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Integration of Microsoft Windows Applications with MDSplus Data Acquisition on the National Spherical Torus Experiment at the Princeton Plasma Physics Laboratory

by

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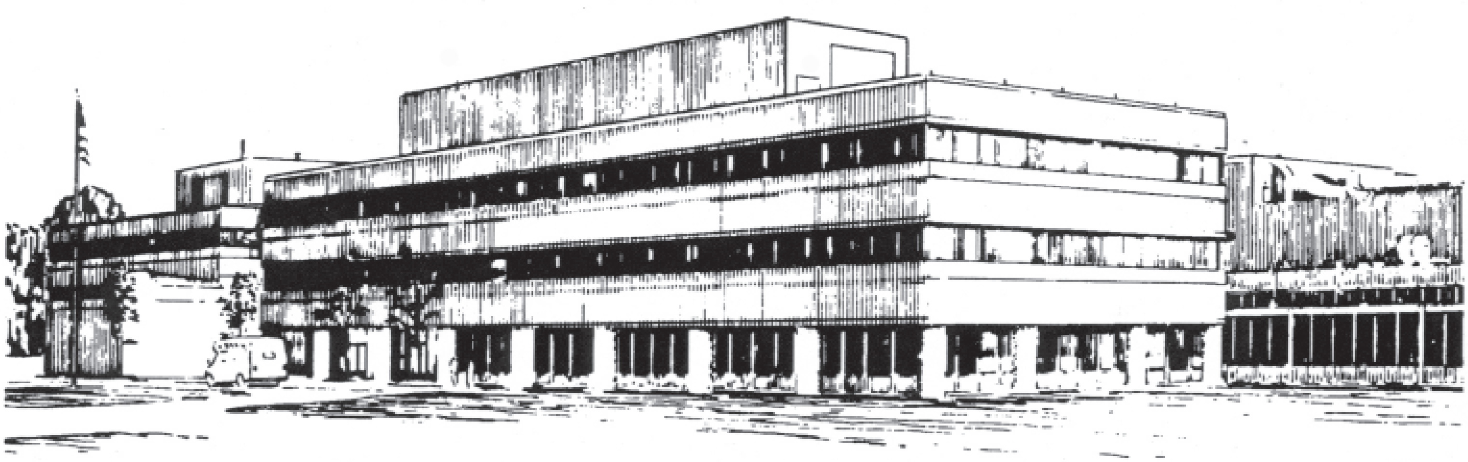

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Data acquisition on the National Spherical Torus Experiment (NSTX) at the Princeton Plasma Physics Lab (PPPL) has increasingly involved the use of Personal Computers (PC's) and specially developed 'turn-key' hardware and software systems to control diagnostics. Interaction with these proprietary software packages is accomplished through use of Visual Basic, or Visual C++ and COM (Component Object Model) technology. COM is a software architecture that allows the components made by different software vendors to be combined into a variety of applications. This technology is particularly well suited to these systems because of its programming language independence, standards for function calling between components, and ability to transparently reference remote processes. COM objects make possible the creation of acquisition software that can control the experimental parameters of both the hardware and software. Synchronization of these applications for diagnostics, such as CCD cameras and residual gas analyzers, with the rest of the experiment event cycle at PPPL has been made possible by utilization of the MDSplus libraries for Windows. Instead of transferring large data files to remote disk space, Windows MDSplus events and I/O functions allow us to put raw data into MDSplus directly from IDL for Windows and Visual Basic. The combination of COM technology and the MDSplus libraries for Windows provide the tools for many new possibilities in versatile acquisition applications and future diagnostics.

Keywords: MDSPlus, Microsoft Windows, Automation, COM, synchronization

I. INTRODUCTION

The National Spherical Torus Experiment (NSTX), at the U.S. Department of Energy's Princeton Plasma Physics Laboratory (PPPL), is a major element in the U.S. Fusion Energy Sciences Program and a national collaboration in Fusion research. NSTX, which began plasma operations in February 1999, has been designed to test the physics principles of spherical torus plasmas. It produces deuterium plasmas that are shaped like a sphere with a hole through its center, different from the "donut" shape of the tokamak. This configuration may have several advantages, a major one being the ability to confine a higher plasma pressure for a given magnetic field. Since the amount of fusion power produced is proportional to the square of the plasma pressure, this design concept could lead to the development of smaller and more economical fusion reactors. [1]

Data acquisition at NSTX has increasingly involved the use of Microsoft Windows PC's and specially developed 'turn-key' hardware and software systems to control diagnostics. The use of 'turn-key' systems, or systems designed by a third-party vendor with software designed specifically by the vendor to work with its own hardware, is desirable because there is often greater stability in the system when the software and hardware are developed and tested together. Also, purchasing the system usually includes vendor support and the result is that a lot of time and effort is saved on in-house development. The challenge in using these systems is integrating them into a pre-existing data acquisition event cycle.

II. CHARACTERISTICS OF WINDOWS DIAGNOSTICS

At present there are three such diagnostics in use on NSTX. The first is a Residual Gas Analyzer (RGA), which is a mass spectrometer that measures contributions to vessel base-pressure resulting from impurity gases evolving from internal surfaces. (Kugel [2]) The mass spectrometer, controlled by RS-232 connection, and its associated control software called Dycor 2000 were purchased from Ametek. The other two diagnostics are both CCD (charged couple device) camera systems used to do spectral analysis by measuring light of different frequencies coming from different areas of the test cell. These are called VIPS (Visible Plasma Spectroscopy) and SPRED (Spectroscopy, Poor Resolution, Extended

Domain), which, as the name suggests, looks over a greater range of frequencies consequently having less spectral resolution. VIPS and SPRED both use CCD cameras, camera controllers, connected by fiber optic to the PC, and the corresponding Winspec software, all of which were purchased from Roper Scientific. There are several common elements in all of these systems. Visual Basic, Component Object Model (COM) and Object Linking and Embedding (OLE) technologies, which are part of the Microsoft Windows operating system. MDSplus dynamic linked libraries (DLLs) for Windows, which were developed at MIT, are used to place experiment parameters into MDSplus and to trigger hardware setup. Callable IDL (Interactive Data Language) is used from Visual Basic to read raw data files and place the data into MDSplus for later analysis.

III. COM/OLE

Component Object Model is the underlying architecture that forms the foundation for higher-level software services, all of which are basic functions of the Microsoft Windows operating system. These components are reusable pieces of software in binary form. [3] COM objects can be plugged into other components from other vendors with relatively little effort. COM accomplishes component object interoperability by defining a binary standard for component communication. It is programming language independent, and provides a mechanism to uniquely identify component interfaces including different versions of component interfaces via a 32-bit global unique identifier. Because COM uses remote procedure calls to communicate with its objects, remote objects are called the same way as local objects and their location is transparent to the caller. [3] Vendors are increasingly exposing COM objects for their software, which are registered at the time of installation in the Windows system registry. Objects can be browsed using the OLE/COM Object Viewer supplied with Microsoft Visual Studio, which is also available for free downloading from Microsoft. OLE is built on top of the COM architecture with support for higher-level functionality such as visual editing, drag and drop and automation. OLE is the part of the Component Object Model that allows one to do things such as insert Excel graphs into Microsoft Word Documents or edit pictures from within a Microsoft Front Page Document. Automation is part of the OLE functionality and is precisely what makes it possible to control third-party vendor software such as Winspec and Dycor 2000 from another application such as one written in C++, Visual Basic or another object oriented language.

IV. VISUAL BASIC CLIENT APPLICATION

In the VIPS, SPRED, and RGA systems a Visual Basic application was created to control the Winspec and Dycor 2000 software respectively. The VB application is written giving the user the ability to change experimental parameters that would normally be changed from the third-party software. For example, in the Visual Basic application written for the VIPS system (Fig.1), the user is given the ability to change parameters such as the exposure time and the wavelength on which to center the camera even though this is really functionality of the Winspec software. At the time the Visual Basic application is loaded, a connection is made with the appropriate COM object. From that point on the client application can call functions related to the Dycor Application Object by name. In this way the client Visual Basic Application can control or automate the Dycor Application, telling it when to begin scanning for masses, save files, convert files to alternate formats or change displays. The operating system keeps track of the number of object references made so that when there are no more references to the object in use it will delete the object from memory.

V. COMMUNICATION WITH MDSPLUS

The VB application communicates directly with our MDSplus system through a series of DLLs provided by MIT, saving information about experimental parameters to the appropriate MDSplus nodes and declaring MDSplus events to enable system hardware to be set up for further data collection.

A. VIPS AND SPRED

For the VIPS and SPRED systems the VB application declares an MDSplus event. The MDSplus functions must be declared in a separate module in the VB project. An object called MDSevent is defined in a VB class module, which uses COM library functions to handle process threads. Then at the time of code execution, a call is made to the MDSplus function MDSSetevent as it would be from Unix or VMS. Setting this event triggers the execution of a batch job running on a VMS server where the MDSplus data is stored. This batch job calculates the time interval between various frames to be taken by the CCD camera based on experimental parameters set by the user, such as the exposure time. It then writes these intervals to a hardware pulse generator connected to the rest of our MDSplus hardware data acquisition system, which will send the pulses to the Roper Scientific camera controller, signaling the camera to take a frame of data.

B. RGA

For the RGA, which does not have an external hardware controller, we purchased a National Instruments Data Acquisition PCI card (called NI 6527) to report a hardware trigger from our MDSplus data acquisition event cycle. The NI 6527 is a 24-channel device, which generates a message when one or more user-selected lines changes from logical high to low or visa versa. The user sets the scan time and the desired

Fig. 1 Graphical User Interface created in Visual Basic for VIPS data acquisition

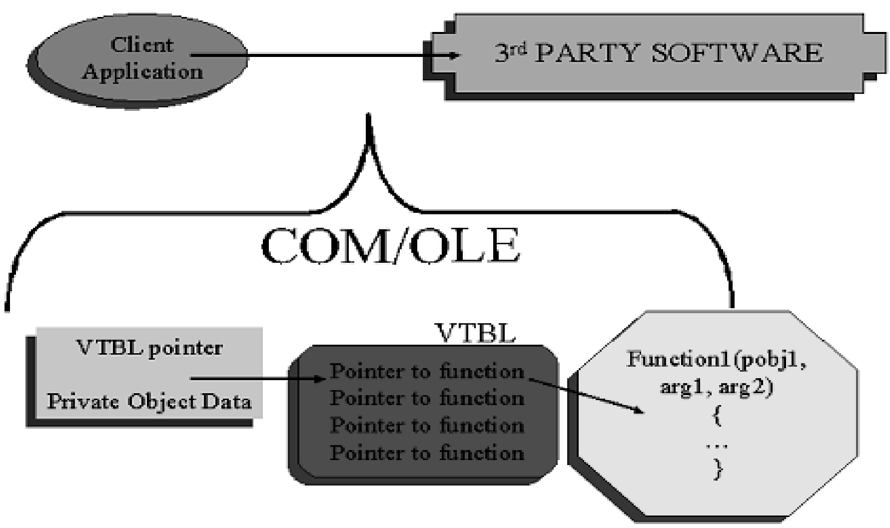

Fig.2 When the client application instantiates an object from the 3rd party software it receives a pointer that references a table of function pointers associated with that object.

MDSplus event with which to trigger the scan from the VB application and this information is saved to MDSplus. Again, an MDSevent is declared and a batch job on a VMS server sets up the hardware trigger for the chosen event. When channel 1 of the NI 6527 receives the desired event from the MDSplus event cycle it sends and interrupt to the VB application, which in turn sends a command to the Dycor 2000 software to begin a mass scan. There is about a 20 millisecond delay between the time the signal is sent from the PC to the RGA and the time when the RGA actually begins sending mass scan data back to the PC. The VB application keeps track of the amount of time that the RGA has been scanning and after the user-specified time has elapsed it sends another command to the Dycor Application to end the scan.

After the Dycor 2000 or Winspec software has completed taking data, the VB application signals the server application to save a data file. Finally, callable IDL is used to call IDL code from within VB to read and process the data files. Callable IDL is readily available and supported for C++, however a C++ DLL of wrapper functions must be created so that it can be used from Visual Basic. The IDL code is used to read raw data files created by the third-party software and then place the data into its appropriate node in our MDSplus data storage system for later analysis. Callable IDL is used rather than VB to ensure that there is no delay in the performance of the VB application while it processes data. The Visual Basic Application passes the filename of the recently created file to IDL for processing and is immediately available for user interaction and setup for future data taking.

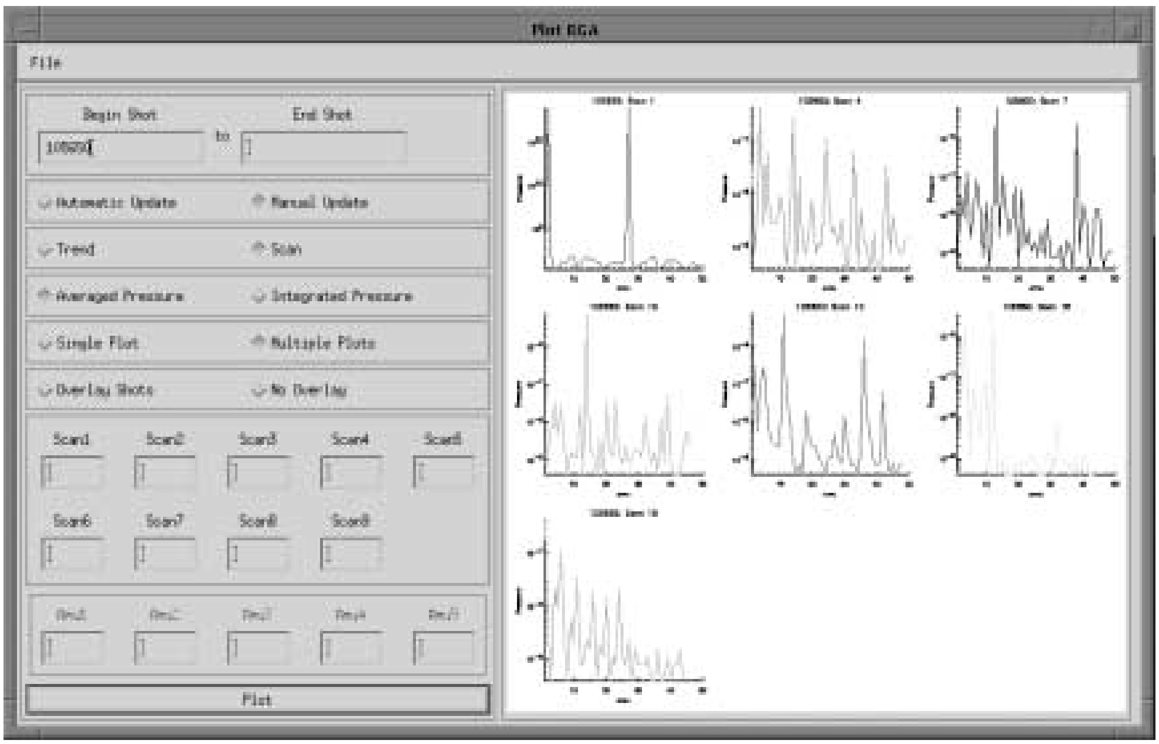

Fig.3 RGA IDL Data Analysis Software in Scan Mode.

VI. ANALYSIS

Because spectral data is put directly into MDSplus from VB instead of moving the data files to the VMS server, the data is available seconds after it is taken. The VIPS and SPRED data is typically viewed using Scopes running on either Unix or VMS. Local users and remote collaborators configure their software to look at the appropriate node names and display the spectral data in an X-Windows display automatically, as the data becomes available. (Davis [4]) A special IDL plotting program also running on Unix and VMS, called RGAshotplot, Fig.3, was written so that users could look at the RGA data in several different formats. In automatic update mode the plot will update the display with the current configuration, as new data becomes available. A typical set of RGA data consists of about 30-50 scans, which were taken over about 7 seconds, of averaged pressures for masses 1-50 amu. Users have a choice of plotting all masses for specific scans, in Scan Mode, or specific masses over all scans, in Trend Mode.

VII. SUMMARY

The availability of COM objects exposed by software vendors for use in client applications is growing. As a result, the powers of OLE automation can easily be used to control data acquisition software and incorporate it with an existing data acquisition system, such as the MDSplus system in use on NSTX at PPPL.

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