A CONTROL ARCHITECTURE PROPOSAL FOR SIRIUS BEAMLINES

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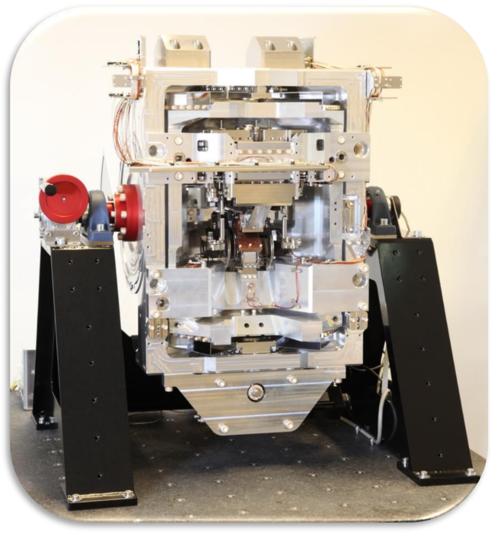
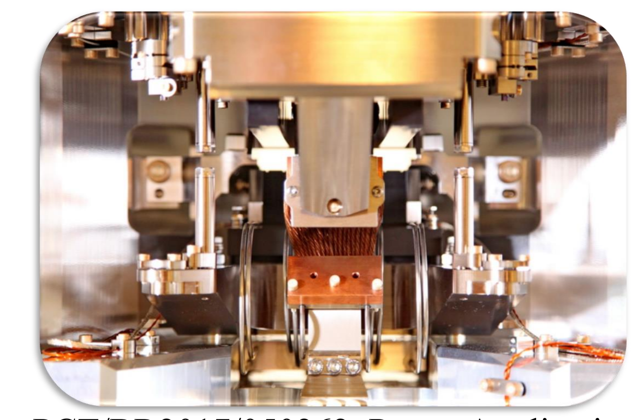


Abstract

With the increased performance provided by 4th generation synchrotron light sources, precise motion control and event synchronization are essential factors to ensure experiment resolution and performance. Many advanced beamline systems, such as a new high-dynamic double crystal monochromator (HD-DCM), are under development for Sirius, the new machine under construction in Brazil. Among the expected performance challenges in such applications, complex coordinated movements during flyscans/continuous scans, hardware synchronization for pump-and-probe experiments and active noise suppression are goals to be met. Two architectures are proposed to cover general-purpose and advanced applications. The HD-DCM controller was implemented in a MATLAB/Simulink environment, which is optimized for RCP. Hence, its software must be adapted to a more cost-effective platform. One candidate controller is the NI cRIO. The portability of both MATLAB and NI PXI, the present standard control platform at LNLS, codes to cRIO is evaluated in this paper. Control resolution, acquisition rates and other factors that might limit the performance of these advanced applications are also discussed.



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Introduction

In 2013, LNLS and National Instruments successfully developed the HYPPIE project for the upgrade of the UVX beamlines. The main features are:

- dual operational system (OS) execution inside NI PXI via NI RT Hypervisor: LabVIEW RT, for accessing PXI hardware, and Linux, for hosting EPICS server;
- DMA (direct memory access) between OSs, to link EPICS to PXI I/O.

Now, in 2017, the LNLS Beamline Software Group is in a strategic moment to review the control system definitions and standards for Sirius beamlines. For the upcoming demands, two control categories using NI cRIO have been created, namely:

- General-purpose control;
- Advanced applications control.

General-purpose control

Proposed features to cover general-purpose control systems with NI cRIO:

1. Digital read/write (arrays, FIFO);
2. Analog read/write (arrays, FIFO);
3. Scaler;
4. Encoder in;
5. Stepper motor out;
6. RS232/RS485 2-wires/RS485 4-wires Serial Port;
7. EtherCAT devices;
8. Triggering.

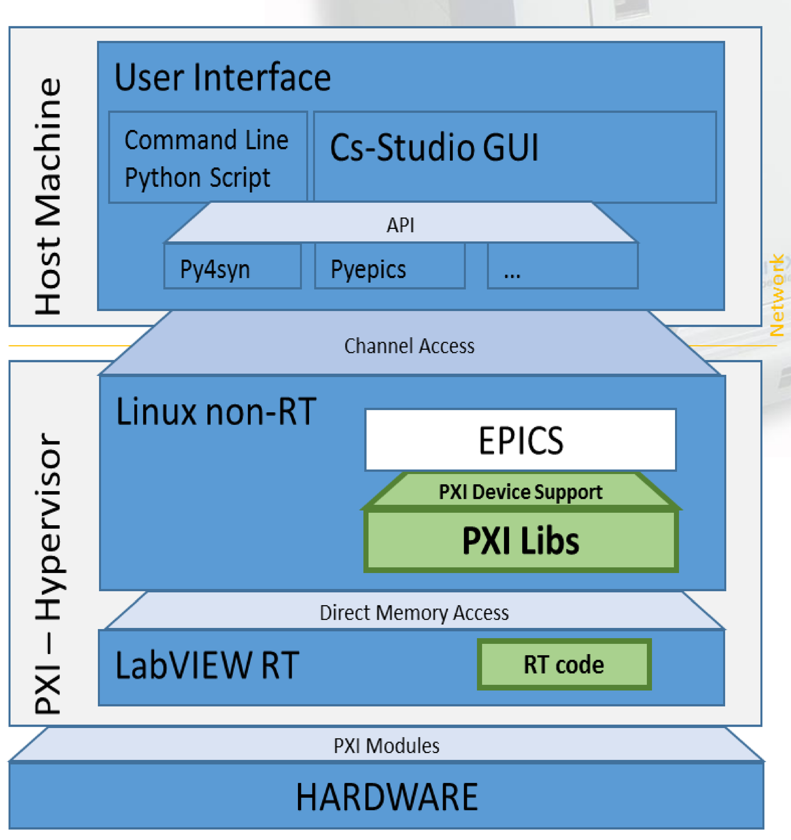

Figure 1: General-purpose control systems architecture on NI PXI platform.

NI PXI to NI cRIO migration

Feature	PXI AND HYPPIE	cRIO1
RT OS	Phar Lap ETC that cannot be upgraded	NI Linux RT
EPICS	Additional Virtual Machine with non-RT OS	Compatible with native RT OS
TSN	-	Compatible
FPGA	Expensive modules	Built-in
Scalability	Limited by virtualization technology	Scalable
Hot swappable	No	Yes

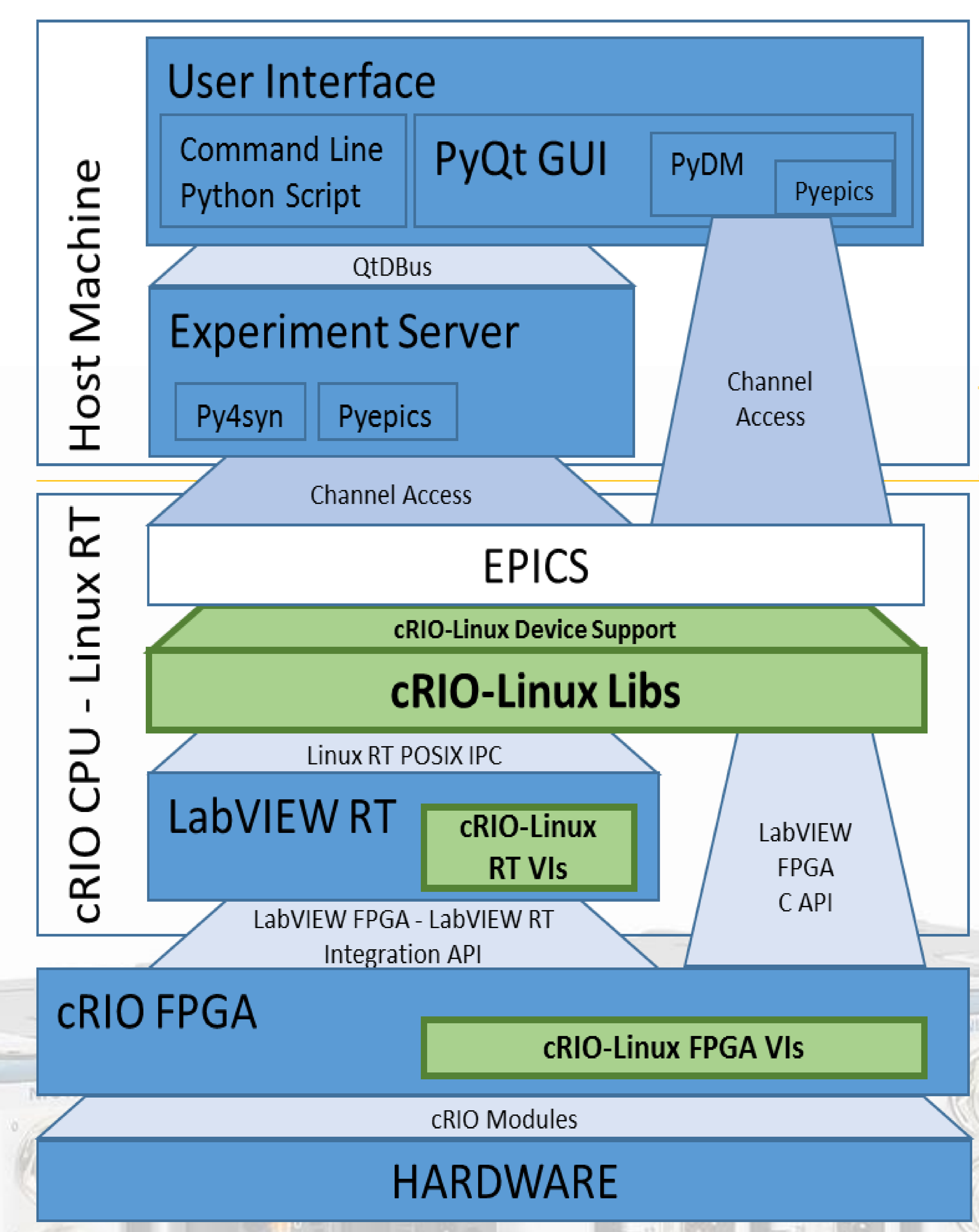

Figure 2: Proposed architecture for general-purpose control, on cRIO platform.

Advanced applications control

The advanced applications characterized by the following:

1. Well-known system plant obtained from system identification procedure;
2. Fully runtime customizable controller, parameterized by transfer-function polynomials or state-space matrices;
3. Control loop feedback sampling above 10 kHz;
4. Need of robust enough software to use the full capacity of the hardware (hardware as bottleneck).

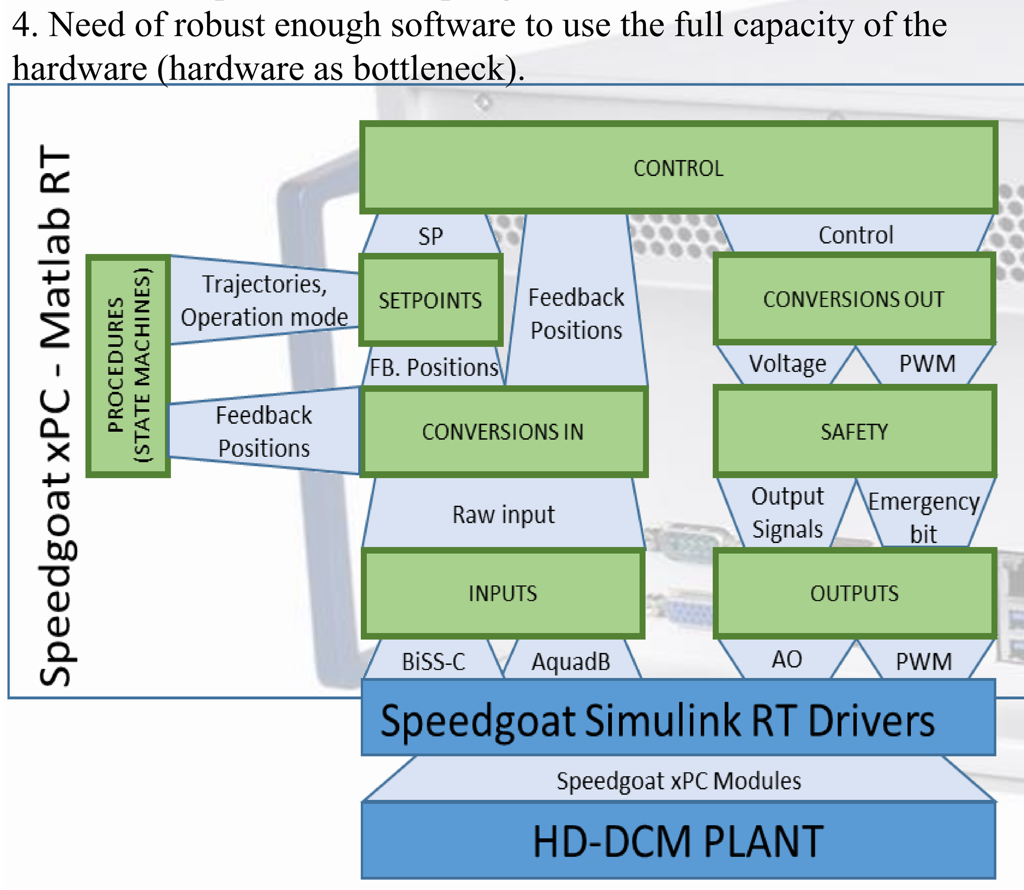

Figure 3: HD-DCM motion control architecture on Speedgoat xPC platform.

HD-DCM Speedgoat to cRIO migration

The main reasons that drive the migration from Speedgoat to cRIO are:

1. Price – cRIO offers a more cost-effective prospect;
2. Support – NI has offices in Brazil and solutions are typically quickly released;
3. Robustness – cRIO is made for industry and it is used even at extreme environments, such as oil plat-forms;
4. Large community – cRIO is used by a wide community, leading to more stable solutions;
5. Signal conditioning – cRIO offers much better solutions.

Tool	Principle	Problems
NI Veristand	Simulink model as DLL file	• Windows 10 incompatibilities • Limited cRIO hard real-time rate (10 kHz)
NI Control Design Simulation Module	Conversion of Simulink model into LabVIEW blocks	Partly-supported or unsupported blocks

***Solution:** Start implementation from scratch in cRIO.

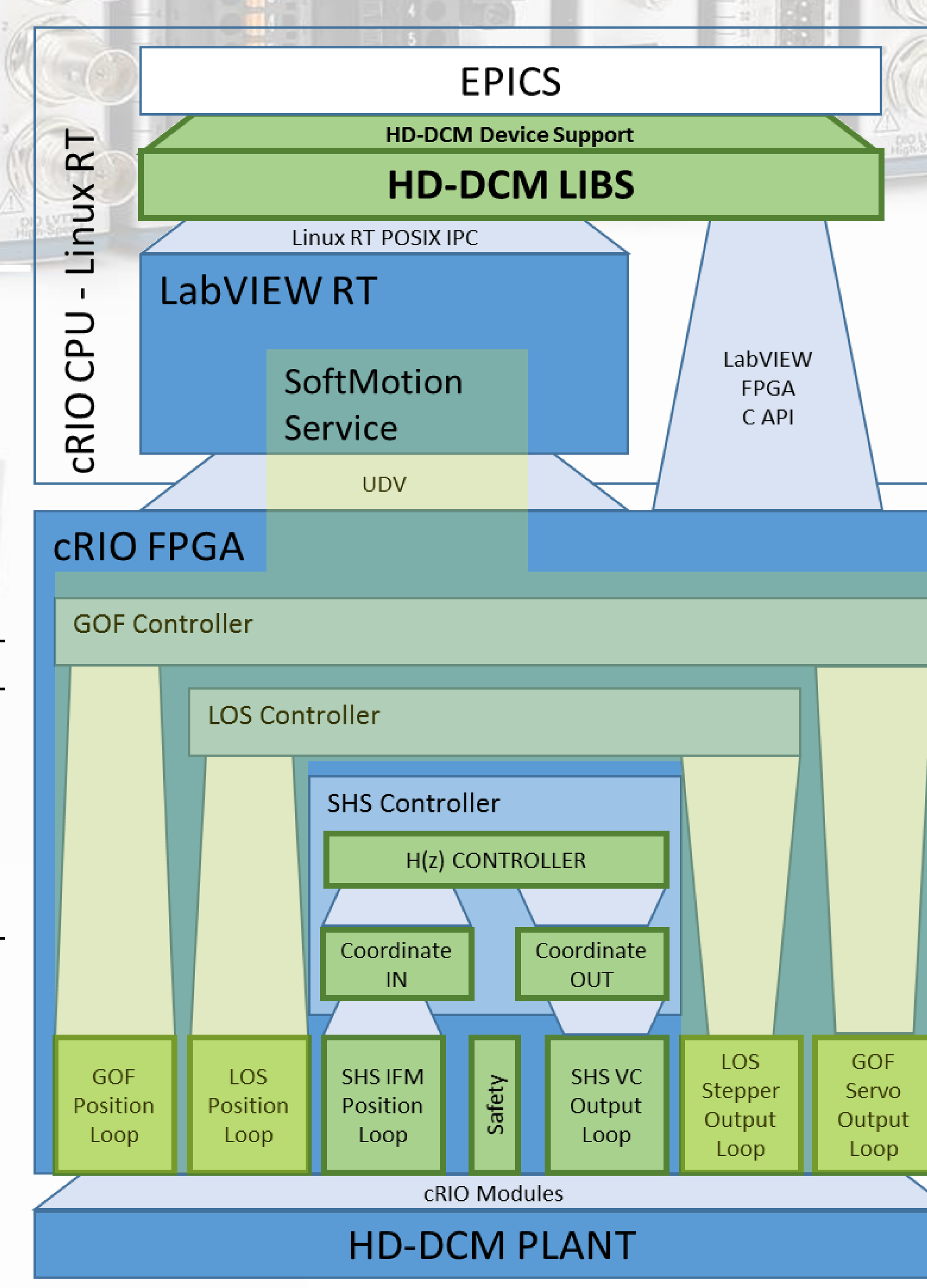

Figure 4: HD-DCM motion control architecture on NI cRIO platform.

Conclusions

- In motion control, working with state-space or transfer functions controller models in powerful controllers, such as Speedgoat and cRIO platforms, creates more flexible and portable solutions than the ones typically available in commercial controllers with limited parameterization;
- NI cRIO performance benchmark results were satisfactory for general-purpose control systems;
- In advanced applications, Speedgoat's real-time OS performance was not achieved by cRIO's real-time OS. However, this limitation in cRIO could be overcome via FPGA implementation;
- Thus, NI cRIO performance results make it a candidate platform to a homogeneous control standard for Sirius beamlines, both in general-purpose and advanced applications.

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