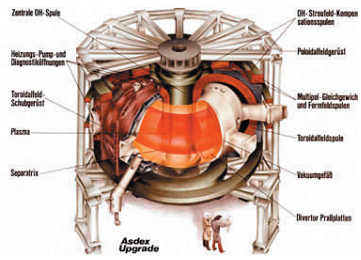
Max Planck Institute for Plasma Physics

RTI selected for next generation Tokamak Control System

"The new control system design requires fast, efficient communications between real-time controllers and the experiment management system," RTI provided the performance we needed, simplified the network programming, and let us mix the real-time and workstation platforms freely."

Dr. Gerhard Raupp,
Head of the control group at the IPP.

Control Engineering *magazine*
April 18th, 2002



Control system design drawing

The Max Planck Institute for Plasma Physics (IPP) is building a new control system for its Tokamak nuclear fusion device ASDEX Upgrade. The Tokamak is used by research physicists to investigate the physical principles underlying a nuclear fusion power plant.

The control system generates data at a rate of several MB/s during the experiment. This data is archived, fed to video consoles, and fed back into the controllers to modify operating parameters during the experiment.

Data distribution among sensors, controllers, display stations, and persistent storage during the experiment had become a big problem. The control system designers looked at different middleware products to handle data distribution. They selected RTI Data Distribution Service (formerly NDDS) from Real-Time Innovations. RTI is network middleware based on the publish-subscribe model that is designed specifically for real-time applications.

Complex Control Signal Distribution

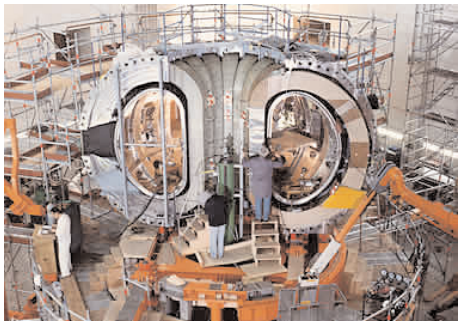
The IPP developers have four goals to improve experiment productivity in the new control system:

- Integrate diagnostic data and control logic.
- Bring data into archive in real-time.
- Provide real-time visualization of the data.
- Add a command interface to the controllers.

As much as possible, the designers are committed to using commercial hardware and software components. For example, the new ASDEX Upgrade control system will be composed of nodes running VxWorks,™ Solaris™ and Windows™ operating systems, with interplatform communications handled by RTI.

To achieve the four goals, designers will use real-time controllers connected to each other using distributed shared memory, a bridge processor to send controller data to management systems, and PC-based hosts for data visualization and archiving.

Preparation and execution of an experiment takes 3–5 minutes while the plasma discharge itself lasts about 10 seconds. During the discharge, 1000 to 2000 control signals



ASDEX Upgrade Under Construction

(4–8 bytes) are generated per millisecond.

The experiment's control logic takes plasma state data, such as temperature, density, energy content, currents, and impurities, and feeds it into multivariable feedback loops that control the experiment. The developers use distributed shared memory to keep data distribution latency below 2–3 microseconds.

At the same time the data needs to be "pumped" to the experiment management system and user workstations. Here, the latency requirement is less rigorous but there is the need to move lots of data without real-time performance degradation. The developers will use a bridge running VxWorks and RTI to capture the data and send it over a network to the experiment management systems using standard Internet Protocols.

RTI Provides Flexible Communications Infrastructure

During the experiment data is generated at a high rate. Its destination can change from one experiment to the next. For example, the new system will have graphic workstations so experimenters can visually recognize subtle differences in data output. In any one experiment, the data can be sent to 10–20 different workstations.

Dynamic configuration and one-to-many data distribution present a very complex network programming challenge. Managing connections, bandwidth consumption, and data representation among nodes with

different processors and operating systems is daunting to even the most experienced network programmer.

RTI is network middleware that "sits on top of" the operating system's standard TCP/IP stack. It is designed for distributed real-time applications working in dynamic environments with one-to-many communications requirements. RTI is available for a wide variety of real-time and workstation operating systems, including VxWorks, Linux, Windows, and Solaris.

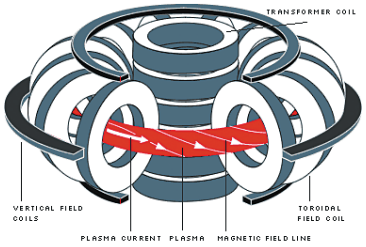
RTI eliminates network programming. Rather than writing sockets code to establish and manage the communications channels, developers define named data types to describe the data to be distributed and named topics to define the publish-subscribe channels.

In the ASDEX control system, for example, the system architect will define the data type for each signal to be published by the bridge. The bridge and workstation application programmers then create the topics for each type. For example, there will be individual topics for temperature, density, energy content, and impurity level.

In the bridge, the application simply declares, "I am publishing temperature, density, energy content," etc. In each user workstation, the application simply declares, "I want to get temperature," or "I want to get density."

During the experiment, RTI then does all the messaging to get each topic issue from the bridge to those registered subscribers This relieves the bridge software from tracking subscriber addresses, connections, and processors. Similarly, each subscriber doesn't need to know each publisher's address and poll continuously for new issues. When a new issue arrives, RTI calls the subscriber-designated callback routine.

RTI will be used to move the 4–8K bytes per millisecond of signal data from the



Example showing data flows

bridge to the management systems for archiving and visualization. This will allow experimenters to capture more data than they are able to now.

Increased Experiment Productivity

RTI will also give the experimenters faster turnaround between experiments. Between experiments, the physicists analyze the data, redefine controller parameters, and modify their workstation application to visualize different sets of signals.

RTI simplifies the experiment programming. The physicists can use their favorite development environment (for example, the out-of-the-box Microsoft or Solaris tools) to create their applications. It takes just four lines of code to create each subscription.

RTI does the publishers-to-subscribers and clients-to-servers channel set up automatically. There is no need for the system administrator to reset the channels between experiments or maintain a name server.

RTI will help IPP get more data from each experiment, interpret that data faster, and configure the next experiment more easily. For more information on RTI go to www.rti.com.

For more information on IPP go to www.ipp.mpg.de.

Conclusion

The experiments run on IPP's ASDEX Upgrade nuclear fusion device provide vital information about the physics behind nuclear fusion. These experiments will advance research efforts that may ultimately make nuclear fusion a viable power source.

IPP had stringent requirements for the communications infrastructure: real-time one-to-many data distribution across multiple platforms, dynamic system reconfiguration, low latency, and impeccable reliability. They chose RTI to fill this essential component in the ASDEX Upgrade project.

About RTI

RTI supplies middleware and distributed data management solutions for real-time systems. With innovative technology and deep expertise in distributed applications, RTI provides an unequaled competitive advantage to customers developing systems that benefit from high-performance access to time-critical data. RTI solutions have been deployed in a broad range of applications including command and control, intelligence, surveillance, data fusion, simulation, industrial control, air traffic control, railway management, roadway traffic monitoring and multimedia communications. Founded in 1991, RTI is privately held and headquartered in Sunnyvale, California.

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