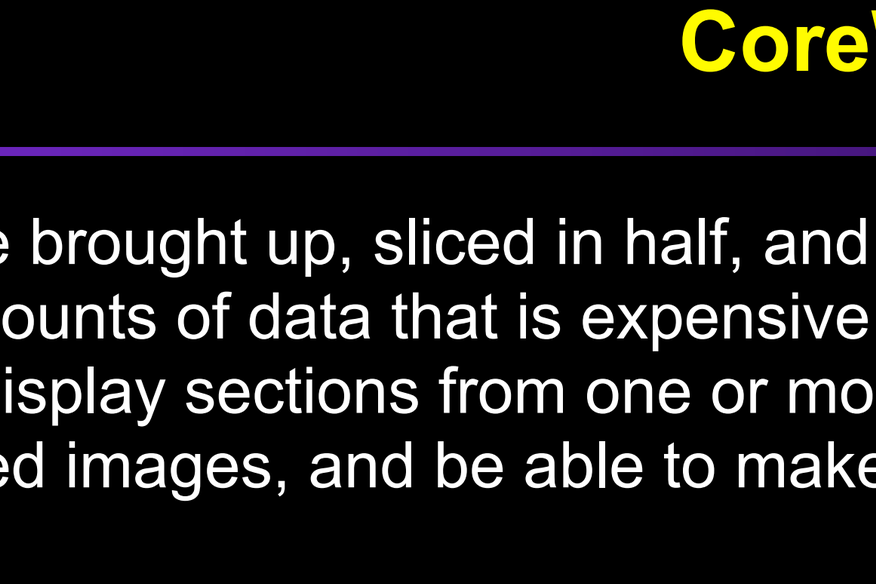






CoreWall

- 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



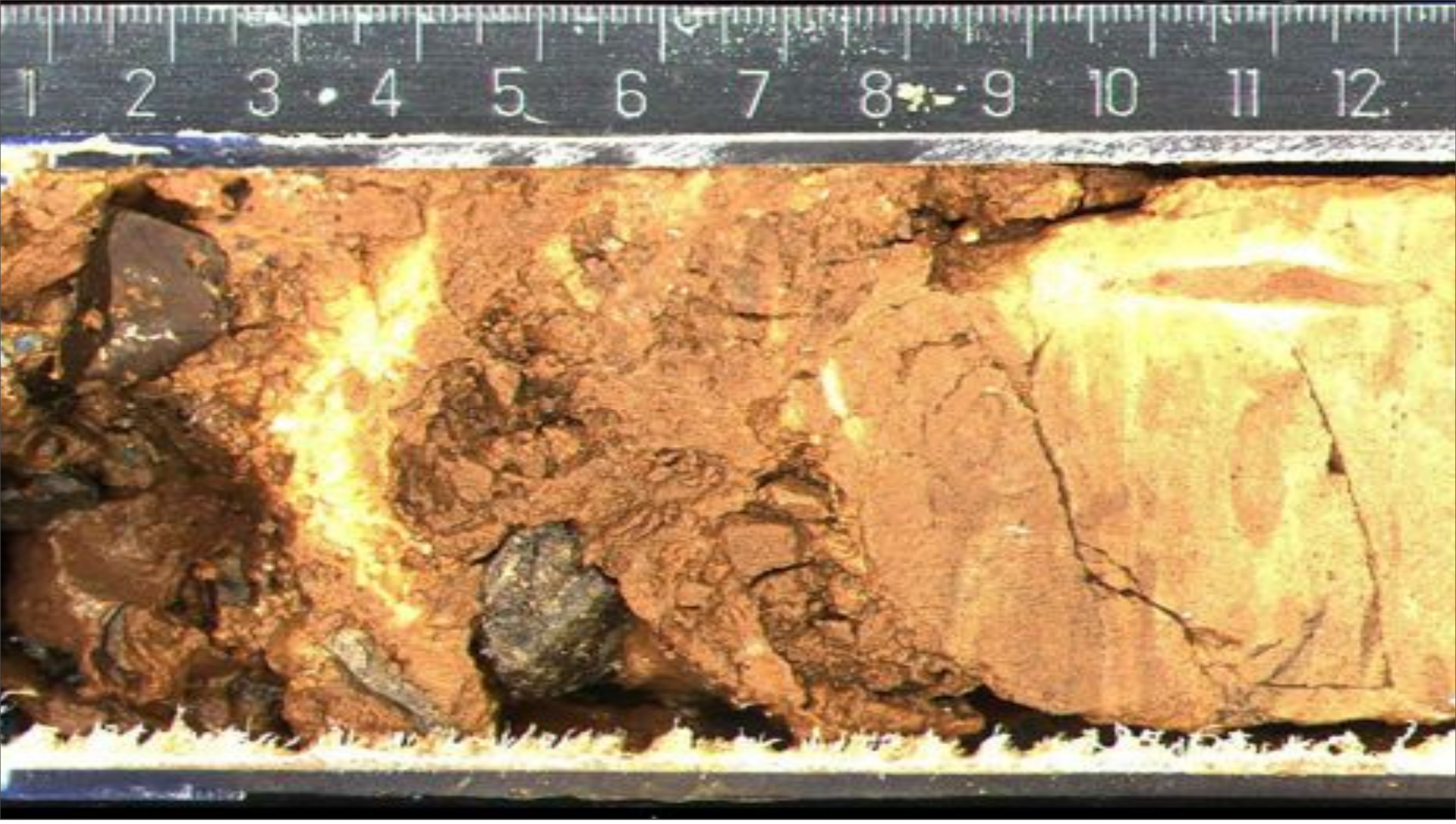


CoreWall

- 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

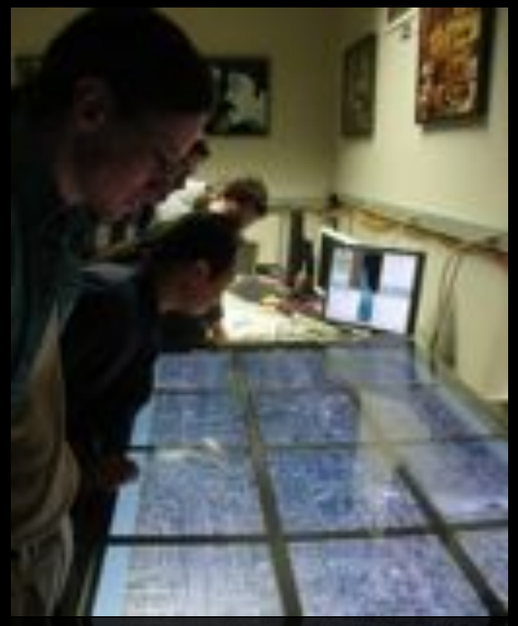
- Want to display sections from multiple cores along with discrete data streams and related images
- 1PC, 2 to 6 LCD screens
- Funded 2006 - 2008 by the National Science Foundation





LambdaTable

- Turned our original tiled 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 LCD panel is 1920x1080 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 2560x1600
- Our table make use of 30” LCD displays
  - 3x2 tiled display
  - 25 Mpixels
  - 3 PCs for display, 3 PCs for tracking


evl
electronic
visualization
laboratory
LambdaTable

Multi-touch Version



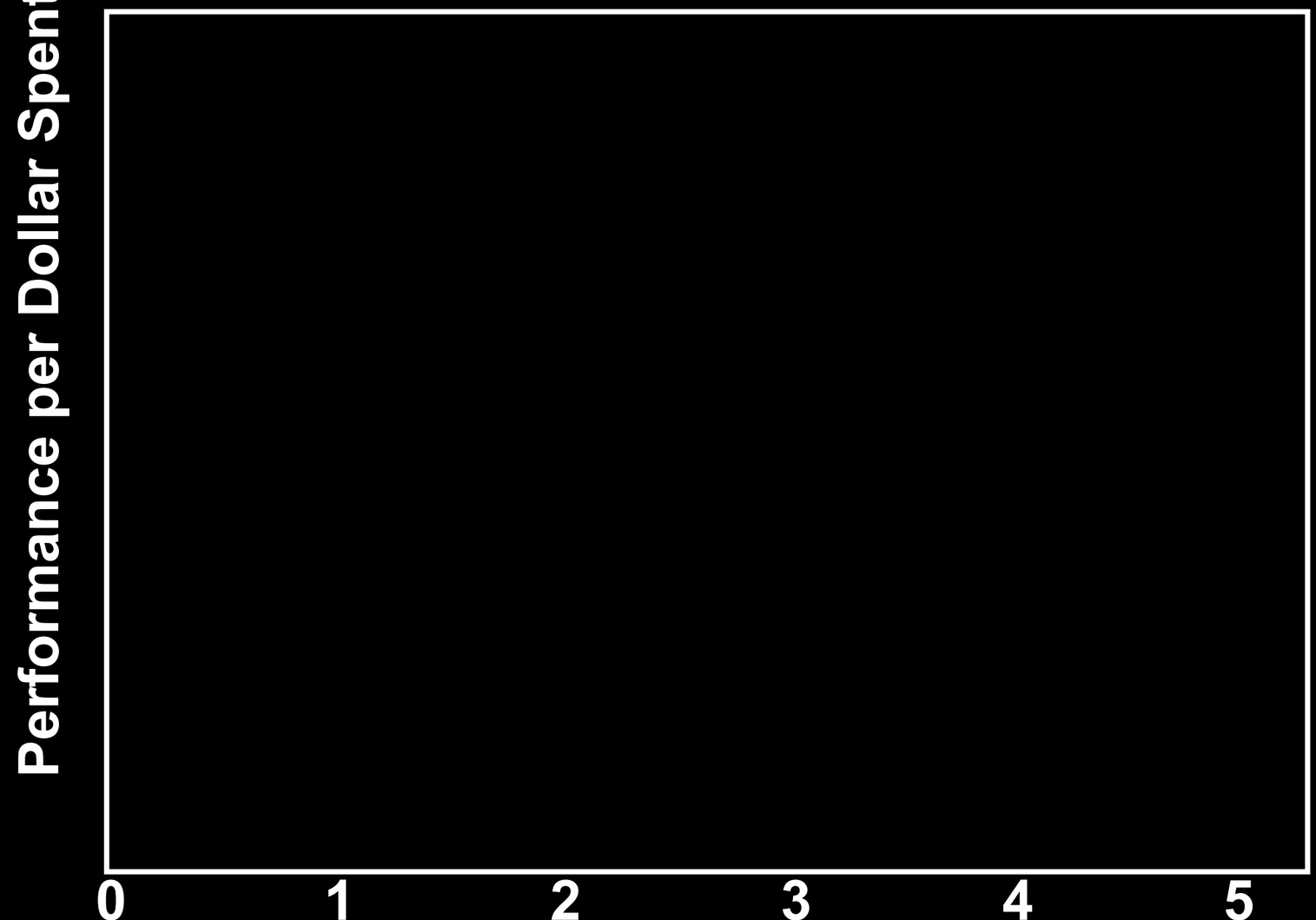


Networking

- Need for speed !

A Technological Opportunity

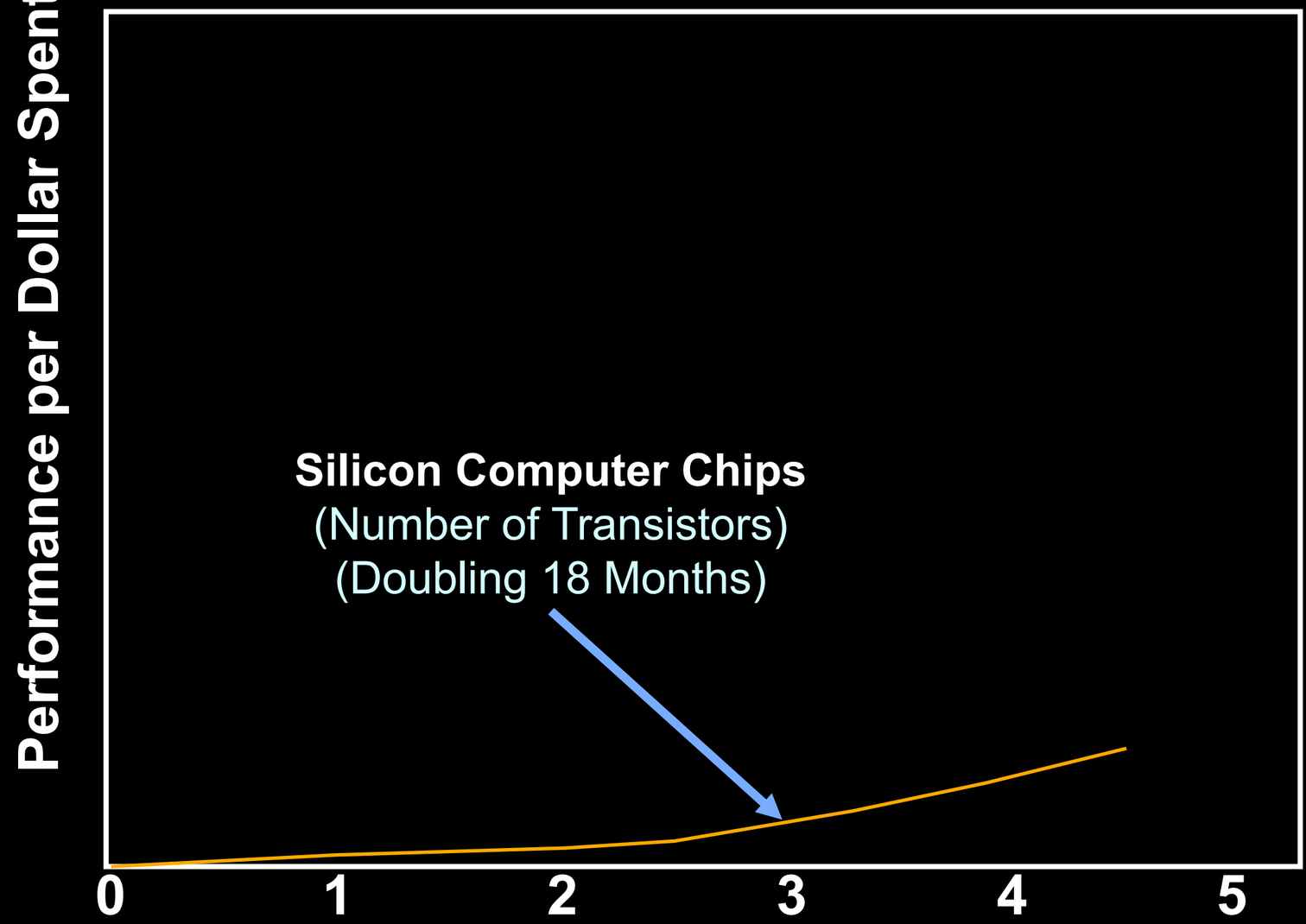
Performance per Dollar between Optical Fiber, Silicon and Data Storage



Scientific American, January 2001

A Technological Opportunity

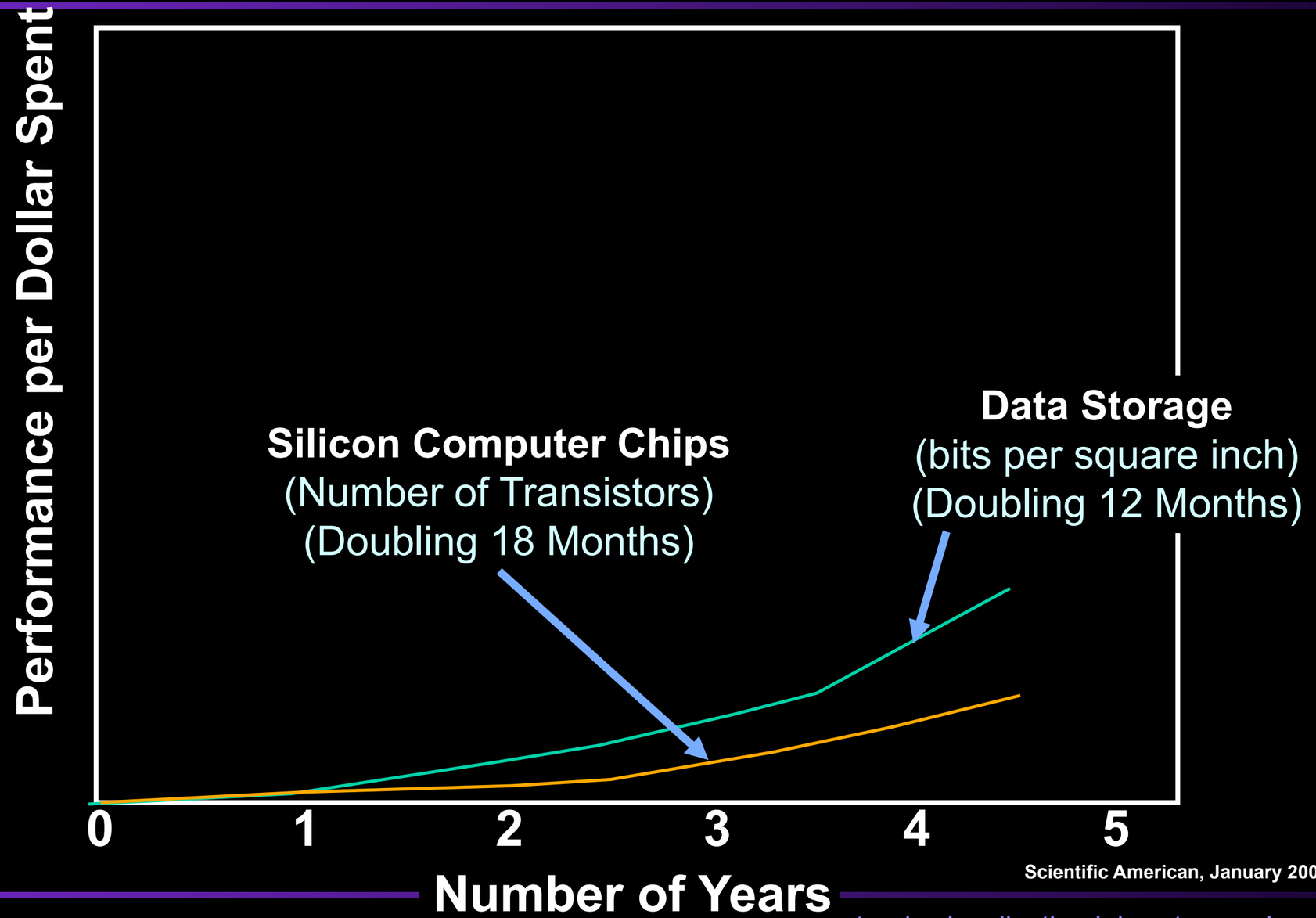
Performance per Dollar between Optical Fiber, Silicon and Data Storage



Scientific American, January 2001

A Technological Opportunity

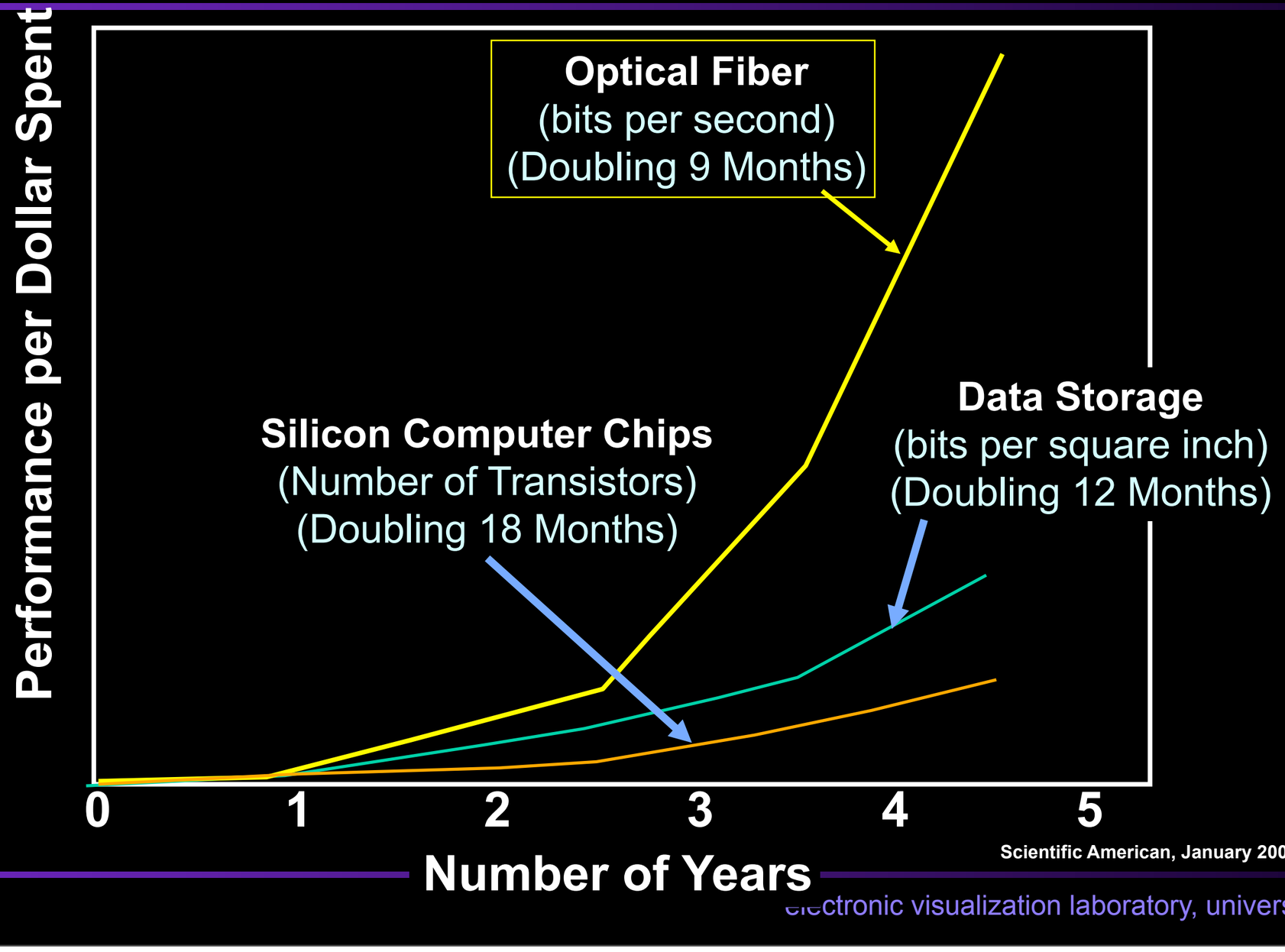
Performance per Dollar between Optical Fiber, Silicon and Data Storage



Scientific American, January 2001

A Technological Opportunity

Performance per Dollar between Optical Fiber, Silicon and Data Storage



Scientific American, January 2001

NSF OptIPuter Project

- The OptIPuter is a NSF Information Technology Research project to examine a new model of computing whereby ultra high speed networks form the backplane of a, planetary scale computer.
- The projects partners include UCSD, UIC, NU, SDSU, TAMU, UCI, UIUC/NCSA, USC/ISI; affiliate partners are USGS EROS Data Center, NASA, UvA, SARA (Netherlands), KISTI (Korea), AIST (Japan)
- Optiputer research focuses on developing technology to enable the real time collaboration and visualization of very large data-sets in the service of science- in particular earth sciences and the biosciences
- It is more cost-effective for scientists to buy bandwidth to connect to shared Cyber-Infrastructure than to redundantly clone more cyber-infrastructure.

Networking

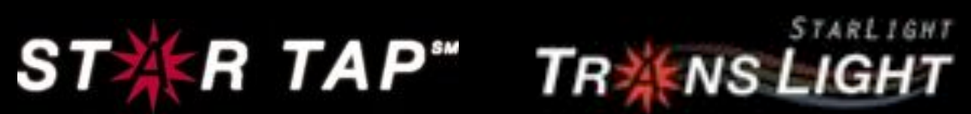
- EVL has been a long-time user of networks

- 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)

International Network Infrastructure

Global Lambda Integrated Facility

Persistent Optical Networking Infrastructure for
Rapid Distribution of Large Scale Instrumentation Data



Founding Partners: UIC, Northwestern and Argonne National Laboratory

International Network Infrastructure



Using High-Speed Networks

- 10 Gbps
  - 10,000x DSL 1Mbps lines
  - over 1GB per second, over 4 TB per hour, ...
- Price
  - 10 Gbps network interface: ~ $500
  - 10 Gbps switch: < $1000 per port
- High-end desktop computer
  - Can put 4x network interfaces (PCI-express cards)

Using High-Speed Networks

- 10 gigabit per second: lots of packets !

- Standard MTU size (1500 bytes)
  - 833,333 packets per second
- Jumbo MTU size (9000 bytes)
  - 138,888 packets per second

Using High-Speed Networks

- Packet loss for TCP

- Throughput <= ~0.7 * MTU / (RTT * sqrt(packet_loss))
  - if RTT is 240ms, MTU 1500, and loss is 0.1%, maximum throughput
    - 1.1 Mbps
  - if RTT is 240ms, MTU 9000, and loss is 0.1%, maximum throughput
    - 6.6 Mbps
  - To get over 6Gbps, need less than 0.000000001 packet loss

- Optical network

Using High-Speed Networks

- Around the globe, 10Gbps networks and 100s ms delays
  - RTT or Round Trip Time
- TCP ***bandwidth-delay*** product refers to the product of a data link's capacity and its end-to-end delay

- Data in flight from KAUST to Chicago RTT: 170 ms
  –
- Data in flight from KAUST to San Diego RTT: 240 ms
  –

Using High-Speed Networks

- Around the globe, 10Gbps networks and 100s ms delays
  - RTT or Round Trip Time
- TCP ***bandwidth-delay*** product refers to the product of a data link's capacity and its end-to-end delay

- Data in flight from KAUST to Chicago RTT: 170 ms
  - **101 MB**

- Data in flight from KAUST to San Diego RTT: 240 ms
  - **143 MB**

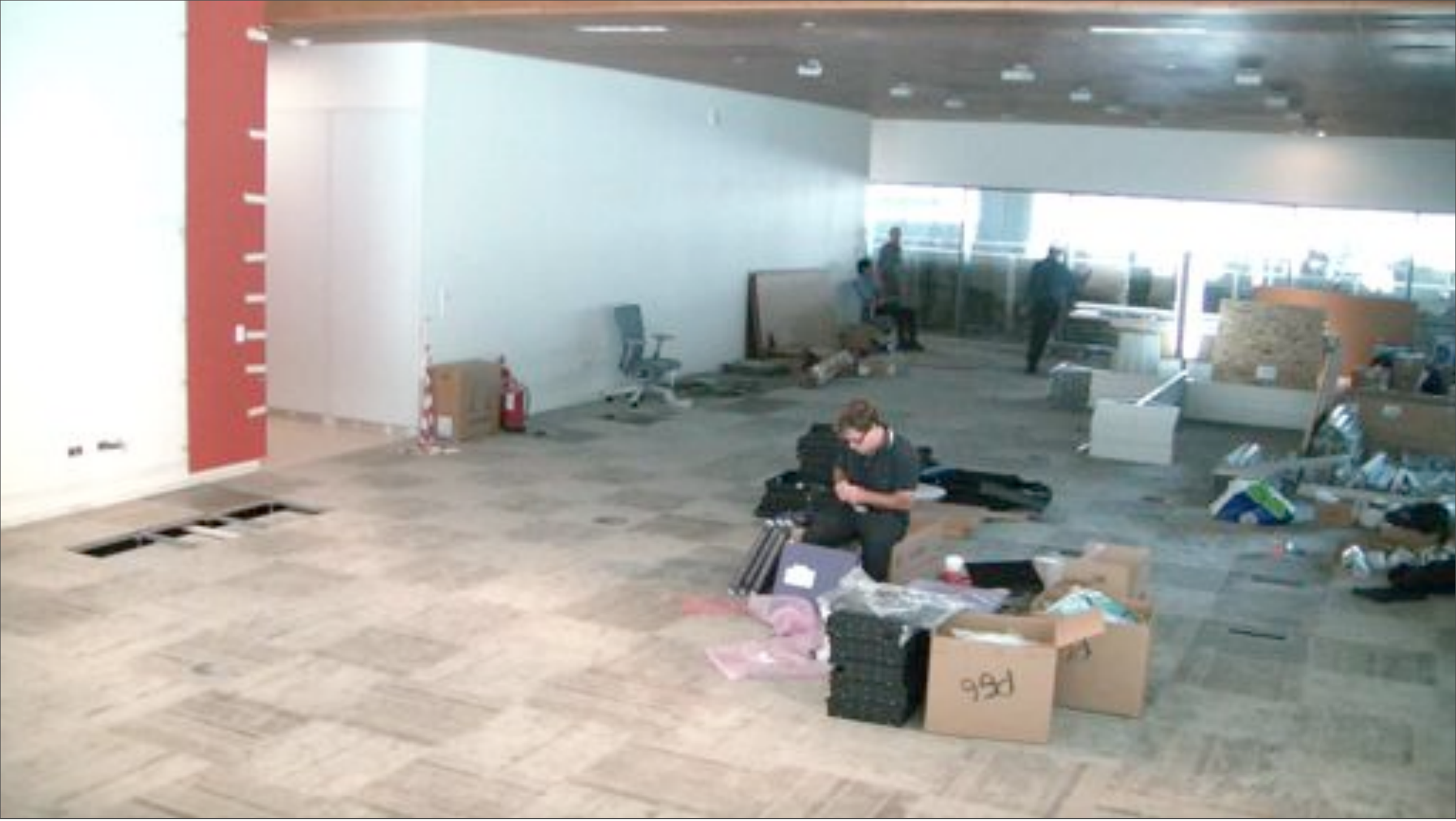
Using High-Speed Networks

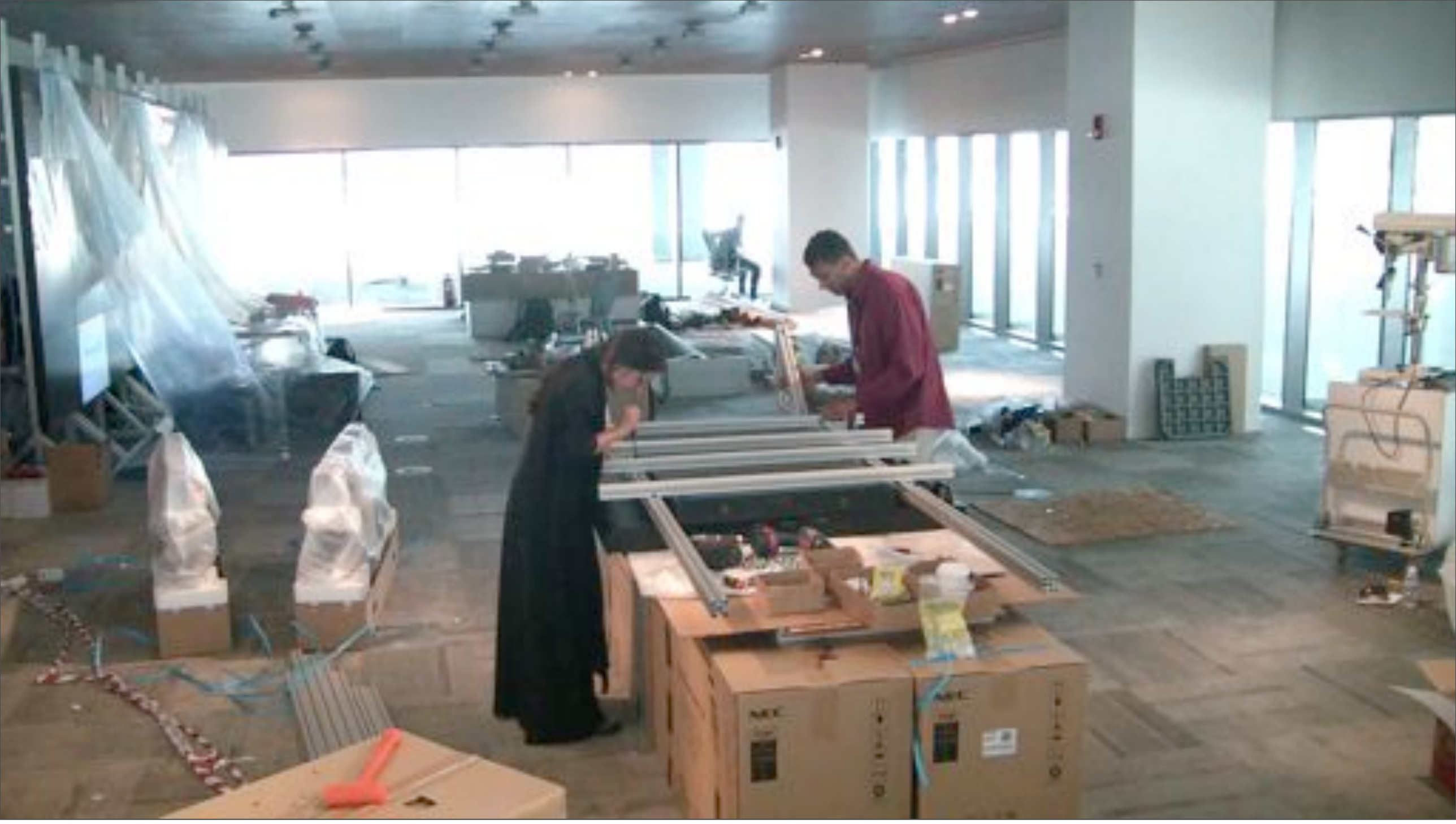
- To effectively use 10 Gpbs around the globe:
  - –Large packets
  - –Do not use TCP, but UDP-based protocols
  - –No packet loss
  - –Optical networks

Pixel Streams at 30fps

	Format	*Bandwidth*
HDV uncompressed	1440x1080 RGB16	~ 700 Mbps
HD video	1920x1080 RGB16	~ 1 Gbps
HD animation	1920x1080 RGB24	~ 1.5 Gbps
HD animation stereo	1920x1080 RGB24	~ 3.0 Gbps
SHD animation	3840x2160 RGB24	~ 6.0 Gbps

Building Tiled Displays





Parallel Approach

- Building cluster computers for graphics
- Combining graphics, networking, storage and compute capabilities to feed content to high-resolution displays
- Exploit consumer-driven off-the-shelf components
- Emergence of wide-area high-speed networks

Tiled Displays

- Typically we are driving 2 displays per node with one graphics card
- Why so many cluster nodes?
  - Balance GPU, CPU, Bandwidth
- You can put several graphics cards into each computer
- Modern PCs can now drive 4x 2560x1600 30” monitors using a pair of GPUs

Tiled Displays: Scalable

- Number of nodes (computers) is 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

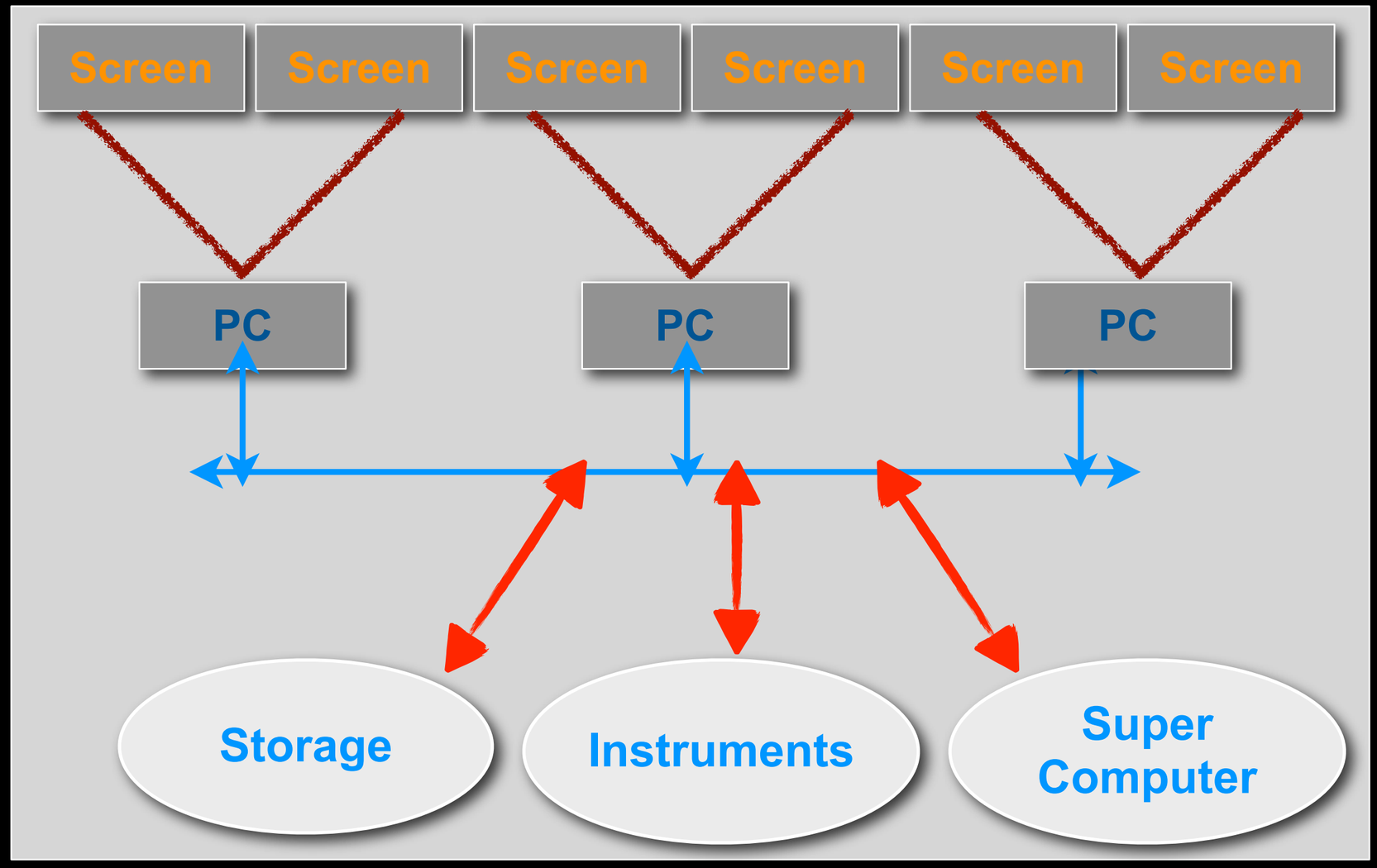
Tiled Displays

Displays

Rendering

Private network

Local and
Wide-area networks



Building a Wall

- KAUST Wall
  - 40 LCD panels, 10x4 layout
  - 46 inch, 3.5 mm border
  - 1360x768 pixels
  - 11-node cluster
  - Intel 64bit dual-quad core
  - NVIDIA GTX 285 graphics cards
  - 10 Gbps network
  - **13600 x 3072 pixels : 41 Megapixels**



Software for Tiled Displays

- Building Visualization Clusters using Rocks
- SDSC project
- Rocks distribution
  - Linux for cluster
  - Add ‘viz’ packages: CGLX, SAGE, ...

The Dark Side of Clusters

- Clusters are phenomenal price/performance computational engines
  - Can be hard to manage without experience
  - 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)

Rocks 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 5.x



Expanding International Community of Users

























SAGE User Community

www.sagecommons.org

Scalable Adaptive Graphics Environment



AARNet, Australia



Calit2, University of California San Diego (OptIPortable)



King Abdullah University of Science and Technology, Saudi Arabia



Masaryk University, Lab of Advanced Networking Technologies, Czech Republic (2)



Monash University - Caulfield, Australia



Adler Planetarium and Astronomy Museum



Calit2, University of California San Diego (Rocks/CAMERA)



Knowledge Graphics Technology Inc., Japan



Monash University - Clayton, Australia

So What's the Problem?

- Building the display is relatively 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



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”

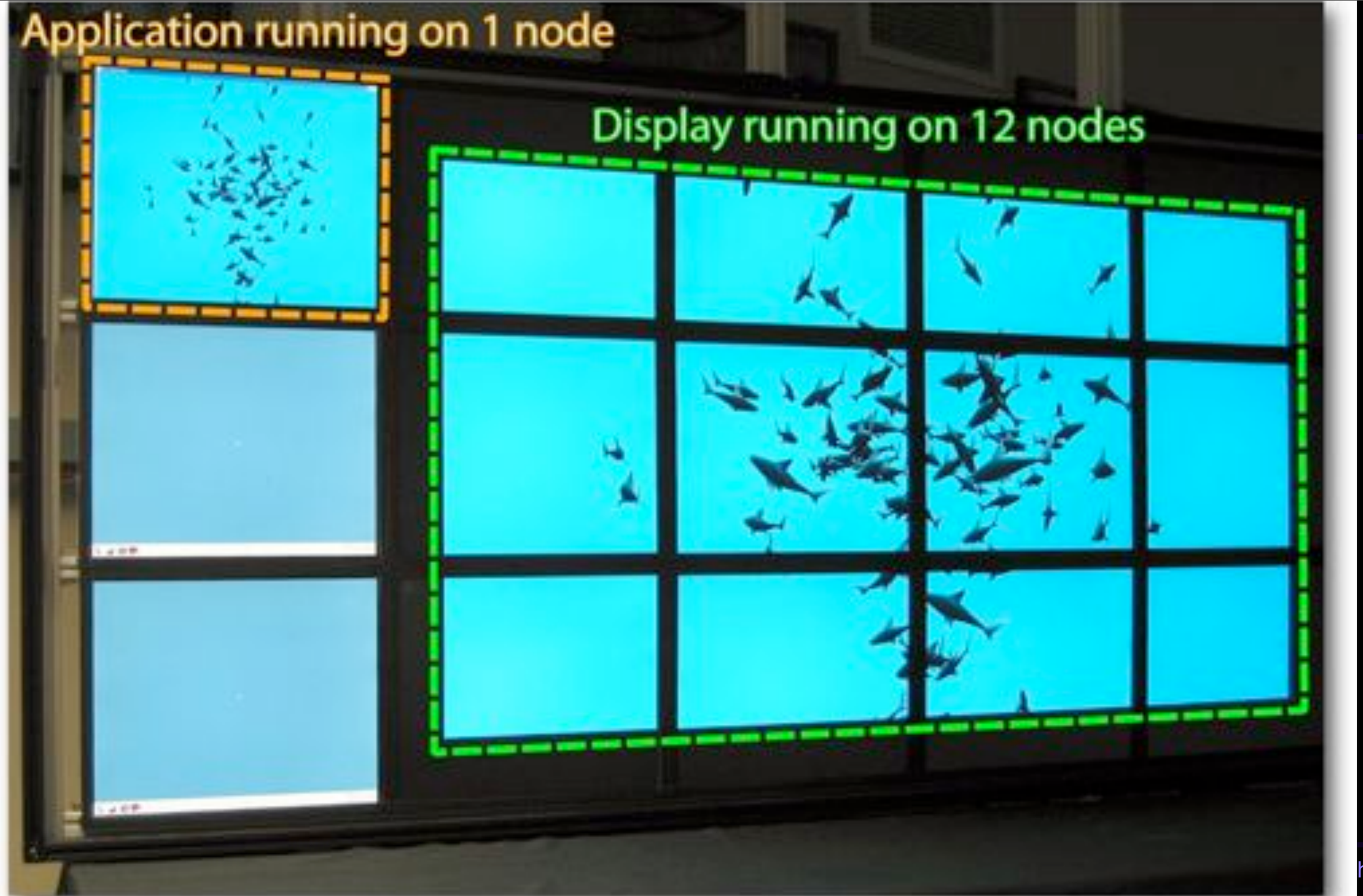
SAGE: Scalable Adaptive Graphics Environment

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

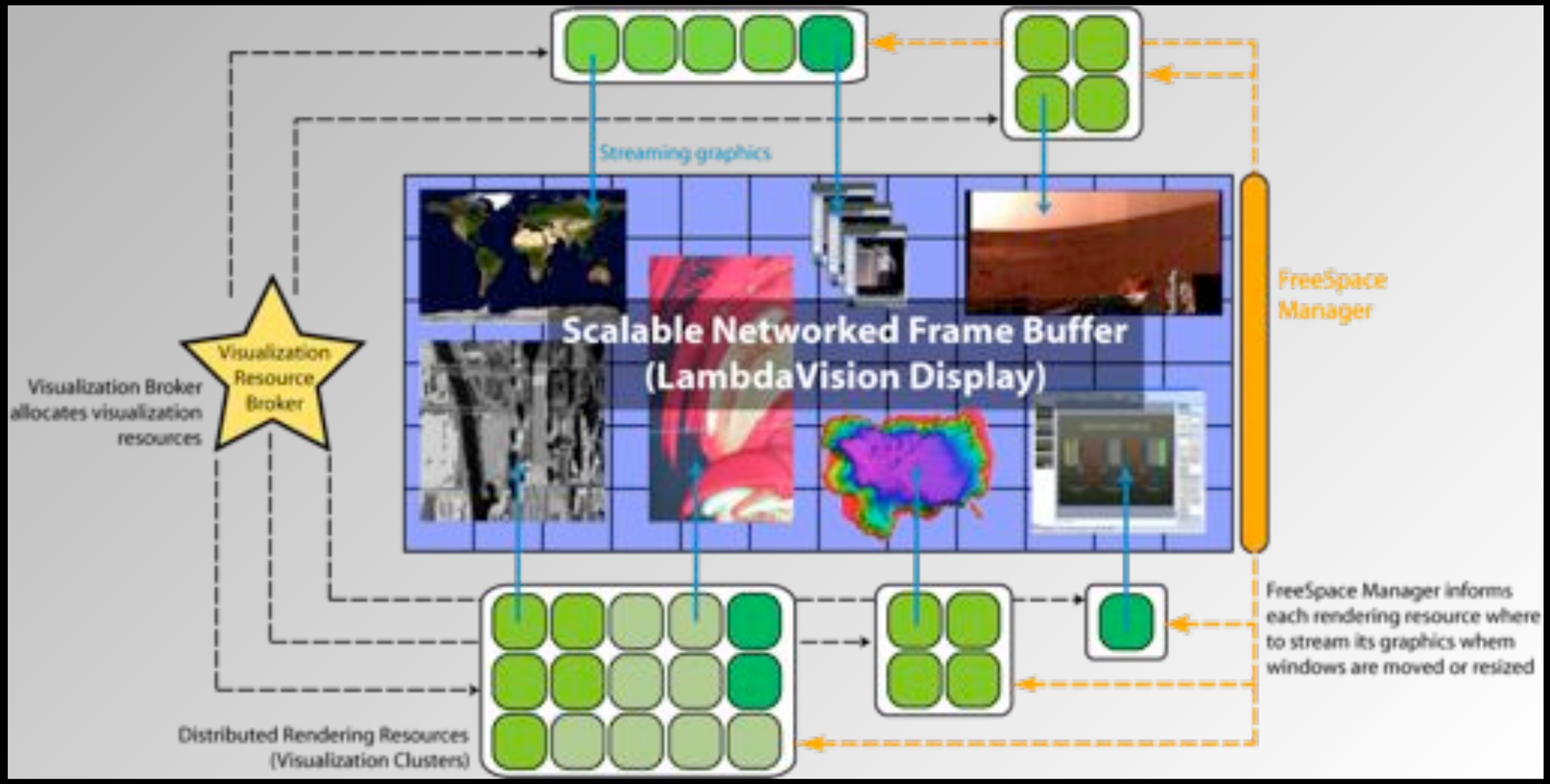
SAGE Steps

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

Result


Application running on 1 node
Display running on 12 nodes

SAGE : to Manage Content on Tiled Displays



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

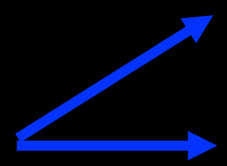
- Streaming phase
  - Copy pixel data into “*rgbBuffer*”
  - **sageInf.swapBuffer(rgbBuffer);**
- That’s it !!

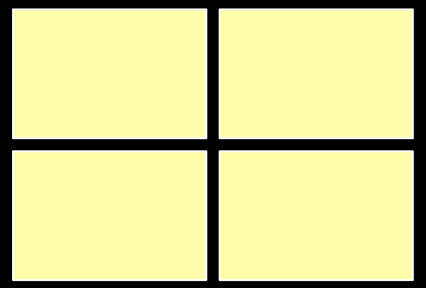
Program a SAGE application

- Event processing

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

Execution Procedure

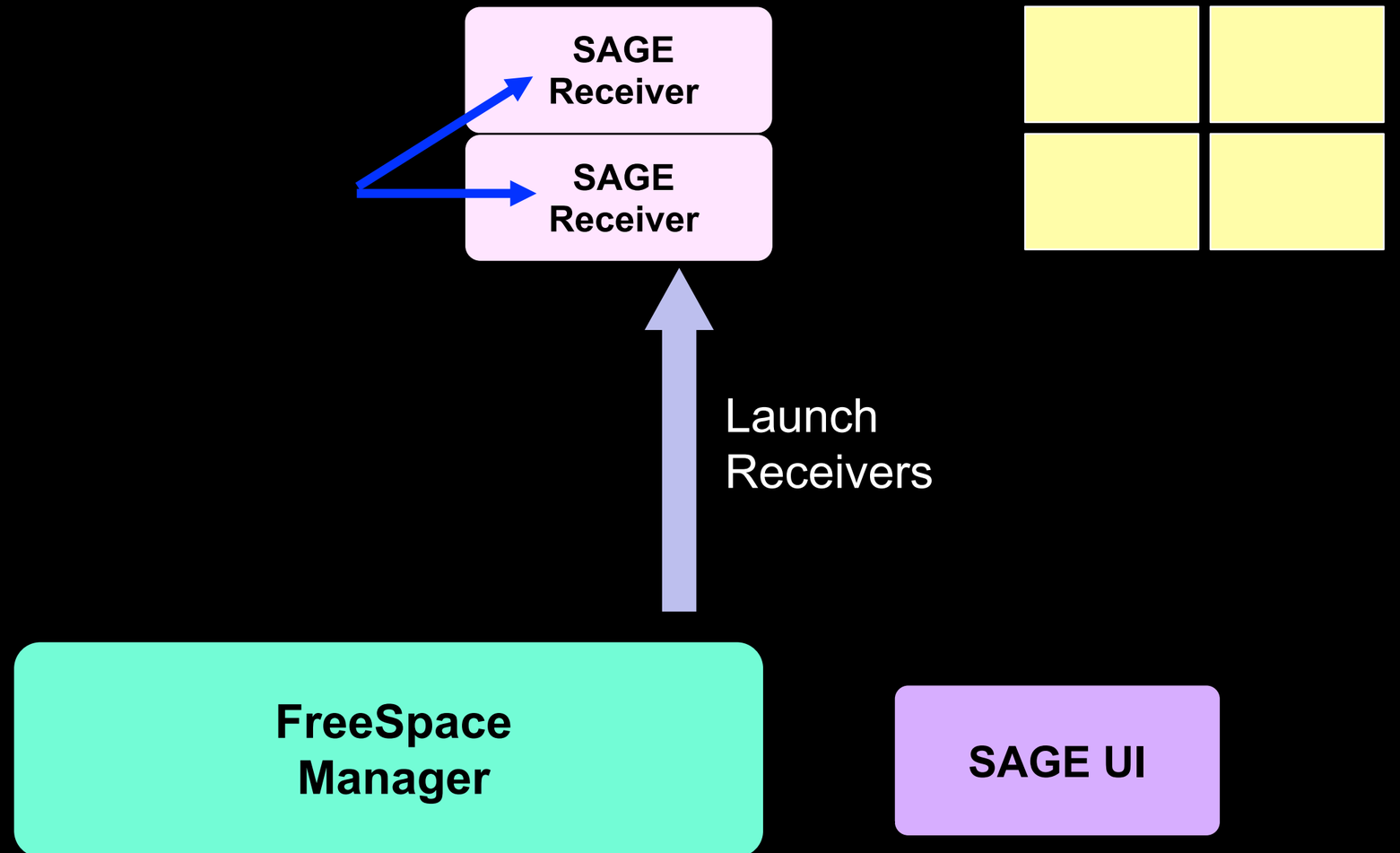




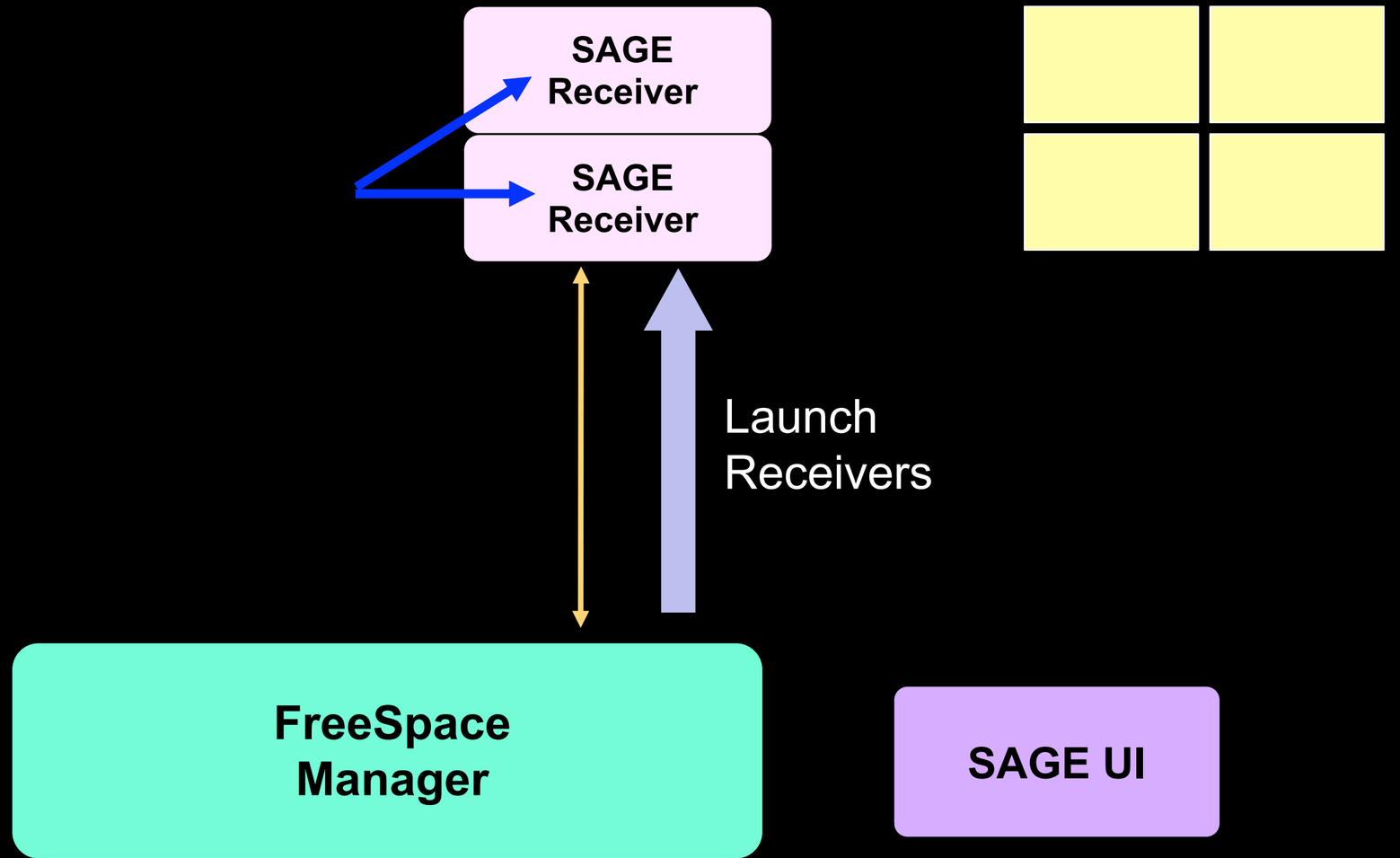
FreeSpace Manager

SAGE UI

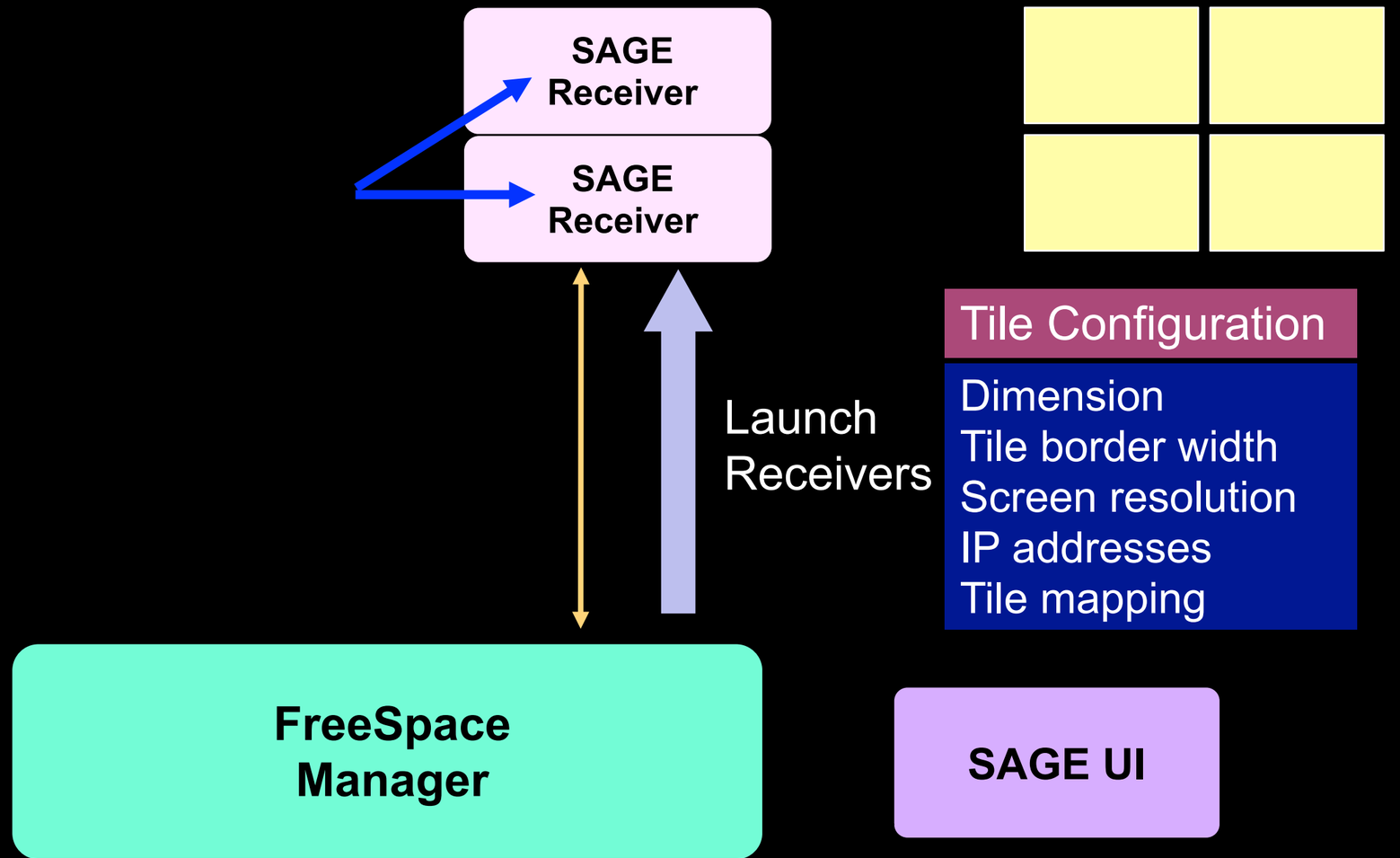
Execution Procedure



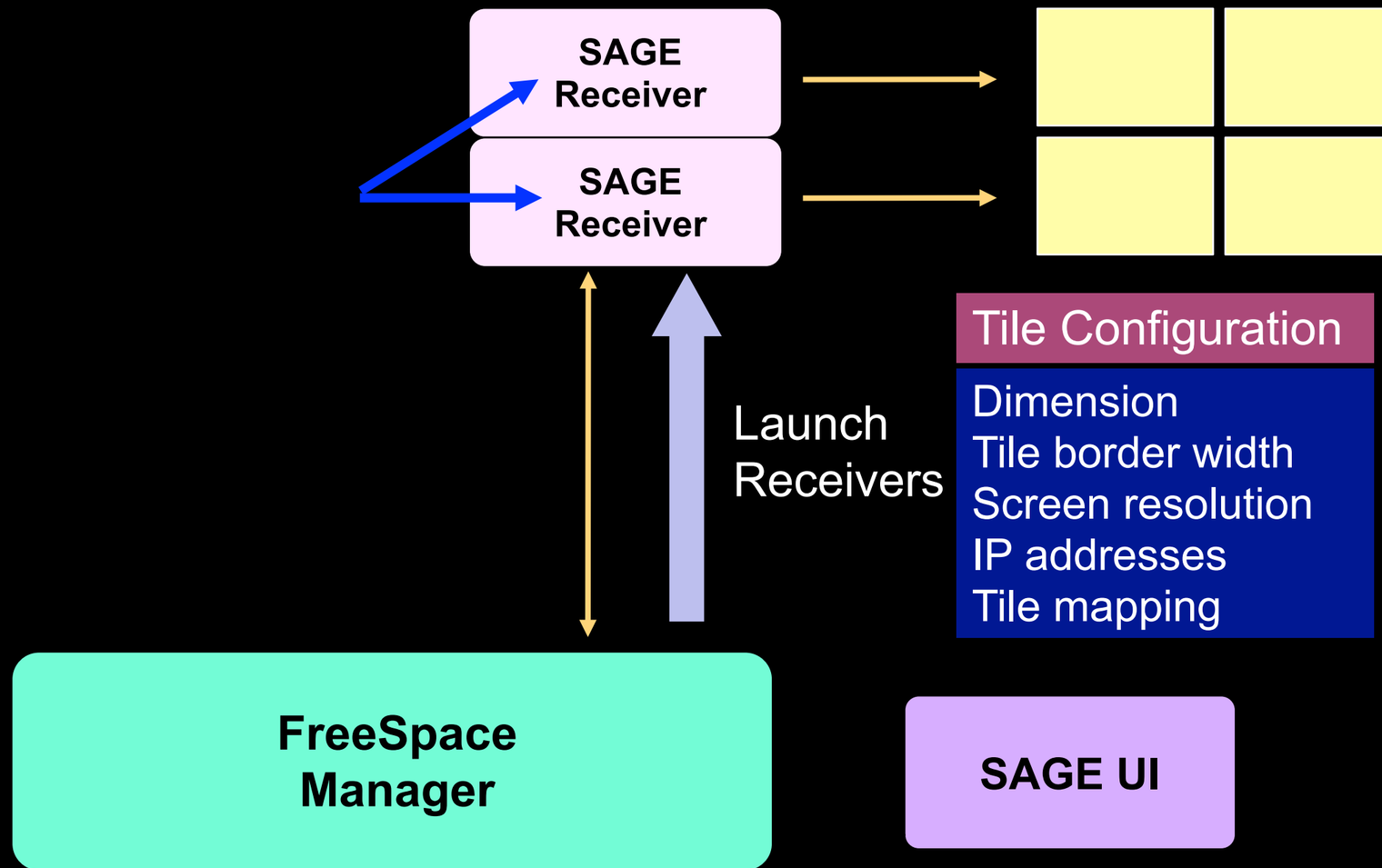
Execution Procedure



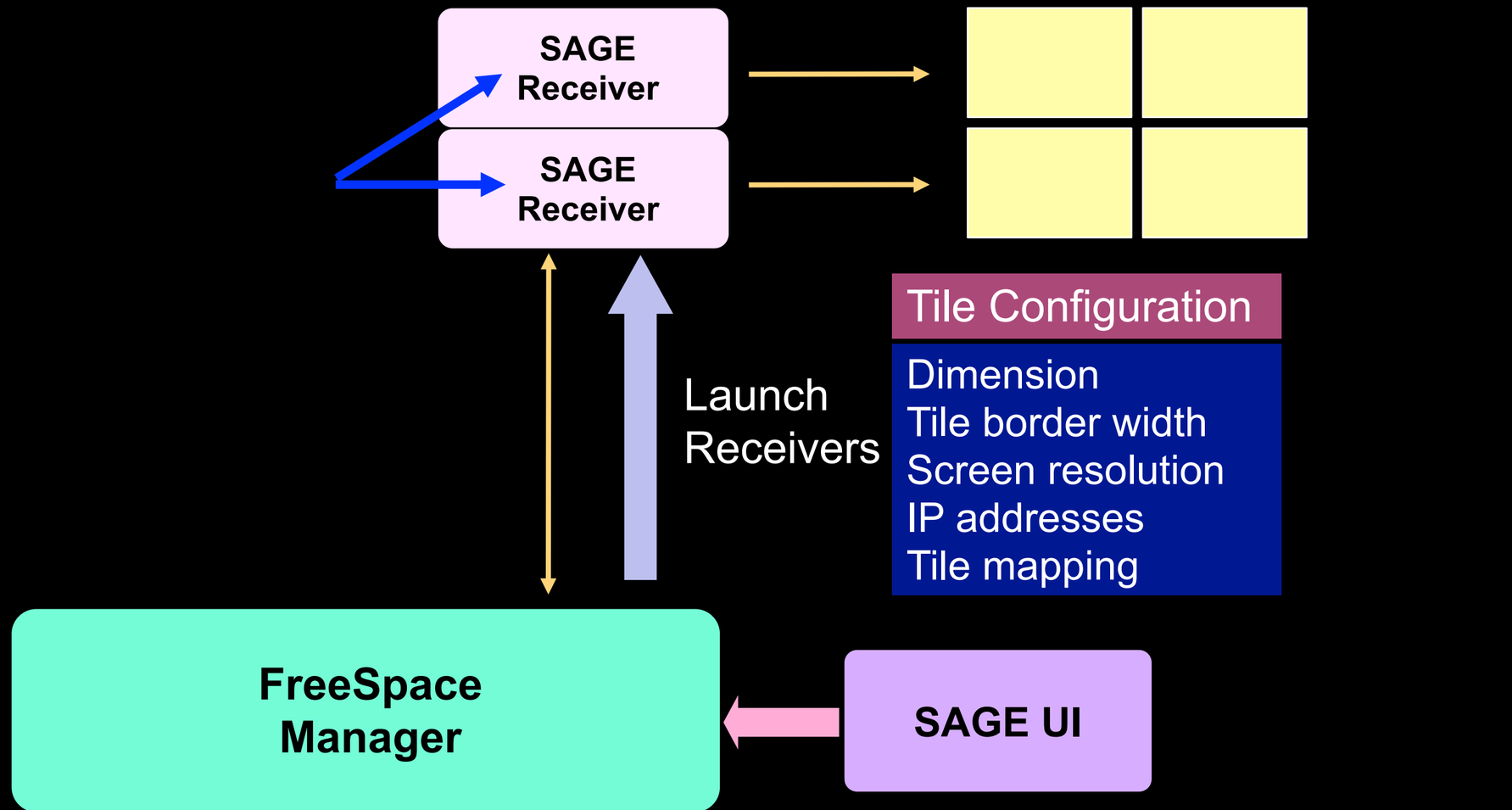
Execution Procedure



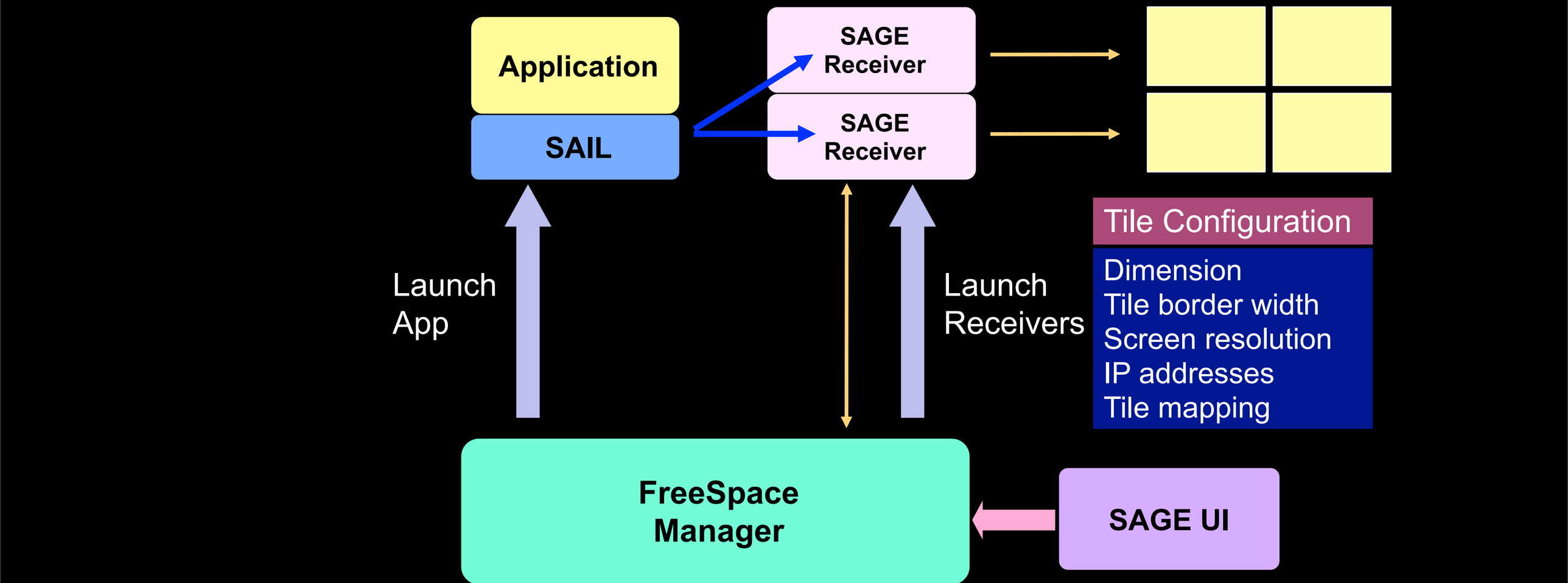
Execution Procedure



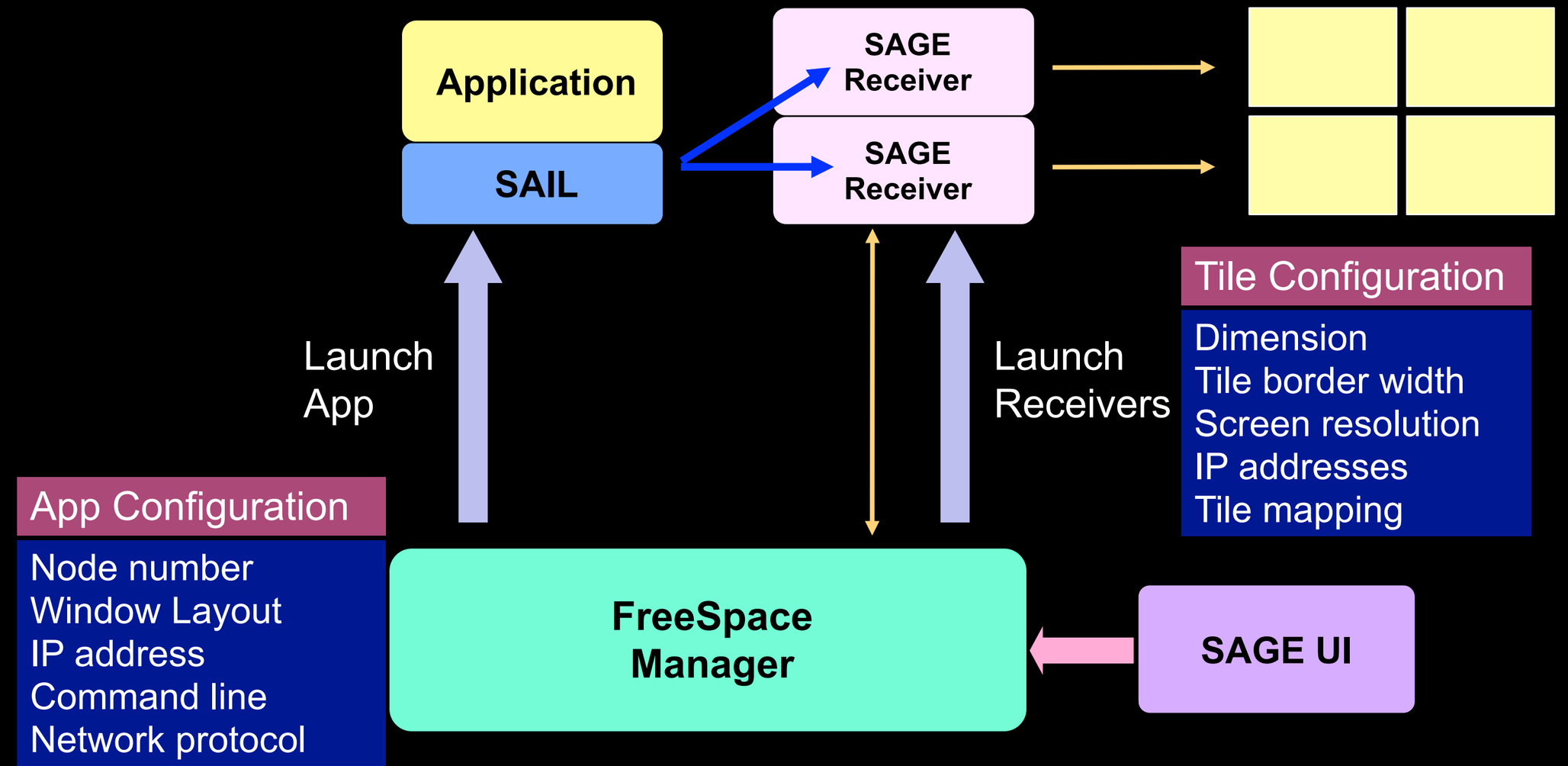
Execution Procedure



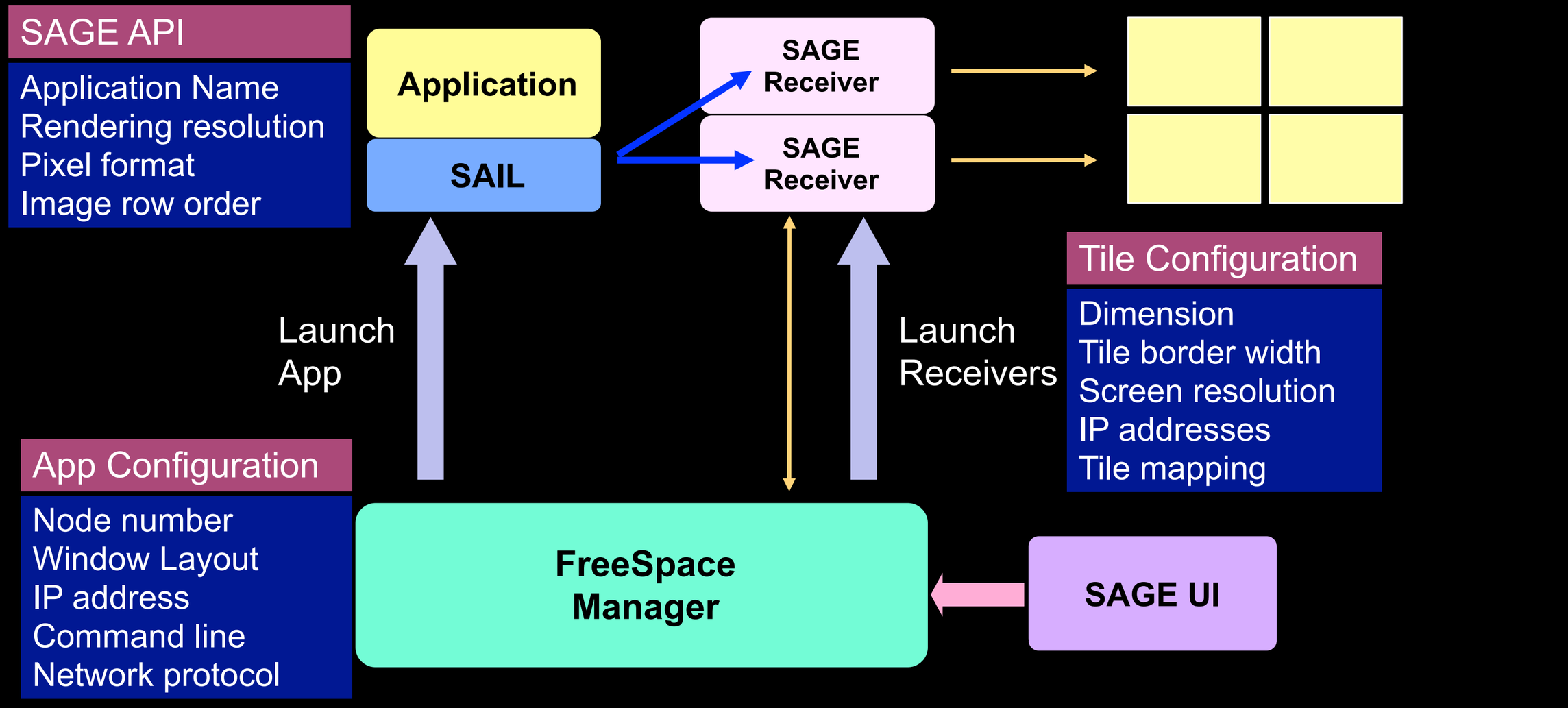
Execution Procedure



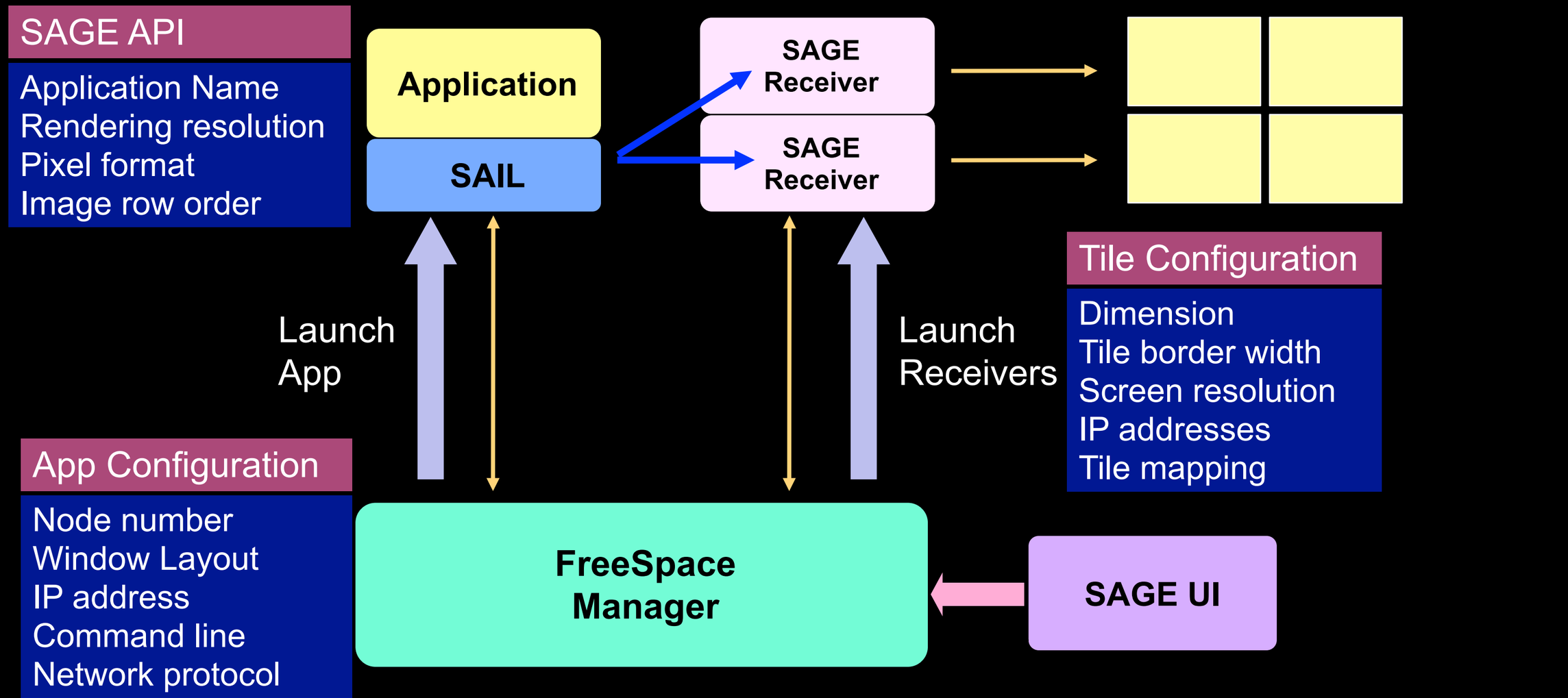
Execution Procedure



Execution Procedure



Execution Procedure



SAGE Applications

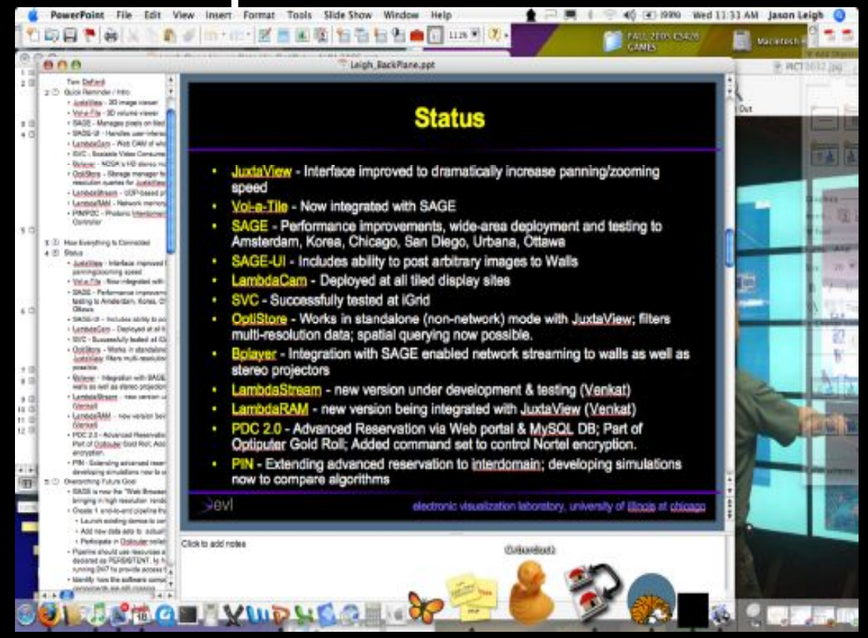
- ImageViewer
- VNC
- Movie players: mplayer and VLC
- JuxtaView and MagicCartpet
- Bitplayer: HD animation
- HD: Live HD video
- ... develop your own...

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

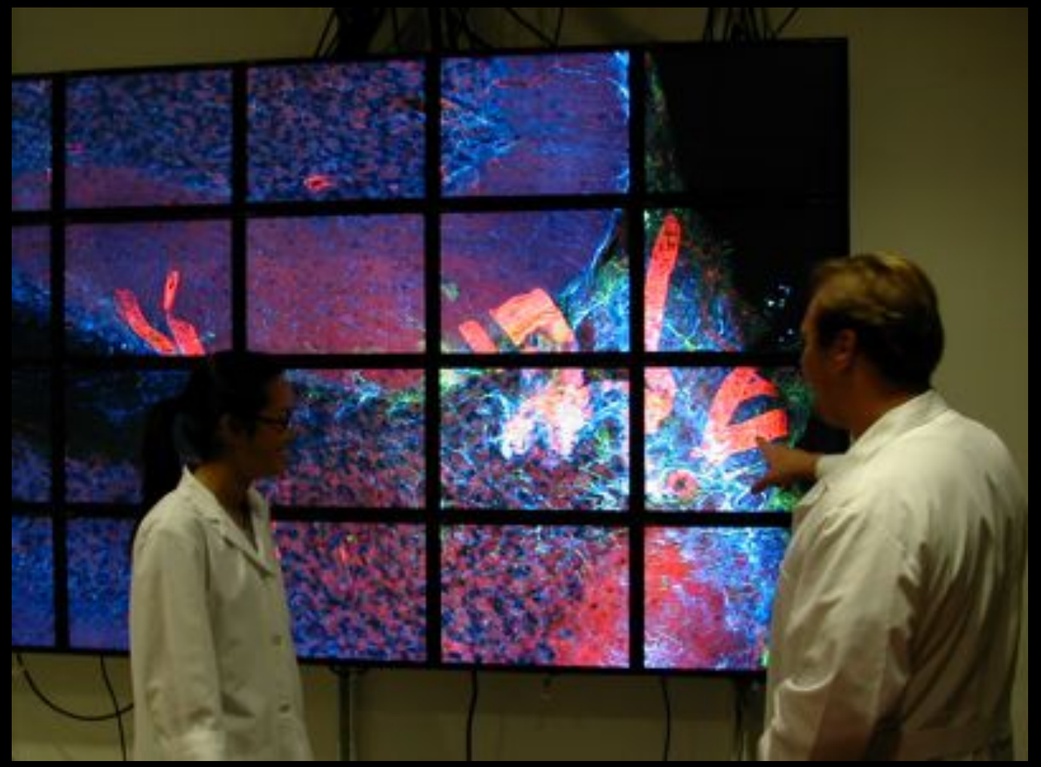


SAGE Applications

- **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

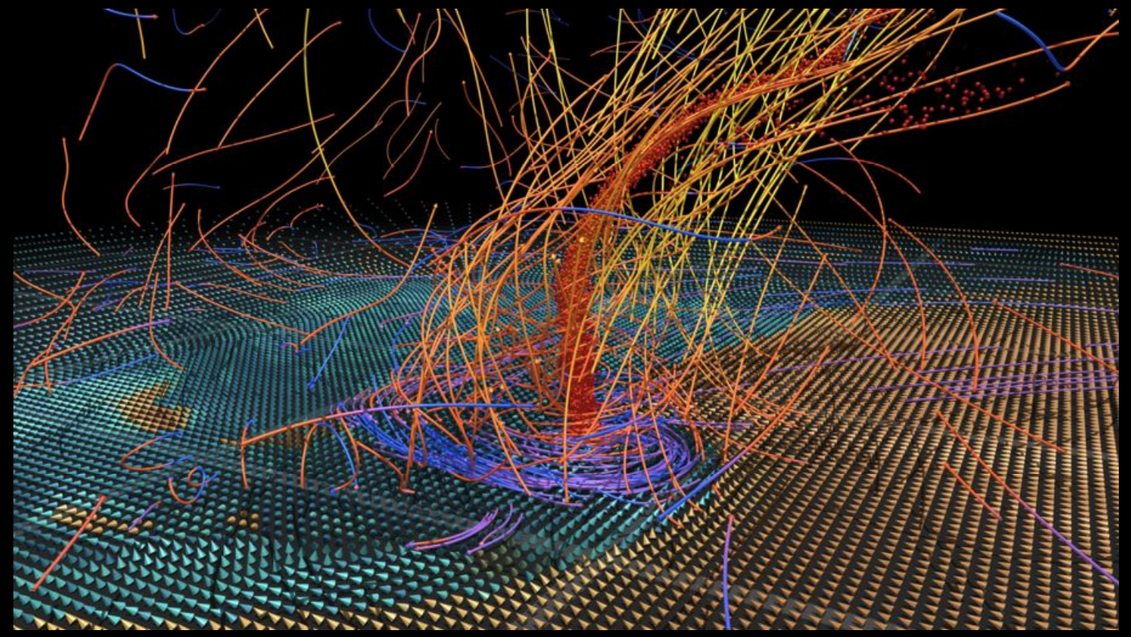
SAGE Applications

- **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
    - HD 1920x1080
    - 4K SHD, 3840x2160
  - –Very demanding for the storage performance



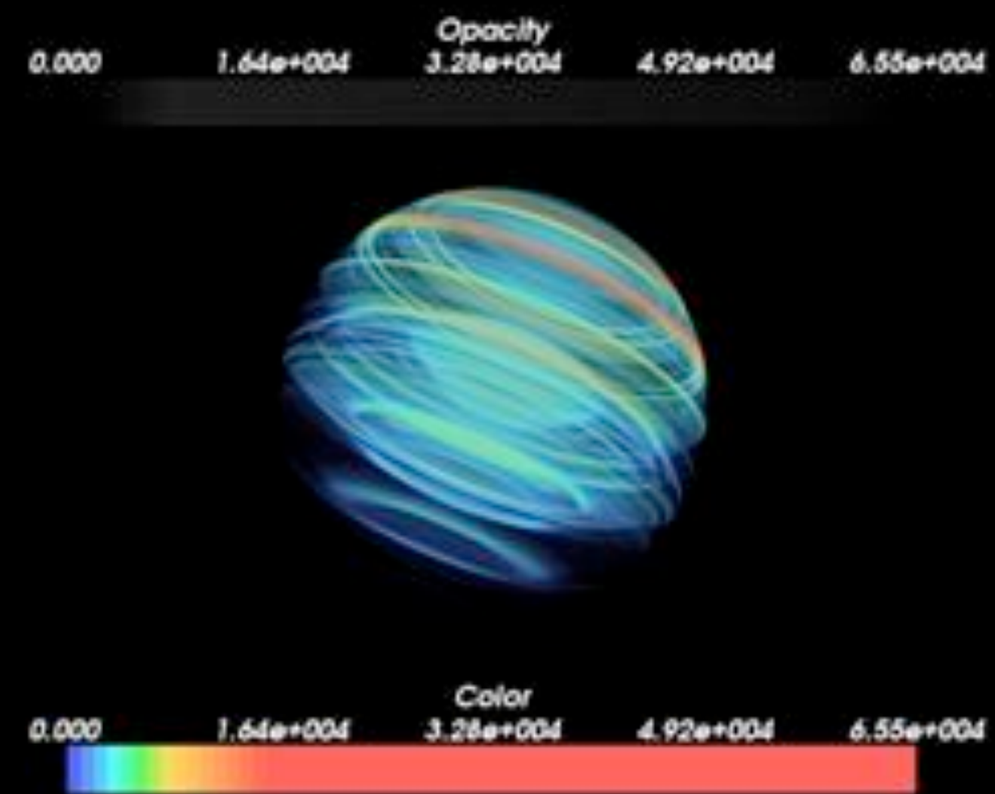
SAGE Applications

- **Live HD video**
  - Streams live HD video from HDMI camera
  - 1920x1080 resolution
  - YUV 422 sampling
  - YUV transport pixel format: 16bits per pixels
  - Streams also audio



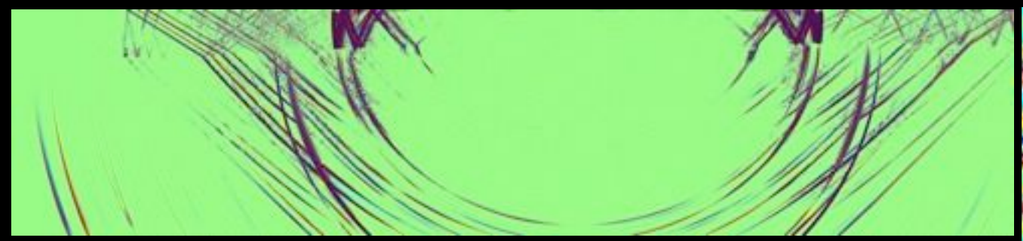
Scenario 1: Visualize the output

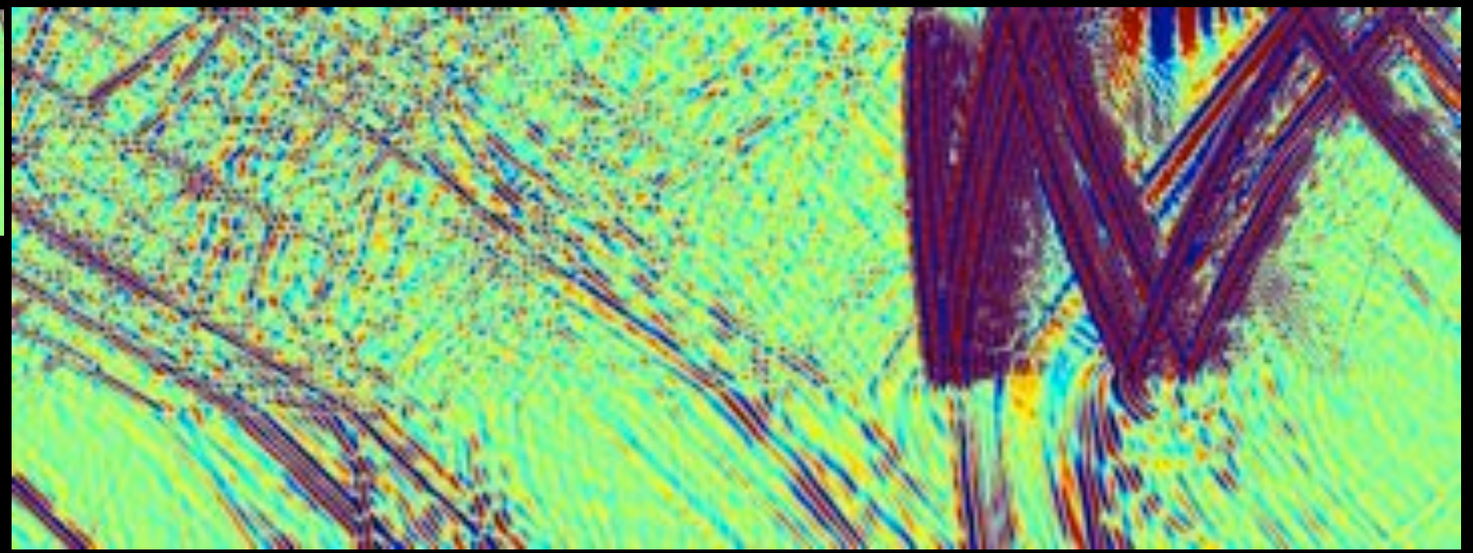
- Images, animations, or videos produced at one site
- Load
  - Images: ‘imageviewer’ application
  - Movies: ‘mplayer’ / VLC plugin
  - Animation: `bitplayer’ NCSA format
- Stream
- Display



Example: SDSC/Geon

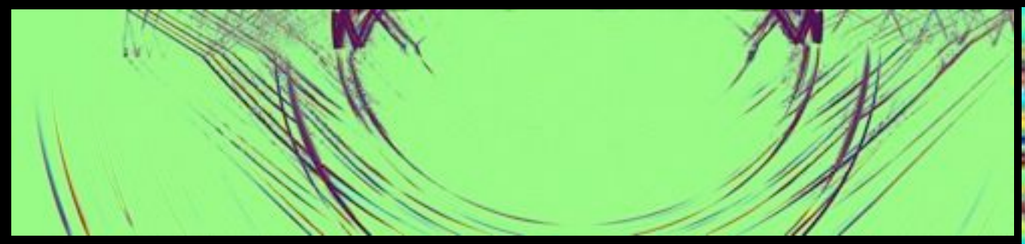
- Images at 8874x2000 pixels, 400 frames
- Movies of X and Z ground velocities from an earthquake simulation





Example: SDSC/Geon

- Images at 8874x2000 pixels, 400 frames
- Movies of X and Z ground velocities from an earthquake simulation





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

- Right
  - OpenGL application
  - HD camera
- Left
  - “remote” site
  - displays visualization and 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);
sageInf.swapBuffer(rgbBuffer);
```

Paraview across the US

Remote Rendering and Parallel Pixel Streaming with ParaView + SAGE

Sungwon Nam
November 13, 2009



Electronic Visualization Laboratory
University of Illinois at Chicago

www.evl.uic.edu

Use cases

- Using tiled displays for science and education

UIC Research Meeting



UIC Research Meeting

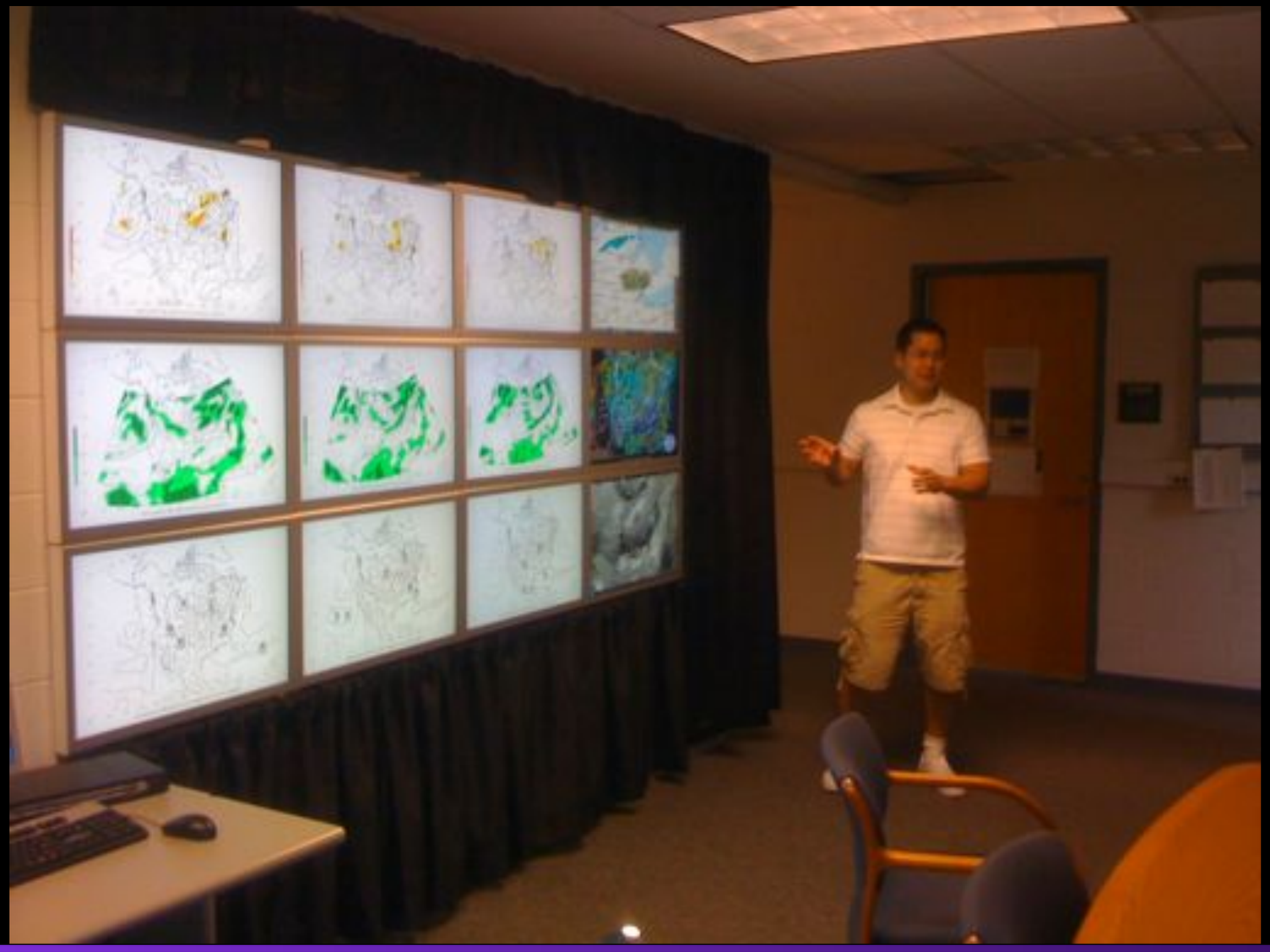




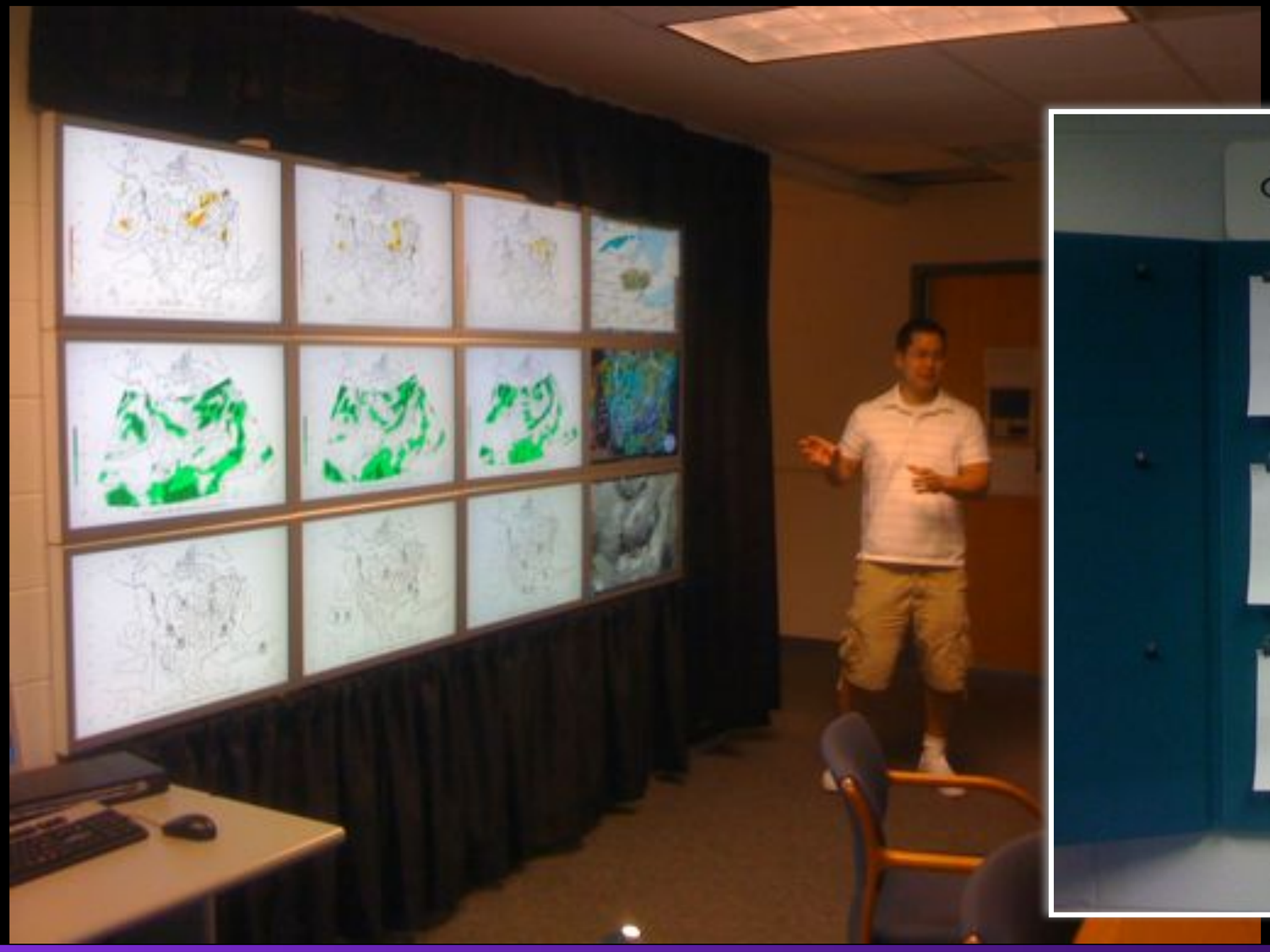
UIC Anatomy Class

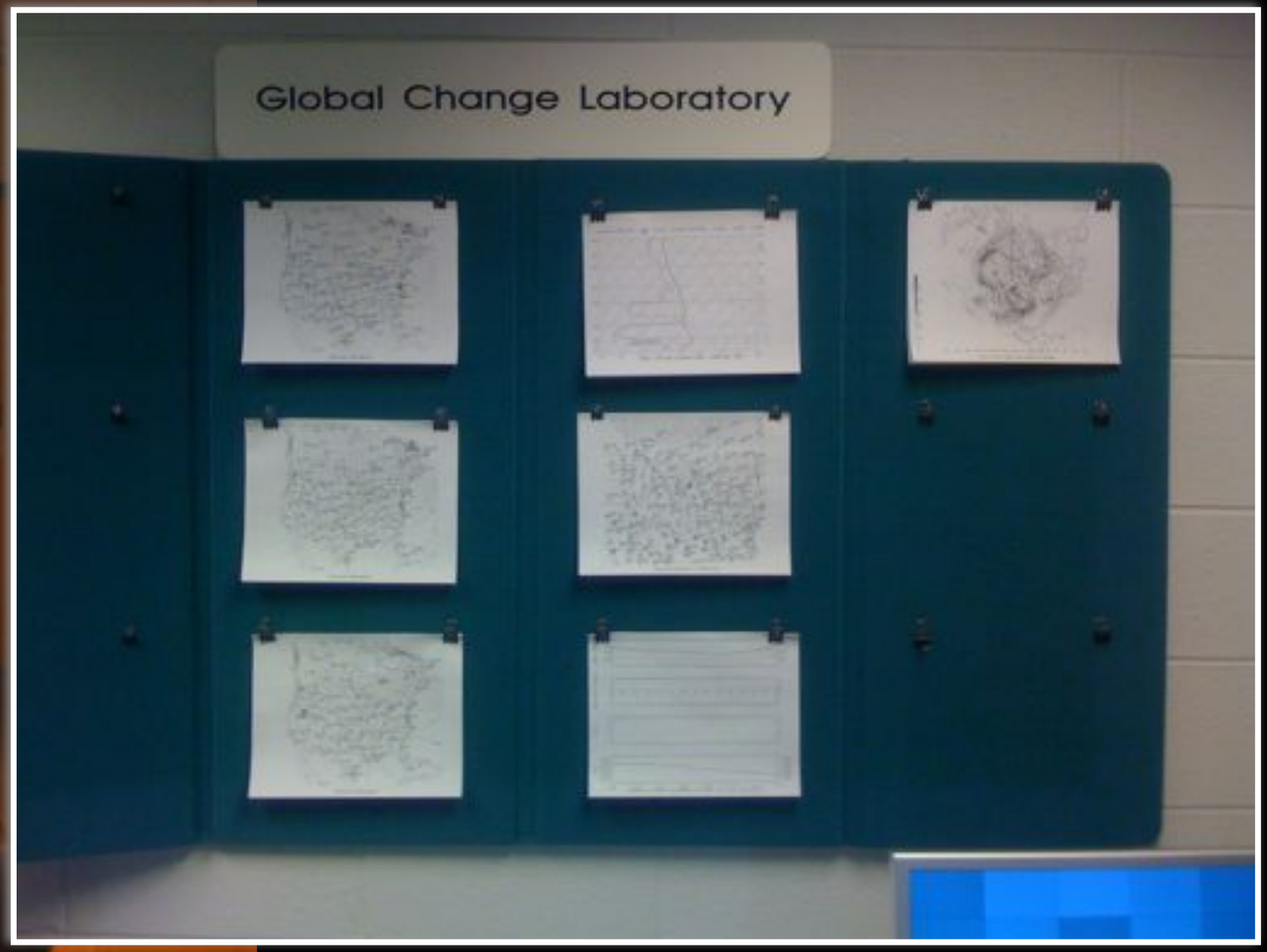


University of Michigan
Atmospheric Sciences Department



University of Michigan
Atmospheric Sciences Department





Sharp Labs of America



Chairman of Sharp

> “In ten years' time entire walls could be screens”
>
> Forbes, June 4, 2007



Virtual School in Petascale Computing



Virtual School in Petascale Computing





Visual Analytics Class at UIC



Visual Analytics Class at UIC





Collaboration

- Distance collaboration over high-speed networks

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.

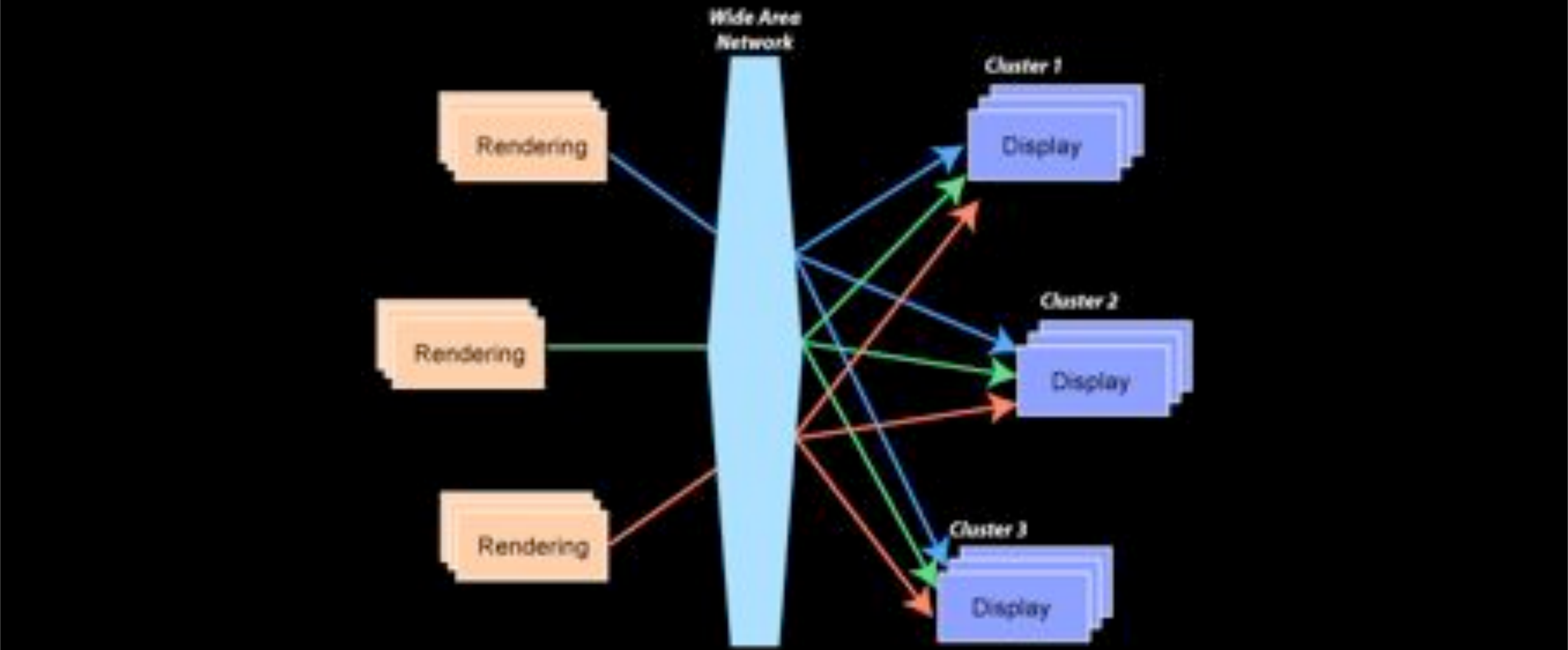




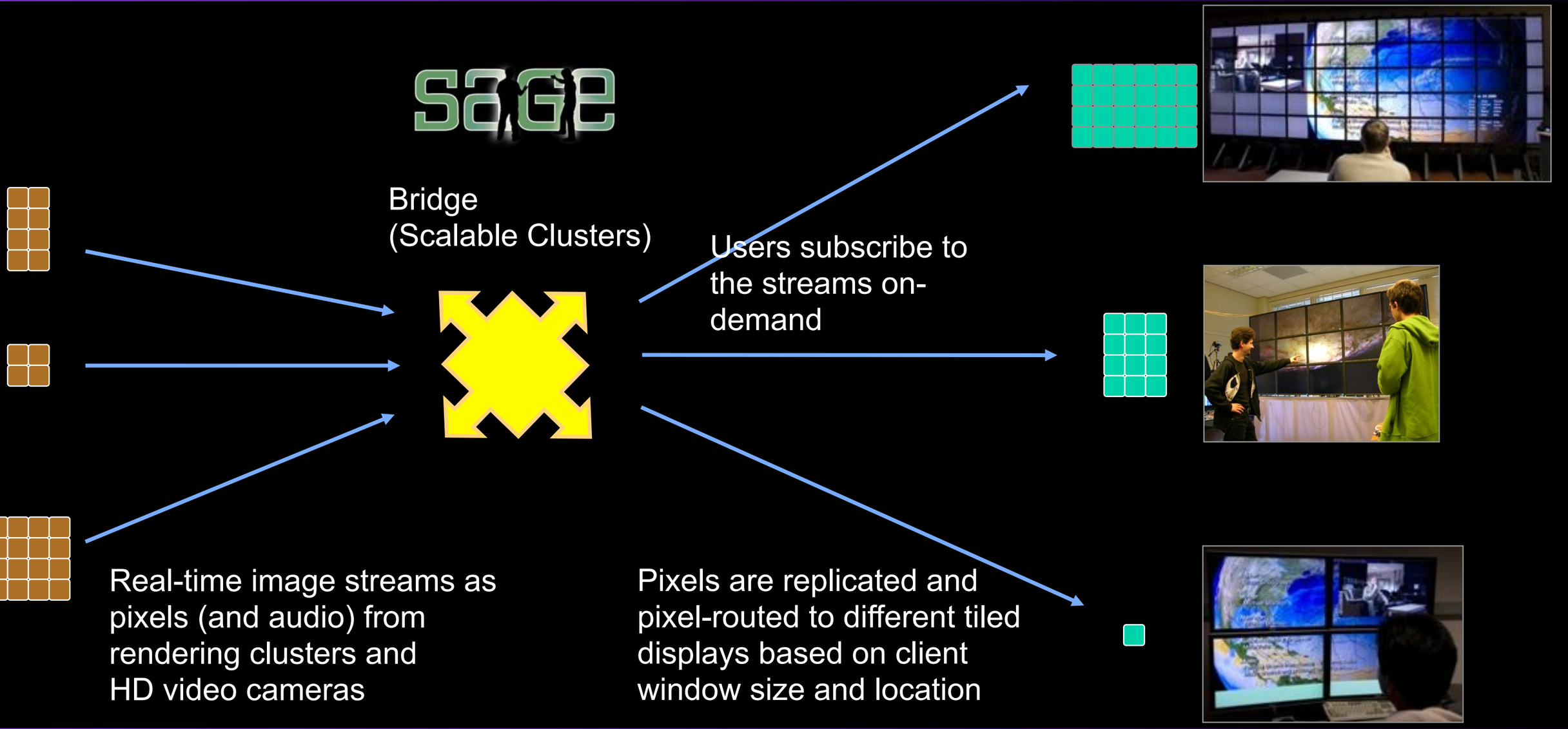
Proposed Solution

- 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.

VisualCasting Model



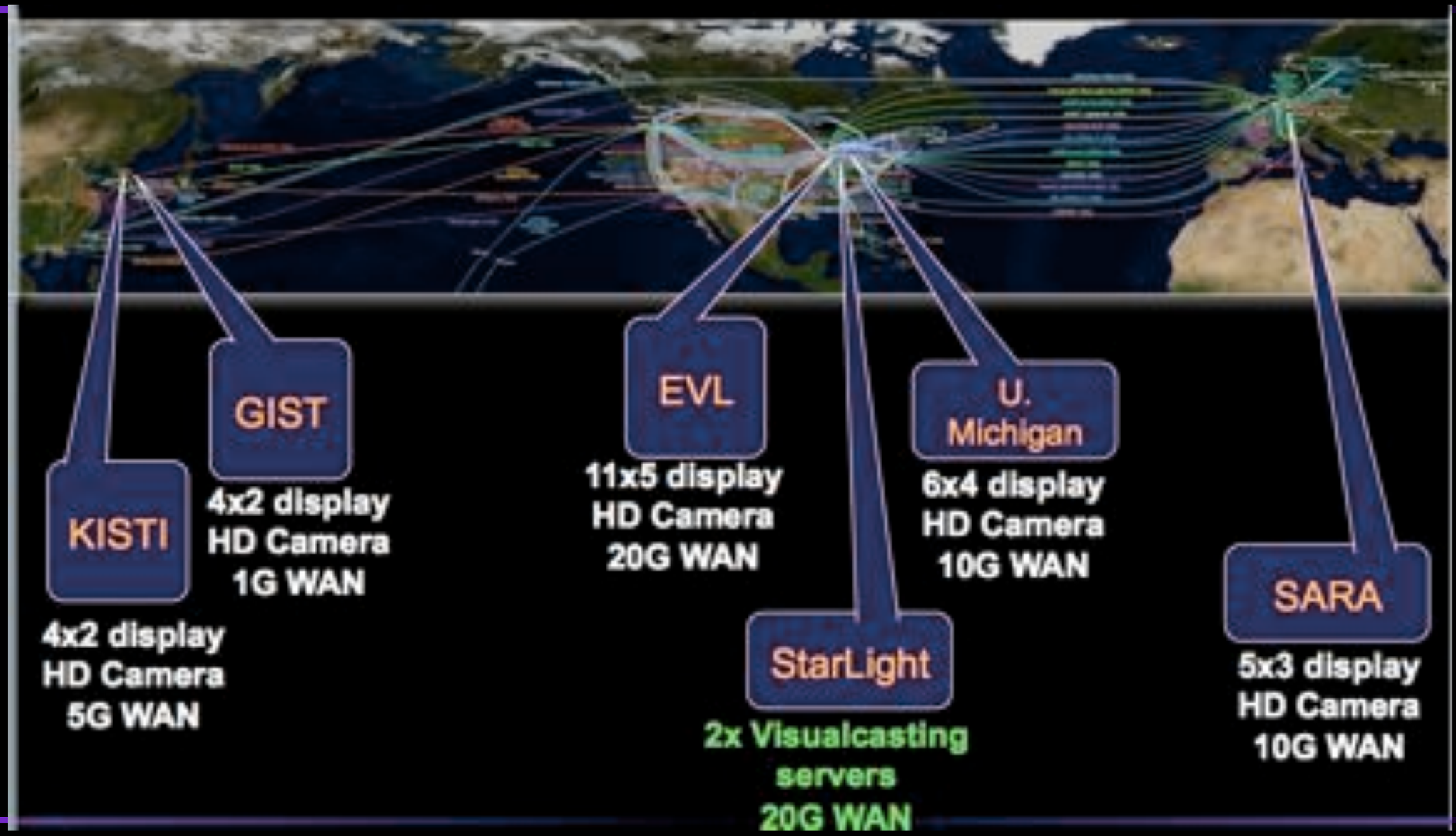
How Visualcasting Works



SAGE VisualCasting Using DXT Compression

Electronic Visualization Laboratory
University of Illinois at Chicago
www.evl.uic.edu
2007

VisualCasting Experiment (Spring 2008)



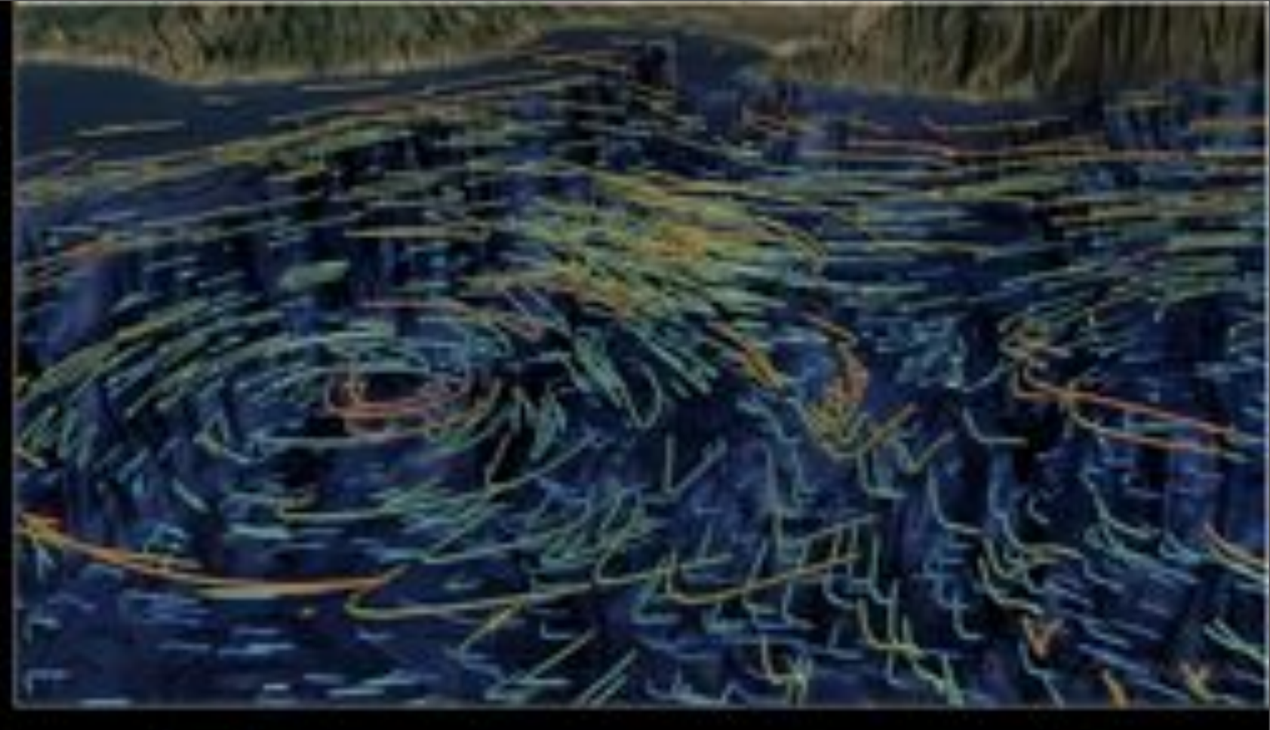
A View from SC'08 on Sharp's prototype 4K



4K Visualization

HD Audio/Videos

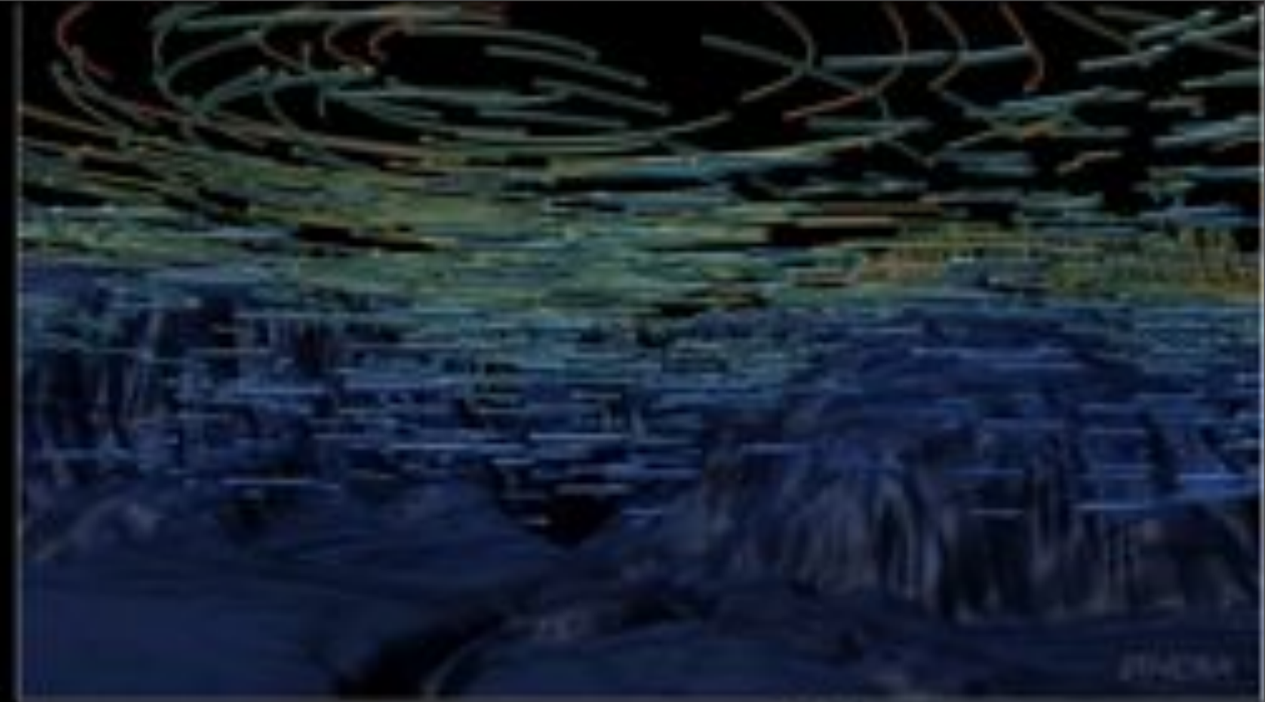









UNIVERSITY OF MICHIGAN




evl





scientific visualization

National Center for Supercomputing Applications
University of Illinois at Urbana–Champaign

visualization producer	Donna Cox
visualization designer	Robert Patterson
research programmer	Stuart Levy
research programmer	Alex Betts
research programmer	Lance Leonard
research programmer	Matthew Hall

Copyright NCSA 2007





A View from Europe



A View from US Midwest





A View from Australia



Views from KISTI (korea) and SARA (netherlands) booths

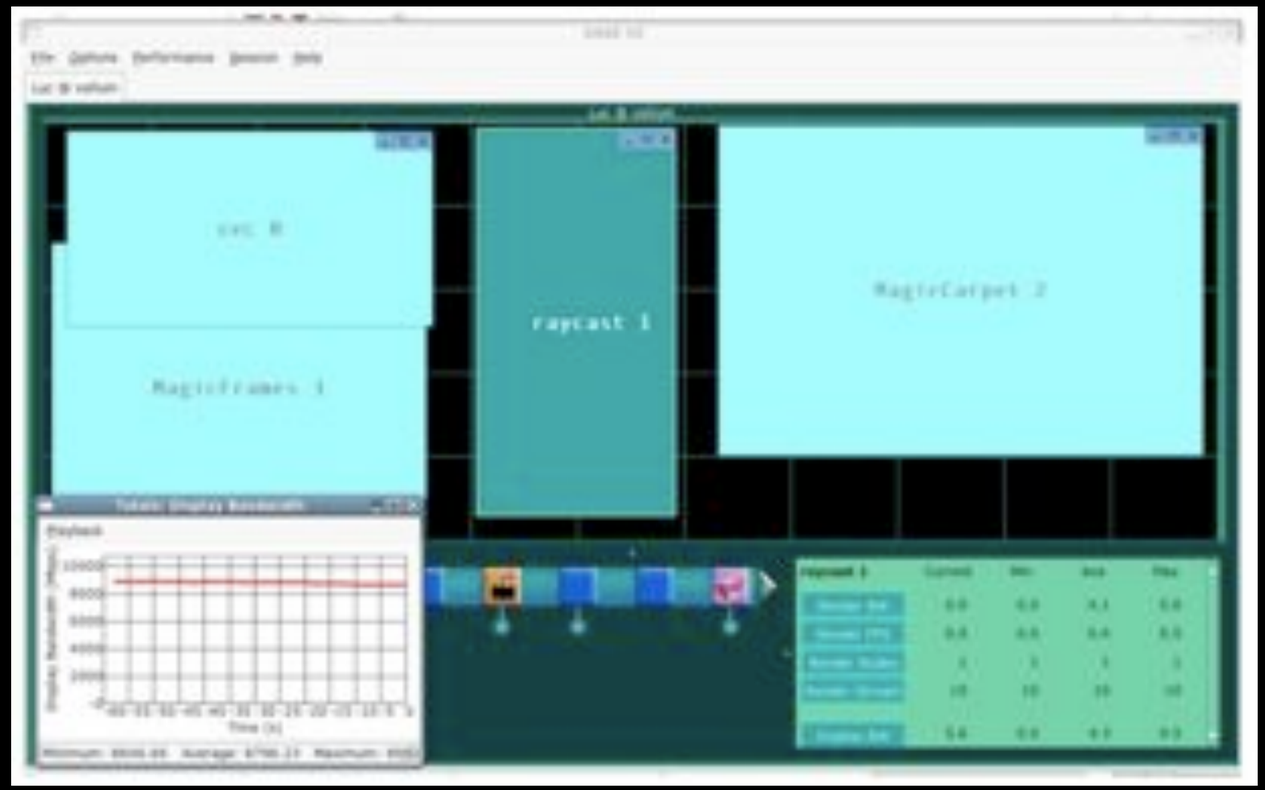




Interaction

SAGE User Interface

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

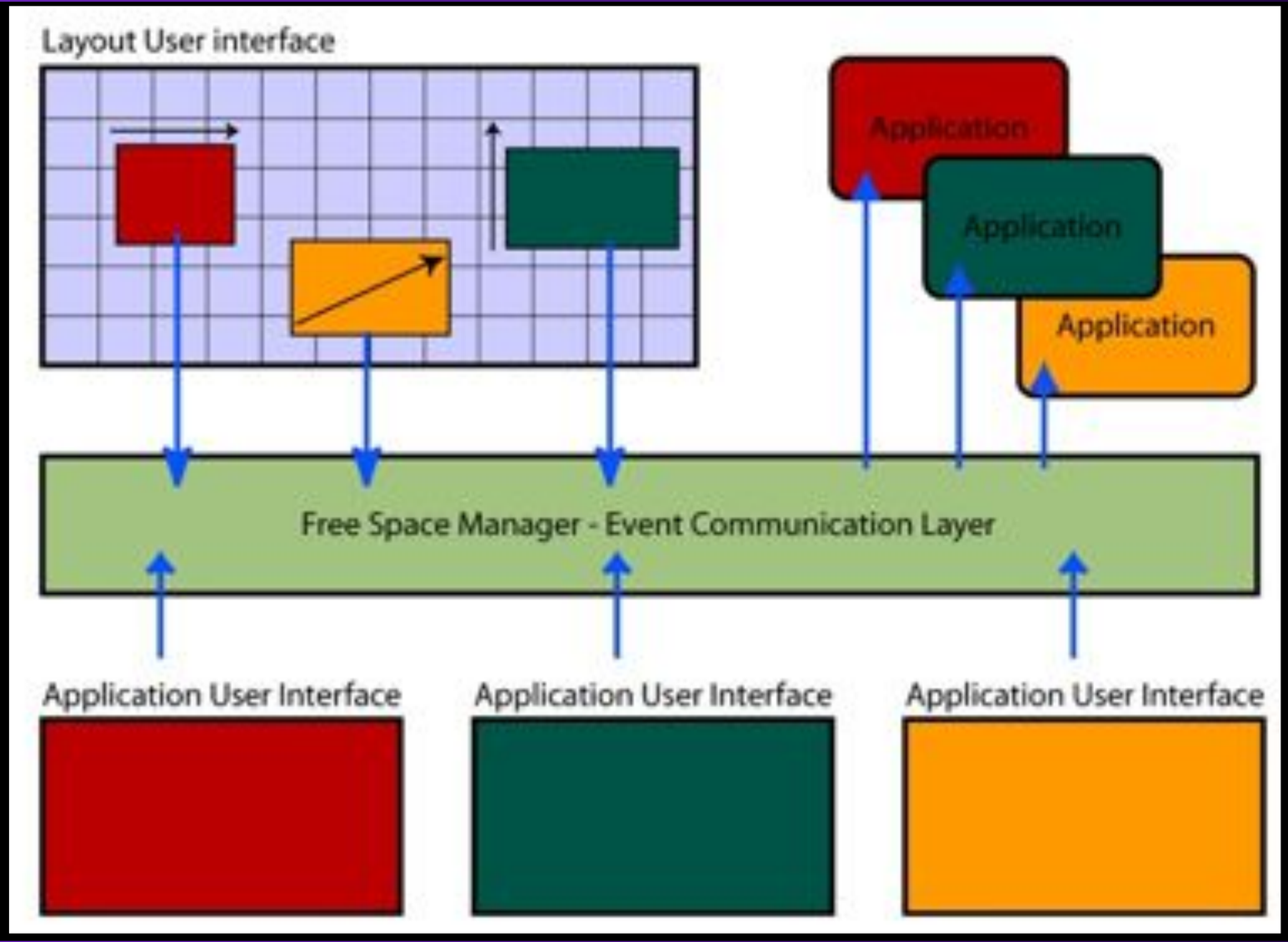


Personal Interaction

- Small application for every laptop user
- Capture keyboard and mouse events
- Enable desktop sharing through VNC
- Drag-and-drop of multimedia files onto the display
  - from desktop or web broswer
  - pictures, videos, PDFs



Application Model



SAGE Widgets

- Applications can define UI widgets
- Overlaid on application window
- Used for direct interaction on the wall
- Shared by all the users



- File browser for pictures, videos, PDFs



- Automatic layout of content
  - grid, tiles, free form

Direct Manipulation

Direct Wall Interaction in SAGE

Ratko Jagodic

November 17, 2009



Electronic Visualization Laboratory
University of Illinois at Chicago

www.evl.uic.edu

Closing Remarks

- Tiled displays bring resolution and size with detail and context
- SAGE enables users to couple displays to powerful visualization resources enabling high-performance visualization and collaboration
- SAGE is deployed around the world all with a variety of tiled display configurations
- Visualcasting enables a persistent collaborative infrastructure for global scientific collaboration

Closing Remarks

- For more info:
  - www.sagecommons.org
  - www.evl.uic.edu
  - renambot@uic.edu

- Work supported in part by Sharp Laboratories of America, the King Abdullah University of Science and Technology (KAUST) (Award US-2008-107/SA-C0064), the National Science Foundation (Award OCI 0943559), and the Office of Advanced Scientific Computing Research, Office of Science U.S. Department of Energy, under Contract No. DE-AC02-06CH11357

