ITER Collaboration: Worldwide Fusion Research

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White Paper: http://www.psfc.mit.edu/people/g/iter-ipv6.doc
● Fusion is a nearly inexhaustible energy source
  — Environmentally attractive

● Highly collaborative science
  — Both within the U.S. and worldwide

● ITER is the next worldwide machine
  — China, Europe, Japan, South Korea, U.S., Russia

● Our partner’s are moving to IPV6
  — They have a lack of address space
  — Potential cyber-security and functional advantages

● Easier to transition before ITER operates
  — Now is the time to understand the problem scope
FUSION: A NEARLY INEXHAUSTIBLE ENERGY SOURCE

What is fusion?
- Joining of small nuclei releasing useable energy
- Fusion keeps stars hot
- Deuterium, Tritium easiest to do

Deuterium (D) + Tritium (T) → Helium (He) + n + energy

Why fusion?
- Plenty fuel
- Minimal radioactive waste
- No carbon waste
- Safe: can’t blow up/melt down
- No fissile materials

How do you make them stick?

What is a plasma?
- Plasma is a hot gas where electrons are no longer attached to nuclei
- Hot plasma has fast moving nuclei
- At ~100 million degrees, the nuclei collide hard enough to fuse
MAGNETIC FIELD CONFINEMENT FOR SUSTAINED NUCLEAR BURN

Plasma particles tied to magnetic field lines:

Use toroidal magnetic bottles to eliminate end losses.

Issues
Stability
Heat transport
External & alpha heating
Plasma–wall interactions
Tritium and power generation
Structural activation
Reliability
USDOE MAGNETIC FUSION ENERGY RESEARCH

- 3 Large Experimental Facilities
  - ~$1B replacement cost

- 40 U.S. fusion research sites
  - Over 1500 scientists

- Efficient collaboration
  - ESnet is critical
EACH INDIVIDUAL PROGRAM IS A LARGE COLLABORATION ITSELF

For example the DIII-D program in San Diego
FUSION RESEARCH IS A WORLDWIDE EFFORT
THE NATIONAL FUSION COLLABORATORY PROJECT

GOALS

– More efficient use of experimental facilities
– Integrate theory and experiment
– Facilitate multi-institution collaboration
– Create standard tool set

- 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
FUSIONGRID: SECURE ACCESS TO RESOURCES

- Authentication: PKI via X.509 certificates
  - FusionGrid CA & RAs
  - Centralized certificate management
  - Onetime login

- Authorization: Customized (ROAM)
  - All resources call central Policy Decision Point (PDP)
  - Policy for all resources in a relational database

Secure worldwide access to fusion data via MDSplus
SUCCESSFUL GRID COMPUTING FOR FUSION SCIENCE

- One physical installation of TRANSP
- **The U.S. TRANSP Service**
- 4,700 cases, 10 fusion exp. Machines
- GATO stability code recently released
SCIRUN TO VISUALIZE COMPLEX SIMULATIONS FOR BETTER UNDERSTANDING

- Open source, multi-platform capable for a wide user base
- To facilitate quantitative comparison of simulations and 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
Not Grid-based rendering

FusionGRID
www.fusiongrid.org

GENERAL ATOMICS
ENHANCED HUMAN COLLABORATION IN EXPERIMENTAL SCIENCE

- Tiled displays installed in fusion control rooms
  - Enhanced collaboration amongst & between large groups

- Access Grid for realtime complex communication
  - Seminars & remote participation in experiments
COLLABORATION CRITICAL TO NEXT GENERATION DEVICES
First on our list is fusion. The prospect of limitless source of clean energy for the world leads with our commitment to join the international fusion energy experiment known as ITER.

– Secretary of Energy Spencer Abraham, November 10, 2003

Introducing the Department’s 20-year plan for building the scientific facilities of the future.
ITER WILL BE AN INTERNATIONAL COLLABORATION

Efficient Use of ITER
Involvement of Worldwide Community

Example: 3 shift/day on site (night shift for monitoring and support of remote experiment)
1 or 2 shift(s)/day on remote experimental sites
Base programme: 2 shift/day operation/experiment on-site

Y. Shimomura, SOFT 2004
PRESENTLY 6 PARTNERS IN THE ITER PROGRAM
ITER PARTNERS’ HAVE ADDRESS SPACE LIMITATIONS

- **IPV4**
  - Sparsely populated subnetworks
  - Address space not evenly distributed around the world
- **Results in a lack of address space for ITER partners’**
  - Some U.S. universities and companies have more address space than China and India combined
- **Engineering “tricks” are being used to get around this problem**
  - NAT for one
ITER AS A NUCLEAR FACILITY HAS SERIOUS SECURITY CONCERNS

- Rigorous requirement for secure communication

- Something like NAT hinders the best techniques for network security
  - Encrypting traffic at the network layer (e.g. IPSec)
  - Providing security that is transparent to applications

- Moving to IPV6 can have a decisive security advantage
REMOTE COLLABORATION IS CRITICAL TO ITER’S SUCCESS

- Many present day applications require direct host to host communication
  - True for next generation applications based on SIP (VoIP)
- Something like a NAT makes this very difficult
  - Behind NAT, a host can not be reached as a peer by general IP host
  - Difficulty in trouble-shooting applications from end-to-end
- Can lead to less capability and reliability
MOVING TO IPV6 EARLY FOR ITER HAS ADVANTAGES

- “Address-poor” countries are already moving
  - China’s CERNET2 is an example
- ITER will have a ~30 year lifetime
  - Transition is when not if
- Early adoption has advantages
  - More forward looking decisions on basic ITER IT architecture
  - Avoid disruption of operation which will be costly
- Early adoption may be aided through partnerships
  - Some IT groups have a strong interest
  - Raise ITER’s visibility in the high tech community
- Spur the U.S. to IPV6 given ITER’s high visibility
CONCLUSIONS AND PROSPECTS

● Following an ITER site decision, more detailed study is needed
  — Understanding the pros and cons of moving soon to IPv6
  — How much effort is required to move to IPv6
  — Greater technical details in support (or not) moving early to IPv6

● Create a detailed white paper for international distribution
  — Sketch out a path for implementation, identify areas of concern

● Interested in working with people inside and outside the fusion community
  — ESnet IPv6 task force, North American IPv6 Task Force (NAv6TF)
  — Other groups?

Further Information
White Paper: http://www.psfc.mit.edu/people/g/iter-ipv6.doc
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