



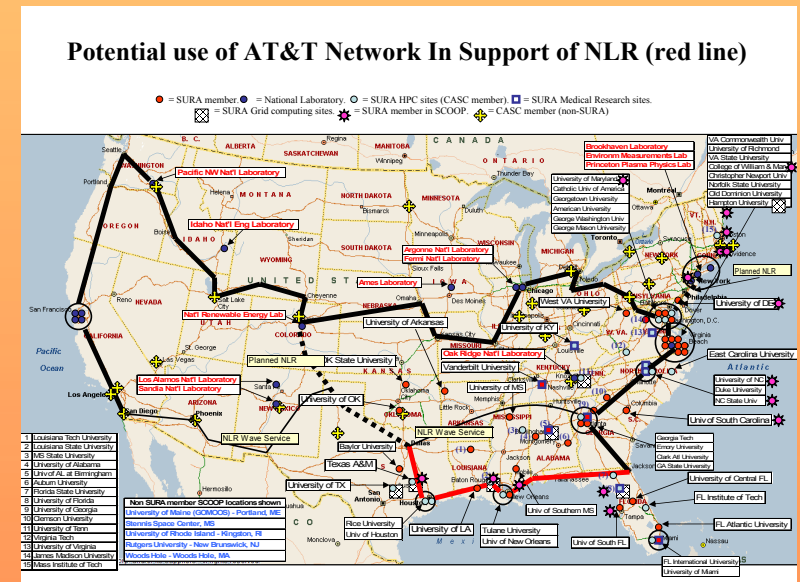
Applications on Grids & Optical Networks

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Applications Research Group, Global
Grid Forum (GGF) Note: Life Sciences!
TWG-Apps, EU Gridstart Project



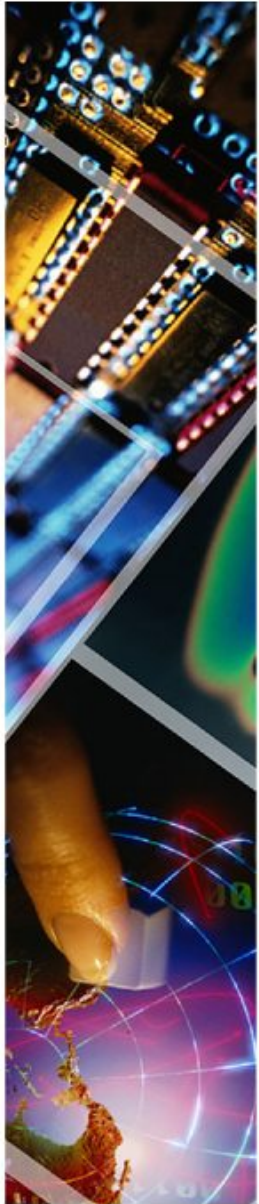


The Grid

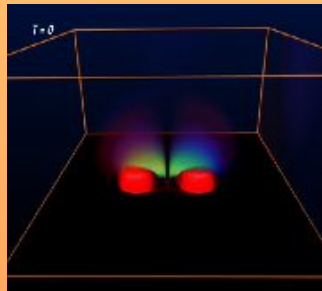
Hot Area in Computational Science, \$\$B

- Computational Devices Scattered Across the World
 - Compute servers (double 18 months)
 - Handhelds
 - Networks (double each 9 months)
 - Playstations, cell phones
 - Sensors
- How to take advantage of this for science, engineering, business, art?
 - Harness multiple sites and devices
 - Make it accessible to scientists, engineers, artists
 - Integrate communities and resources
 - Do science in new ways

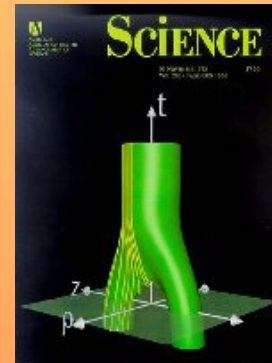




Grand Challenge Collaborations Science and Eng. Go Large Scale: Needs Dwarf Capabilities



- **NASA Neutron Star Grand Challenge**
 - 5 US Institutions
 - Solve problem of colliding neutron stars (try...)



- **NSF Black Hole Grand Challenge**
 - 8 US Institutions, 5 years
 - Solve problem of colliding BH (try...)



- **EU Network Astrophysics**
 - 10 EU Institutions, 3 years, €1.5M
 - Continue these problems
 - **Entire Community becoming Grid enabled**

- **Examples of Future of Science & Engineering**
 - Require Large Scale Simulations, beyond reach of any machine
 - Require Large Geo-distributed Cross-Disciplinary Collaborations
 - Require Grid Technologies, but not yet using them!
 - Both Apps and Grids **Dynamic...**

Huge funding opportunities for
Collaborations: NSF, DOE, NOAA, NIH, EU...

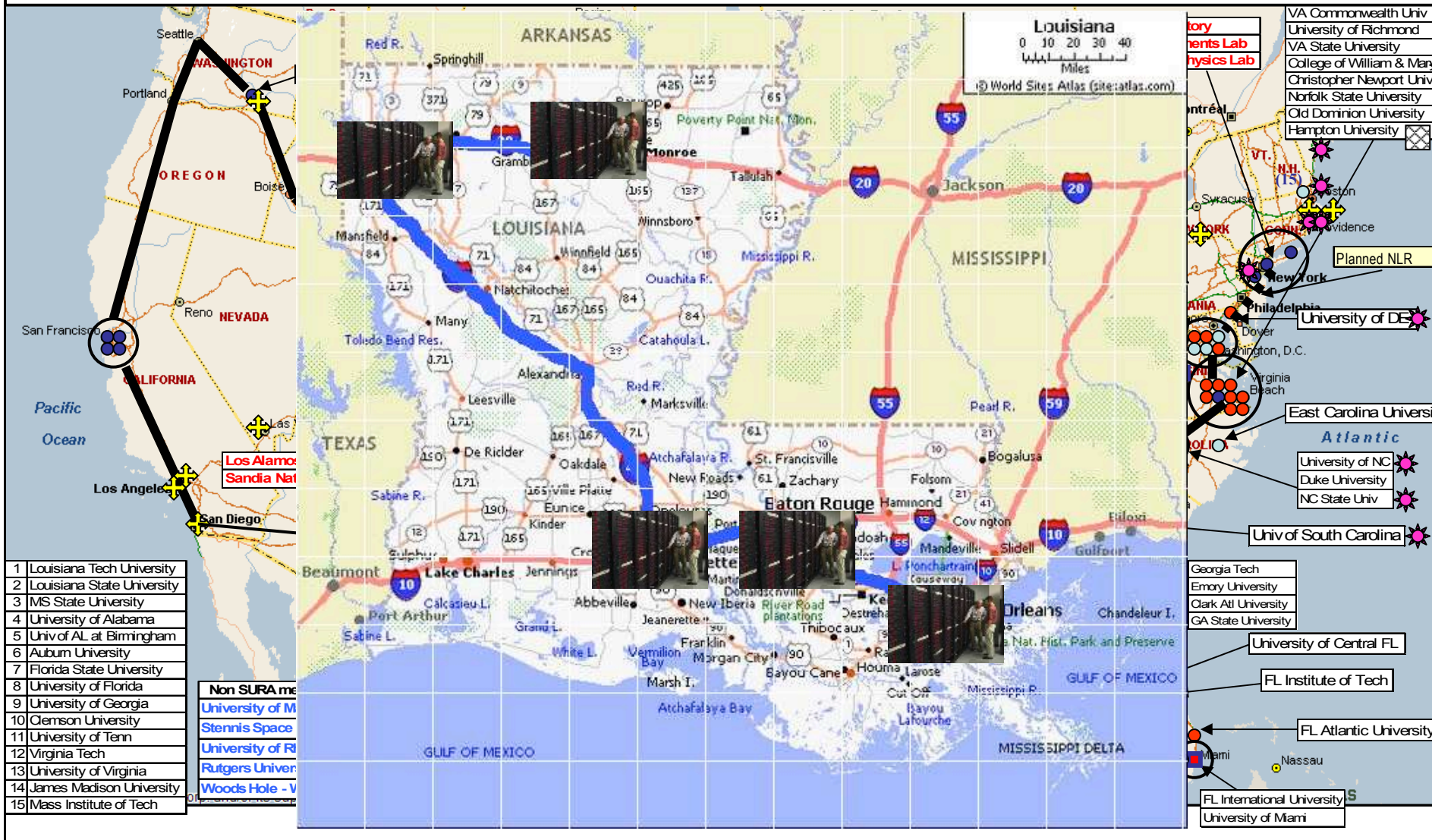


Optical Networks

- New Technology for Next Decade: 1000x faster many present networks
 - “Lambda’s available at affordable prices
- National Lambda Rail
 - ~ \$100M USA Optical Network
 - Backbone for next generation research
- Other countries
 - Poland: \$100M, Holland, Czech, etc
- 2 dozen states committed to local opticals
 - Louisiana: LONI

Tom DeFanti: *“Bandwidth is cheaper than disk space”*

National Lambda Rail & State Networks



2004 International Lambdas

European lambdas to US
 -10Gb Amsterdam—Chicago
 -10Gb London—Chicago
 -3Gb CERN — Chicago

Canadian lambdas to US
 -10Gb Chicago-Canada-NYC
 -10Gb Chicago-Canada-Seattle

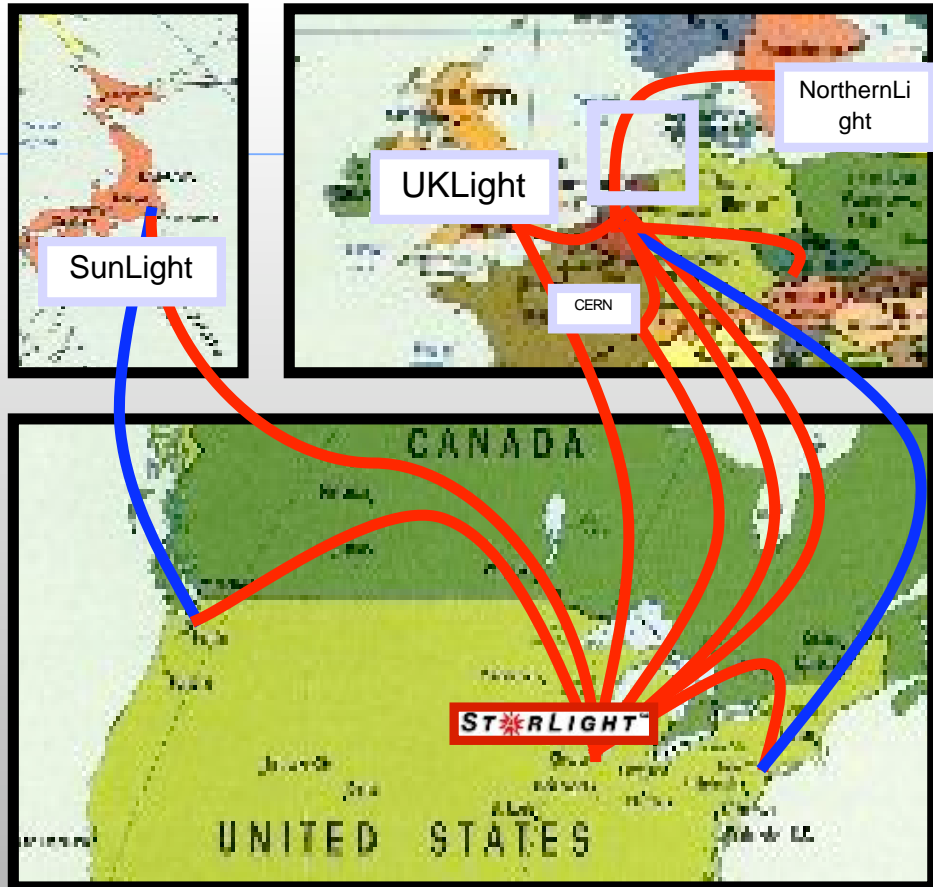
US lambda to Europe
 -7Gb Chicago—Amsterdam

US/Japan lambda
 -10Gb Chicago—Tokyo

European lambdas
 -10Gb Amsterdam—CERN
 -2.5Gb Prague—Amsterdam
 -2.5Gb Stockholm—Amsterdam
 -10Gb London—Amsterdam

IEEAF lambdas (blue)
 -10Gb NYC—Amsterdam
 -10Gb Seattle—Tokyo

UIC



Lightpaths Available for Switching

Thanks to Tom DeFanti



Future view: much of it here now

- Scale of computations much larger: Grids!
- Complexity approaching that of Nature
 - Simulations of the Universe and its constituents
 - Black holes, neutron stars, supernovae
 - Human genome, heart modeling, data mining, computer aided surgery
- Teams of researchers working together
 - Must support efficient, high level problem description
 - Must support collaborative computational science
- Ubiquitous Grid Computing
 - **Future applications will be empowered to use self-collected information and make grid-compatible requests for resources**
 - Very dynamic apps, even deciding their own future
 - Apps may find services themselves: distributed, spawned, etc...
 - Monitored, viz'ed, controlled from anywhere, with colleagues elsewhere



Current Grid App Types

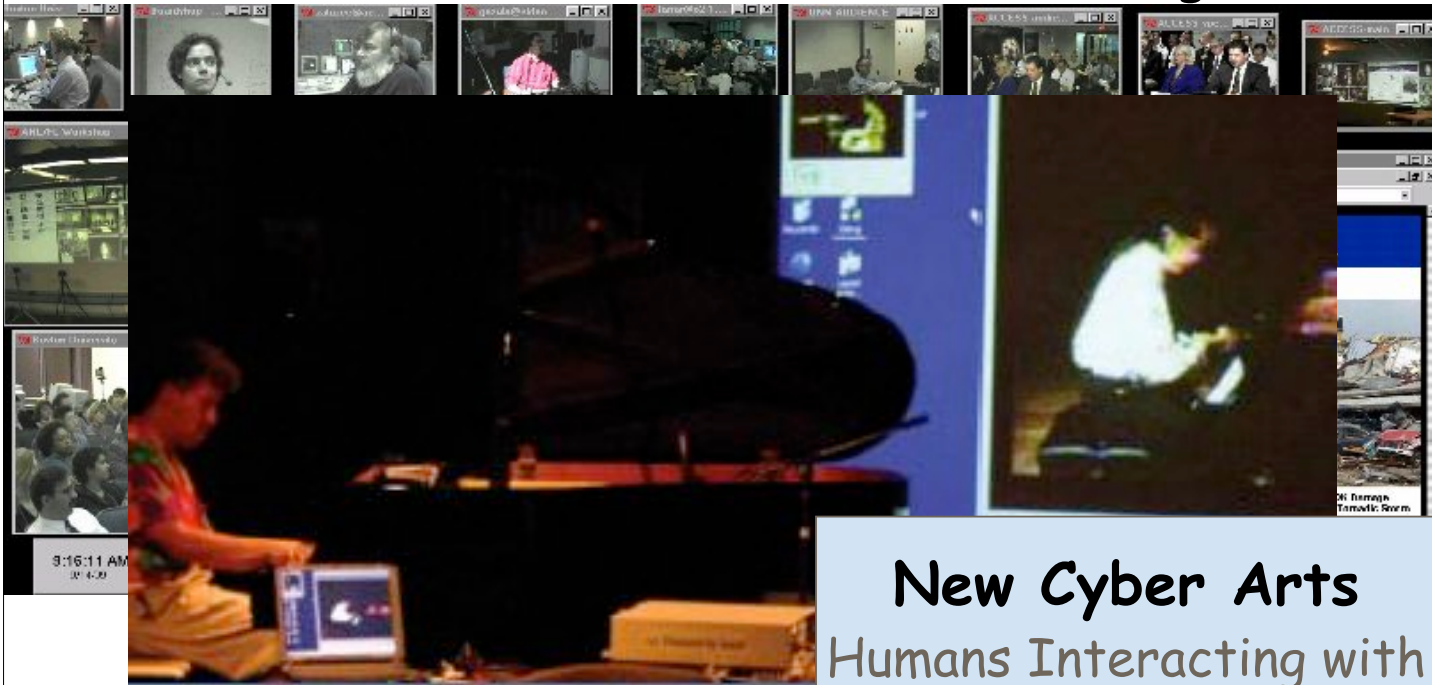
- Community Driven
 - Distributed communities share resources
 - Video Conferencing
 - Virtual Collaborative Environments
- Data Driven
 - Remote access of huge data, data mining
 - Weather Information systems
 - Particle Physics
- Process/Simulation Driven
 - Demanding Simulations of Science and Engineering
 - Task farming, resource brokering, distributed computations, workflow
- Interactive
 - Remote, steered, etc...



Networks as Rallying Point

- Create state/national Grid & virtual supercomputers
- Brings researchers together
 - Complementary expertise: CS, discipline specific
 - Huge funding pools available for multi-institutional science/IT projects
- Next generation applications enabled
 - Have special expertise in Grid applications
 - New classes of problems to be studied
- Grid-based collaboration/education

From Telephone Conference Calls to Access Grid International Video Meetings



Internet Linked Pianos

New Cyber Arts
Humans Interacting with
Virtual Realities

Source: Smarr

Access Grid Lead-Argonne
NSF STARTAP Lead-UIC's Elec. Vis. Lab

Grand Challenge: Manipulating Multi-Gigabyte Science Data Objects

- Hundred million-pixel 2-D images
 - Microscopy or telescopes
 - Remote sensing
 - 32 bits/pixel
- GigaZone 3-D (1Kx1Kx1K) objects
 - Supercomputer simulations
 - Seismic or medical imaging
 - Zones are multiple 64-bit word entities
- Interactive analysis and visualization of such data objects is **impossible** over today's Internet with current protocols
- Focus of the OptIPuter project (Smarr)
- Give researchers what students have with P2P
 - Just-in-Time Proposal: Karmous-Edwards, Allen, Reed, Seidel

UIC

Thanks to Tom DeFanti



Black Hole Simulations on Grids

Main Cactus BH Simulation starts here



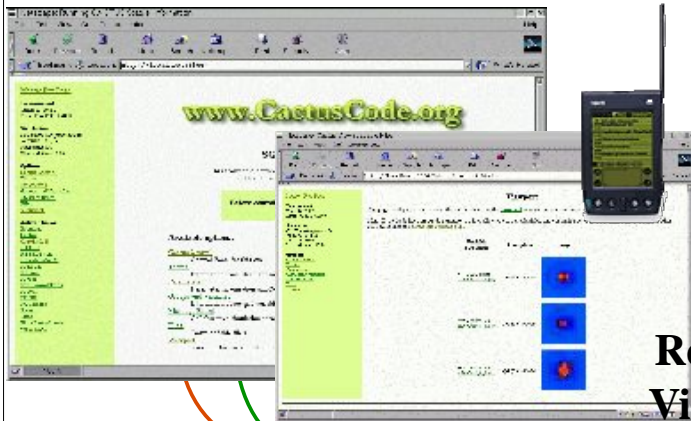
All analysis tasks spawned automatically to free resources worldwide



User only has to invoke “Spawner” thorn...



Remote Viz/Steering watch/control simulation live...



Any Viz Client:
LCA Vision, OpenDX

Remote
Viz data
Streaming HDF5
Autodownsample

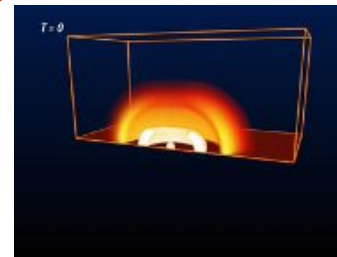
Changing any steerable parameter

- *Parameters*
- *Physics, algorithms*
- *Performance*



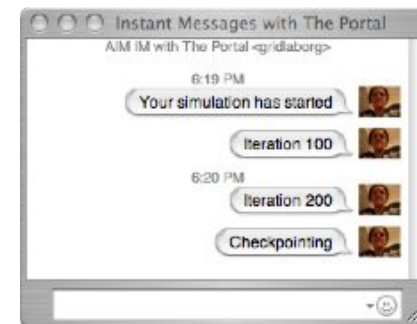
www.cactuscode.org

Remote
Viz data



Amira ridlab.org

Notification



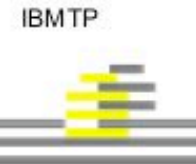
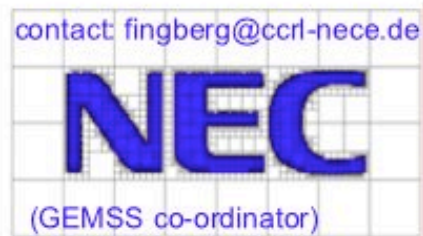


IST-2001-37153

<http://www.gemss.de>



The GEMSS Consortium:

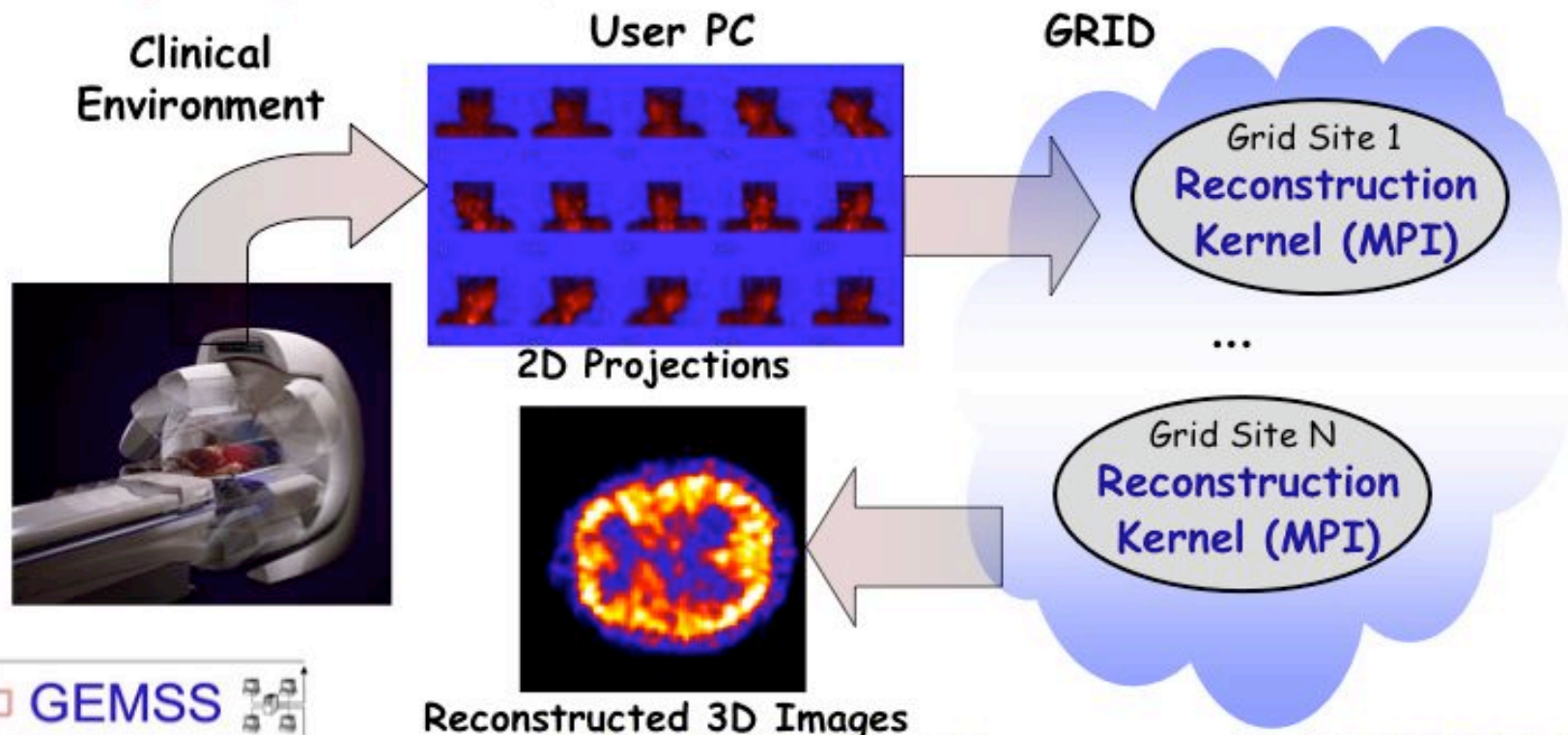


GEMSS Applications

Name	Domain	Class
Maxillo-facial surgery simulation	Medicine - pre-surgical planning	On demand / distributed supercomputing
Neurosurgery support	Medicine - intra-operative planning	On demand
Radiotherapy planning	Medicine - Monte Carlo treatment simulation	On demand / distributed supercomputing
Inhaled drug delivery planning	Medicine - air flow dynamics	On demand / distributed supercomputing
Cardio-vascular system simulation	Medicine - blood flow dynamics	On demand
Advanced image reconstruction	Medicine - nuclear / in vivo diagnostics	On demand

Image Reconstruction Service (SPECT)

- Single photon emission computed tomography (SPECT) is an effective & robust method for diagnosis of cancer, heart diseases and functional pathologies.
- our method takes into account: scanner geometry, scatter, attenuation, etc.
→ large computational requirements



ST4.1 Maxillo-facial Surgery Simulation

Distraction osteogenesis: new treatment for facial malformations.

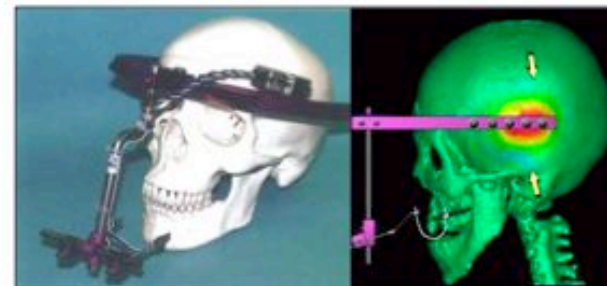
Provide a virtual try-out space for the pre-operative planning of maxillo-facial surgery.

Numerical modelling & simulation can improve surgical planning and predict outcome.

Requires large resources & parallel computers: distributed on-demand supercomputing.



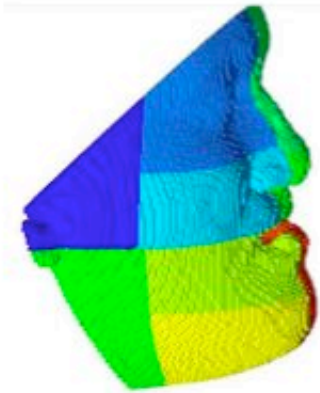
Pre- and post surgery
Courtesy Dr. Dr. Th. Hierl,
Clinic for Facial Surgery,
University Clinic Leipzig.



Modelling the distraction procedure

Tool Chain: Remote Simulation

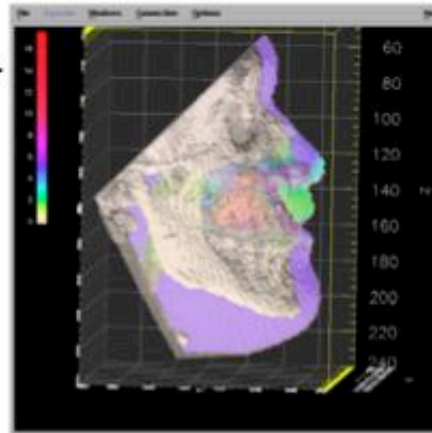
Remote FEM Simulation:



- Typical mesh size: **0.5 million nodes**
- Partitioned by DRAMA (NEC)
- Discretized by FEBiNA (NEC)
- Linear solver: BoomerAMG (LLNL) (research only)
- Memory consumption: **12 GByte**
- Computing time: **150 sec on 16 AMD 1.6GHz CPUs**
for a linear elastic simulation.
Several hours for a nonlinear simulation

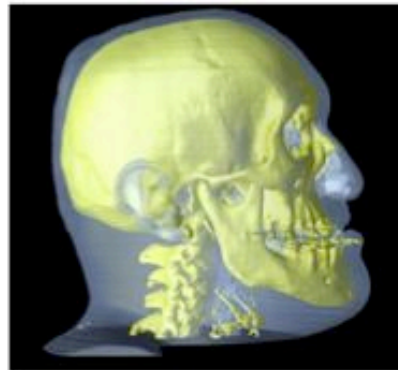
Tool Chain: Visualisation of Results

- Displacements, strains, stresses, etc. projected onto the FEM mesh by OpenDX.

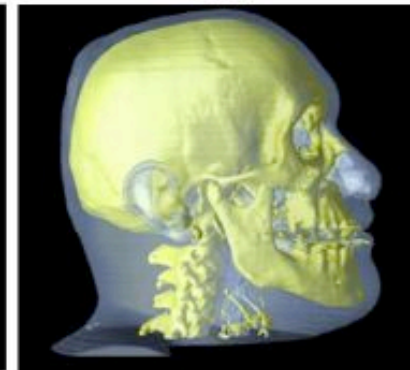


- Displacements projected onto the CT data set and re-rendered by OpenDX.

before:



after:





Southeastern Coastal Ocean Observing Program (SCOOP)

- Data transmission from across all over Gulf Data
- Gr...
- Fe...
- Gr...
- Inc...
- dir...
- A...
- S...
- Co...
- res...
- Class of data driven apps. Modeling spread of disease, bio-terrorism, etc



Source: Wilhelmson, Jewett, Shaw



Summary

- Grids, Optical Networks are coming
 - A lot of hype, promise, but definitely coming
- Will be critical for exploiting resources, integrating communities
- New applications must be created to take advantage
 - New paradigms
 - New Tools and Toolkits for creating new apps
 - Think creatively!
- We are in the early phases
 - Similar to parallel computing decade ago
- Many opportunities: partner with your local (or remote) computational scientists!
 - Life Sciences at GGF
 - <https://forge.gridforum.org/projects/lsg-rg>