An Experimental OptIPuter Architecture for Data-Intensive Visualization and Collaboration

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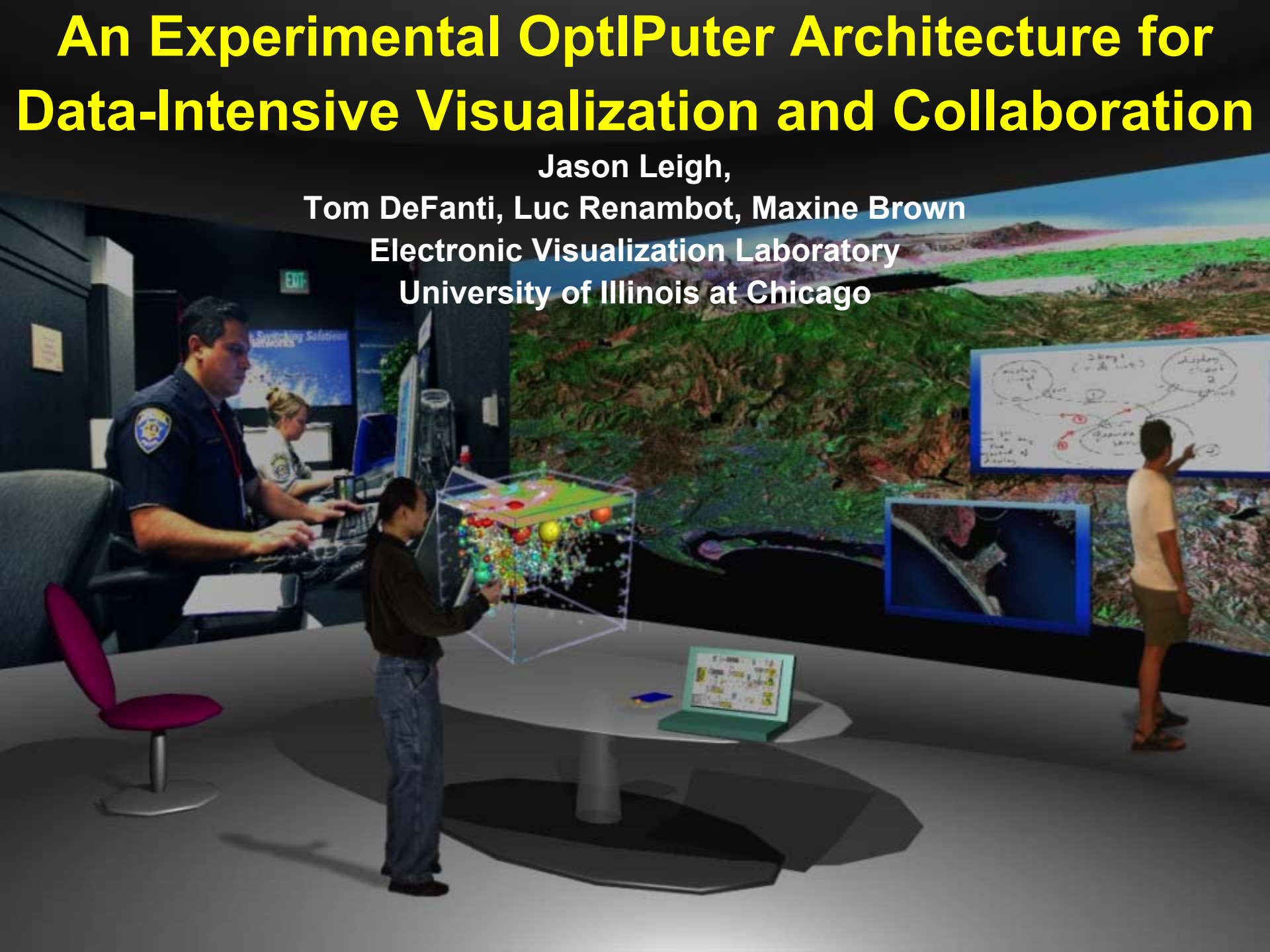
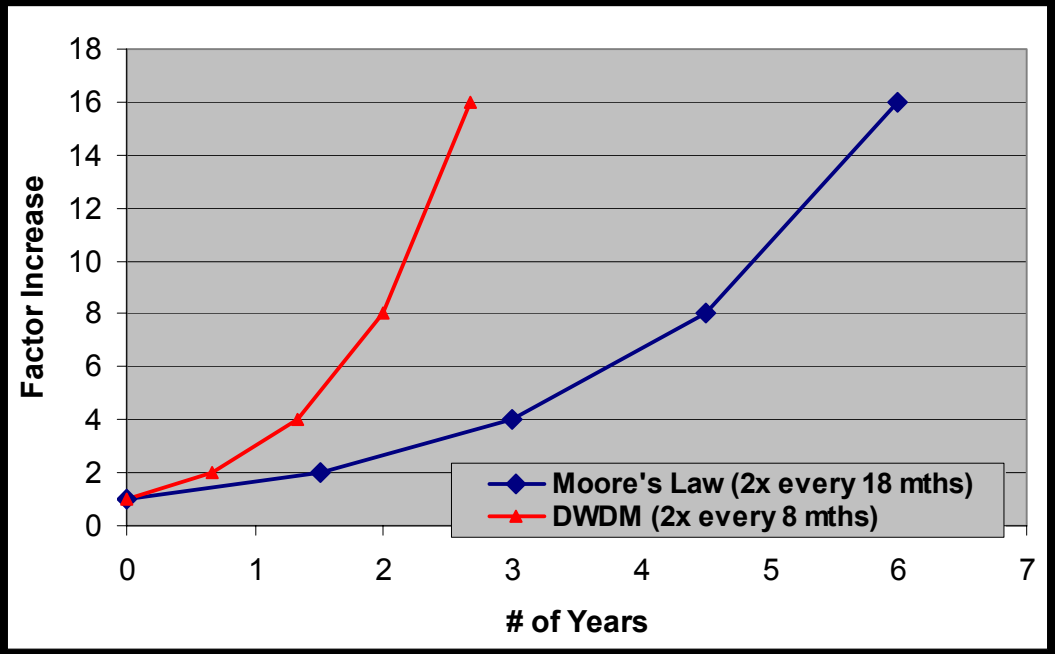


Obligatory Trend Graph

Bandwidth/Computation Inversion:

- Historically computers have been able to generate data faster than networks can handle the data.
- Now networks are faster than computers are able to generate data.
- Creates new opportunities and challenges:
- E.g. Join a terabyte database between NCAR and WHO to fight Cholera or SARS



The OptIPuter – Exploit the Inversion

- Exploit the inversion- use extreme networks as the system bus for a large scale computer where the clusters are the computer peripherals.
- NSF Large ITR grant to study this problem and to support Geoscience and Neuroscience
- Partners include:
  - University of California San Diego, leader – Larry Smarr, Andrew Chien, Phil Pappodapolis
  - University of Illinois at Chicago, co-leader – Tom DeFanti, Jason Leigh, Maxine Brown
  - Scripps Institute of Oceanography – John Orcutt, Graham Kent
  - National Center for Microscopy and Imaging Research – Mark Ellisman
  - US Geological Survey – Brian Davis, Dan Steinwand
  - University of Southern California Information Sciences Institute – Carl Kesselman
  - University of California Irvine
  - Northwestern University
  - San Diego State University
  - Texas A&M University
  - Plus, the University of Amsterdam

Keeping up with bandwidth

The problem with trying to keep up with the rate of growth of bandwidth is that routers that can keep up become extremely expensive.

Data Correlation and Visualization Pipeline

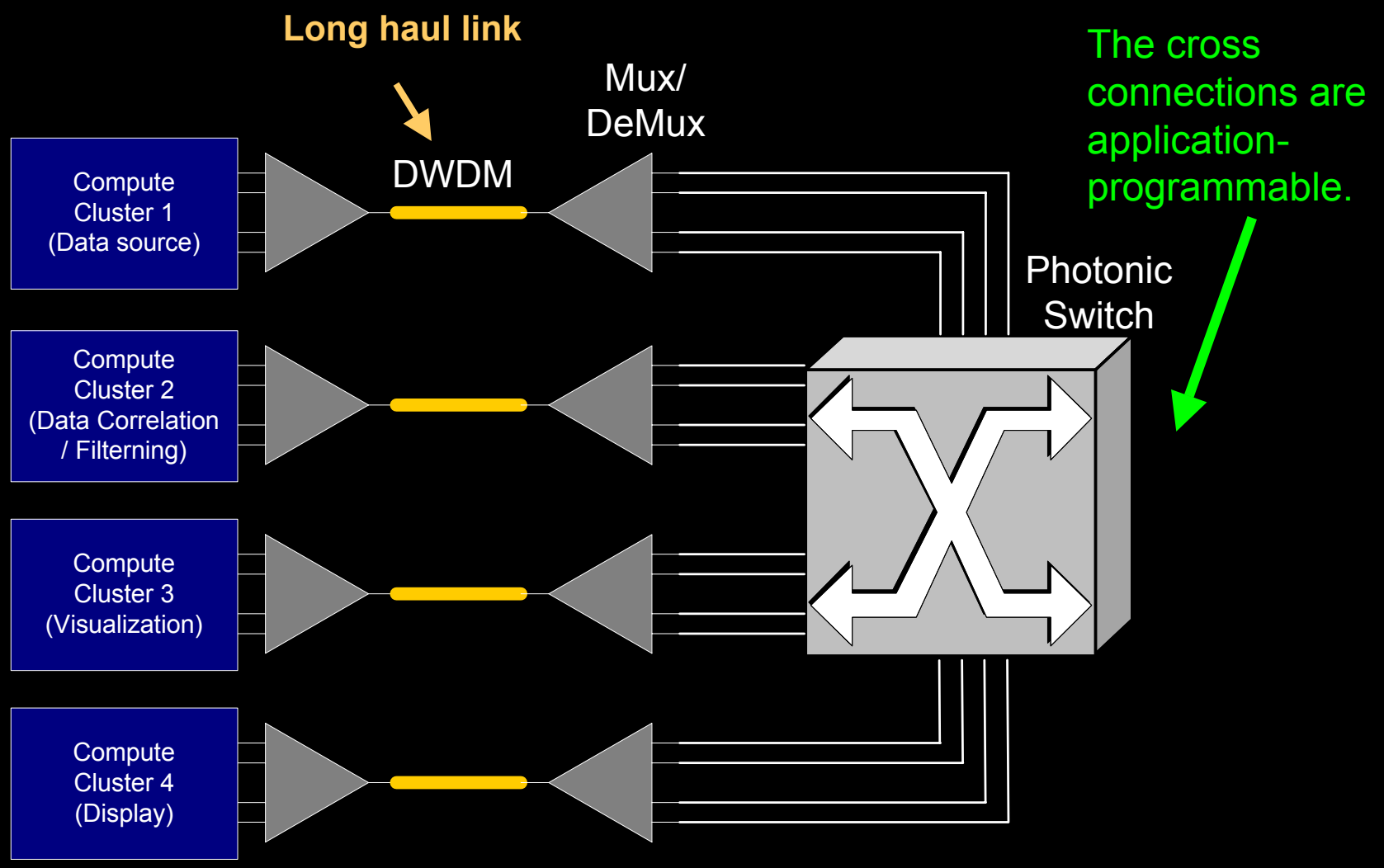
Data Source → Correlate → Render → Display

Data Source → Render → Display
Data Source → Render + Display
Data Source → Correlate → Render + Display
Data Source + Correlate → Render + Display
Data Source + Correlate → Render → Display

Since pipelines are mostly static, there is no need to look at every packet when transferring data → Routing is a waste.

Proposed Solution is to use Photonic (all Optical network devices)

- MEMS switches that can bounce light from an input port to an output port. (Calient / Glimmerglass)
- E.g. 64x64 10Gb:
  - $100,000 O-O-O switched (Photonic Switching)
  - $1,000,000 O-E-O switched (Optical Switching)
  - $10,000,000 O-E-O Routed (Electronic Routing)
  - Upgrade cost for Photonic switching is ZERO.

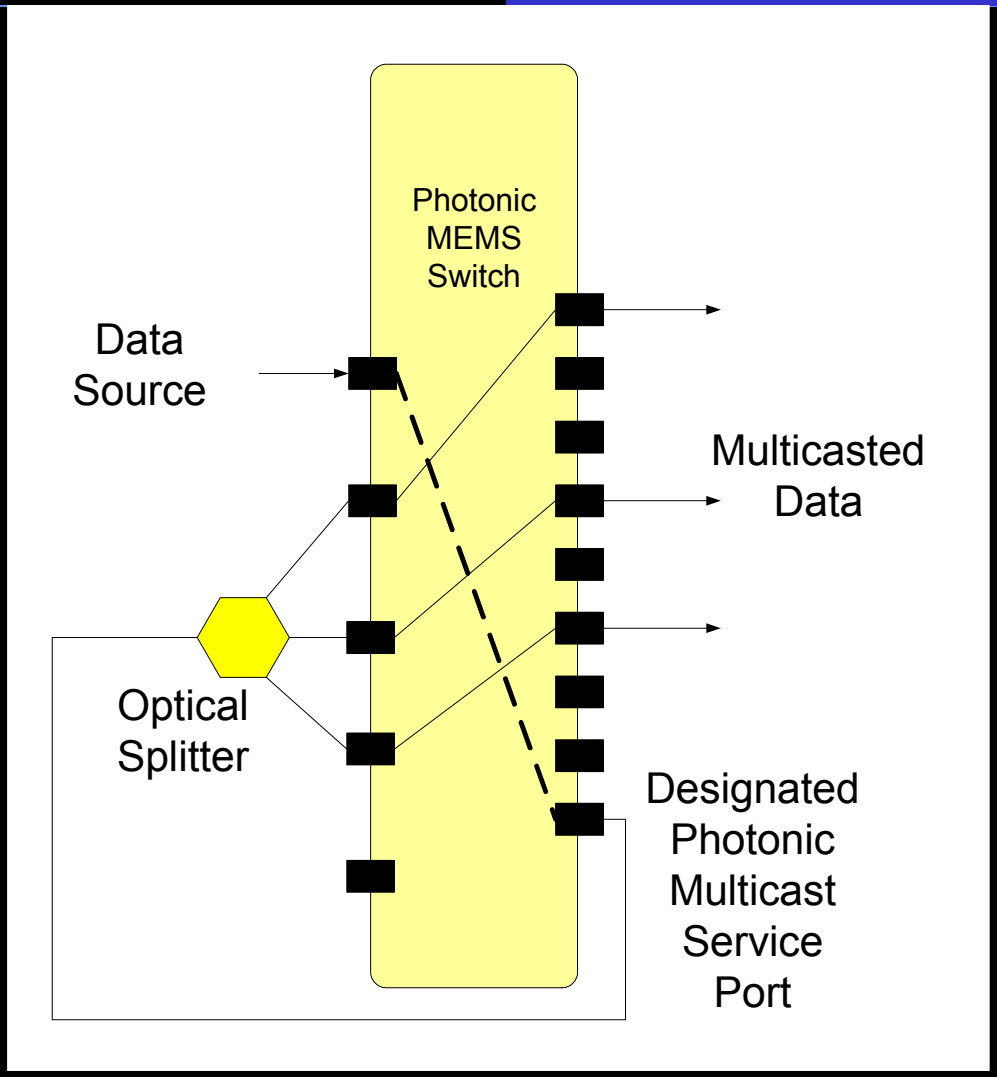

Long haul link
Mux/
DeMux
DWDM
The cross connections are application-programmable.
Photonic Switch
Compute Cluster 1 (Data source)
Compute Cluster 2 (Data Correlation / Filterning)
Compute Cluster 3 (Visualization)
Compute Cluster 4 (Display)

In Collaborative Work, Data or Visualization needs to be Distributed to Collaborating Sites

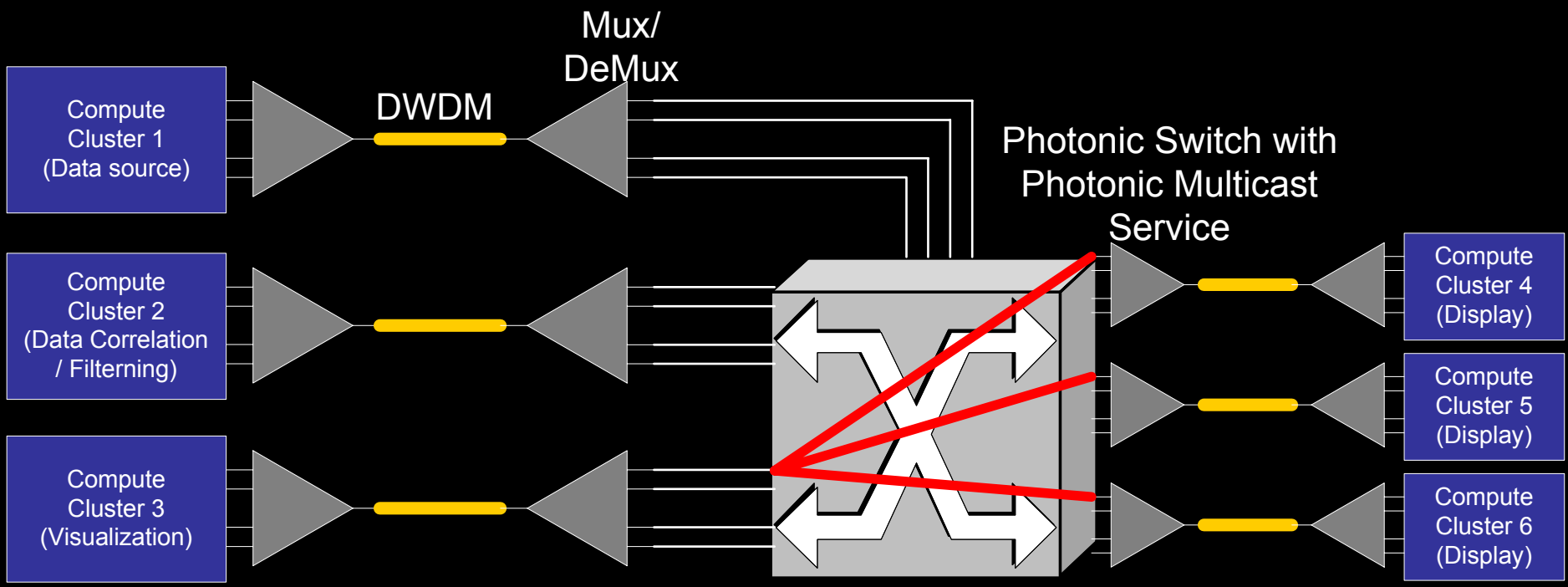
Data Source → Correlate → Render ➔ Display

Data Source ➔ Render + Display
Data Source → Render ➔ Display
Data Source → Correlate ➔ Render + Display
Data Source + Correlate ➔ Render + Display
Data Source + Correlate → Render ➔ Display

Photonic Multicast Service



Photonically Multicasting a Visualization

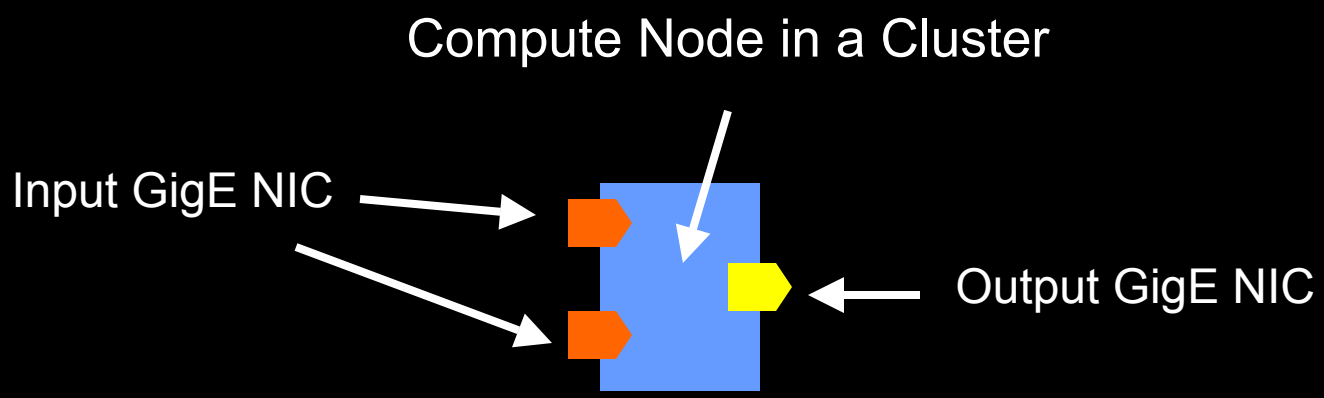


Have to use unidirectional protocols

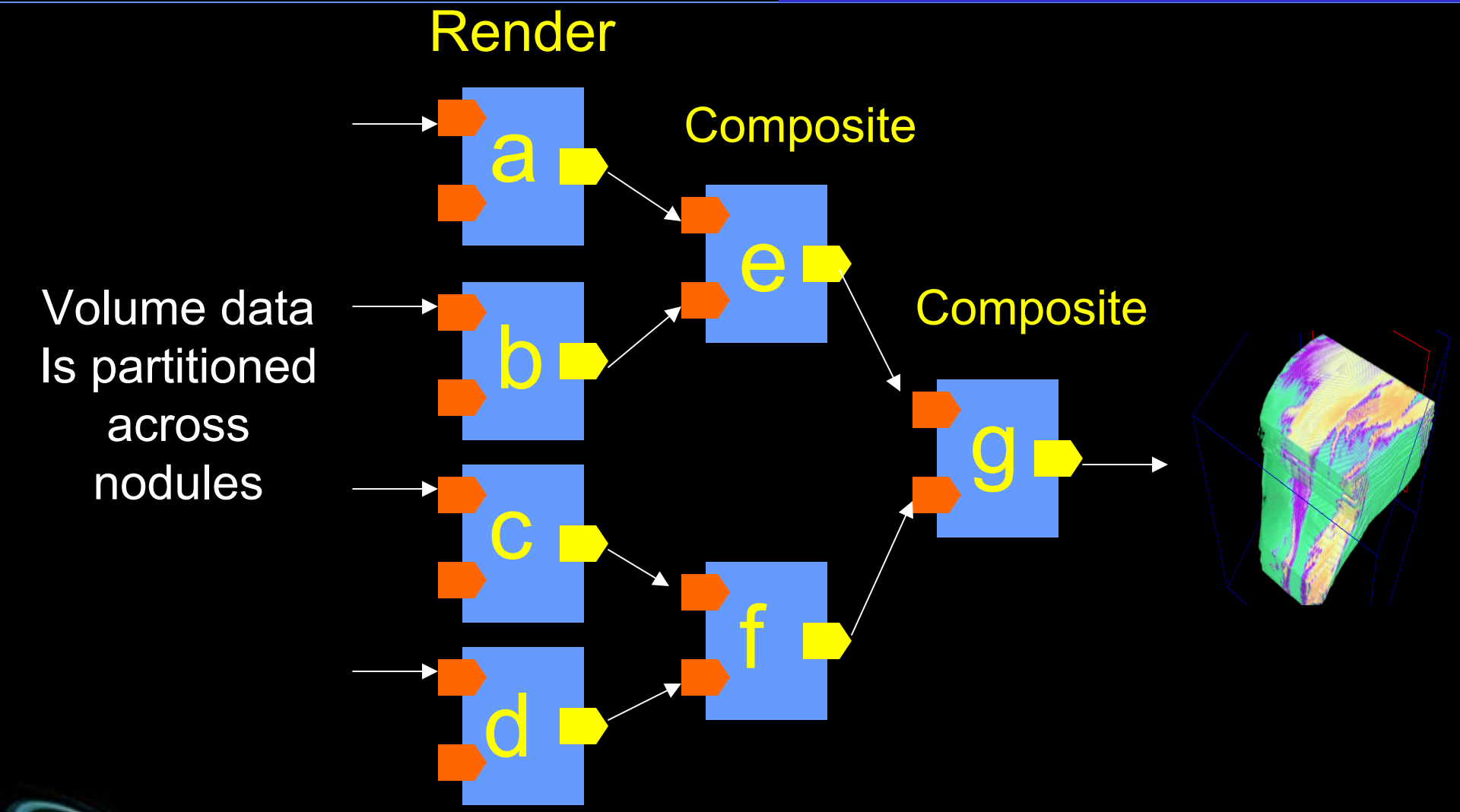
For reliable transmission, need back channel ACK/NAK.

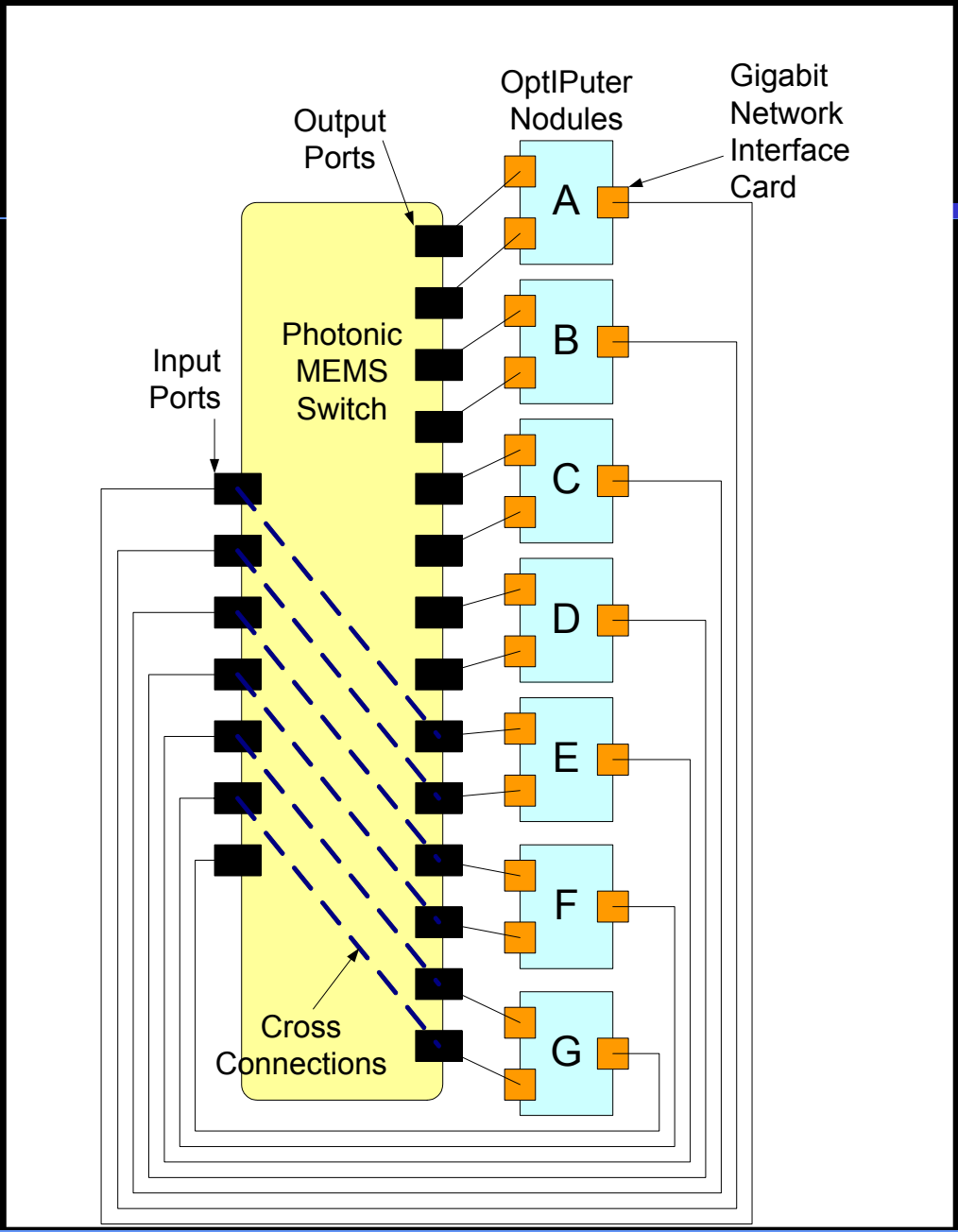
Another way to use Photonic Networks is to attempt to bring Photonics closer to the CPU

- Currently you can get 2.4GHz processors but only 500MHz system buses.
- Work is underway to bring light closer to the CPUs.
- But it will take 5-10 years for chip-to-chip connections.
- In the meantime:

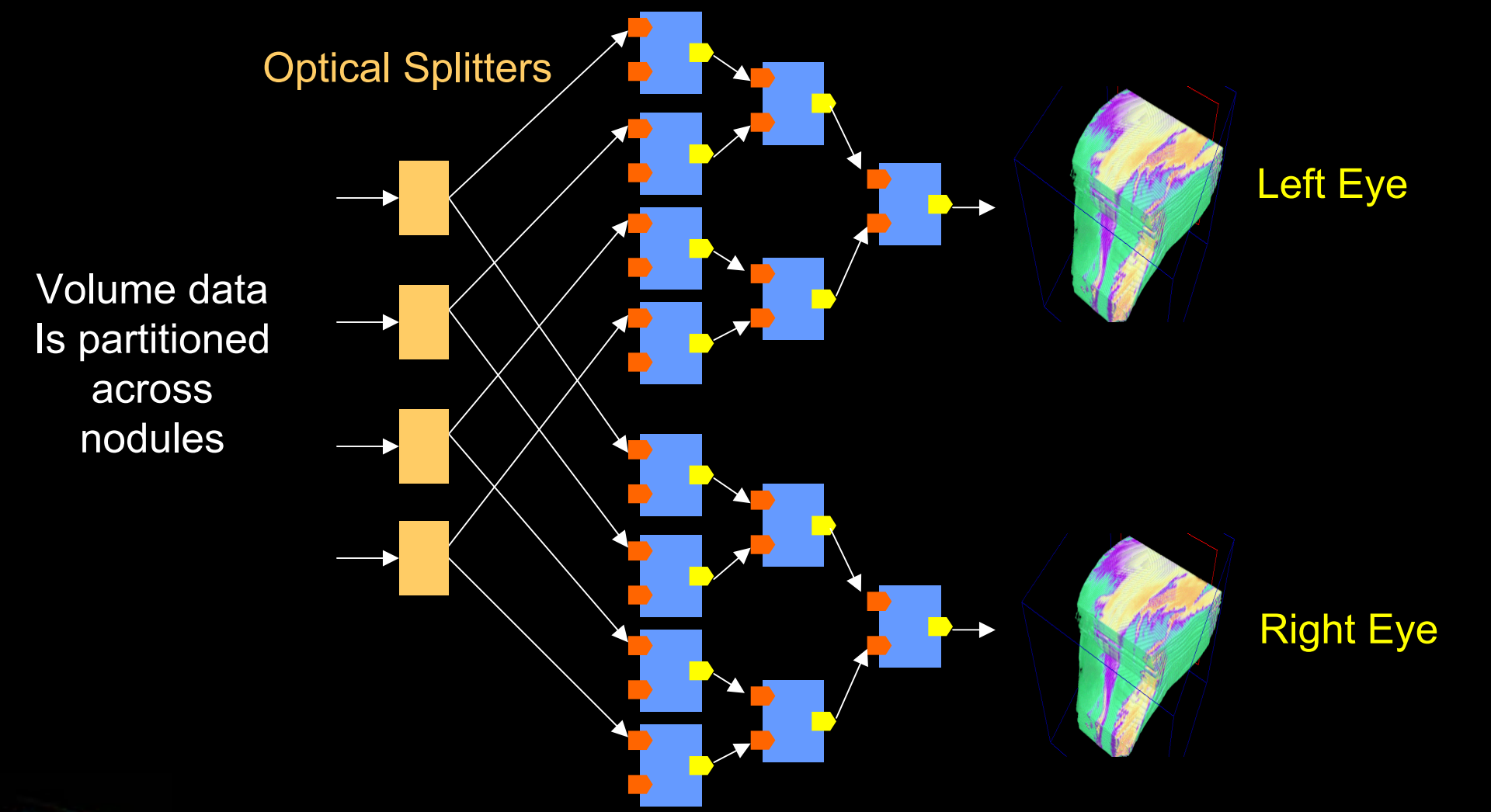


Consider a sort last visualization algorithm using OptIPuter nodules




OptIPuter
Nodules
Gigabit
Network
Interface
Card
Output
Ports
Photonic
MEMS
Switch
Input
Ports
A
B
C
D
E
F
G
Cross
Connections

Consider trying to do stereoscopic volume rendering for the GeoWall



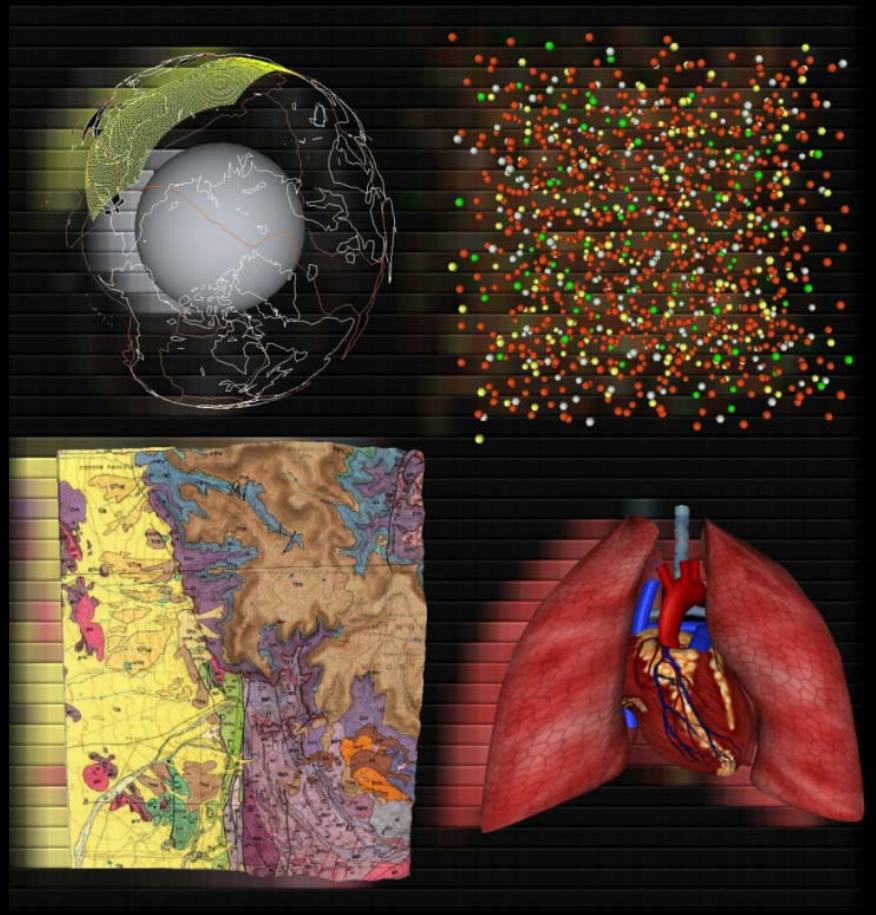
Current Status

- **TeraScope – build software components for a photonic data exploration pipeline.**
- **Data Source → Correlation & Caching (LambdaRAM) → Visualization.**
- **JuxtaVision – displays high resolution montages using this pipeline.**
- **TeraVision – graphics streaming adapter that can multicast high resolution graphics.**
- **TeraVision already confirmed to work in unicast on Calient/Glimmerglass photonic switches.**
- **Multicast photonic switch is being built now & will be delivered in September.**

JuxtaVision on a 20 million pixel tiled LCD display

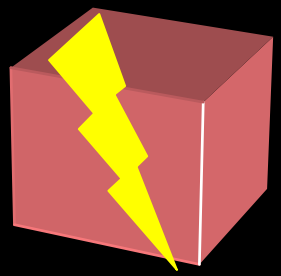
TeraVision : A High Resolution Graphics Distribution Appliance

- The Networked Powerpoint Projector
- PC with fast image capture board for streaming graphics over GigE
- Digitizes computer output at 1024x768 @ 30fps and streams it to remote sites for viewing on PCs or Geowalls
- Demo at iGrid2002 streamed from Greece to Amsterdam and Chicago to Amsterdam
- Suitable for multi-screen displays driven by remote clusters



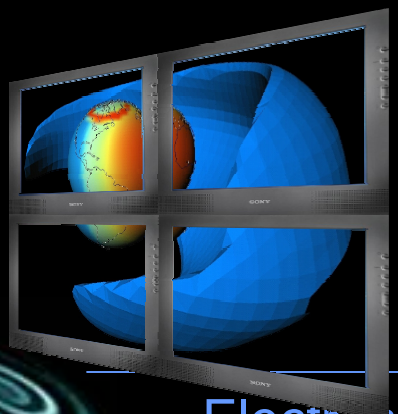
TeraVision : High Resolution Graphics Distribution

VGA / DVI capture



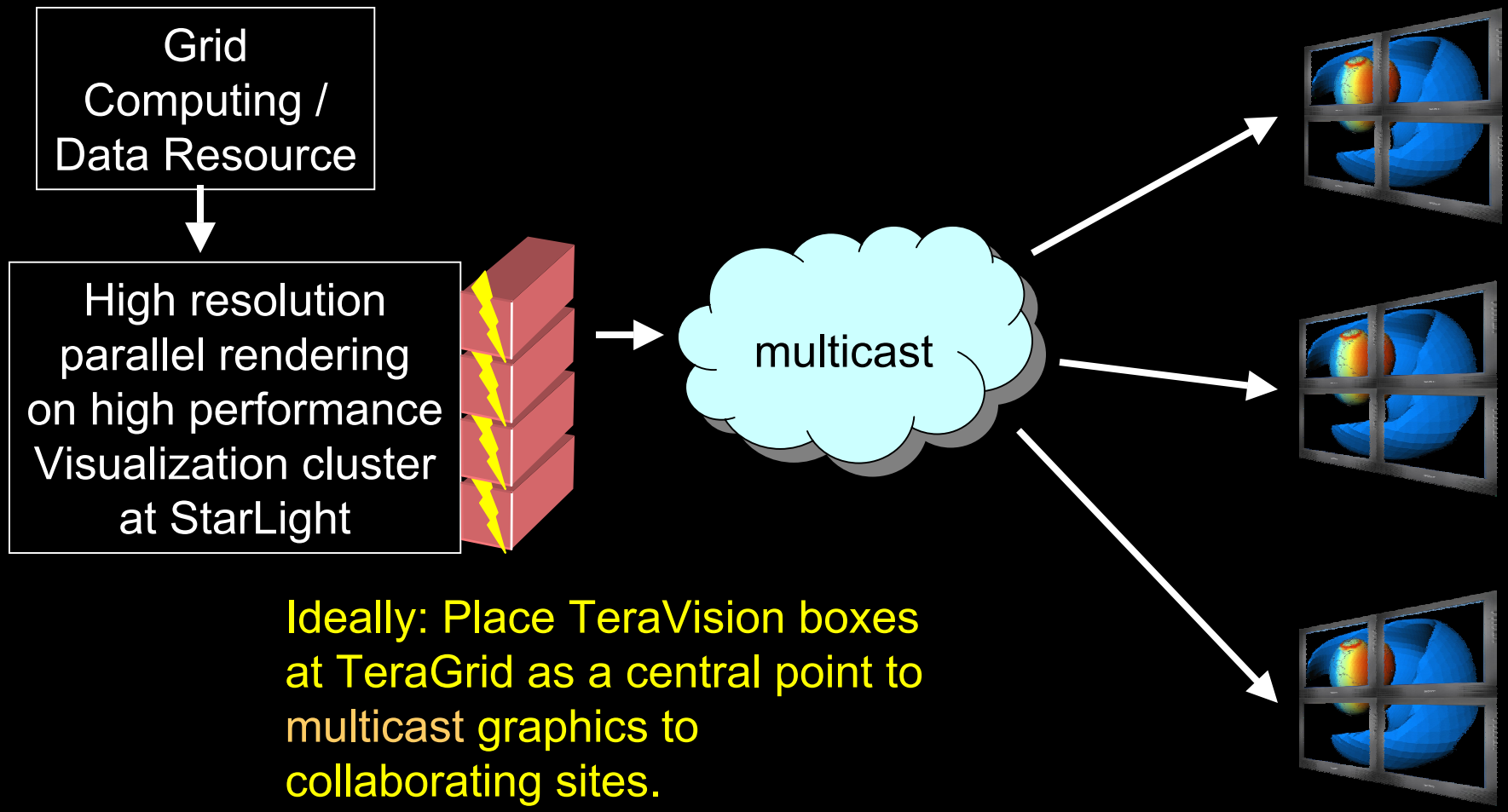
GigE or 100BT

Remote Display



- Like a Powerpoint projector with a Gigabit NIC built into it.
- Capture raw image @ 1024x768 30fps
- 500Mbps uncompressed stream
- Next generation version will let us capture twice the resolution.

Gang TeraVision Boxes to Stream a Tiled Display



Ideally: Place TeraVision boxes at TeraGrid as a central point to multicast graphics to collaborating sites.

For more Info

www.evl.uic.edu/cavern/optiputer

www.startap.net/starlight

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