Advances in Remote Participation for Fusion Experiments

Presented by

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at

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Poster Session P2–C
This Afternoon in Capriate Hall

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ACKNOWLEDGMENT

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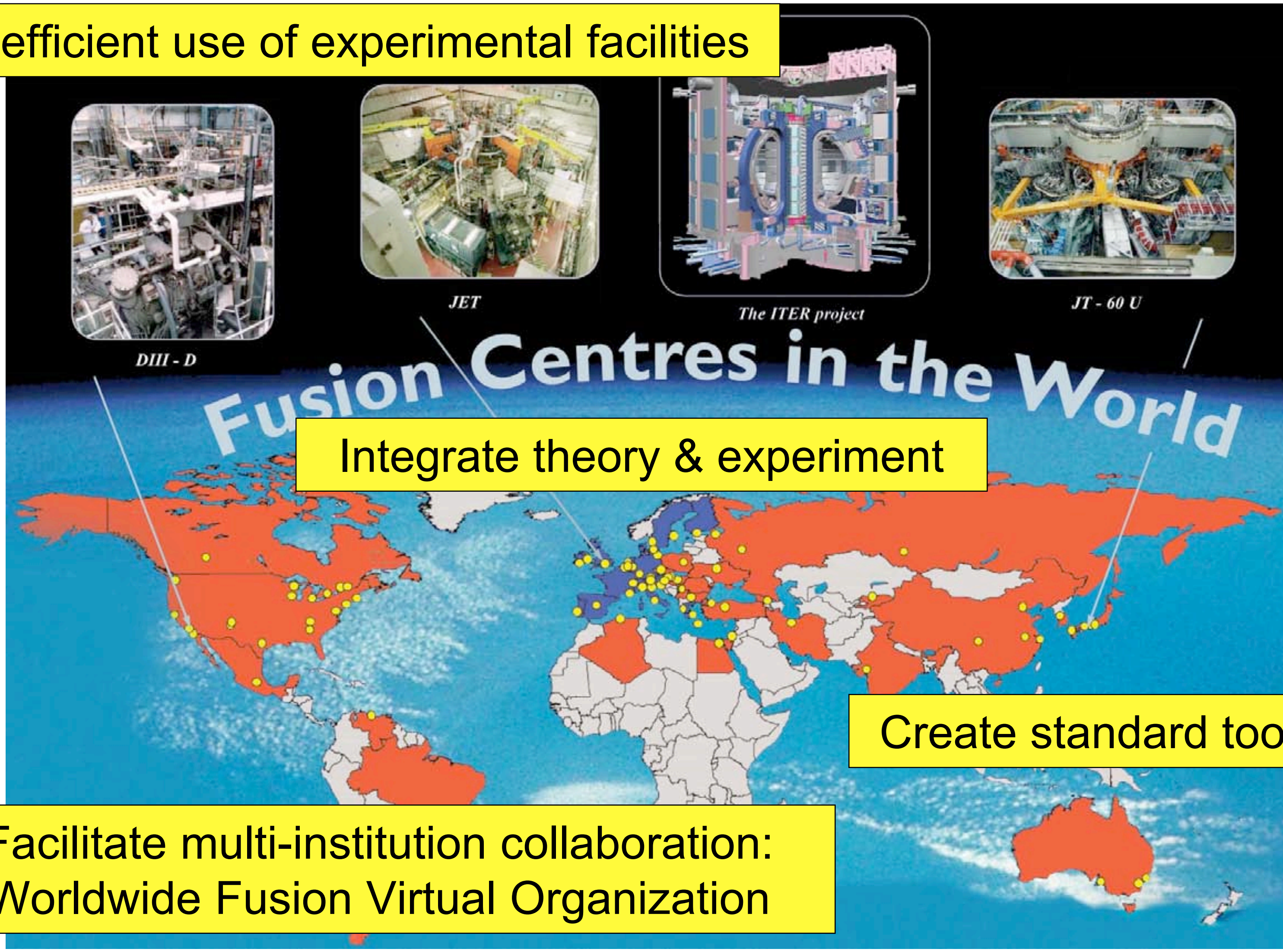
  - Office of Fusion Energy Sciences
  - Office of Advanced Scientific Computing Research
  - National Fusion Collaboratory Project (http://www.fusiongrid.org/)
    - * ANL, GA/DIII-D, LBNL, MIT/C-Mod, PPPL/NSTX, Princeton University, University of Utah
- In Europe, supported by the European Commission
  - European Fusion Development Agreement (EFDA)

PRESENTATION'S KEY POINTS

- Collaborative technology critical to the success of the FE program
  - Experimental: Fewer, larger machines in future (KSTAR, ITER)
  - Includes design, engineering and construction phase
  - Computation: Moving toward an integrated simulation
- Both the EU and US programs are implementing and testing new collaborative technologies for fusion research
  - Being used to benefit daily FE research
- Work is still needed to make RP technology suitable for routine use
  - Ease-of-use, but not neglecting security ("security with transparency")
  - Interoperability of technologies

THE GOAL OF RP TECHNOLOGY IS TO ADVANCE UNDERSTANDING & INNOVATION IN FUSION RESEARCH

More efficient use of experimental facilities



Integrate theory & experiment

Create standard tool set

Facilitate multi-institution collaboration:
Worldwide Fusion Virtual Organization

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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
  - Real time interactions of geographically extended teams

OUR WORK FOCUSES ON FOUR AREAS

- Production computational Service: Grid Computing
  - Grid computing: large-scale integration of distributed computer systems
  - Power grid analogy: remote resources accessible from your laptop much the same way as electricity is delivered to your home
- Compare theory & experiment: Access to large datasets
  - Both a visualization and data handling challenge
- Fully engaged remote scientists
  - Real-time human interaction at a distance
- Tiled display wall for collocated collaboration
  - For the large groups in the tokamak control room

THE VISION FOR RP TECHNOLOGIES

- Data, Codes, Analysis Routines, Visualization Tools should be thought of as network accessible services
  - Access is stressed rather than portability
  - Transparency and ease of use are crucial elements
  - Not CPU cycle scavenging or "distributed" supercomputing

- Shared security infrastructure with distributed authorization and resource management
  - Ease of use: "security with transparency"
  - X.509 certificates from a trusted Certificate Authority
  - Distributed authorization allows stakeholders to control their resources

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

Optimize the most expensive resource - people's time

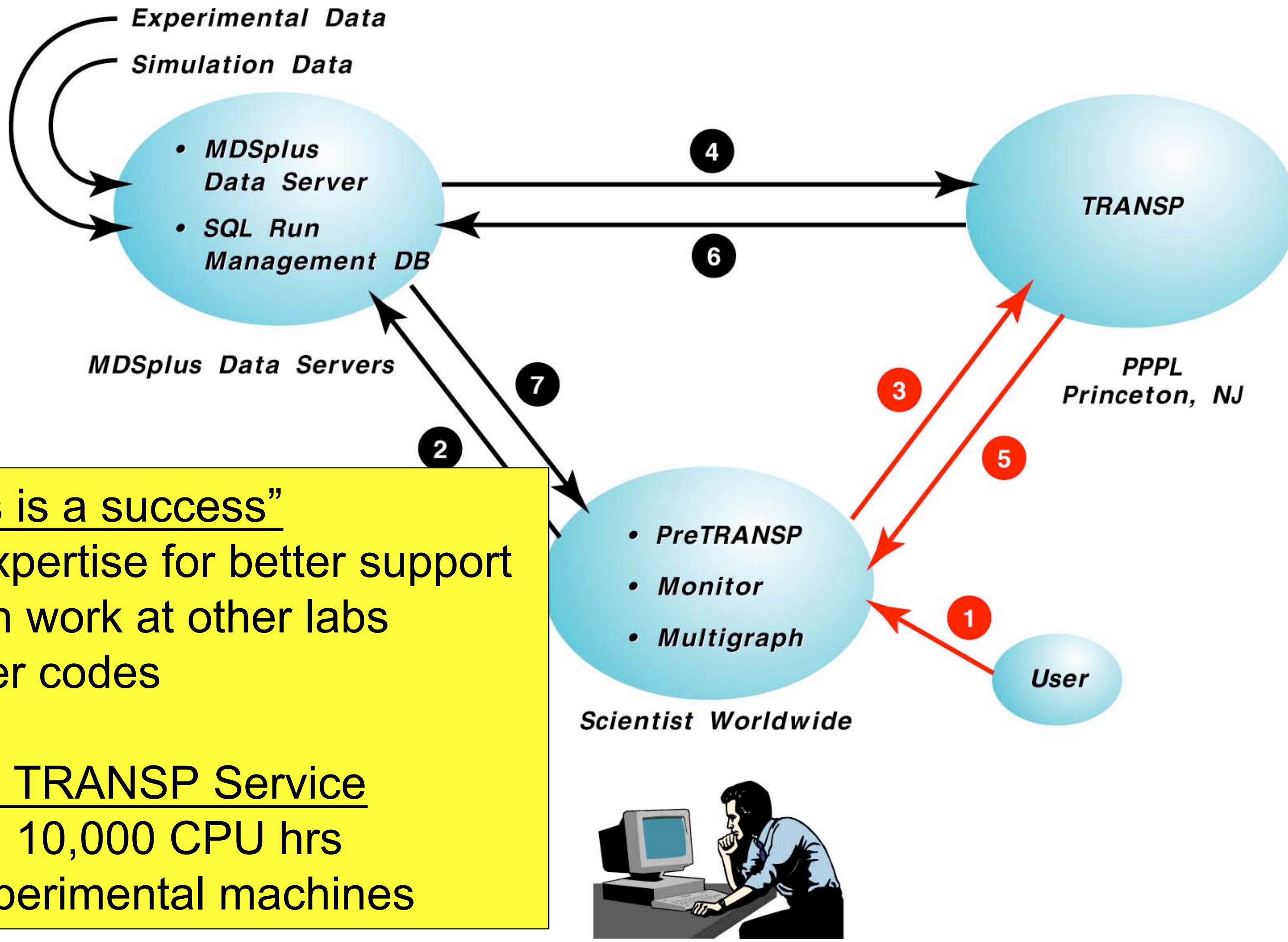
PLACING DISTRIBUTED APPLICATIONS OUT ON THE WAN PRESENTS SIGNIFICANT CHALLENGES

- 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

MDSplus: SECURE ACCESS TO FUSION DATA

- MDSplus: remote access based on client-server model
  - In use for over 10 years (robust)
- Wide adoption worldwide
  - Unifying the data interface (e.g. Visualization)
- MDSplus data access secured with Globus GSI
  - X.509 certificates

SUCCESSFUL GRID COMPUTING FOR FUSION SCIENCE



<u>"This is a success"</u>

- Centralized expertise for better support
- Reduce admin work at other labs
- Model for other codes

<u>***The*** U.S. TRANSP Service</u>

- 4,200 cases, 10,000 CPU hrs
- 10 fusion experimental machines

ADVANCED RESERVATION COMPUTATION FOR DATA ANALYSIS TO SUPPORT EXPERIMENTAL SCIENCE

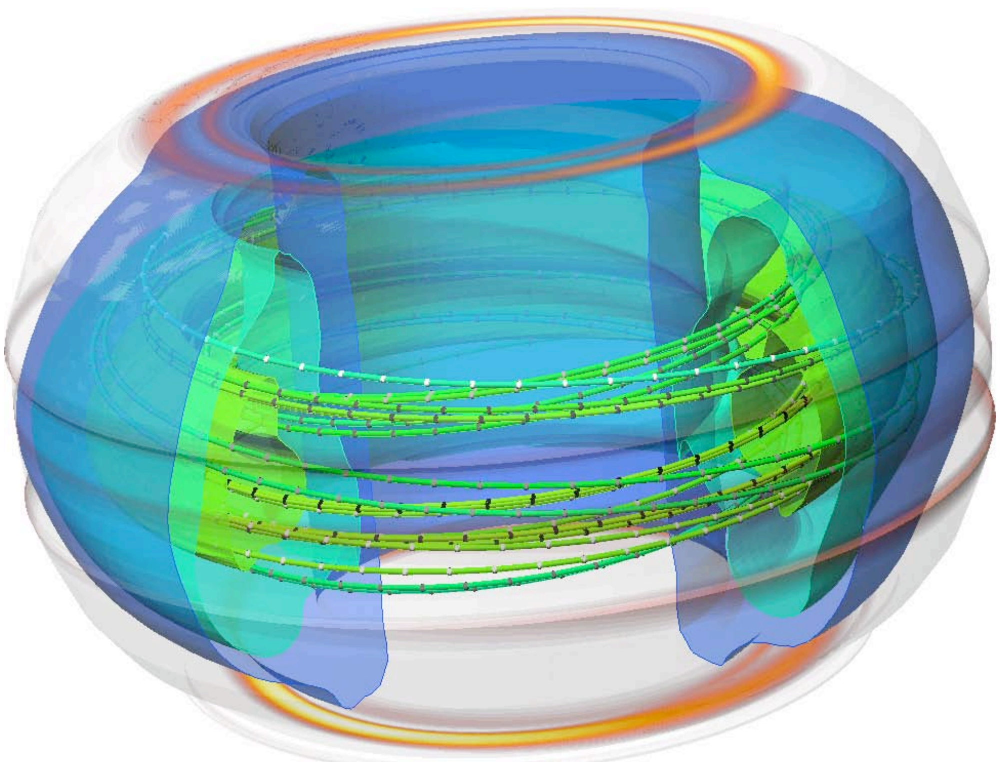
- Long-term vision: code runs on supercomputers between pulses
  - Data management
  - Network QoS
  - Visualization
  - CPU scheduling
  - Faster CPUs and algorithms

- End-to-end agreement being prototyped on FusionGrid
  - CPU reservation
  - Network transfer agreements based on simple prediction

- FusionGrid service TRANSP being tested between pulses
  - First such capability for fusion energy research

VISUALIZE COMPLEX SIMULATIONS WITH EXPERIMENTAL DATA FOR BETTER UNDERSTANDING

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



NIMROD Simulation of a DIII-D Plasma

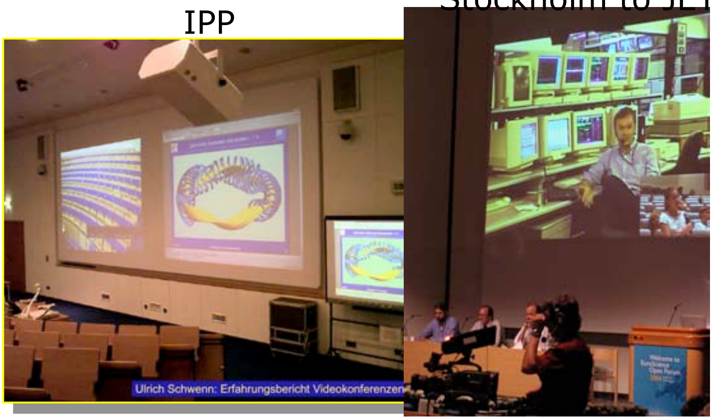
Raising the challenge of very large datasets
- – MDSplus
- – Storage method
- – Data location
- – Parallel I/O

ADVANCED COLLABORATIVE ENVIRONMENTS ENABLE INCREASED PRODUCTIVITY FOR COLLABORATIVE WORK

IP VideoConference: Commerical H.323

IPP

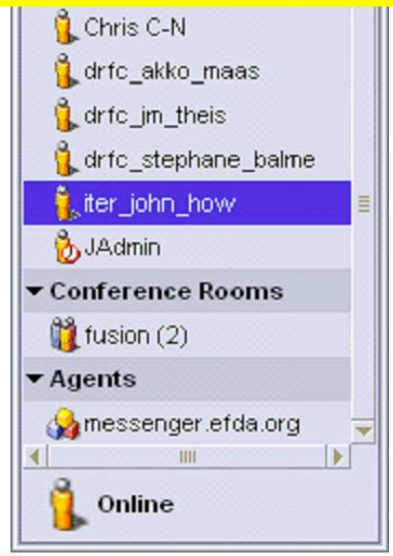
Stockholm to JET



IP Desktop Sharing

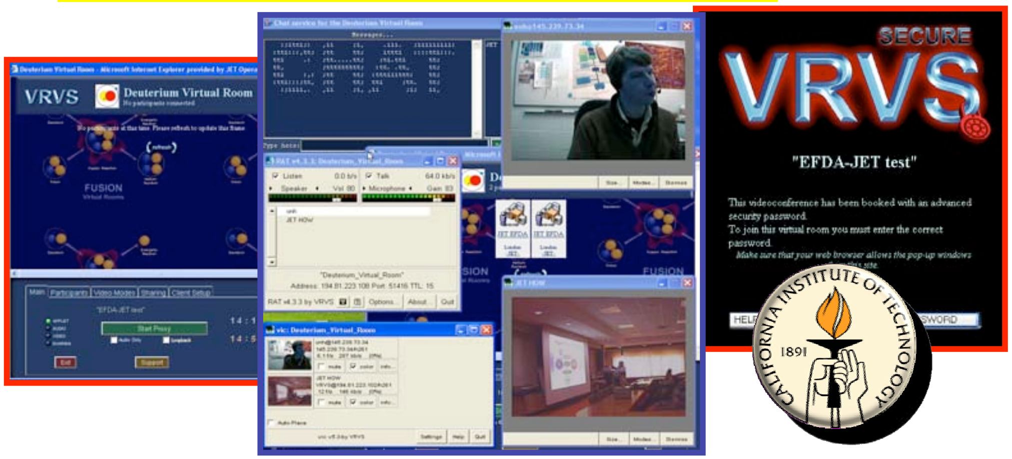
REAL VNC

Instant Messaging: Asynchronous Communication



Jabber SoftwareFoundation

IP VideoConference: VRVS



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ACCESS GRID: REAL TIME COMPLEX COMMUNICATION

- Small to large immersive nodes
  - Open source software
  - Commodity hardware
- Software framework for Collab.
  - Shared applications
  - Customized software allowed

- Being used for seminars, working meetings, tokamak operations
- AG nodes are international: 300 nodes and counting
  - All UK e-Science centers have AG rooms

Interoperability of technologies is critical

TILED DISPLAYS INSTALLED IN FUSION CONTROL ROOMS

DIII-D Tokamak Control Room

NSTX Tokamak Control Room

- Enhanced collaboration within a large control room
  - “Publish” your analysis for the group to see and discuss
- Share and collaborate between tiled displays
  - Clone of tokamak control room (discussed for ITER)

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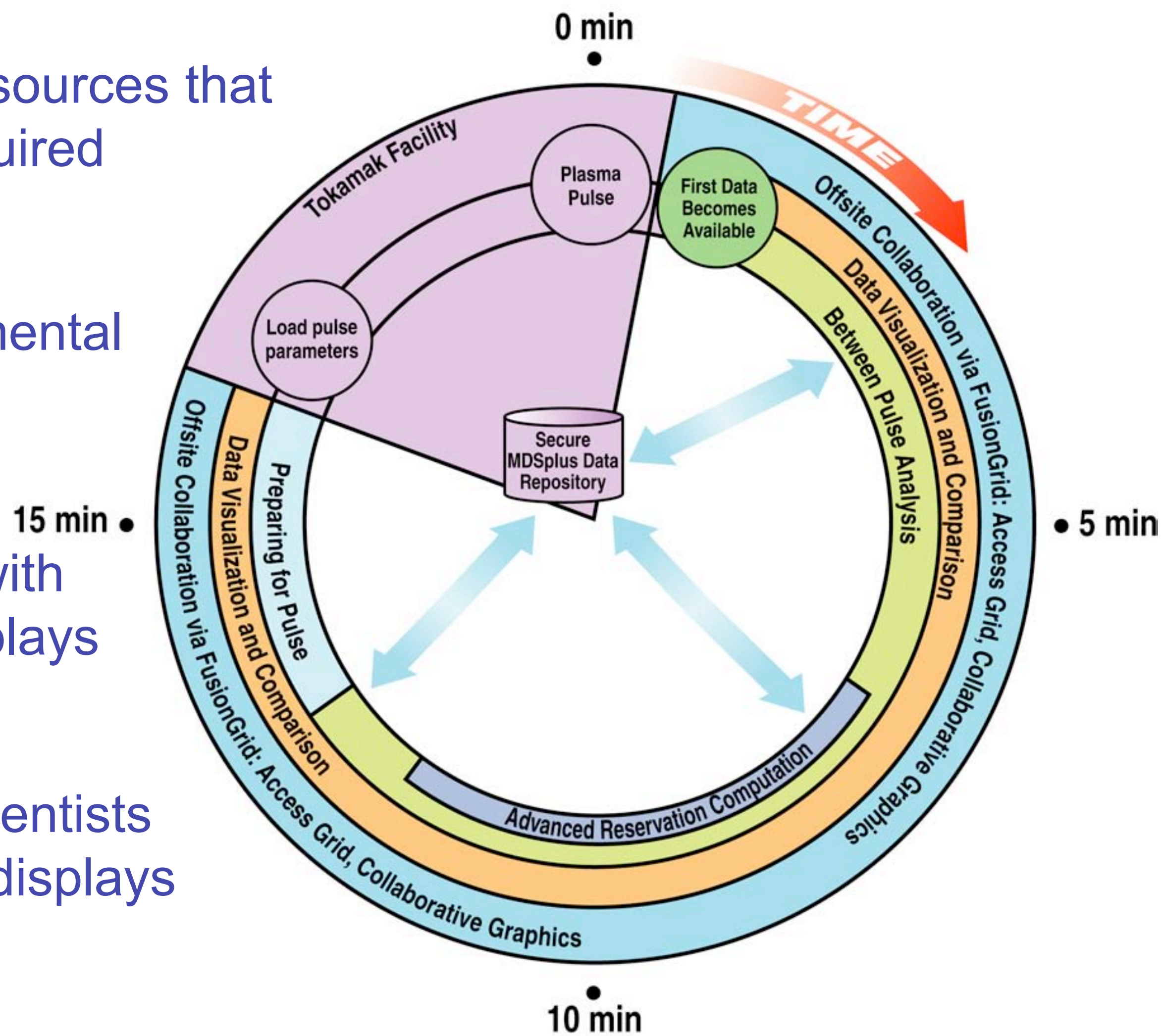
THE COLLABORATIVE CONTROL ROOM IS FUNDAMENTAL TO ADVANCING FUSION SCIENCE

- 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 via audio, video, shared displays



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REMOTE LEADERSHIP OF THE JET TOKAMAK IN ENGLAND FROM SAN DIEGO USING RP TECHNOLOGY

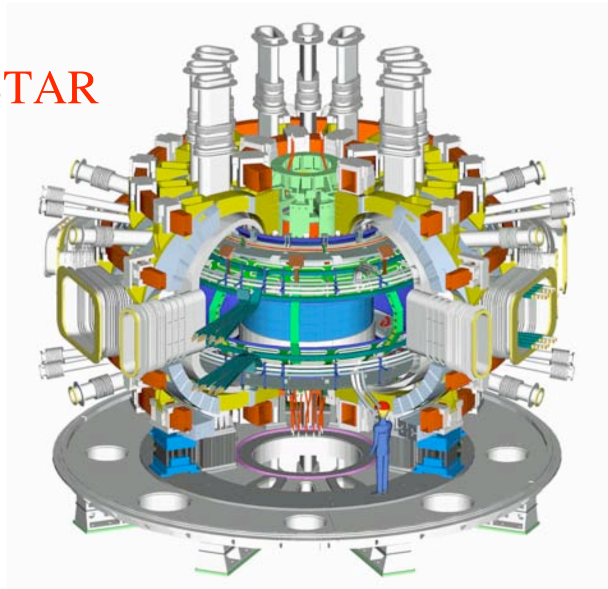
January 2004, San Diego

<u>Example of Diagnostic Control</u>
Langmuir Probe, DRFC (France) & INRS (Quebec)

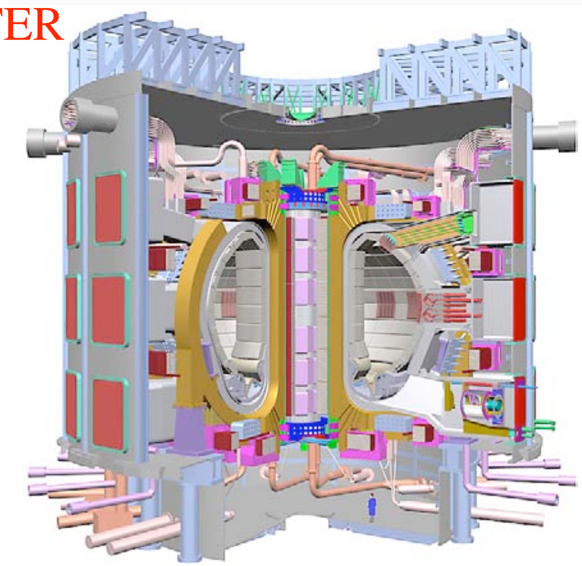
- It is becoming more common: Japan - US, US - Germany, EFDA-JET

RP TECHNOLOGIES SCALE TO THE NEXT DEVICE

KSTAR



ITER



- One physical location
  - International collaboration
- Pulsed experiment with simulations
  - ~TBs of data in 30 minutes
- Successful operation requires
  - Large simulations, shared visualization, decisions back to the control room
  - Remote Collaboration via FusionGrid
- RP technologies critical to the success of these programs
  - Including construction phase

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LESSONS LEARNED AND OUTSTANDING ISSUES

- Difficulties combining Grid-security and Site-security (firewalls)
  - Working on an integrated solution
- Manipulating large multi-dimensional datasets is still a challenge
  - Need to test new approaches
- Control room presence is more than audio/video & shared apps
  - Include things one sees & hears when physically in control room
- Difficulty combining H.323, VRVS, and AG into one united meeting
  - Unlikely one solution is adopted, need easy interplay between systems
- Education, training and shared documentation
  - Users, developers, and system administrators
- Continue to learn and interact with other scientific domains
  - No need to reinvent the wheel; e.g. LHC from HEP in 2007

CONCLUDING COMMENTS

- Collaborative technology critical to the success of the FE program
  - Experimental: Fewer, larger machines in future (KSTAR, ITER)
  - Computation: Moving toward an integrated simulation

- The requirements of the collaborative control room encompass in one instantiation the collaborative needs of fusion research
  - The most demanding since it is time critical and failure intolerant

- Both the EU and US programs are implementing and testing new collaborative technologies for fusion research
  - Being used to benefit daily FE research

- Technology has broad applicability beyond tokamak plasma physics
  - Design, engineering, and construction of diagnostics and machines
  - Applicable to KSTAR and ITER during construction phase

BACKUP

EXPERIMENTAL AND THEORETICAL FUSION RESEARCH IS A WORLDWIDE EFFORT

US Labs

ANL (Argonne, IL)
INEL (Idaho Falls, ID)
LANL (Los Alamos, NM)
LLNL (Livermore, CA)
ORNL (Oak Ridge, TN)
PNL (Richland, WA)
PPPL (Princeton, NJ)
SNL (Sandia, NM)

US Industries

CompX (Del Mar, CA)
CPI (Palo Alto, CA)
Creare (Hanover, NH)
Digital Finetec (Ventura, CA)
FAR Tech (San Diego, CA)
HiTech Metallurgical (San Diego, CA)
IR&T (Santa Monica, CA)
Orincon (San Diego, CA)
SAIC (La Jolla, CA)
Surmet (Burlington, MA)
Thermacore (Lancaster, PA)
TSI Research (Solana Beach, CA)

US Universities

Alaska (Fairbanks, AK)
Auburn (Auburn, Alabama)
Cal Tech (Pasadena, CA)
Colorado School of Mines (Golden, CO)
Columbia (New York, NY)
Georgia Tech (Atlanta, GA)
Hampton (Hampton, VA)
Lehigh (Bethlehem, PA)
Maryland (College Park, MD)
MIT (Boston, MA)
Palomar (San Marcos, CA)
New York U. (New York, NY)
Texas (Austin, TX)
UCB (Berkeley, CA)
UCI (Irvine, CA)
UCLA (Los Angeles, CA)
UCSD (San Diego, CA)
U. New Mexico (Albuquerque, NM)
Washington (Seattle, WA)
Wisconsin (Madison, WI)

Russia

Ioffe (St. Petersburg, Russia)
Keldysh (Udmurtia, Moscow, Russia)
Kurchatov (Moscow, Russia)
Moscow State (Moscow, Russia)
Triniti (Troitsk, Russia)
Gycom (Nizhny Novgorod, Russia)

European Community

Cadarache (St. Paul-lez, Durance, France)
Consorzia RFX (Padua, Italy)
Culham (Culham, Oxfordshire, England)
Frascati (Frascati, Lazio, Italy)
FOM (Utrecht, The Netherlands)
IPP (Garching, Greifswald, Germany)
JET-EFDA (Oxfordshire, England)
KFA (Julich, Germany)
Kharkov IPT, (Ukraine)
Lausanne (Lausanne, Switzerland)
Chalmers U. (Goteberg, Sweden)
Helsinki U. (Helsinki, Finland)
U. Naples (Naples, Italy)
U. Strathclyde (Glasgow, Scotland)
U. Wales (Wales)

Japan

JAERI (Naka, Ibaraki-ken, Japan)
JT-60U
JFT-2M
Tsukuba University (Tsukuba, Japan)
NIFS (Toki, Gifu-ken, Japan)
LHD

Other International

Australia National U. (Canberra, AU)
ASIPP (Hefei, China)
KAIST (Daegon, S. Korea)
KBSI (Daegon, S. Korea)
National U. (Taiwan)
Nat. Nucl. Ctr. (Kurchatov City, Kazakhstan)
SWIP (Chengdu, China)
U. Alberta (Alberta, Canada)
U. of Kiel (Kiel, Germany)
U. Toronto (Toronto, Canada)

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THE VISION FOR RP TECHNOLOGIES

- 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

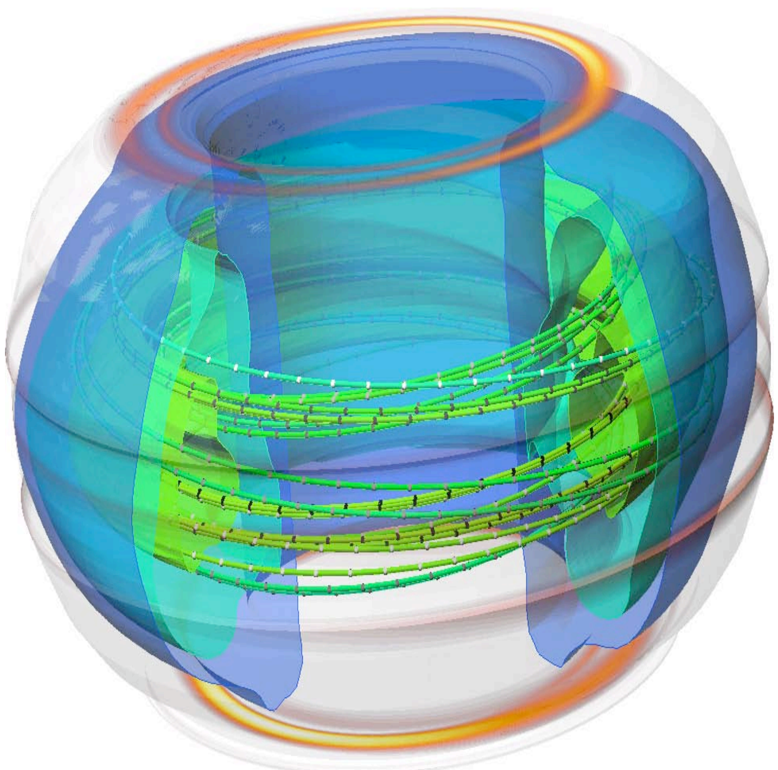
- Security with transparency
  - Ease-of-use requirement

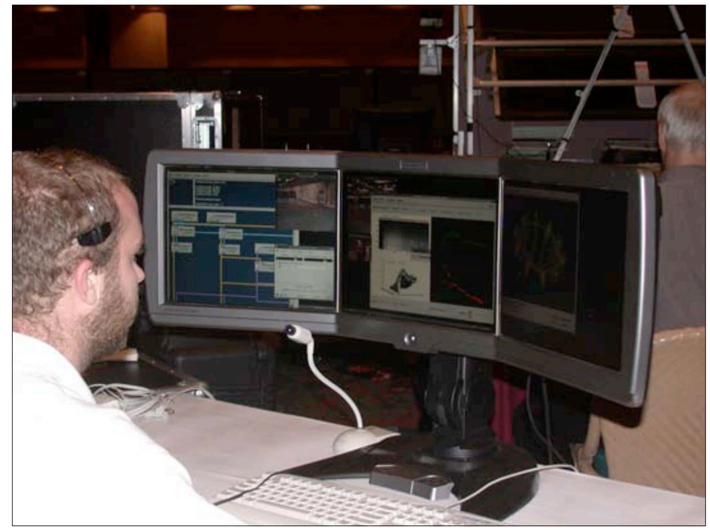
- Strong authentication identifies users currently based on X.509 certificates from trusted Certificate Authority
  - Interoperability with international Grid Certificate Authorities

- 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





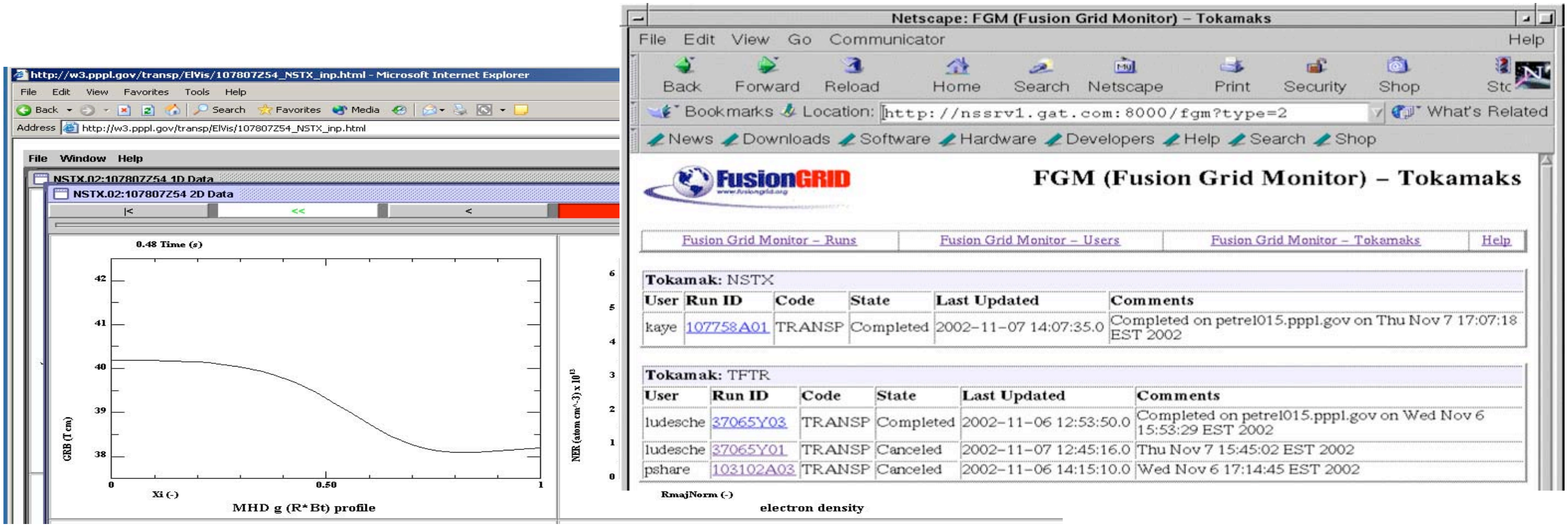
- Use of extended tool sets for remote collaboration
  - Flexible collaboration environment
  - Shared applications

NOT FOCUSING ON *CONVENTIONAL* GRID APPLICATIONS – CYCLE SCAVENGING & DYNAMIC CONFIGURATION

- Traditional computational Grids, arrays of heterogeneous servers
- Computers can join and leave
- Adaptive discovery: where problems find resources
- Workload balancing and cycle scavenging
- Bandwidth diversity where not all computers 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

FUSION GRID MONITOR: AN EFFICIENT APPLICATION MONITORING SYSTEM FOR THE GRID ENVIRONMENT



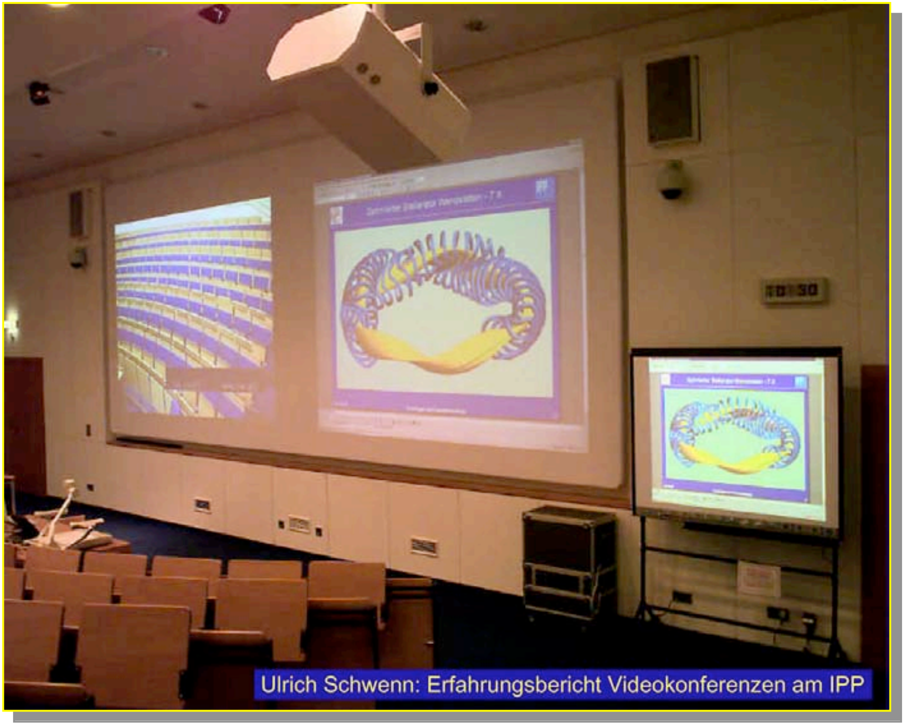
- Users track and monitor the state of applications on FusionGrid
  - Output dynamically via HTML, Built as Java Servlet (JDK2.1)
- Code maintenance notification
  - Users notified, queuing turned off, code rebuilt, queue restarted
- Results of simulation visualized during run
  - Both input and output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

VIDEO CONFERENCING OVER IP: COMMERCIAL H.323 SYSTEMS

- Numerous commercial systems available
- Point-to-point & multipoint (requires MCU)
- Hardware has built-in echo cancellation
- Video quality adjusts to available bandwidth

Stockholm to JET

IPP



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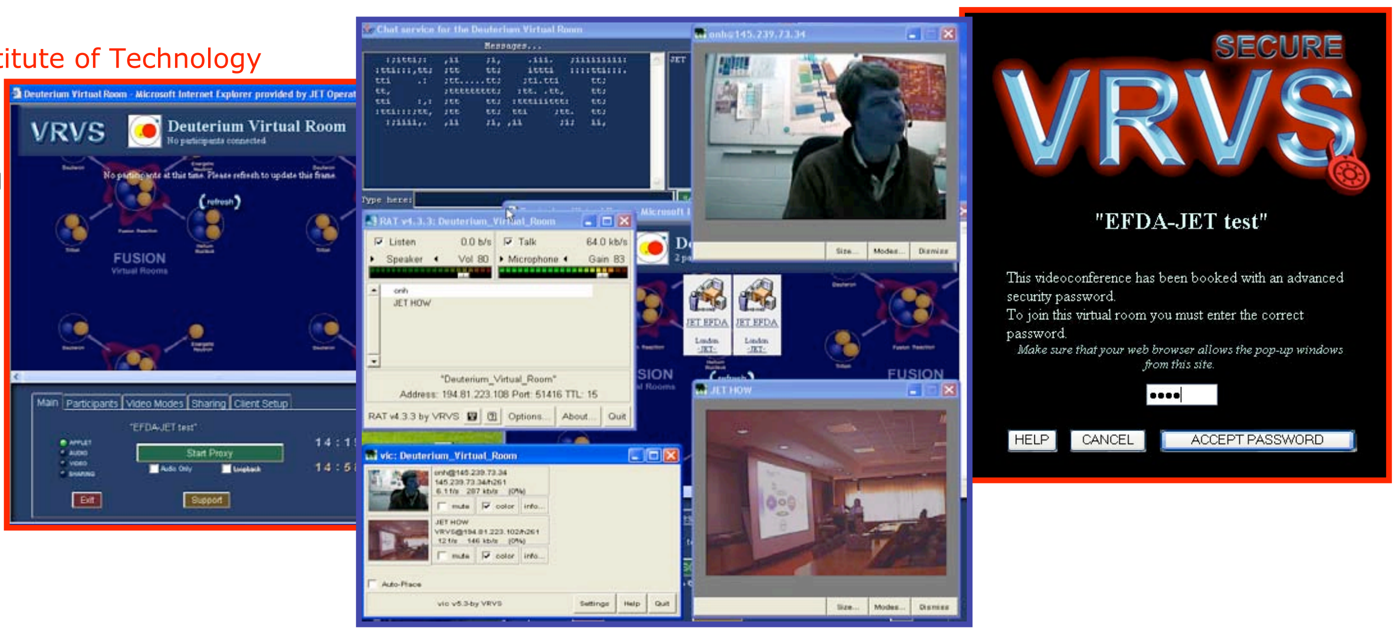
VIDEO CONFERENCING OVER IP
VRVS "Virtual Room Videoconferencing System"

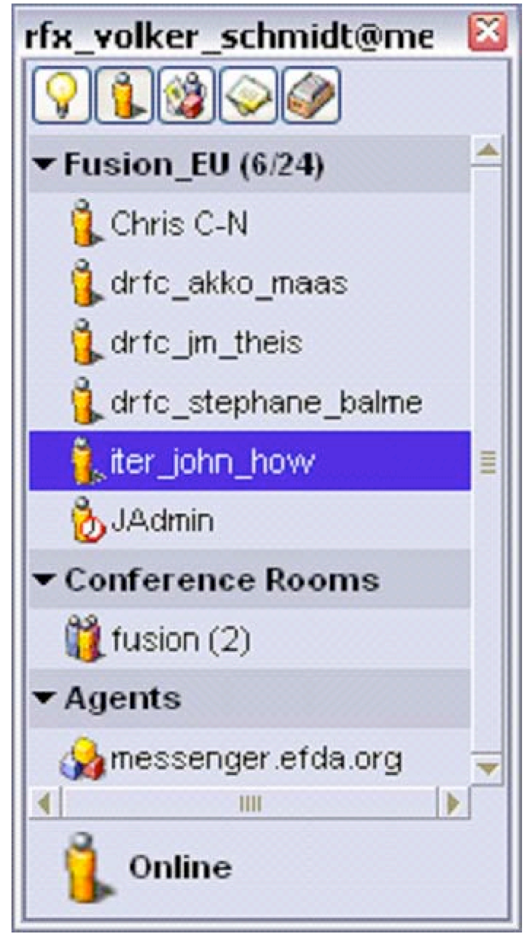
- Web-oriented, low-cost, bandwidth-efficient extensible
- Concept is of a virtual meeting room with booking system
- Grew out of HEP community but now in use elsewhere
- Proprietary infrastructure supporting a number of collaboration tools
- Uses distributed reflectors to optimize IP traffic between sites

* California Institute of Technology



INSTANT MESSAGING FOR ASYNCHRONOUS COMMUNICATION

- Instant Messaging ("Chat")
  - Self-documenting tool halfway between telephone and e-mail exchanges
  - For teleconference setup & non-intrusive communication during the meeting
- Several IM tools in use in the EFDA labs
  - Originally public Yahoo Messenger, but phased out due to security concerns
  - New EFDA Garching-based secure private server running Jabber
  - VRVS and AG have their own built in chat tools



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COMPUTER DESKTOP SHARING
VNC ‘Virtual Network Computing”

- The European Fusion community has de facto adopted VNC
  - Allows sharing a remote desktop over the Internet
  - Viewing clients with small footprint available for most platforms
  - Open source, good support, active user community

- VNC is being routinely used for
  - one-to-one discussion meetings
  - slide presentations in tele-meetings
  - Control room screen broadcast
  - Remotely-shared engineering design work

REAL VNC

EXPERIMENTAL SCIENCES PLACES A LARGE PREMIUM ON RAPID DATA ANALYSIS IN NEAR-REAL-TIME

DIII-D Control Room

- Pulsed experiments
  - 10s duration plasma every 20 minutes
- 20-40 people in control room
  - More from remote locations
- 10,000 separate measurements/plasma
  - kHz to MHZ sample rates
  - Between pulse analysis

- Not batch analysis and not a needle in a haystack problem
  - Rapid “real-time” analysis of many measurements
- More informed decisions result in better experiments
  - The collaborative control room

DRFC (France) & INRS (Quebec, Canada) JOINTLY OPERATE THE LANGMUIR PROBE DIAGNOSTIC ON TORE SUPRA

- Fully operational remote control room participation scenario
- Employs several RP techniques
  - Video conferencing video VRVS
  - Passive screen sharing in both directions via VNC
  - Secure remote computer login at DRFC via encrypted CITRIX
  - Data analysis tasks on INRS computers synchronized with Tora Supra pulse sequence using MDSplus events