The National Fusion Collaboratory
A DOE National Collaboratory Pilot Project

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PRESENTATION’S KEY POINTS

- Collaborative technology critical to the success of the FES program
  - Experimental: Fewer larger machines & smaller innovative machines
  - Computation: Moving toward integrated simulation

- The National Fusion Collaboratory Project is implementing and testing new collaborative technologies for fusion research
  - FusionGrid services being used daily to benefit FES research

- The work and experience gained by the National Fusion Collaboratory Project is directly applicable to the ICC community
NATURE OF FUSION RESEARCH DRIVES REQUIREMENTS FOR COMPUTING AND NETWORKING

● Experiments
  — Real time interactions of large, geographically extended teams
  — Real time interactions between specialized small groups
  — Faster between-pulse analysis translates directly to productivity
  — Building an extended team of experts from small groups
  — Barriers to use of powerful analysis tools can be significant

Theory and Computation
  — Simulations producing very large data sets (GB=>TB=>PB)
  — Interactive visualization and analysis presents a severe challenge for computing and networking
  — Increased code sharing and collaborative development

The National Fusion Collaboratory Project (NFC) is addressing these needs
THE GOAL OF THE NFC IS TO ADVANCE SCIENTIFIC UNDERSTANDING & INNOVATION IN FUSION RESEARCH

- **Experimental Facilities**
  - More efficient use resulting in greater progress with less cost

- **Theory & Modeling**
  - Integrate theory & experiment

- **Facilitate multi-institution collaboration**
  - Integrate geographically diverse groups

- **Create standard tool set**
  - To build in these services in the future

**DOE ASCR:**
Half-way through a total of 5 years at $1.8M/year

[Image: FusionGRID logo]
THE NFC PROJECT BENEFITS FROM A DIVERSE TEAM

Synergistic benefits derived from interdisciplinary interactions

- Basic Computer Science Research
  - New capabilities

- Applied Computer Science Research
  - Demonstration
  - User education

- Deployment of Technology
  - Software hardening
  - Ease of use
  - Maintenance & support

Feedback

- ANL: Distributed Systems Lab
- ANL: Futures Lab
- General Atomics: DIII-D Fusion Lab
- LBNL: Distributed Systems
- MIT: C–Mod Fusion Lab
- Princeton Computer Science
- PPPL: NSTX Fusion Lab
- Utah: Scientific Computing & Imaging

FusionGRID
www.fusiongrid.org
NOT FOCUSING ON TRADITIONAL GRID APPLICATIONS – CYCLE SCAVENGING & DYNAMIC CONFIGURATION

- Traditional computational Grids, arrays of heterogeneous servers
- Machines can arrive and leave
- Adaptive discovery where problems find resources
- Workload balancing and cycle scavenging
- Bandwidth diversity where not all machines are well connected

This model is not well suited to fusion computation:
We are aiming to move high-performance distributed computing out onto the wide area network
PLACING DISTRIBUTED APPLICATIONS OUT ON THE WAN PRESENTS SIGNIFICANT CHALLENGES

- Crosses administrative boundaries
- Increased concerns and complexity for security including authentication and authorization
- Resources not owned by a single project or program
- Distributed control of resources by owners is essential
- Needs for end-to-end application performance & problem resolution
  - Resource monitoring, management & troubleshooting not straightforward
  - Higher latency challenges network throughput & interactivity
- People are not in one place for easy communication
THE VISION FOR THE FUSION COLLABORATORY

● Data, Codes, Analysis Routines, Visualization Tools should be thought of as network accessible services

● Shared security infrastructure with distributed authorization and resource management

● Collaborative nature of research requires shared visualization applications and widely deployed collaboration technologies
  — Integrate geographically diverse groups

● Not focused on CPU cycle scavenging or “distributed” supercomputing (typical Grid justifications)

Optimize the most expensive resource - people’s time
VISION – RESOURCES AS SERVICES

- Resources are computers, codes, data analysis routines, visualization tools, experimental operations
- Access is stressed rather than portability
- Users are shielded from implementation details
- Transparency and ease–of–use are crucial elements
- Shared toolset enables collaboration between sites and across sub–disciplines
- Knowledge of relevant physics is still required of course
VISION – SECURITY INFRASTRUCTURE

● Strong authentication identifies users currently based on X.509 certificates from DOE science Grid
  — Interoperability with international Grid Certificate Authorities

● Distributed authorization allows stakeholders to control their own resources
  — Facility owners can protect computers, data, and experiments
  — Code developers can control intellectual property
  — Fair use of shared resources can be demonstrated & controlled
VISION – VISUALIZATION AND A/V TOOLS

- Maximum interactivity for visualization of very large datasets

- Use of extended tool sets for remote collaboration
  - Flexible collaboration environment
  - Shared applications
THE COLLABORATIVE CONTROL ROOM ALLOWS US TO STRESS TEST ALL OF OUR TECHNOLOGIES

- Secure computational resources that can be scheduled as required
- Rapidly compare experimental data to simulation results
- Share individual results with the group via shared displays
- Fully engaged remote scientists with audio, video, shared displays
WORK TOWARDS THE COLLABORATIVE CONTROL ROOM

- Secure Data via MDSplus
- Prototype Computational Service
- Authorization & Enforcement
- Monitoring
- SCIRun Enhancements + Refinements
- Prototype Large Simulation Data Storage
- Simulation Data Server at NERSC

Production Computational Service
Between Pulse Analysis
Prototype Computational Reservation
Control Room Access to Large Simulation Datasets
Usage and Evaluation During Tokamak Experiments

Collaborative Control Room

- Fusion AG Venue with Shared Applications
- AG on Tiled Walls
- Prototype Desktop AG
- Wall to Wall Sharing
- Prototype Tile Walls at D3D/NSTX
- Full Wall Install at D3D/NSTX
- Fully Utilized Tiled Displays in Control Room
- X-Windows Sharing Software

FusionGRID
www.fusiongrid.org
SECURE ACCESS TO FUSION DATA VIA MDSplus

- MDSplus: remote access based on client-server model
  - Used at more than 30 sites (robust)

- Service rather than file oriented

- Hierarchical, self descriptive, extensible, scalable, simple but powerful API

- MDSplus secured on FusionGrid via Globus GSI
  - Underlying technologies are X.509 certificates and OpenSSL

- Parallel network transfer via XIO - useful for high latency networks
TRANSP WAS FIRST GRID SERVICE DEPLOYED:
ANY CODE CAN BE A GRID SERVICE

“This is a success”
- Better support for users
- Users get latest versions
- Better support with less effort
- Access to faster computations

The U.S. TRANSP Service
- 1,800 cases, 10,000 CPU hrs
- 9 fusion experimental machines
FUSION GRID MONITOR: AN EFFICIENT APPLICATION MONITORING SYSTEM FOR THE GRID ENVIRONMENT

- Users track and monitor the state of applications on FusionGrid
  - Output dynamically via HTML, Built as Java Servlet (JDK2.1)
- Code maintenance notification
  - Users notified, queuing turned off, code rebuilt, queue restarted
- Results of simulation visualized during run
  - Both input and output quantities
SCIRUN TO VISUALIZE COMPLEX SIMULATIONS FOR BETTER UNDERSTANDING

- Open source, multi-platform capable for a wide user base
- To facilitate quantitative comparison of simulations & experimental results

SciDAC CEMM NIMROD Simulation of a DIII-D Plasma

Raising the challenge of very large datasets
- MDSplus
- Storage method
- Data location
- Parallel I/O

FusionGRID
www.fusiongrid.org
TILED DISPLAYS INSTALLED IN FUSION CONTROL ROOMS

- Enhanced collaboration within the control room
  - Software for application sharing to tiled walls

- Very well received by fusion scientists
  - Fusion research funds used to purchase tiled walls for control rooms
ACCESS GRID: REAL TIME COMPLEX COMMUNICATION

- Multi-site participants
  - Rich collaborative environment
  - Includes application & data sharing

- Modest cost of entry
  - Open source software
  - Commodity hardware

- Being used for seminars, working meetings, tokamak operations

Personal Interface to the Grid (PIG) motivated by Fusion research
REMOTE LEADERSHIP OF THE JET TOKAMAK IN ENGLAND FROM SAN DIEGO USING FUSIONGRID SERVICES

January 2004, San Diego

Successful and subsequently done: Japan - US & Germany US
ITER:
NFC TECHNOLOGIES SCALE TO THE NEXT DEVICE

● ~$5B class device, over 20 countries
  — Number 1 DOE/SC Facility Priority
  — International collaboration

● Pulsed experiment with simulations
  — ~TBs of data in 30 minutes

● Successful operation requires
  — Large simulations, shared vis, decisions back to the control room
  — Remote Collaboration via FusionGrid

● NFC technology being considered as the model for ITER
ICC COMMUNITY:
NFC TECHNOLOGIES DIRECTLY APPLICABLE

- Reach critical mass of people via remote participation
  - Staff multiplier if full-time travel not required

- Seminars (AG)
  - Share new developments, discuss new ideas

- Diagnostician supporting multiple machines (AG)
  - Remotely operate, analyze data, discuss results, direct maintenance

- Analysis/simulation code shared & widely available (Grid computing)
  - Eliminates multiple installations and support requirements

- Common data interface for easy sharing (MDSplus)
  - Critical for people supporting multiple machines
  - MDSplus includes data acquisition and visualization tools
ICC 2004 DEMO: FUSIONGRID COMPUTING & ACCESS GRID

Stop by for a demonstration!

Grid Monitor

Grid Code GUI

Access Grid: ANL, GA, MIT, ICC

Shared Application
CONCLUDING COMMENTS

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- The National Fusion Collaboratory Project is implementing and testing new collaborative technologies for fusion research
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- FusionGrid services directly applicable to the ICC community
  - Increase the number of collaborators without increasing travel

- The NFC Project welcomes working with new groups
  - We are funded to bring our services to new users
  - Stop by our demonstration in the poster room