ST-Ericsson Manages Communication Protocols With FPGA RF Instrumentation Based on NI FlexRIO

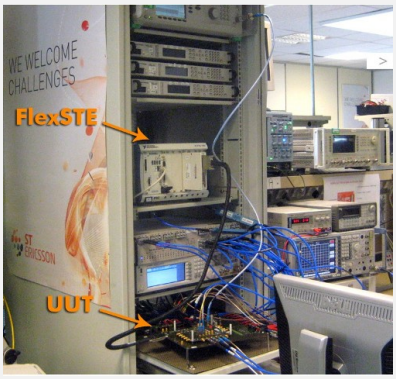

Figure 1. The RF bench validation and characterization system based on NI FlexRIO at ST-Ericsson uses the FlexSTE instrument.

"The flexibility of NI FlexRIO helped us meet the time and technical constraints of the project."
- Jean-Louis SCHRICKE, Mesulog

The Challenge:
Implementing an autonomous, scalable, programmable instrument to manage digital communication protocols in an automated test solution.

The Solution:
Using an NI FlexRIO module integrated in a PXI Express chassis to implement communication protocol management using the NI LabVIEW FPGA Module.

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ST-Ericsson is a leader in integrated circuit design for mobile phones. Faster implementation and validation of communication protocols used in mobile phones is a strategic area for new product research and development. In addition, designing and validating RF circuits requires strong skills in electronic analog and digital mixed test.

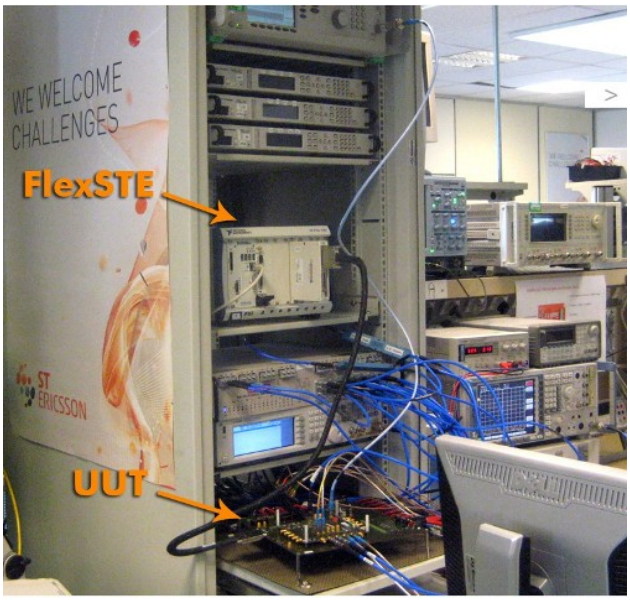
ST-Ericsson approached Mesulog, a National Instruments Alliance Partner, to design and implement the FlexSTE solution, a new tool that fully integrates into the CSFR test platform. We designed this equipment to quickly integrate customized solutions with dedicated equipment that could easily be used in a complex test. We also designed it to separate analog and digital tests so ST-Ericsson engineers would not have to focus on both during the bench implementation.

FlexSTE: PXI Express Chassis Used as an Instrument

RF circuit characterization and validation require a large number of test configurations using dedicated high-performance instruments.

The conventional approach uses a tool to emulate required communications protocols. In this case, the protocols that need to be validated are currently under development, and tools to test them do not exist.

Therefore, we designed FlexSTE, an instrument similar to an on-the-shelf measurement instrument. This new stand-alone instrument is a PXI Express chassis equipped with NI FlexRIO modules, an NI PXIe-7962R module, and an NI PXIe-8108 controller that communicates with Windows 7 through a Gigabit Ethernet link.



Each protocol is associated with a set of instructions to, for example, conduct a continuous emission pattern, write or read in a register of the circuit, read the response of the circuit on the communication bus, and so on.

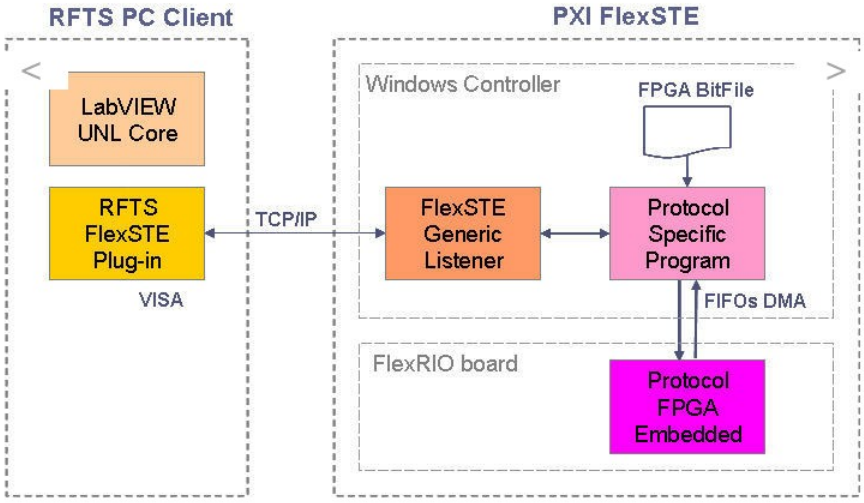
An Instrument Without a Front Panel

The instrument does not have a front panel, built-in screen, buttons, mouse, or keyboard connected to its USB ports. The lights on the custom controller chassis indicate that a protocol is loaded or an error has occurred. In case of an error (syntax unknown act incompatible with the status of the instrument), the details of the error are accessible through shared variables on the network.

It is also possible to connect to the executable front panel via remote desktop in Windows to view the current I/O status, as well as the history of commands sent to the instrument. With the software managing the hardware, the concept of virtual instrumentation displays its full potential.

Scalable Architecture

The software architecture is simple. A generic module is listening to a TCP/IP port. If it detects a request to load a new protocol, then the corresponding host VI for this protocol is loaded under Windows and the compiled field-programmable gate array (FPGA) code is loaded in less than a second into the FPGA. Orders for reading and writing are then transmitted to the FPGA FIFO by DMA.



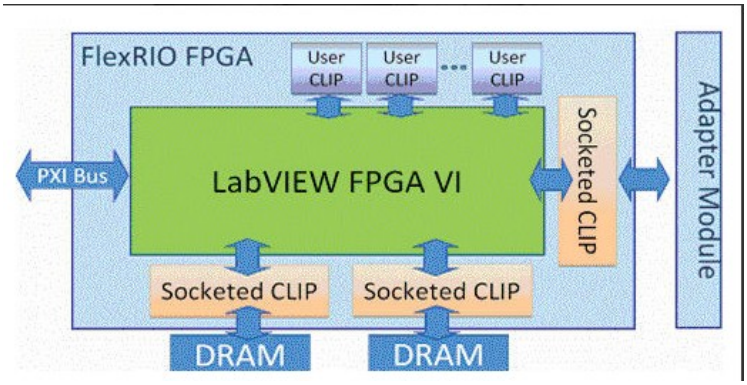
The client side, using Virtual Instrument Software Architecture (VISA) over TCP/IP, maintains the connection between the instrument and the platform test CSFR (LabVIEW, NI TestStand), which steers the bench. That way, the user can run LabVIEW VIs interactively and discontinuously, without having to worry about maintaining an inherently point-to-point TCP connection.

Using this architecture, we can easily add a new protocol to a new version of the executable FlexSTE, which starts automatically at start up.

NI FlexRIO: Customization at All Levels

NI FlexRIO, which contains a Xilinx Virtex-5 FPGA, requires an adapter module to access its digital I/O at high speeds. We used the NI 6581 digital adapter module for NI FlexRIO, which can access I/O at up to 100 Mbit/s, to start the project.

We customized the socketed Component-Level IP (CLIP) Node that interfaces with the NI 6581 to include a Digital Clock Manager (DCM). It performs a layout of the external clock and provides some protocols and derived clocks (multiplied by 2, divided by 2, and divided by 4) to the bench.



As the project advanced, we needed a digital RF high-speed (1.4 Gbit/s) transfer, so we developed an adapter module using the NI FlexRIO Adapter Module Development Kit. This module replaces the NI 6581 and provides differential RF channel (RX, TX, and CLK) transfer speeds that are still unrivaled.

The Encapsulation Protocol Written in VHDL

Initially, we transcribed protocols in the LabVIEW FPGA Module. One of the most interesting developments was using NI FlexRIO to directly integrate VHDL code. Developed by engineers at ST-Ericsson during the design phase and simulation of the circuit, then encapsulated in a socketed CLIP-specific protocol, VHDL code directly accesses the I/O adapter module.

Thanks to VHDL code reuse, it is possible to quickly implement a complex protocol without having to rewrite it in the LabVIEW FPGA single-cycle Timed Loop.

LabVIEW FPGA: An Intuitive Approach

Mesulog, which specializes in developing with LabVIEW and NI TestStand, had little experience with VHDL before starting this project. However, development engineers used the familiar LabVIEW FPGA graphical environment to program the FPGAs, so along with support from National Instruments, we achieved quick and encouraging initial results.

FlexSTE: A Success Story

The flexibility of NI FlexRIO helped us meet the time and technical constraints of the project, which was initiated in June 2009. The FlexSTE instrument was quickly recognized as a strategic element for laboratory characterization and validation with ST-Ericsson. It is currently deployed at multiple sites internationally.

Powerful, innovative, and as simple to implement as an on-the-shelf instrument, the new tool complements the array of equipment needed to implement the circuit points in our future mobile phones.

ST-Ericsson now has the ability to easily and quickly implement a customized instrument.

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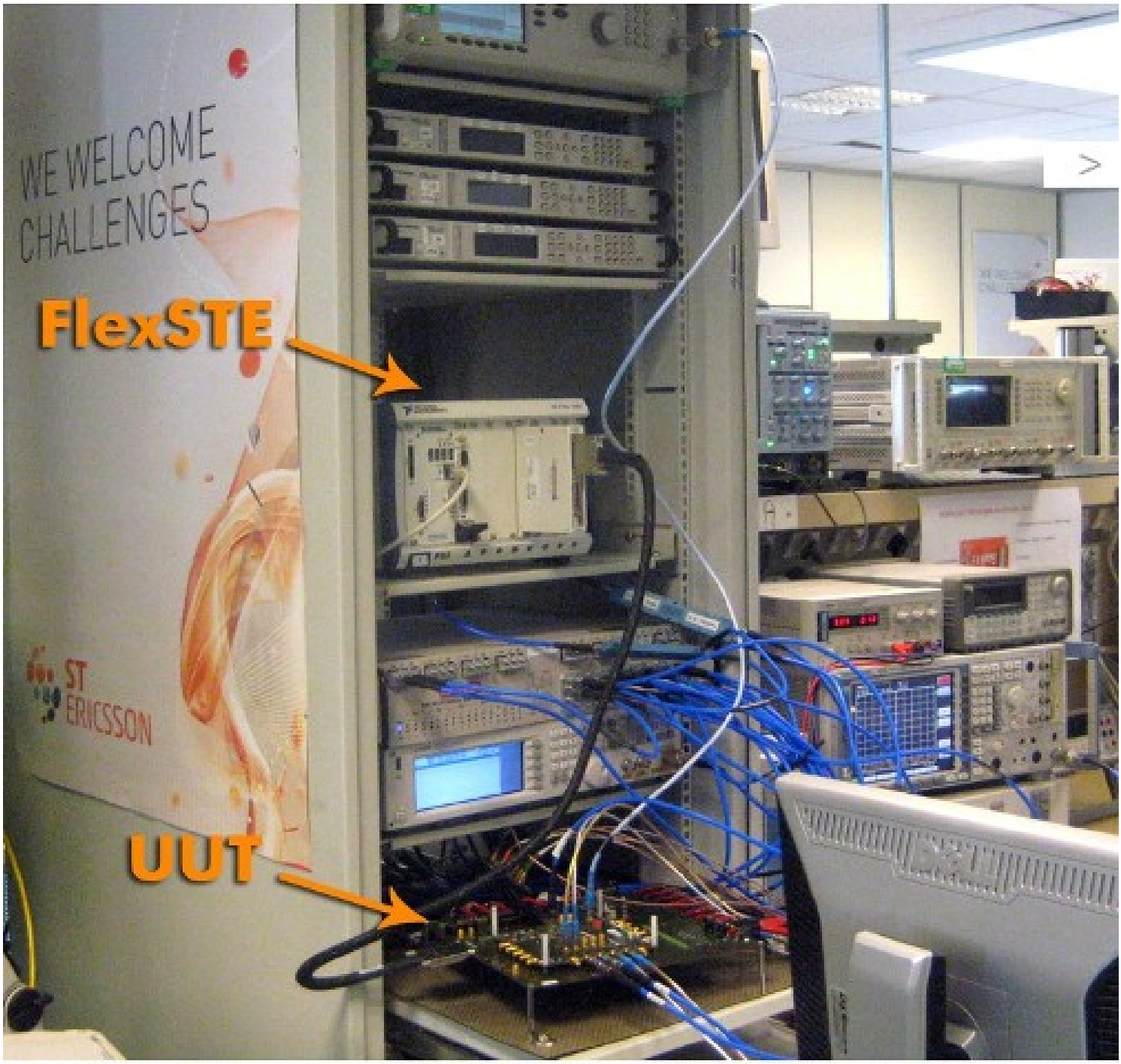

Figure 1. The RF bench validation and characterization system based on NI FlexRIO at ST-Ericsson uses the FlexSTE instrument.

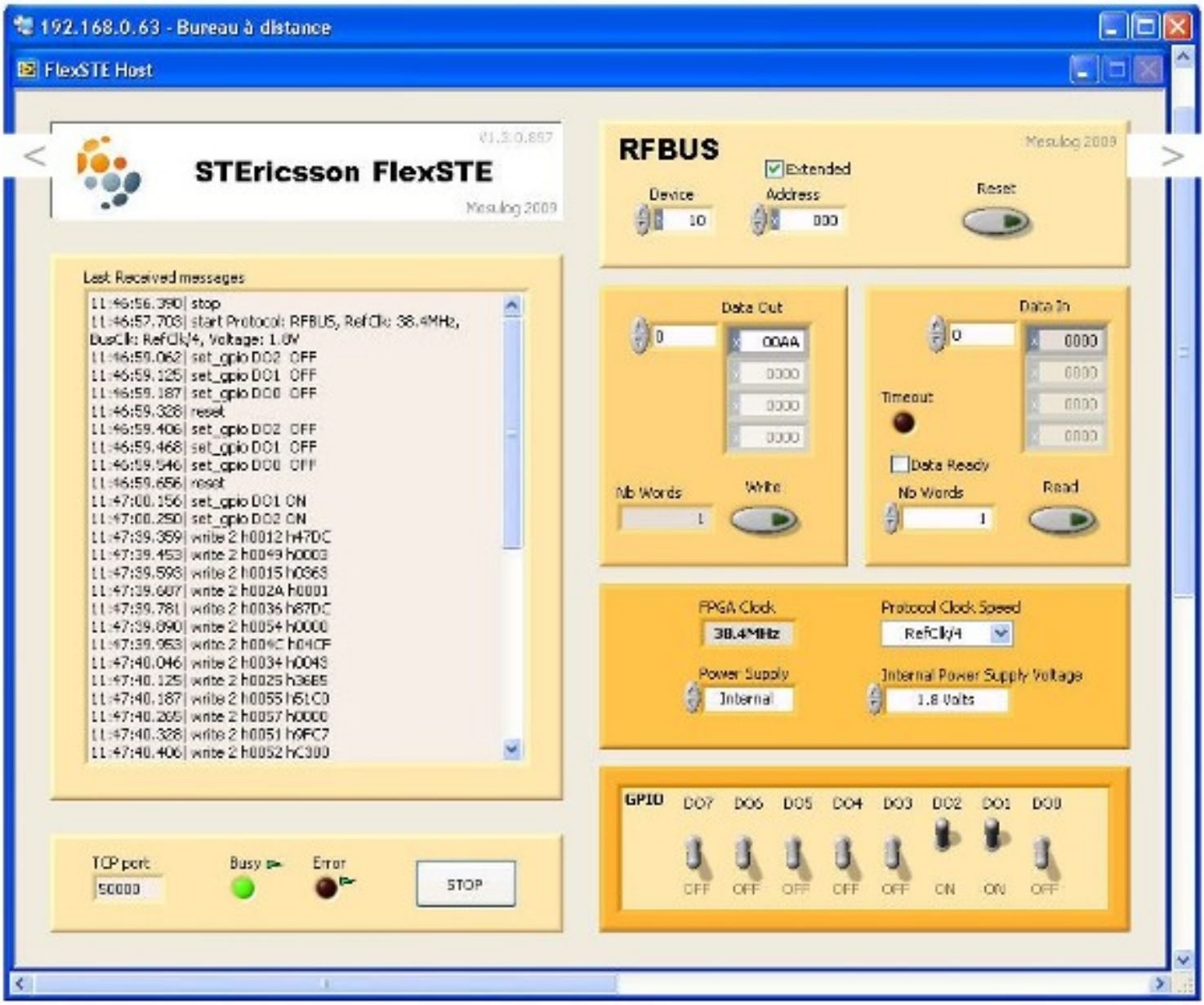

Figure 2. View of the State Input/Output and the History of Commands Sent to the Instrument

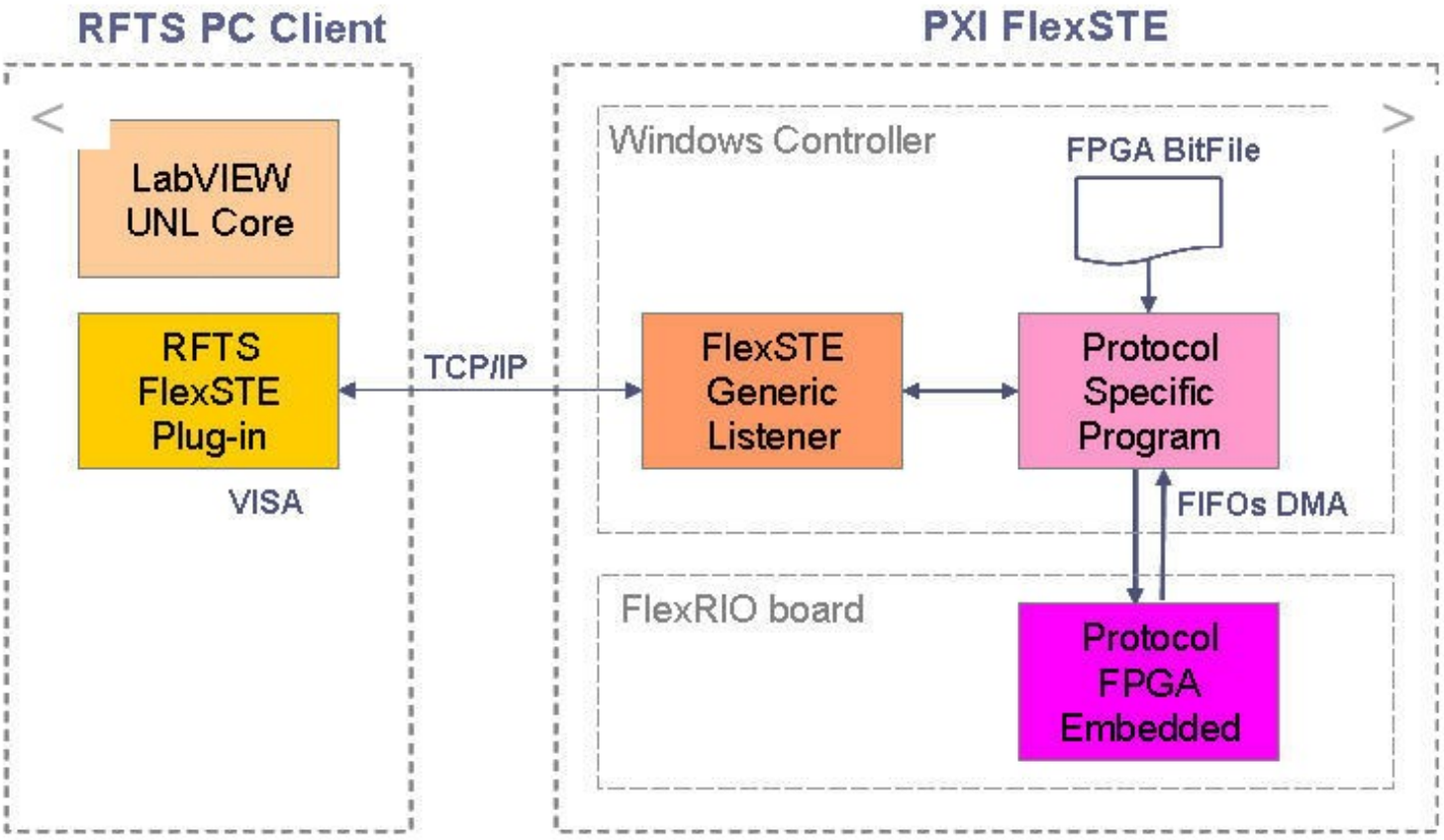

Figure 3. The scalable software architecture lets users easily add a new protocol in a new version of the FlexSTE executable.

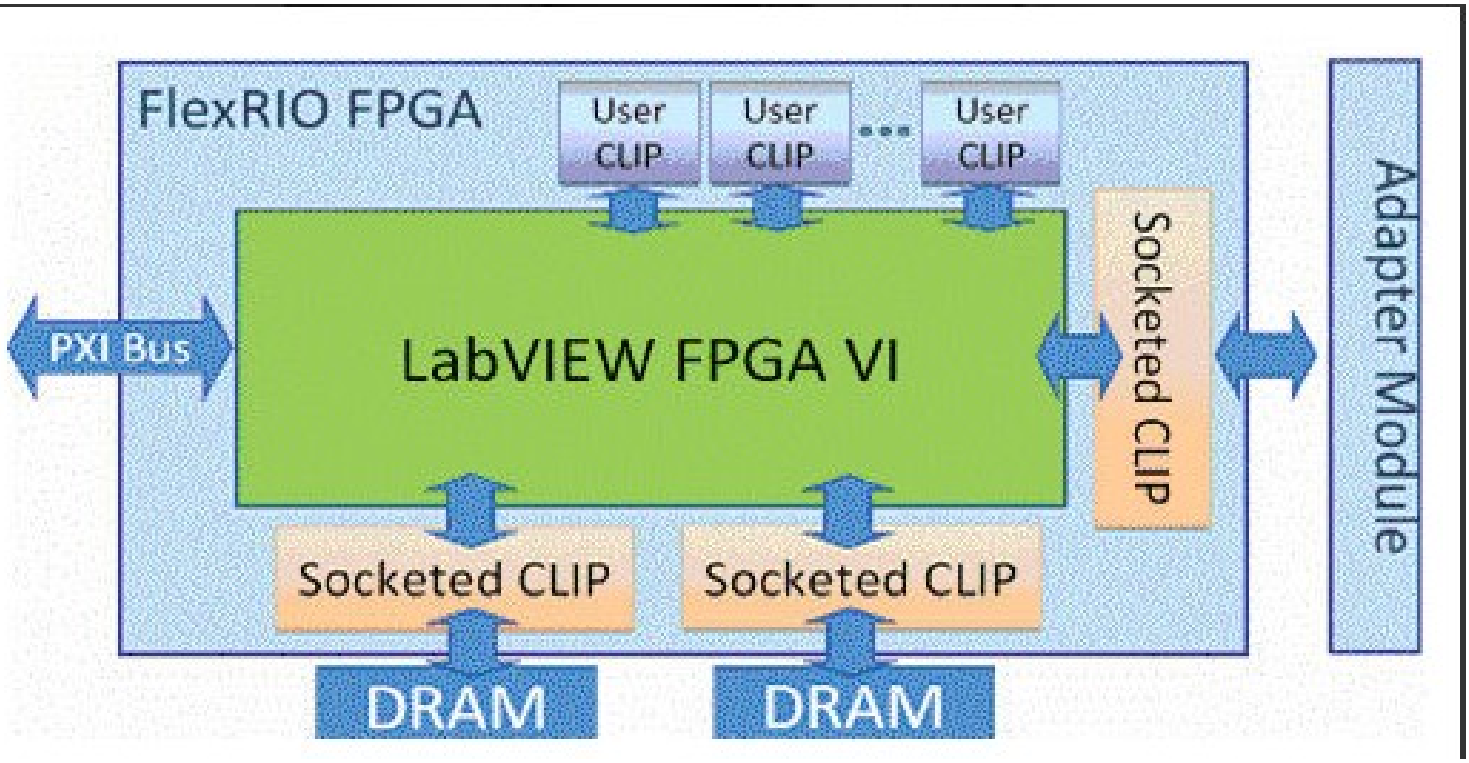

Figure 4. Customization of the software components for interfacing the FlexRIO card ("socketed CLIP") helped to integrate an external clock manager.