Adaptable Industrial Double-Team: OPC UA and EtherCAT

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NI Product(s) Used:
NI cRIO-9064
LabVIEW 2017
LabVIEW 2017 Real-Time
NI-RIO Scan Engine
LabVIEW OPC UA 2017 Toolkit
NI-Industrial Communications for EtherCAT Software 2017
NI Replication and Deployment Utility (RAD)

Category:
Industrial Machinery

The Challenge

Design a reusable/scalable/adaptable software architecture for a human-guiding hydraulic valve assembly stand utilizing a cRIO-9064 in conjunction with Beckhoff EtherCAT IO modules.

The Solution

Data Science Automation leveraged the LabVIEW OPC UA toolkit along with the NI RIO Scan Engine and EtherCAT Communication to provide hardware abstraction and make the input and output values of the system accessible to any desired client.

Introduction

For 25 years, Data Science Automation® (DSA) has been a premier automation systems integrator, leveraging commercial off-the-shelf tools in the design and implementation of custom-engineered, complete, and highly-adaptive solutions in laboratory automation, embedded/new product development, manufacturing and test automation. The company provides an extensive array of automation engineering, programming, consulting & training services to dramatically improve research, manufacturing, government & business operations. DSA is fast and methodical, staffed with exceptional, multi-disciplinary, NI Certified professionals that consistently apply CSIA-certified best practices to deliver the lowest total cost of ownership.

Our customer opted to have one of our CLED/CLA LabVIEW developers produce a reusable and adaptable architecture for use on multiple systems with the same basic hardware layouts.

Help for the humans

DSA's client was building a guided production line for their hydraulic valve assembly process. The line consisted of multiple parts bin with part picking guide light to direct the operators. Torque gun assembly tools are connected to the digital IO to provide feedback of correct torque application. The new production line was being built to provide higher throughput while at the same time lowering instances of incorrect assemblies to provide higher product yield.

The pilot station was immediately going to be cloned to provide multiple stations with the same capability, increasing throughput for the production line. The adaptable nature of the code allows for use in other stations with minimal code changes on the cRIO due to IO hardware changes.

The human guiding assembly stations were needed in the plant to increase throughput, reduce assembly errors and later rework and provide for assembly/component serial number tracking in the event of warranty claims or issues discovered in batch components.

OPC UA and EtherCAT IO Server

The cRIO-9064 was used to interact with the Beckhoff IO modules. The NI-Industrial Communications for EtherCAT driver allows the cRIO to act as the master for the Beckhoff IO modules that connect to the instrumentation utilized on the bench. Combined with the NI Scan Engine the EtherCAT support provides access to the Beckhoff modules through LabVIEW IO Variables. See Figure 1. Configuration of the EtherCAT modules is a very simple affair with the developer loading pre-existing EtherCAT XML Device Description File(s) for the third-party slave devices right through the LabVIEW Project interface.

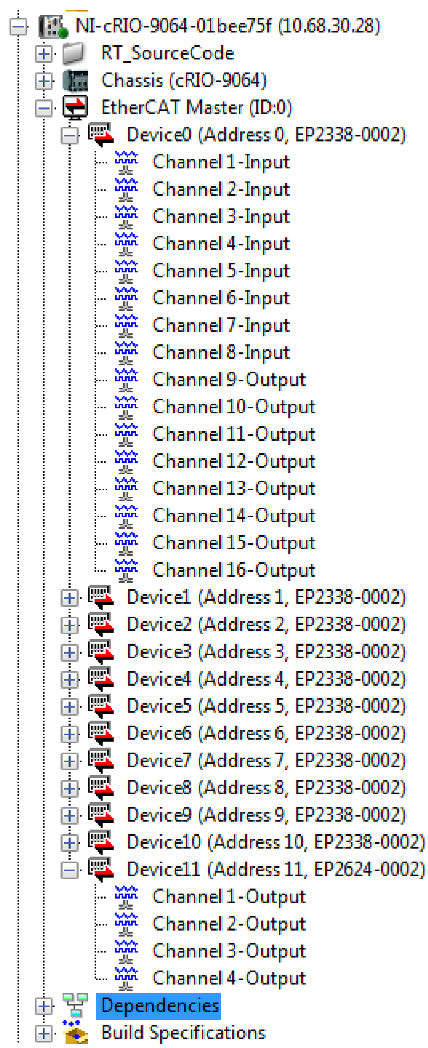

Figure 1 - cRIO-9064 EtherCAT Master - Beckhoff IO

The IO Variables were accessed in the Real-Time code through the Programmatic Shared Variable API in order to provide the highest level of reusability and adaptability. This SV API allowed for the linking of the OPC UA tags to the IO Variables in the Tag definitions. The code was then written for the Input/Output Servers utilizing Variant LUT architecture to pull the IO Variables dynamically, thus the IO engines adapt with minimal code changes if additional channels are added in the future. Another added adaptability benefit of this approach is the hardware abstraction. The current system leverages the Beckhoff EtherCAT IO modules, but in the future the system could leverage the NI Remote IO hardware to replace the Beckhoff modules and the code would not have to be changed, only the Tag Configuration File with the new IOVar properties for the Tag linking and the LabVIEW project would need to be updated. This provides for a huge time savings when the system is adapted in the future.

The Tag/IOVar linking was implemented utilizing the hierarchical nature of the tags afforded by the OPC UA specification. OPC UA Tags can have properties assigned to a parent tag. Properties of Tags were leveraged to link the Tag to the IO Variables. Each Tag that had an associated IOVar channel thus made use of a Tag Property with the IOVar linked by the Property Default String Value in the Tag Specification file. See

Figure 2.

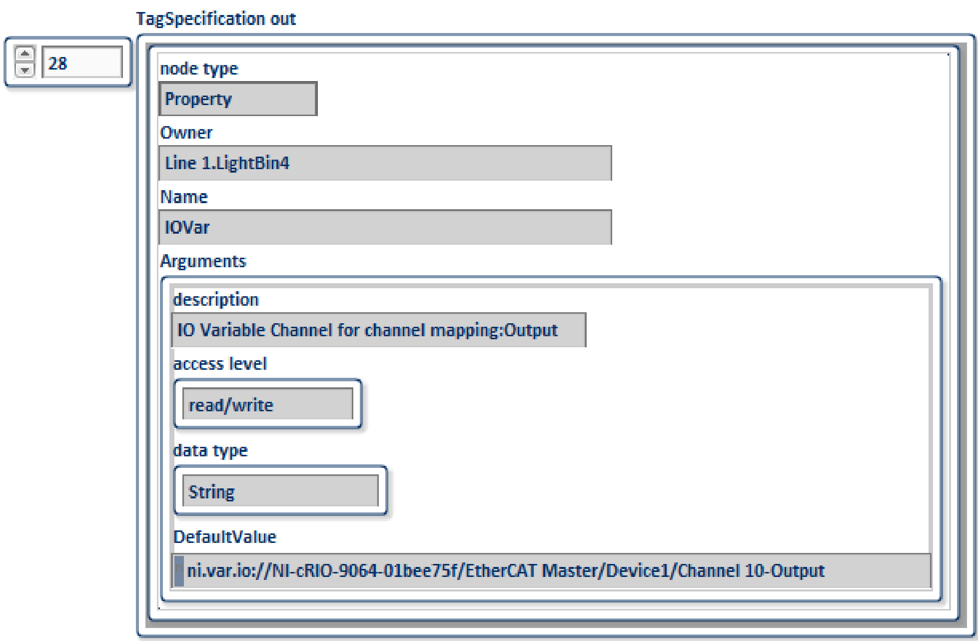

Figure 2 - IOVar Linking to OPC UA Tag Through Tag Property Item

The OPC UA toolkit allows for Value Change Detection registration by a client so that a User Event Structure can be set up to wake up on Tag value changes. This was leveraged for the Output Tags that the HMI would set. The CPU usage on the RT was minimized as the output engine would sleep until a Tag Value change was detected. See

Figure 3.

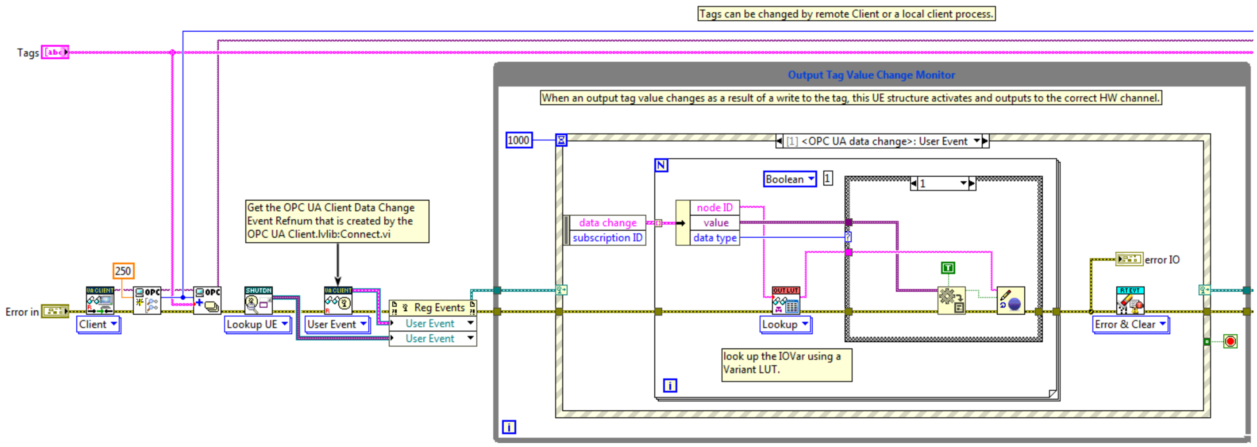

Figure 3 - Output Engine, OPC UA Client Tag Value Change Registration and Code

Scan Engine support in LabVIEW allows for While Loops to be timed to the Scan Engine Period so that the system reads only freshly updated values. Any input changes could be detected on every scan cycle of the Scan Engine and then written to the appropriate Tags, which would then update any Client OPC UA process.

The use of OPC UA to provide the communication between the HMI and the cRIO systems also allowed for future expansion of the system if other third-party code or devices needed to be utilized. For instance, if the code was keeping track of number of parts per hour, or other SPC or OEE information, such as station running or not running – an MES system could register as a Client with the OPC UA Server and utilize the information for improved operational understanding. OPC UA allows for a wider variety of external connections than if the Tags were implemented using Shared Variables or CVT/CCC, or even Traditional OPC DA. While Shared Variables host on the PC could have allowed for use of the OPC DA Server – there would be no choice to utilize OPC on the cRIO target for greater system flexibility. OPC UA allowed for the Server to be hosted on the cRIO or the PC or a centralized server location with RT and Windows code access.

Integrating with Familiar Code

The client was able to leverage their existing HMI code libraries for putting their assembly information into their corporate database while abstracting the hardware IO functionality to the cRIO/EtherCAT IO module system. They were able to greatly reduce assembly stand bring-up time by removing the need to rewrite their existing state machines and simply integrating the OPC UA Tags where any value reads and writes were leveraged in the past. This also greatly increased their in-house support capability for existing and future test stands as the code reworked to utilize OPC UA tags instead of direct IO code was developed by the customer. The level of hardware abstraction provided will greatly reduce any rewrites for the HMI code in the future if the IO hardware is modified.

Ease of Maintenance

Another benefit of a loosely coupled hardware layer is that replacing an HMI PC is easily accomplished with preconfigured spares that run multiple stations of the same hardware setup. Since the connection to the cRIO is detailed by the IP address saved in the station configuration file, no HMI code change need to be made at all by the production engineers, they simply need to modify the IP address in the configuration file and the system would be back up and running.

Replacement of any damaged cRIO is also a very simple affair for the customer's engineers. Data Science Automation recommended that the client utilize the Replication and Deployment Utility (RAD) for maintenance and system cloning. Once a "base" station cRIO is programmed with its desired OPC UA Tag List an "lvappimg" file is created of the cRIO. This image can then be applied to any other station cRIO that is being used with the same EtherCAT hardware configuration without the need for the engineers to go into the original LabVIEW project and manually deploy the project code.

Conclusion
The combination of the hardware support for third-party devices and the adoption by National Instruments of multiple industrial hardware communication protocols greatly reduced the time-to-production of the test stands. In addition, the pre-built RAD Utility greatly reduces the maintenance and station replication efforts for the customer's engineers.

The highly scalable and adaptable architecture developed will allow our customer to save time and money on future assembly stand bring-up. The customer made use of custom training to make them the experts on the solution delivered so that they could leverage their internal LabVIEW resources going forward.

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