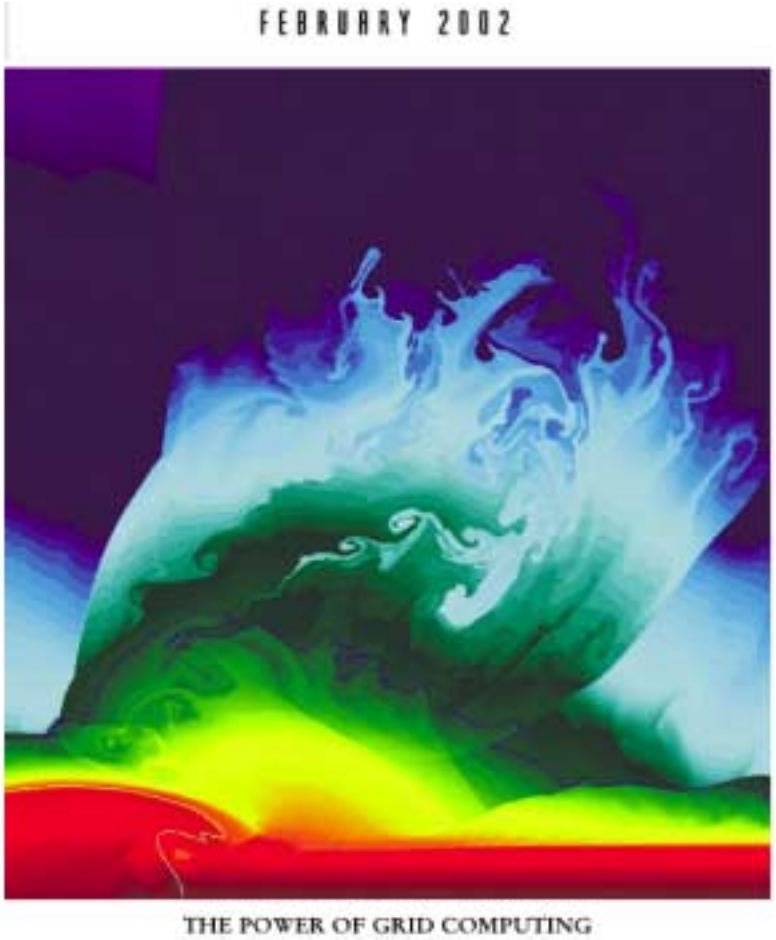
The Grid from an Application Viewpoint

PHYSICS TOMORROW



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+

Lots of colleagues…

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Co-Chair, GGF Applications Working Group

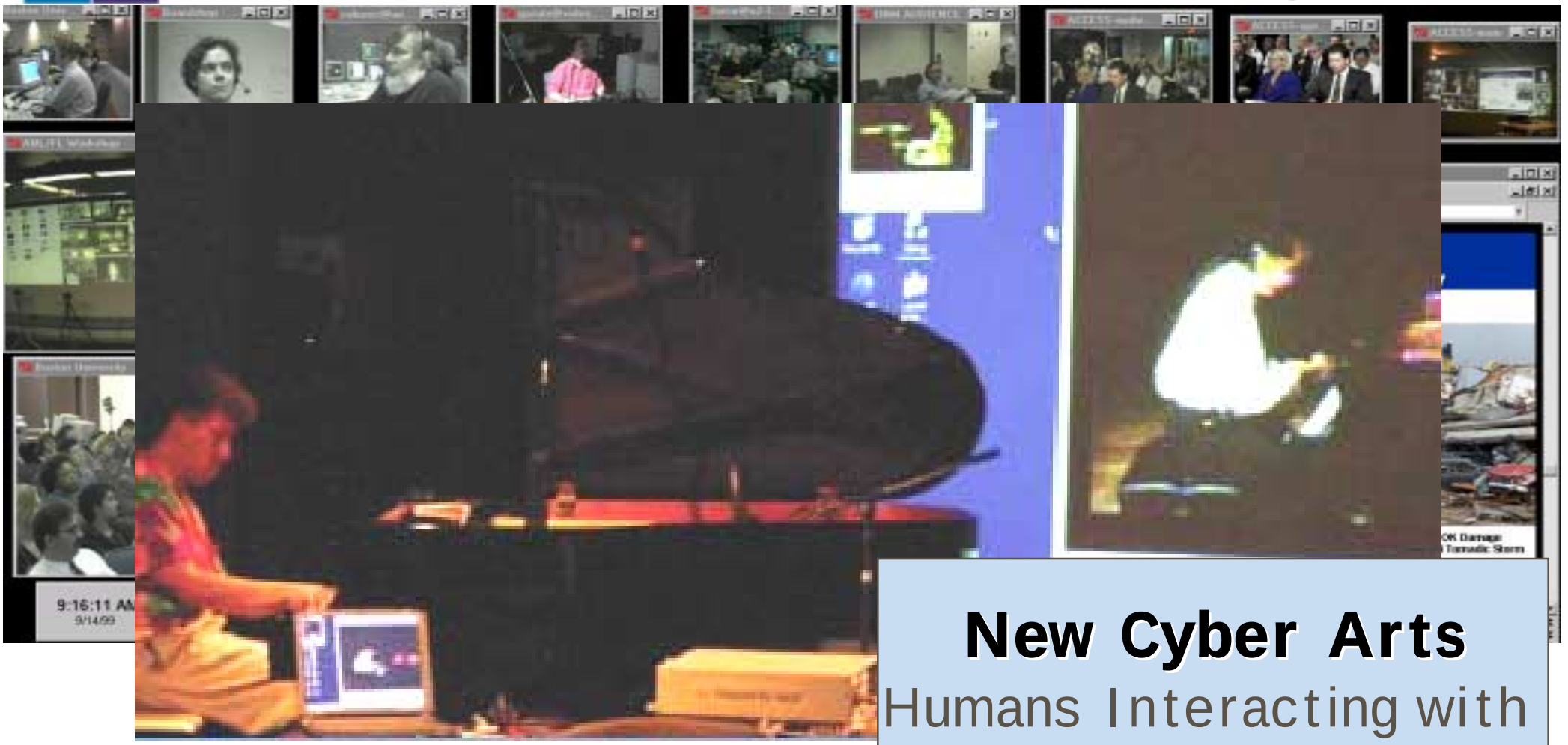
Current Grid Application Types

- Community Driven
  - Serving the needs
  - Video Conferencin
  - Virtual Collaborati
    - Code sharing to "
- Data Driven
  - Remote access of
  - Weather Infor
  - Particle Physi
- Process/Simu
  - Demandin imulati
  - Get less attention in the Grid world, yet drive HPC

Present Examples:
- "simple but very difficult"

Future Examples:
- Dynamic
- Interacting combinations of all types

From Telephone Conference Calls to Access Grid International Video Meetings



Internet Linked Pianos

New Cyber Arts
Humans Interacting with Virtual Realities

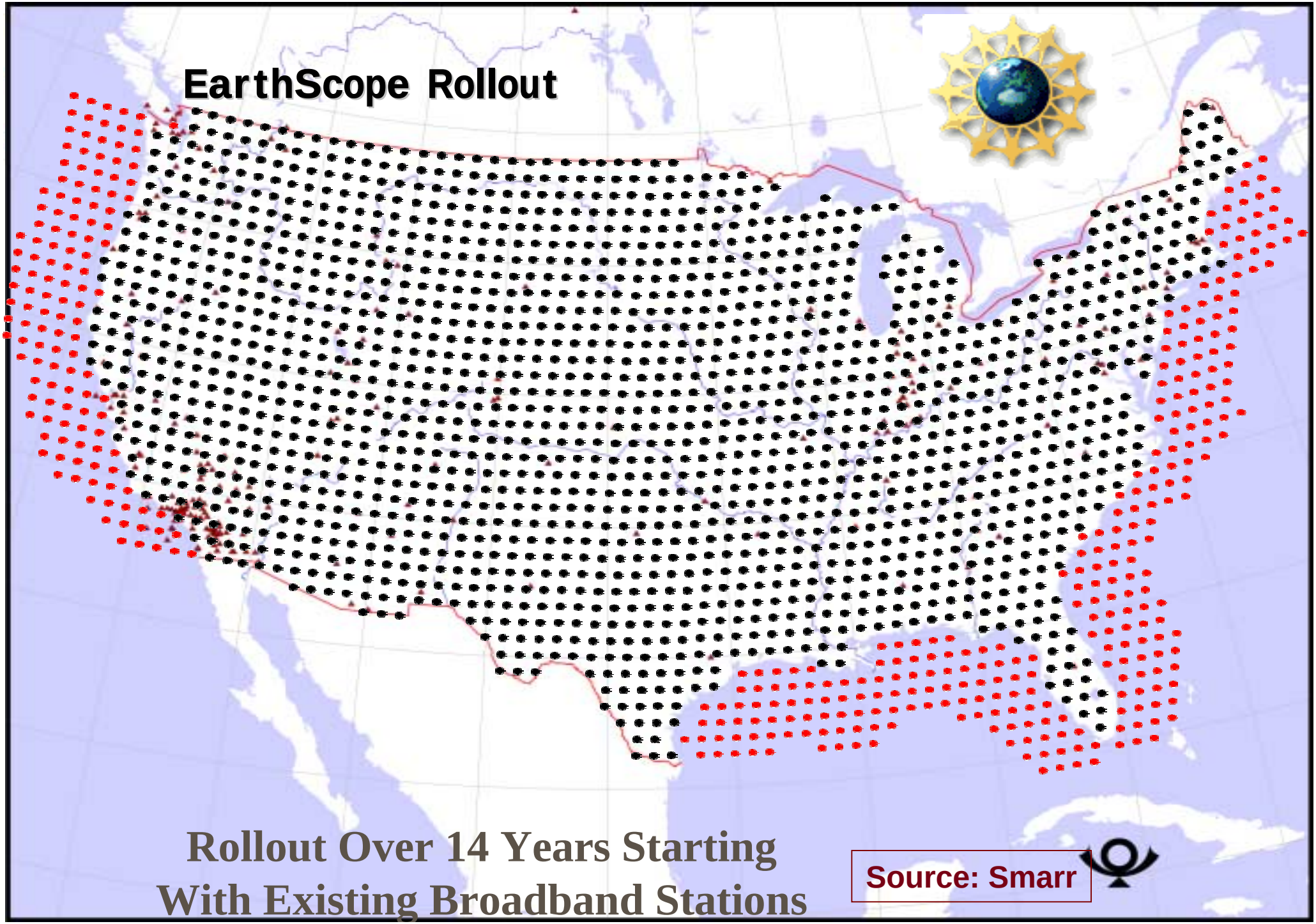
Source: Smarr

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

NSF's EarthScope--USArray:
Explosions of Data! Typical!

- High Resolution of Crust & Upper Mantle Structure
- Transportable Array
  - Broadband Array
    - 400 Broadband Seismometers
      - ~70 Km Spacing
      - ~1500 X 1500 Km Grid
  - ~2 Year Deployments at Each Site
    - Rolling Deployment Over More Than 10 Years
- Permanent Reference Network
  - Geodetic Quality GPS Receivers
- All Data to Community in Near Real Time
  - Bandwidth Will Be Driven by Visual Analysis in Repositories
- Realtime Simulations to use live data feed

Source: Smarr/Frank Vernon (IGPP SIO, UCSD)


EarthScope Rollout
Rollout Over 14 Years Starting
With Existing Broadband Stations
Source: Smarr

A Wide Range of Scientific Disciplines Will Require a Common Infrastructure

- Common Needs Driven by the Science/Engineering
  - Large Number of Sensors / Instruments
  - Daily Generation of Large Data Sets
  - Data is on Multiple Length and Time Scales
  - Automatic Archiving in Distributed Federated Repositories
  - Large Community of End Users
  - Multi-Megapixel and Immersive Visualization
  - Collaborative Analysis From Multiple Sites
  - *Complex Simulations Needed to Interpret Data*
- Some will need Optical Networks
  - Communications → Dedicated Lambdas
  - Data → Large Peer-to-Peer Lambda Attached Storage

Source: Smarr

Issues for Complex Simulations

- Huge amounts of data needed/generated across different machines
  - How to retrieve, track, manage data across Grid
  - In this case, had to fly Berlin to NCSA, bring data back on disks!
- Many components developed by distributed collaborations
  - How to bring communities together?
  - How to find/load/execute different components?
- Many computational resources available
  - How to find best ones to start?
  - How to distribute work effectively?
- Needs of computations *change* with time!
  - How to adapt to changes?
  - How to monitor system?
- How to interact with Experiments? Coming!

3 Components fo

These are widely developed but not yet well deployed! You can help…

1. Resources: e.g., GGF
   - Worldwide "Virtual
2. Infrastructure: Globus Metacomputing Toolkit
3. Grid Aware Applications
   - Grid Enabled Modular Toolkits for Parallel Computation: Provide to Scientist/Engineer…
     - GridLab to develop Grid Application Toolkit (GAT)
     - Plug your Science/Eng. Applications in!
   - Must Provide, Find, *Grid Services*
     - Ease of Use: automatically find resources, given need!
     - Distributed simulations: use as many machines as needed!
     - Remote Viz and Steering, tracking: watch what happens

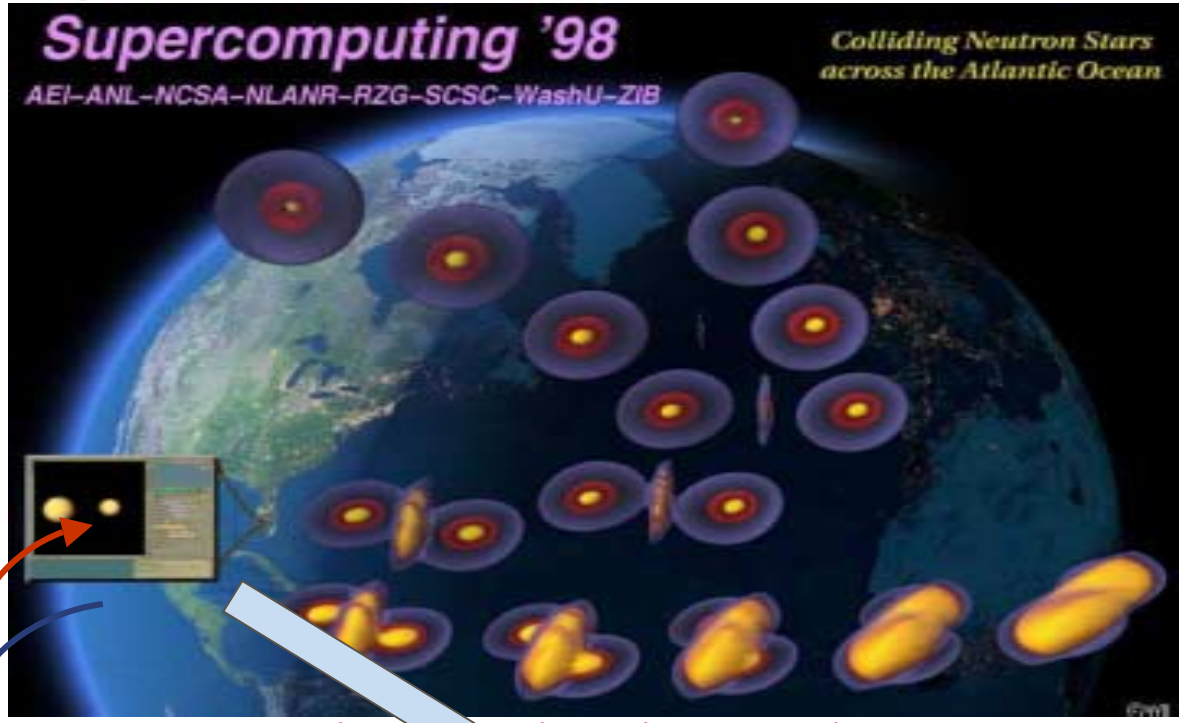
Future view: much of it here already...

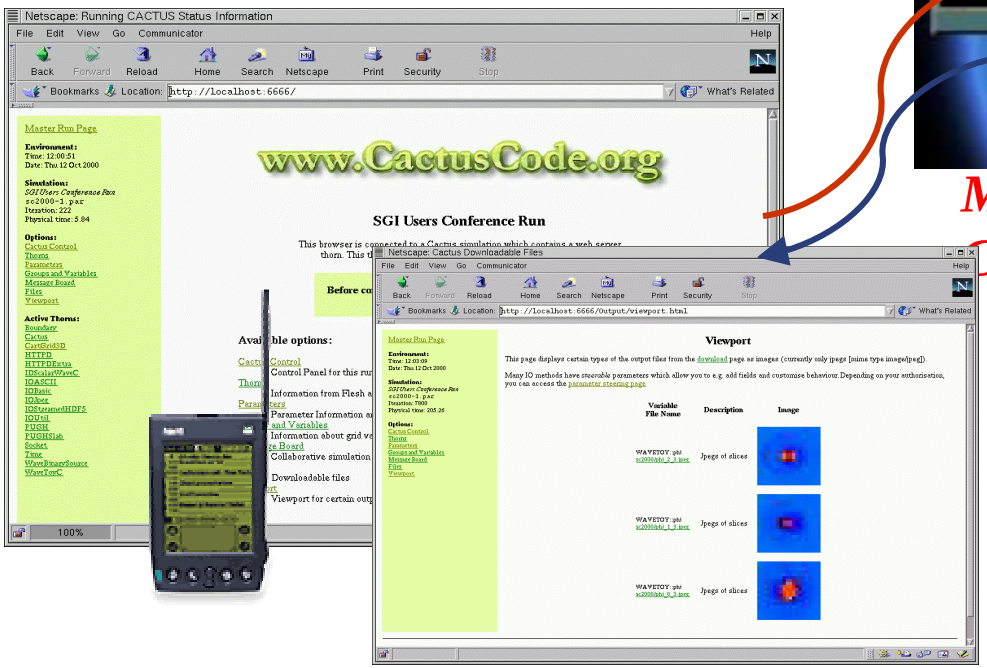
- Scale of computations much larger: Need Grids to keep up…
  - Much larger processes, task farm many more processes (e.g. Monte Carlo)
  - Also: how to simply make better use of current resources
- Complexity approaching that of Nature
  - Simulations of the Universe and its constituents
- Teams of computational scientists working together: the future of science and engineering needs
  - efficient, high level problem description
  - collaborative computational science: look at Grand Challenges
  - all different languages
- Ubiquitous Grid Computing
  - Resources, applications, etc replaced by abstract notion: *Grid Services*
  - Very dynamic simulations, even deciding their own future
  - Apps may find the services themselves: distributed, spawned, etc…
  - Must be tolerant of dynamic infrastructure
  - Monitored, viz'ed, controlled from anywhere, with colleagues elsewhere

Grid (Simulation) Applications so far...

Need to go far beyond this

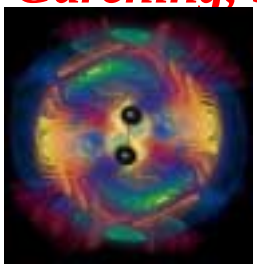
- SC93 - SC2001
- Typical scenario
  - Find remote resource
    - Where? Portal!
  - Launch job
  - Visualize results
  - Steer job





Metacomputing the Einstein Equations:
Connecting T3E's in Berlin, Garching, San Diego

Remote Viz,
Streaming HDF5
Gridftp
Autodownsample

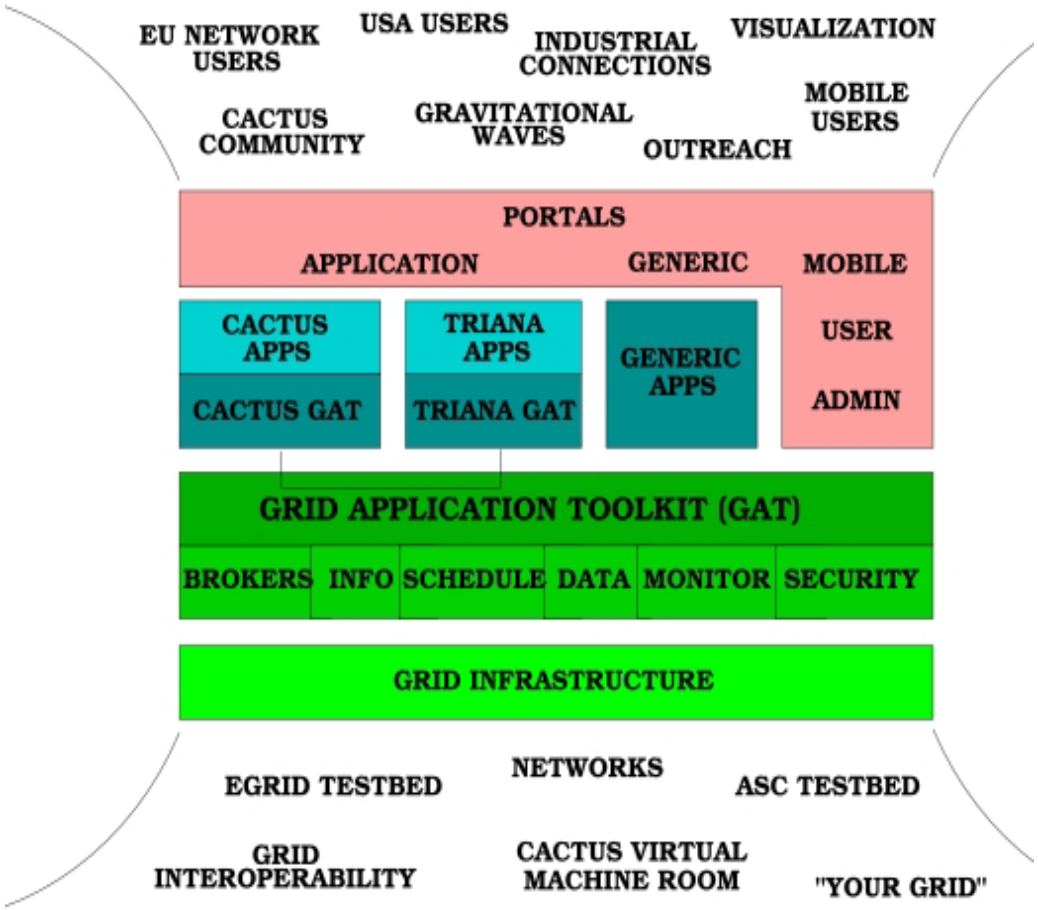


Any Viz Client:
LCA Vision, OpenDX

GridLab: Enabling *Dynamic* Grid Applications

Going far beyond the static model

- EU Project ~€5M led by Jarek Nabrzyksi
- AEI, ZIB, PSNC, Lecce, Athens, Cardiff, Amsterdam, SZTAKI, Brno, ISI, Argonne, Wisconsin, Sun, Compaq
- Testbeds connected across EU, US, Asia
- Grid Application Toolkit for application developers and infrastructure (APIs/Tools)
- Develop new grid scenarios for 2 main apps:
  - Numerical relativity
  - Grav wave data analysis



www.GridLab.org

GridLab: New Paradigms for Dynamic Grids

- Code/User/Infrastructure should be aware of environment
  - What *Grid Sevices* are available??
    - Discover resources available NOW, and their current state?
    - What is my allocation?
    - What is the bandwidth/latency between sites?
- Code/User/Infrastructure should be able to make decisions
  - A slow part of my simulation can run asynchronously…spawn it off!
  - New, more powerful resources just became available…migrate there!
  - Machine went down…reconfigure and recover!
  - Need more memory (or less!)…get it by adding (dropping) machines!
- Code/User/Infrastructure should be able to publish to central server for tracking, monitoring, steering…
  - Unexpected event…notify users!
  - Collaborators from around the world all connect, examine simulation.
- Rethink Algorithms: Task farming, Vectors, Pipelines, etc all apply on Grids… The Grid IS your Computer!

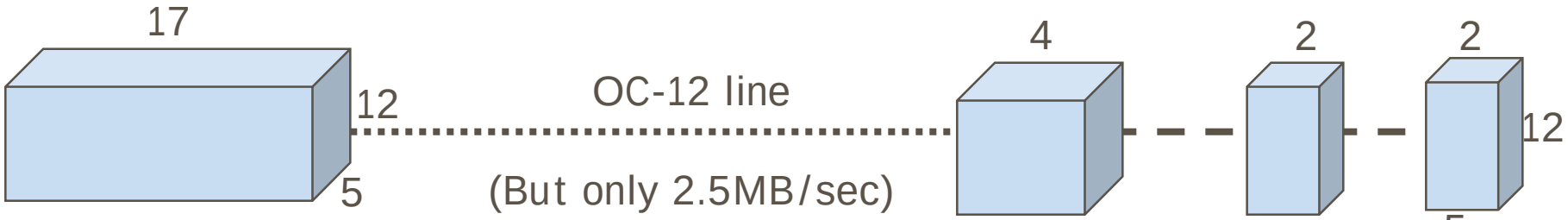
New Grid Applications: some examples

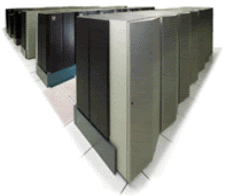
Must get application community to rethink algorithms…

- Intelligent Parameter Surveys, Monte Carlos
  - May control other processes!
- Dynamic Staging: move to faster/cheaper/bigger machine ("Grid Worm")
  - Need more memory? Less?
- Multiple Universe: create clone to investigate steered parameter ("Grid Virus")
- Automatic Component Loading
  - Needs of process change, discover/load/execute new calculation component
- Automatic Convergence Testing
  - from initial data or initiated during simulation
- Look Ahead
  - spawn off and run coarser resolution to predict likely future
- Spawn Independent/Asynchronous Tasks
  - send to cheaper machine, main simulation carries on
- Routine Profiling
  - best machine/queue, choose resolution parameters based on queue
- Dynamic Load Balancing: inhomogeneous loads, multiple grids

Examples of what can be done now

- Three Current Examples, work Now: Building blocks for the future
  - Dynamic, Adaptive Distributed Computing
    - Increase scaling from 15 - 70%
  - Migration: Cactus Worm
  - Spawning





SDSC IBM SP
1024 procs
5x12x17 =1020

NCSA Origin Array
256+128+128
5x12x(4+2+2) =480

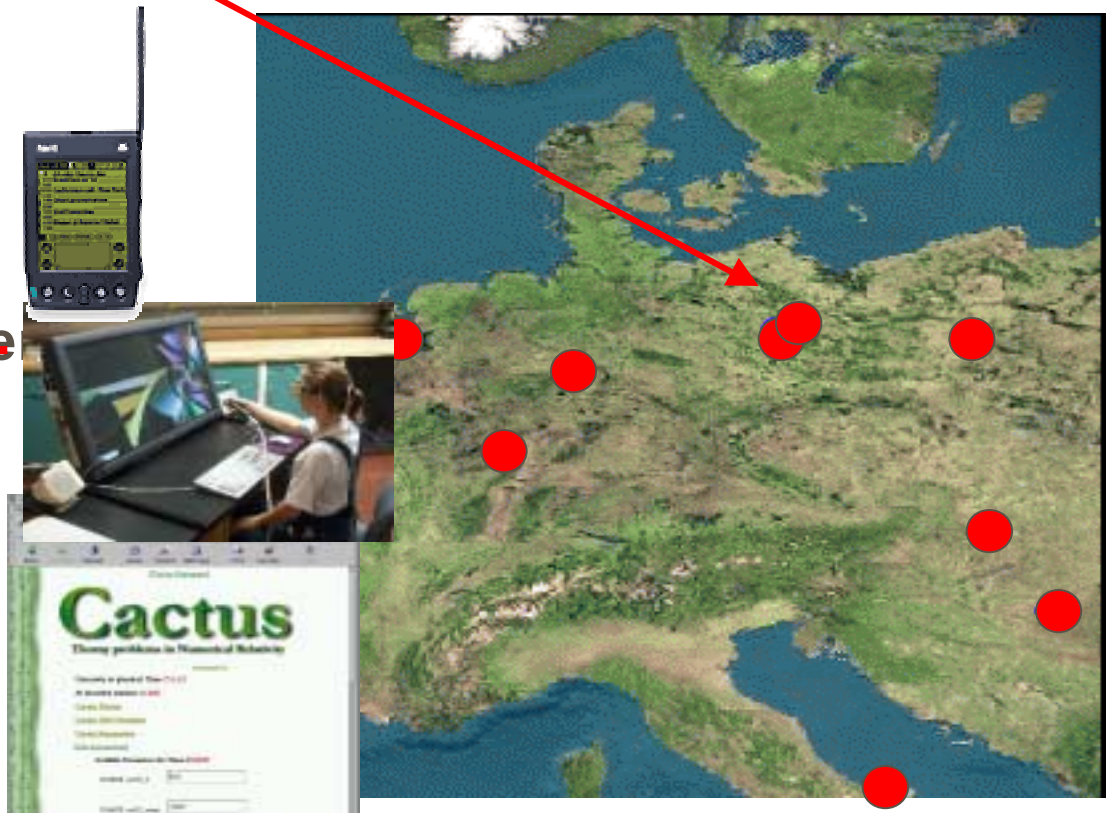
Dynamic Adaptation: Number of ghostzones, compression, …

Won
"Gordon Bell Prize" 2001

Dynamic Grid Computing

- **Migration: "Cactus Worm" demonstrated last year**
  - Launch Job
  - Queries a Grid Information Server, finds available resources
  - Migrates itself to next site
  - Registers new location to
  - User tracks/steers
- **Spawning: New!**
  - User invokes "Spawner"
  - Analysis tasks outsourced
  - Globus enabled resource

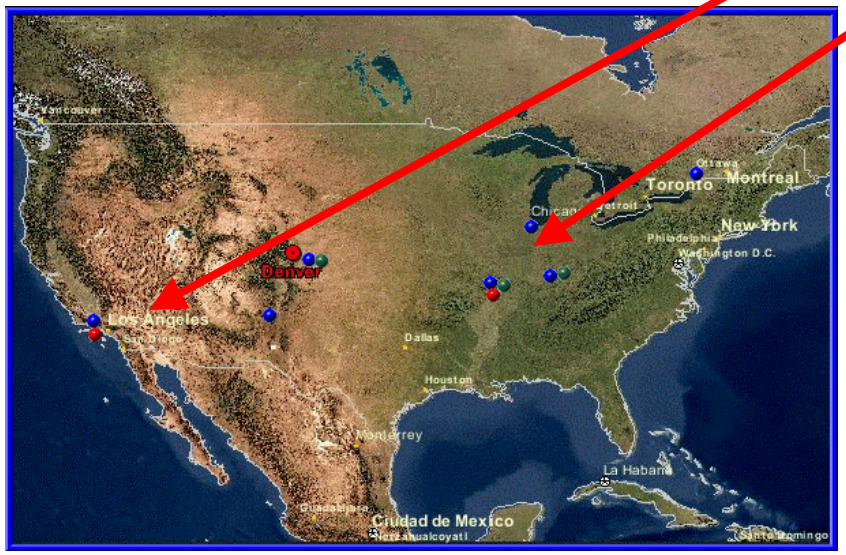
  Discovery, login, data transfe
  - It works!



Spawning across ARG Testbed

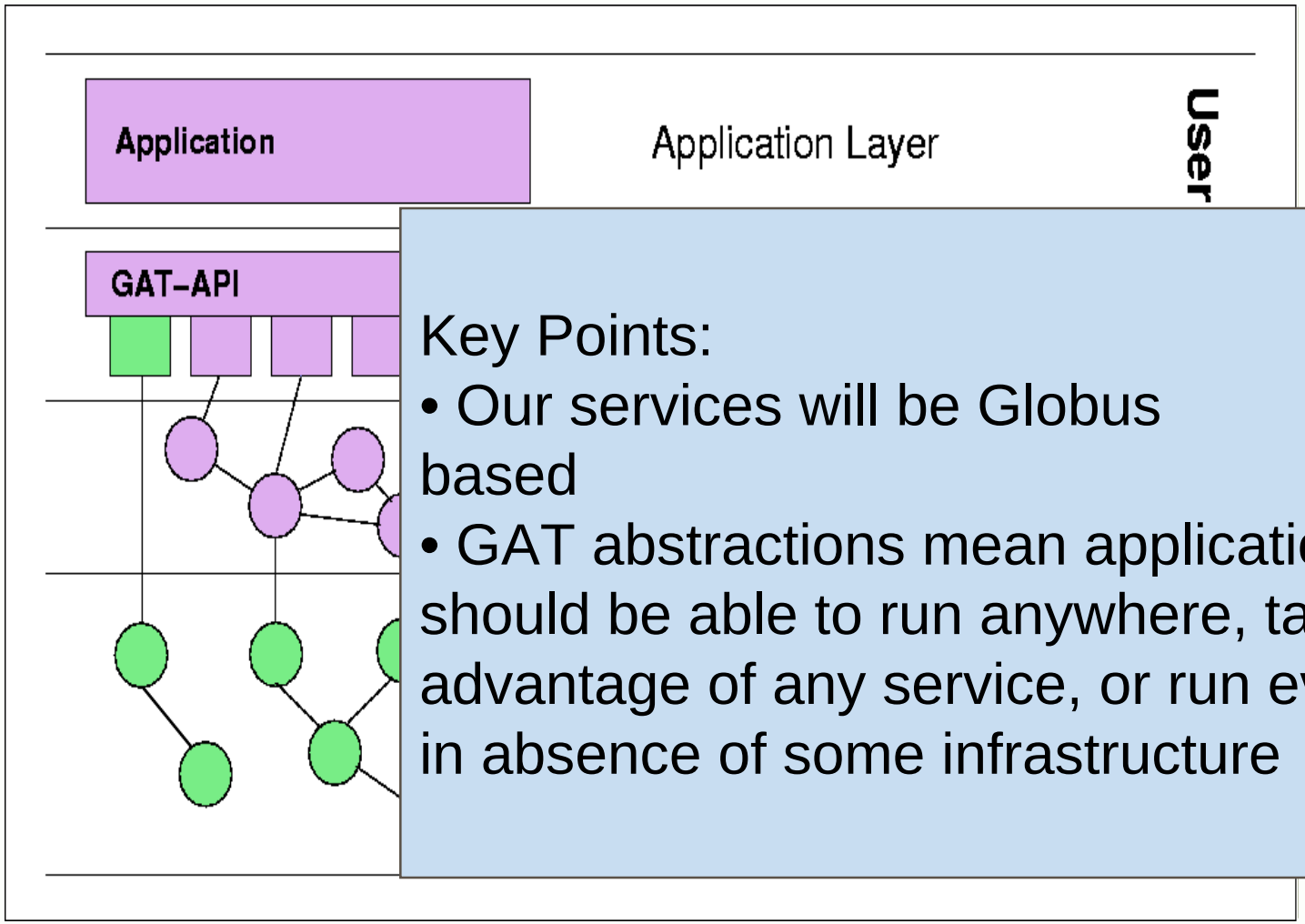
Main BH Simulation starts here

All analysis tasks spawned automatically to free resources worldwide



User only has to invoke "Spawner" thorn…

GAT Architecture



Key Points:

- Our services will be Globus based
- GAT abstractions mean application should be able to run anywhere, take advantage of any service, or run even in absence of some infrastructure

Dynamic Grid Computing

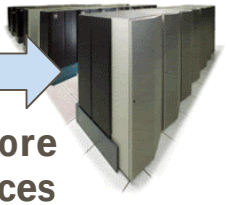
GridLab

We see something,
but too weak.
Please simulate
to enhance signal!

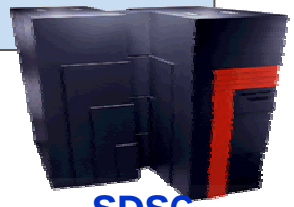
Free CPU

LRZ

SDSC



Add more
resources



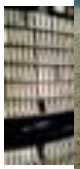
SDSC

eue time over,
l new machine

th
ameter

Calculate/Output
Invariants

Further
Calculations

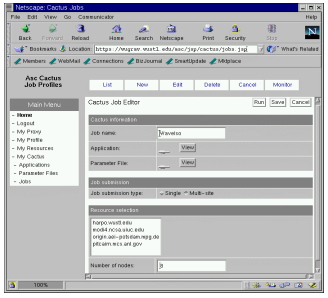


Found a black hole,
Load new component

Look for
horizon

Calculate/Output
Grav. Waves

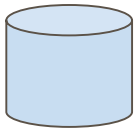
AEI



Find best
resources

NCSA

Archive to LIGO



Summary

- Science/Engineering Drive/Demand Grid Development
  - Problems very large, need new capabilities
- Grids will fundamentally change simulation research
  - *Enable problem scales far beyond present capabilities*
  - *Enable larger communities to work together (they'll need to)*
  - *Change the way researchers/engineers think about their work*
- Dynamic Nature of Grid makes problem much more interesting
  - *Harder*
  - *Matches dynamic nature of problems being studied*
- Need to get applications communities to rethink their problems
  - *The Grid is the computer…*
- Join the Applications Working Group of GGF
- Join our project: http://www.gridlab.org