

NATIONAL FUSION COLLABORATORY: BUILDING THE FUSIONGRID

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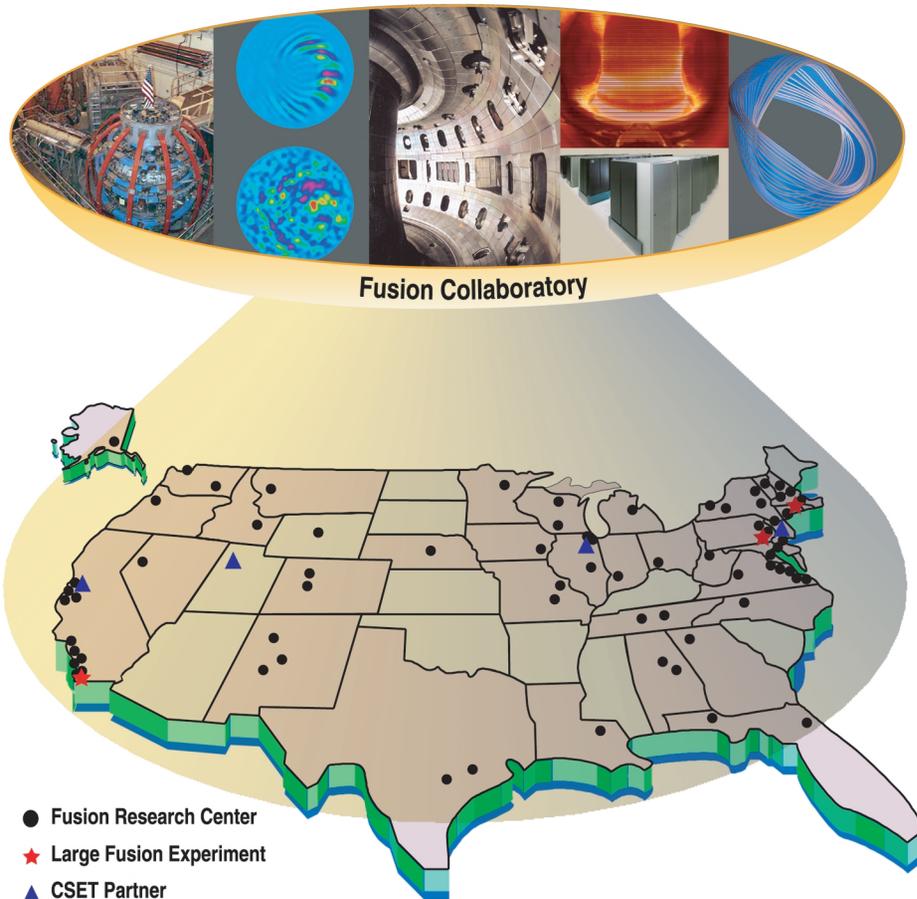
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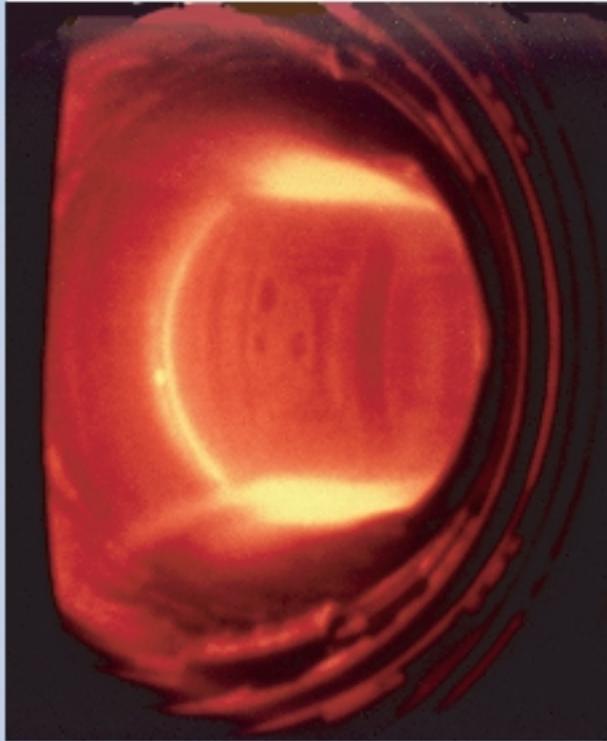


THE COLLABORATORY WILL EMBRACE 40 US SITES IN 37 STATES



- The Collaboratory is being created by a diverse team
 - 3 large fusion experiments
 - * C-Mod, DIII-D, NSTX
 - 4 computer science centers
 - * ANL, LBNL, Princeton U., U. of Utah
- Coordinated with the user community
 - Main experimental sites
 - Theory & simulation community
- 3 year (FY02-04) costing \$5.4 million funded by OASCR SciDAC
 - 2/3 CSET and 1/3 Fusion
 - For software, not hardware

FUSION REPRESENTS A NEARLY INEXHAUSTIBLE ENERGY SOURCE



- Fusion: the joining of two light nuclei releasing energy ($E=mc^2$)
 - Pickup truck of fusion fuel = 21,000 railcars of coal
- Like charges repel so fusion requires high temperature (velocity)
- High temperature rips the electrons away – plasma
- Long term goal – develop reliable energy system that is environmentally and economically sustainable

THE GOAL OF THE FUSION COLLABORATORY IS TO ADVANCE SCIENTIFIC UNDERSTANDING & INNOVATION IN FUSION RESEARCH

- **Enable more efficient use of existing experimental facilities through more powerful between pulse data analysis resulting in a greater number of experiments at less cost**
- **Allowing more transparent access to analysis and simulation codes, data, and visualization tools, resulting in more researchers having access to more resources**
- **Enable more effective integration of experiment, theory, and modeling**
- **Facilitate multi-institution collaborations**
- **Create a standard tool set for remote data access, security, and visualization allowing more researchers to build these services into their tools**

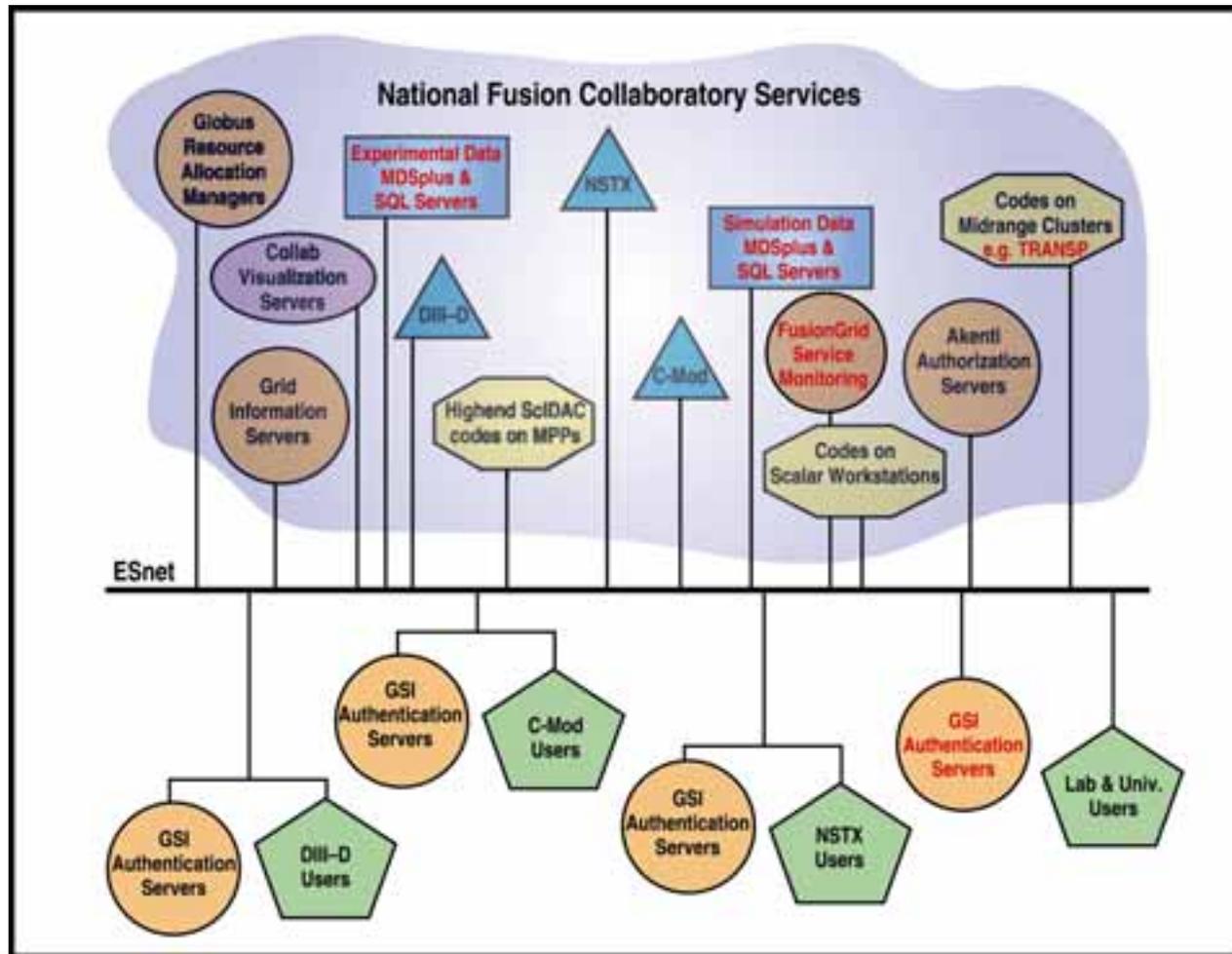
THE NFC PROJECT IS CREATING & DEPLOYING COLLABORATIVE SOFTWARE TOOLS FOR THE FUSION COMMUNITY

- **Create transparent and secure access to local/remote computation, visualization, and data servers**
- **Develop collaborative visualization that allows interactive sharing of graphical images among control room display devices, meeting room displays, and with offices over a wide area network**
 - 3 large fusion machines, ~\$1B replacement value, “Radical Collocation”
 - ~40 research sites in the US, ~1500 scientists
- **Enable real-time access to high-powered remote computational services allowing such capabilities as between pulse analysis of experimental data and advanced scientific simulations**
 - Experiments pulsed every ~20 minutes, time critical analysis
 - Can we do between pulses what today we do the next day?

THE COMPUTER SCIENCE RESEARCH NECESSARY TO CREATE THE COLLABORATORY IS CENTERED AROUND THREE AREAS

- **Security (Globus & Akenti)**
 - Valuable resources need to be protected: data, codes, & vis tools
 - Collaboratory will require authentication, authorization, and encryption
 - Fair use of shared resources
- **Remote and Distributed Computing (Globus, MDSplus)**
 - Share the community's computational resources
 - Job scheduling, monitoring, exception handling, and accounting
- **Scientific Visualization (SCIRun, AG nodes, Tiled Walls)**
 - Increased data quantities and ease of collaboration requires better visualization technology
 - Collaborative control rooms & meeting rooms, and enhanced vis tools

DATA, ANALYSIS AND SIMULATION CODES AND VISUALIZATION TOOLS BECOME NETWORK SERVICES

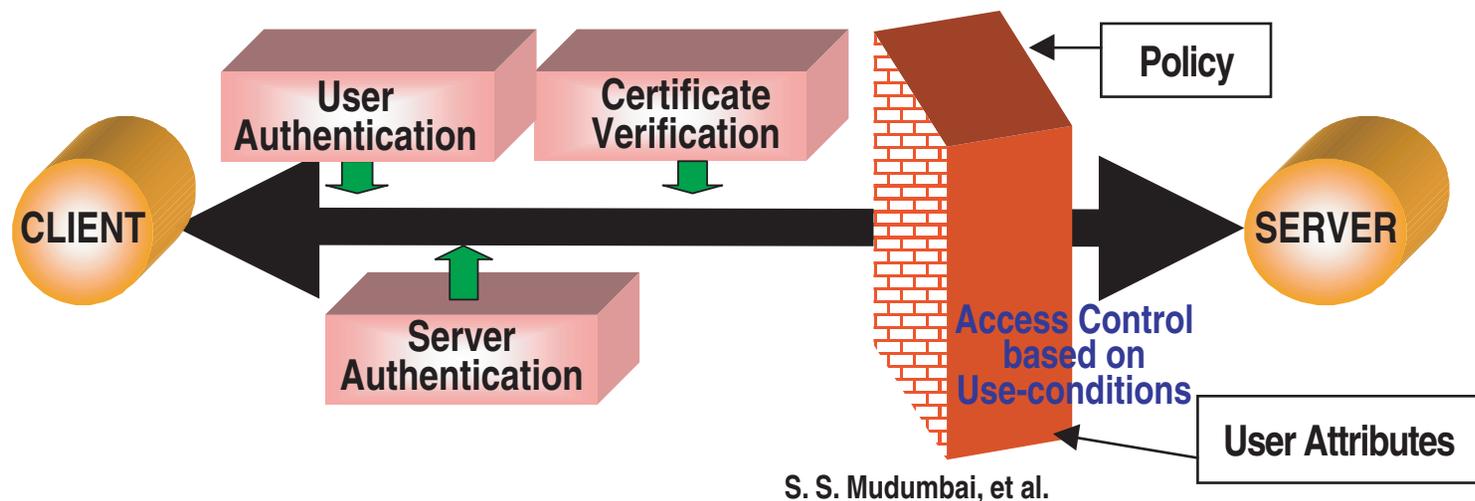


MDSplus PROVIDES A COMMON, SHARED NETWORK ENABLED INTERFACE TO ALL DATA

- **MDSplus is a data system jointly developed by MIT, LANL, & Padova Italy**
 - Provides for acquisition, storage, access, and organization of data
 - Client/server system utilizing TCP/IP
 - Can store experimental, simulation & theoretical data
- **Presently used to serve data at 4 sites in US and 8 worldwide**
 - Includes the 3 large US tokamaks
 - Clients at many sites
- **Many physics analysis codes have been or are being integrated with MDSplus**
 - Transport: MIST, ONETWO, TRANSP
 - MacroStability & Equilibrium: DCON, EFIT, M3D, NIMROD, PEST
 - MicroTurbulence: GS2

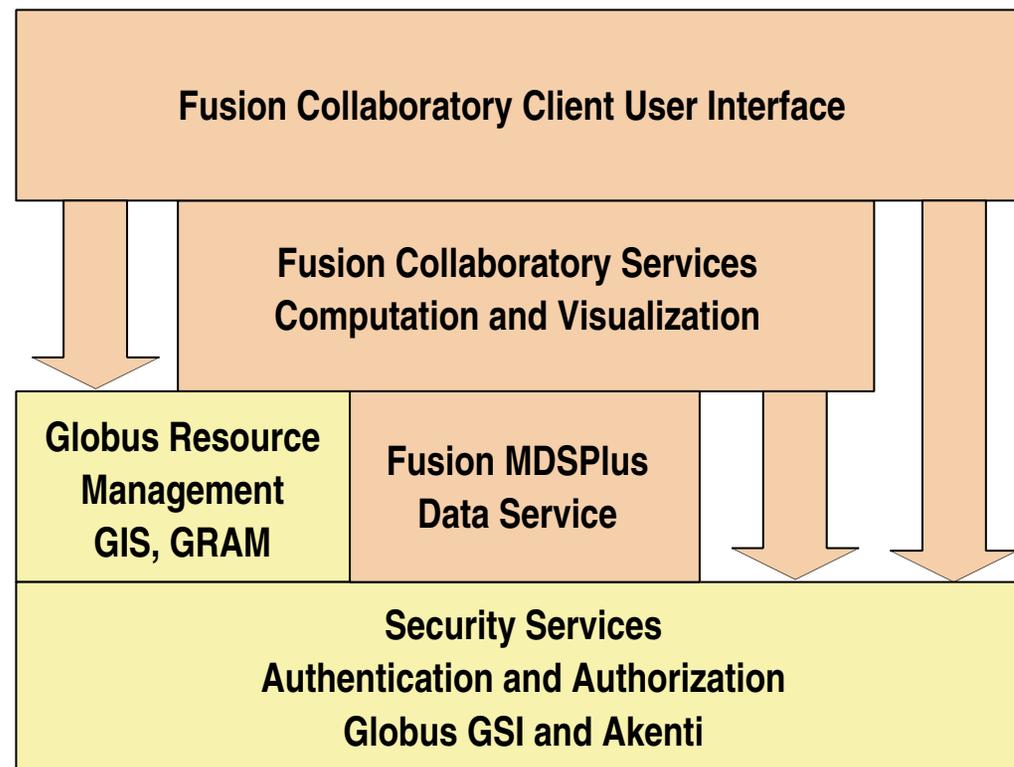
SECURITY: THE COLLABORATORY WILL UTILIZE THE GLOBUS SECURITY INFRASTRUCTURE & AKENTI AUTHORIZATION SERVICE

- Globus is an R&D project for grid based scientific computing
 - Collaborative use of computers, network, & data from multiple organizations
- Akenti is an R&D project for access control
 - Restricted access to distributed resources controlled by multiple organizations
- Fusion codes will be modified to use this infrastructure
- The middleware tools will be extended to meet collaboratory needs



SERVICES ARE LAYERED TO HIDE COMPLEXITY WHILE PROVIDING POWERFUL TOOLKITS FOR DEVELOPERS

- MDSplus will provide the common data access for the Collaboratory
- Globus and Akenti will provide the necessary middleware



TRANSP - A SET OF TOOLS FOR TIME DEPENDENT SIMULATION OF TOKAMAK OPERATION

- TRANSP provides a comprehensive end-to-end modeling capability for magnetic confinement fusion energy experiments
 - Over 20 years development by Princeton Plasma Physics Lab (PPPL)
 - 1,000,000+ lines FORTRAN, C, C++ code
 - 10,000s of lines of supporting script code: Perl, python, shell-script
 - Internationally shared
- TRANSP is fully integrated with MDSplus data system
 - Standard MDSplus trees used by PPPL, MIT, GA
 - Standard software understand both MDSplus and NetCDF representation of results data



TRANSP - DEPLOYED AS FUSIONGRID SERVICE

- Advantages to TRANSP users worldwide
 - Access to PPPL compute servers
 - PPPL maintains single production version
 - PPPL experts debug and sometimes fix failed runs
 - The TRANSP grid service produced 100s of TRANSP runs for APS2002
- PPPL TRANSP run production servers
 - 8 dual processor 1.7GHz Linux cluster nodes
 - Scheduled by dedicated PBS queue
- A suite of client and utility tools are provided
 - For job submission, cancellation and data conversion
 - For monitoring and post processing



FIVE COMPONENTS OF GRID-TRANSP INTERACT THROUGH A GLOBUS-ENABLED MDSplus

- PreTRANSP controller for setting up the TRANSP inputs and starting the run (on user's desktop)
- An MDSplus data server where TRANSP data is read from and written to (at GA)
 - MDSplus server is Globus-enabled
- TRANSP, a data analysis and simulation package (at PPPL)
 - Job submission is through Globus and Akenti server
- FGM monitoring the status of TRANSP analysis jobs (on desktop)
- Scientific visualization of the results with Multigraph (on desktop)



MDSplus and TRANSP are first components of the Production FusionGrid

1) User Authentication

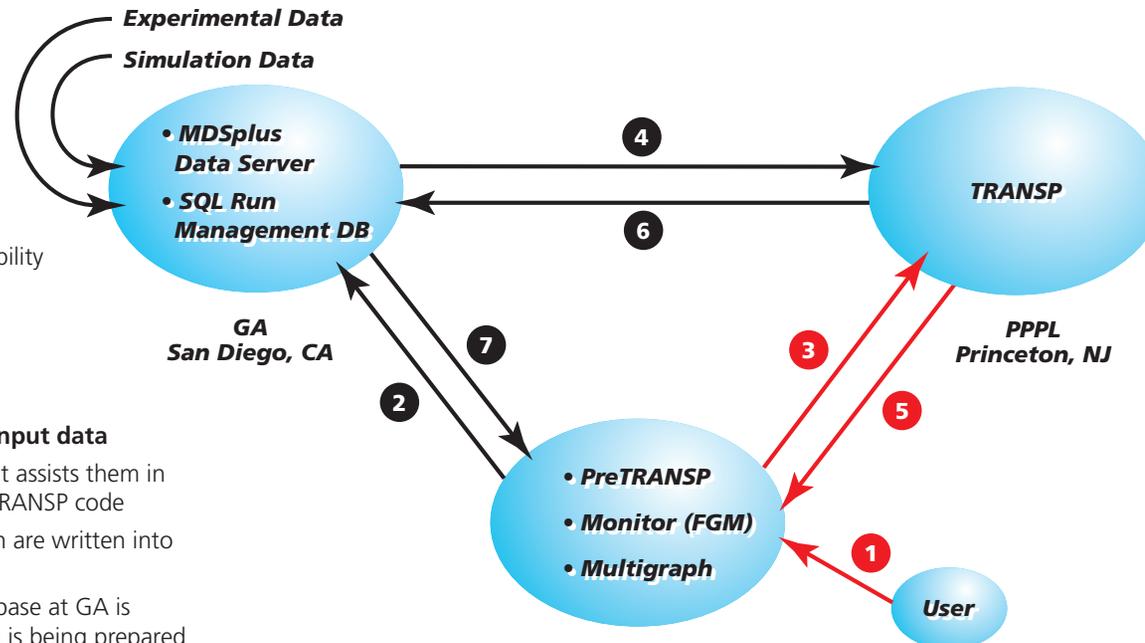
- Person has previously joined the collaboratory by obtaining a credential from the DOE Science Grid Certificate Authority which is an X.509 identity certificate
- User logs onto the FusionGrid using the credential
- Logging onto the Grid uses the Globus GSI single sign-on capability
- Creates a short term proxy certificate that persists through your Grid session

2) PreTRANSP prepares input data

- The user runs a GUI that assists them in creating inputs to the TRANSP code
- Inputs for a TRANSP run are written into MDSplus at GA
- Run management database at GA is updated to indicate run is being prepared
- Data access contingent on authentication & authorization of original user

3) Authorize & Start TRANSP

- Transparently to the user, the TRANSP job is started remotely using Globus GRAM
- Globus GSI transparently verifies that the user is who the credential says it is
- Globus GRAM calls Akenti to check the authorization policy for the user
- If authorized, the TRANSP run is queued for execution



4) TRANSP reads input

- TRANSP reads input data from MDSplus and Run Management Database located at GA
- Data access contingent on authentication & authorization of original user

5) TRANSP runs with monitoring

- TRANSP runs on PPPL Linux cluster
- FusionGrid Monitoring system allows the user to track the status of their run

6) TRANSP writes data

- TRANSP output is written to MDSplus and the Run Management Database located at GA

7) Visualize TRANSP data

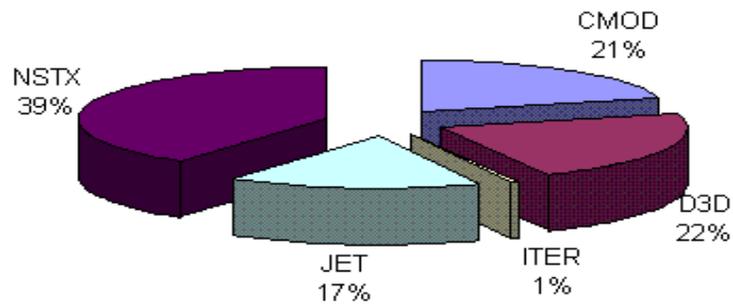
- When the TRANSP run is completed data can be viewed on any visualization system that is MDSplus aware
- For shorter time-frame calculations, an event can be declared upon job completion that automatically triggers a visualization

Desktop Anywhere

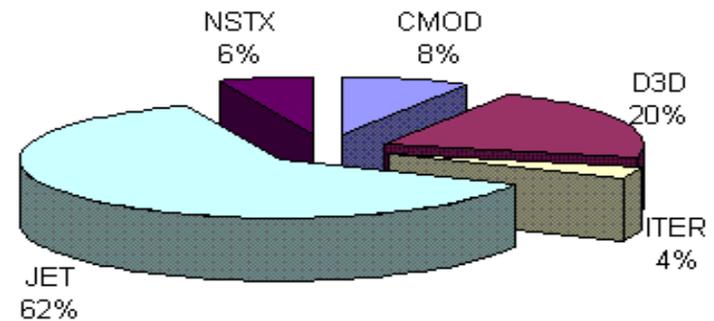


TRANSP RUNS ON FUSIONGRID - OCTOBER 2002

The Month before APS/Division of Plasma Physics Annual Meeting



Total of 300 Runs

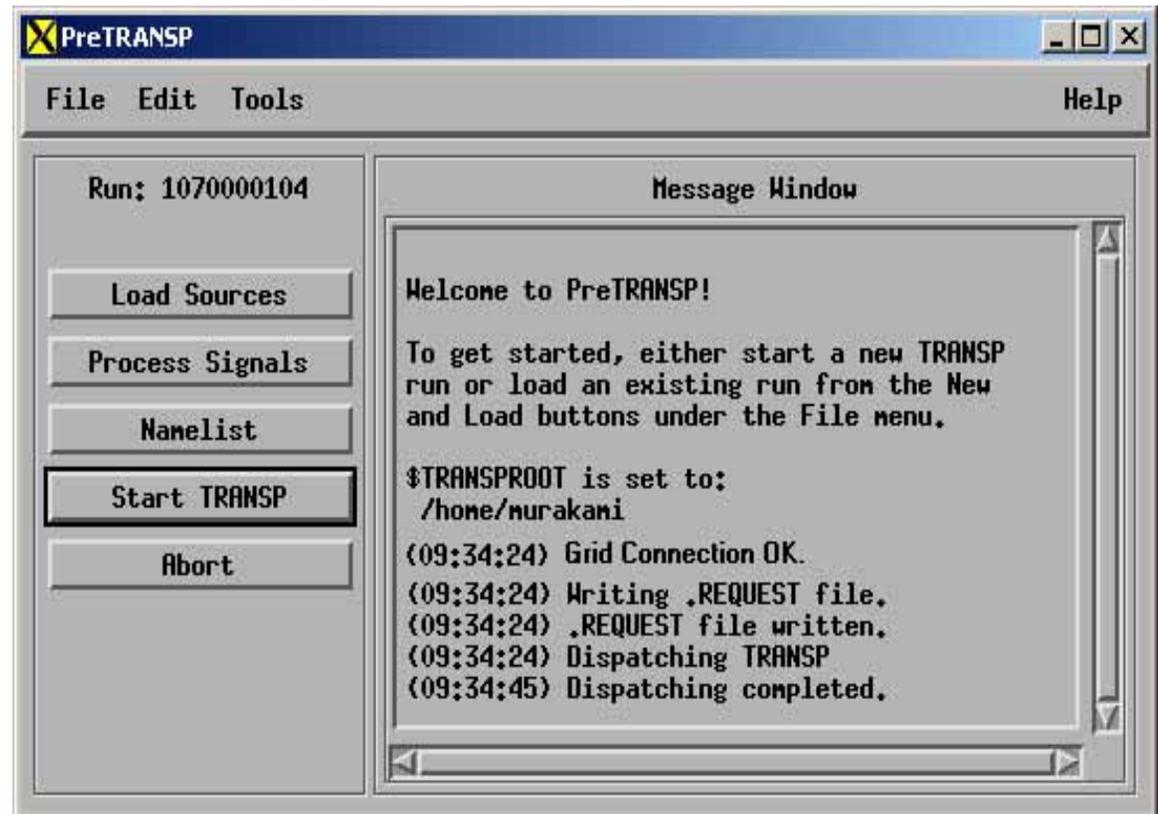


Total of 1474 Hours on 1.7GHz P4s
- PPPL Linux Cluster.

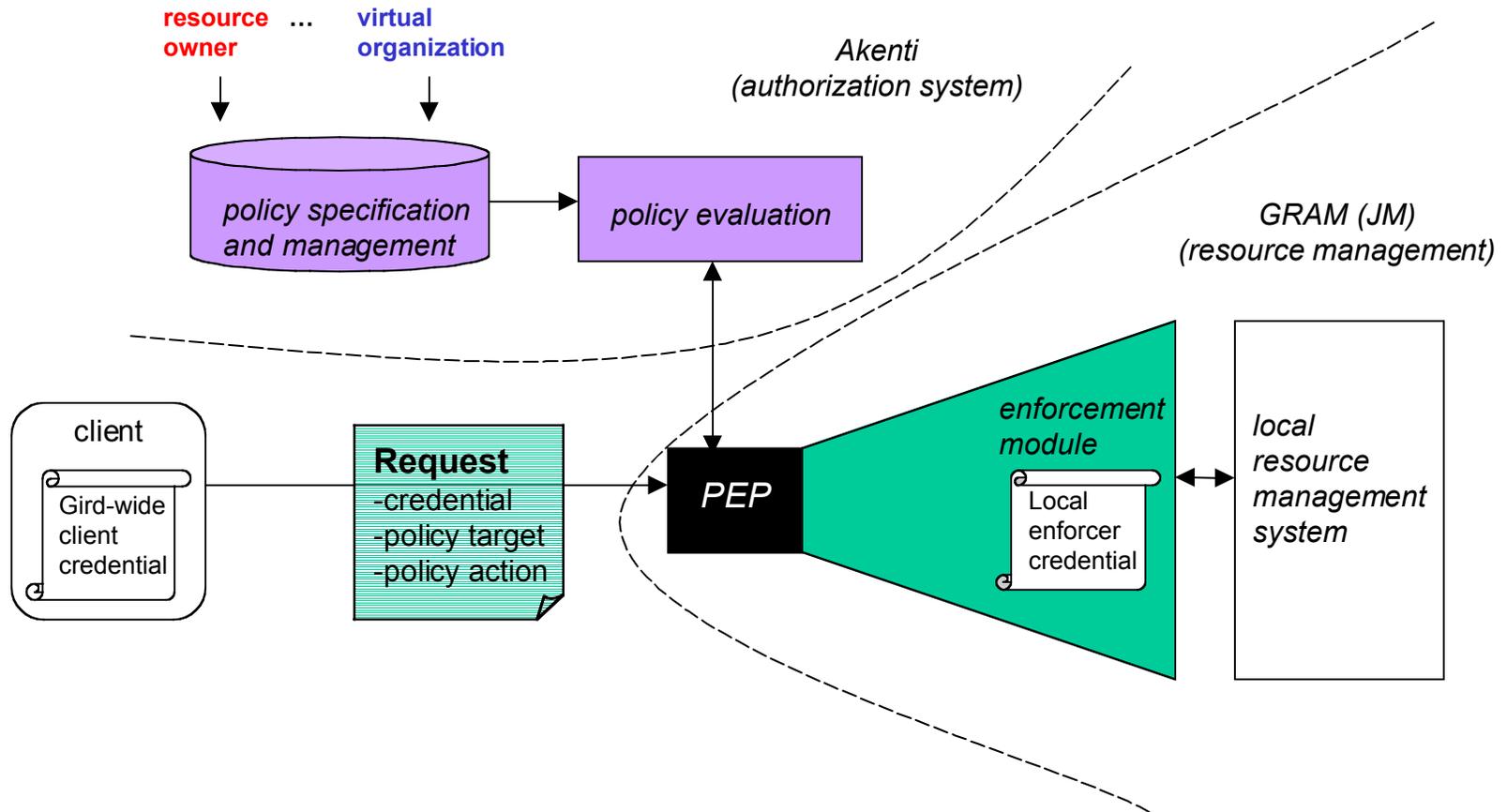


PRETRANSP WITH DATA DRIVEN DESIGN TO SETUP AND LAUNCH A TRANSP RUN FROM ANY SITE

- Log onto FusionGrid
- Prepare data for TRANSP run and store inputs in MDSplus
- Submit TRANSP
- Monitor state of run
- TRANSP writes results to MDSplus
- Visualize TRANSP data



ISSUES OF TRUST



FINE-GRAIN AUTHORIZATION OF JOB AND RESOURCE MANAGEMENT REQUESTED

- Authorization solution enables a system to perform fine-grain authorization of user requests for job startup and management
- At job startup
 - Evaluate users Resource Specification Language (RSL) request against rights defining policies on resource usage
 - how much CPU, memory a user can use on a given resource, which executable one can run
- Allow virtual organization (VO) members other than the user who started the job to manage the user's job



AUTHORIZATION SOLUTION WITH GLOBUS TOOLKIT 2 (GT2) AND AKENTI

- An authorization module plugin in the Globus GRAM Job Manager code
 - Called at job startup or when management action is performed
 - Configurable by the site administrator
 - Plugin passes to authorization module: GSS security context of users, action to be performed, job identifier, job info in RSL
- Authorization module implemented with Akenti
 - Interface module extracts X.509 certificate of the requestor
 - Akenti server returns the rights of the user
 - Authorizes a request or returns authorization error to the Job Manager



FUSION GRID MONITOR (FGM) - A FAST AND EFFICIENT MONITORING SYSTEM FOR GRID ENVIRONMENT

- FGM allows users to track and monitor the state of applications on the FusionGrid
 - Centralized monitoring capabilities are required to maintain a manageable workload by the FusionGrid users
 - Capable of tracking multiple applications running on the grid environment
- How FGM achieves its speed and efficiency
 - Not CPU intensive
 - Does not rely on polling of data on the client side
 - Does not handle numerical intensive calculations itself
 - Receives information generically from other computers on the grid



IMPLEMENTATION OF FGM

- Build as Java Servlet (using JSDK2.1)
 - Receives information as HTTP post request from remote applications running on FusionGrid
 - Allows any application, written in any languages with a system call capability to post status from any host with basic Java installation
 - Only acknowledges messages posted from authorized/specified hosts
- Provides outputs through HTML dynamically
 - Server push allows FGM to update each client in real time
 - IE does not support server push, client pull is used
 - FGM web page allows sorting by code runid, username, or tokamak
 - Include status of individual jobs and general code update notice
 - Detailed log files of a run are accessible from FGM





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FGM (Fusion Grid Monitor) - Tokamaks

[Fusion Grid Monitor - Runs](#)[Fusion Grid Monitor - Users](#)[Fusion Grid Monitor - Tokamaks](#)[Help](#)

Tokamak: NSTX

User	Run ID	Code	State	Last Updated	Comments
kaye	107758A01	TRANSP	Completed	2002-11-07 14:07:35.0	Completed on petrel015.pppl.gov on Thu Nov 7 17:07:18 EST 2002

Tokamak: TFTR

User	Run ID	Code	State	Last Updated	Comments
ludesche	37065Y03	TRANSP	Completed	2002-11-06 12:53:50.0	Completed on petrel015.pppl.gov on Wed Nov 6 15:53:29 EST 2002
ludesche	37065Y01	TRANSP	Canceled	2002-11-07 12:45:16.0	Thu Nov 7 15:45:02 EST 2002
pshare	103102A03	TRANSP	Canceled	2002-11-06 14:15:10.0	Wed Nov 6 17:14:45 EST 2002

Tokamak: D3D

User	Run ID	Code	State	Last Updated	Comments
pshr0009	111203A39	TRANSP	Canceled	2002-11-07 07:18:54.0	Thu Nov 7 10:18:52 EST 2002
burruss	111203A04	TRANSP	Completed	2002-11-06 21:59:45.0	Completed on petrel015.pppl.gov on Thu Nov 7 00:58:50 EST 2002
peng	0A05	TRANSP	Canceled	2002-11-07 12:16:31.0	Cancel requested



100%

3K read (stalled)

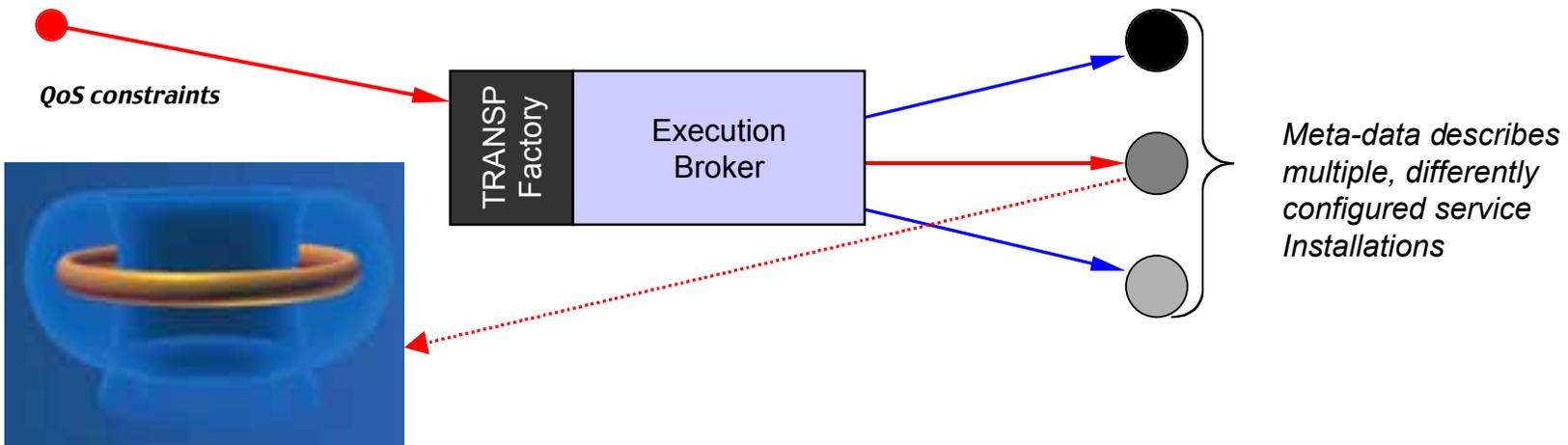


VIRTUAL APPLICATION SERVICES (VAS) FOR RESOURCE MANAGEMENT

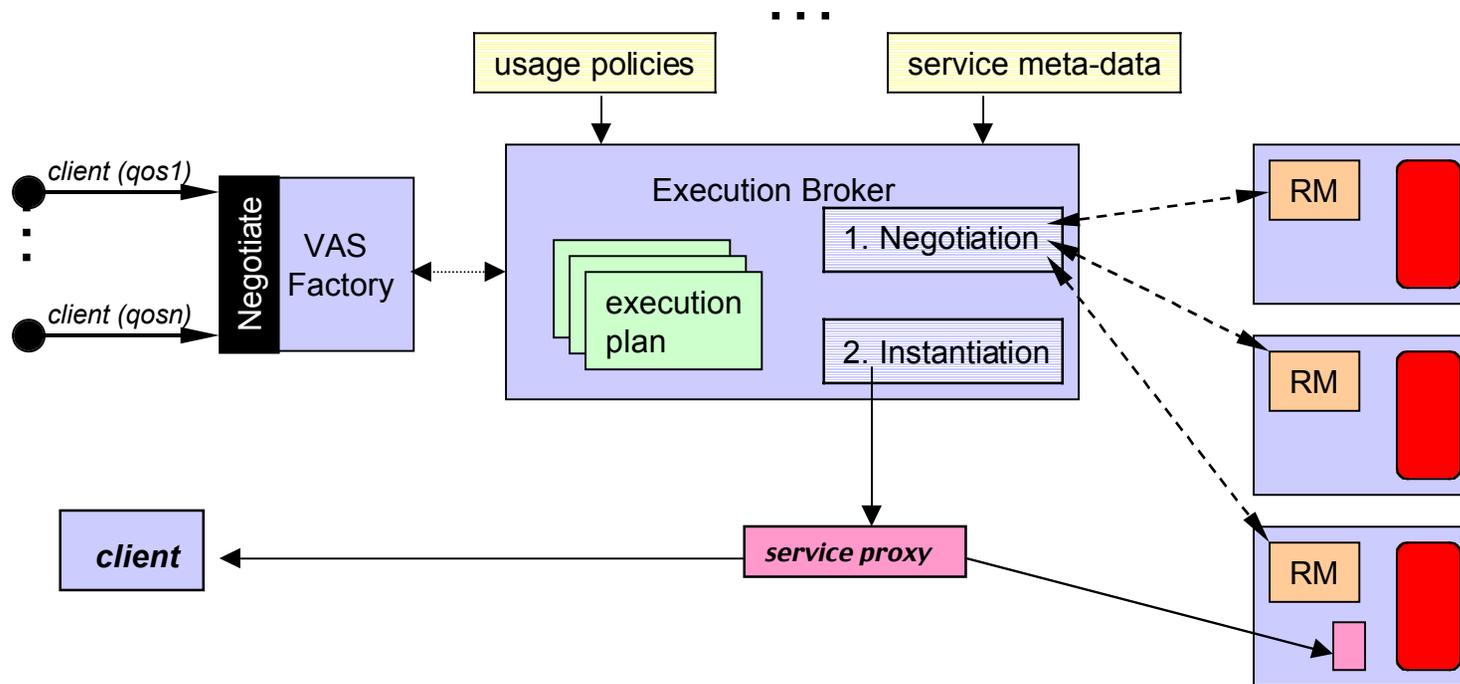
- Requirements
 - Codes as “network services” (portability reasons)
 - Different interaction modes
 - Real-time constraints (between experimental pulses: ~15mins)
 - Batch jobs where accuracy is important

Client's view:

Service Provider's view:



VAS: BEHIND THE SCENES



- Adaptive capabilities
- Capable of adjusting to different models

FIREWALL - THE MAJOR ISSUE ENCOUNTERED DURING GRID-TRANSP DEPLOYMENT

- **Globus Toolkit requires**
 - Opening specific ports for services (e.g. GRAM)
 - Opening a range of non-deterministic ports for both client and server
- **Site policies require**
 - Blocking ports; only opening ports for specific IPs
 - Authenticating firewall with SecureID card
 - NAT configuration
- **Security issues being discussed with ESNET community**
 - Motivating site-security and grid-computing groups to work together toward an agreeable and manageable solution
 - How to integrate international partners



SCIENTIFIC VISUALIZATION IS AN INTEGRATED COMPONENT OF THE NFC PROJECT

- Scientific visualization with 3-D simulation code
 - SCIRun adapted for fusion with NIMROD 3-D simulation code as the first testing code
- Shared visualization between tiled display walls demonstrated
 - Simulate communication to tokamak experiment control room
 - Both workstation-to-wall and wall-to-wall are possible
- Small desktop Access Grid personal node (PIG) demonstrated
 - Target for the small research center
 - Can be used for communication to control room



FUTURE WORKS ON BUILDING THE FUSIONGRID

- Building the infrastructure
 - Deploy dedicated CA and GSI services
 - Refine Akenti mechanisms
 - Expand Globus resource management to support between-pulse analysis
- Adapt fusion tools to the grid
 - Develop fusion specific resource policies
 - Implement between-pulse grid based experimental data analysis
 - Add more fusion codes to the FusionGrid
- What impact will the complete redesign of Globus have on NFC project?



SUMMARY

- The 3-year project to create a Fusion Collaboratory is in its second year
 - Demonstrations to and feedback from the scientific community
 - TRANSP as FusionGrid service released in October 2002
- Team effort comprised of fusion scientists and computer scientists
- The collaboratory will enable networked real-time data analysis of instantaneous communication amongst geographically dispersed teams and experimentalists and theoreticians
- More information at <http://www.fusiongrid.org>

