Board Bring-Up with FPGA Framework and ChimeraTK on Yocto

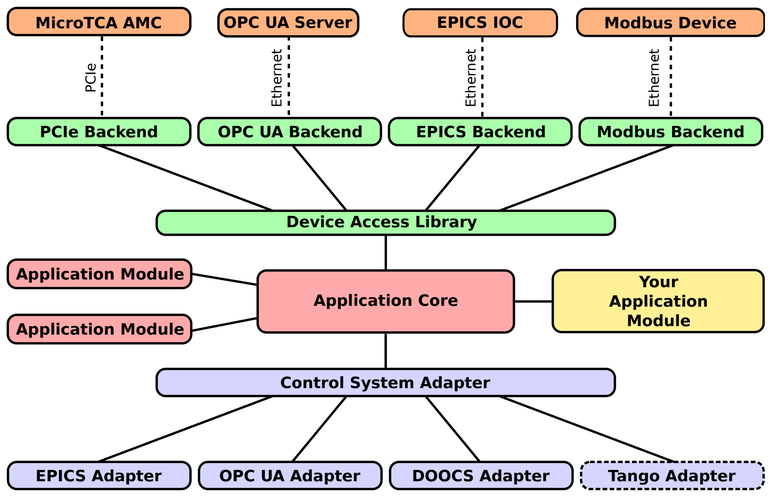
A Jump-Start For Hardware Deployment and Early User Feedback

Hardware time-to-machine is slow

Why we need a better way of HW bring-up

- Custom-built hardware is introduced, running its algorithms on powerful FPGAs.
- The FPGAs mostly can work without user interaction, except algorithm parameter setup and status monitoring.
- Such software is often written from scratch for each new piece of hardware.
- Slow feed-back between users and developers due to long delay between availability of the hardware and introduction of the users to the hardware.
- Limited potential for re-use of hard- and software without additional effort.

ChimeraTK bridging worlds



Cutting out the middle man

...by taking advantage from building blocks from DESY MSK and the global OpenSource community.

- Out-of-the box interoperability of the FPGA Framework (DESY FWK) with our software stack ChimeraTK.
- Use industry standard protocols such as EPICS and OPC UA for communication.
- Running a small Linux on an on-FPGA SoC, the board can operate quasi stand-alone.
- Hardware can be integrated into running control environment without the necessity for additional software on an external host.

Assembling established building blocks

Aggregating software and workflows

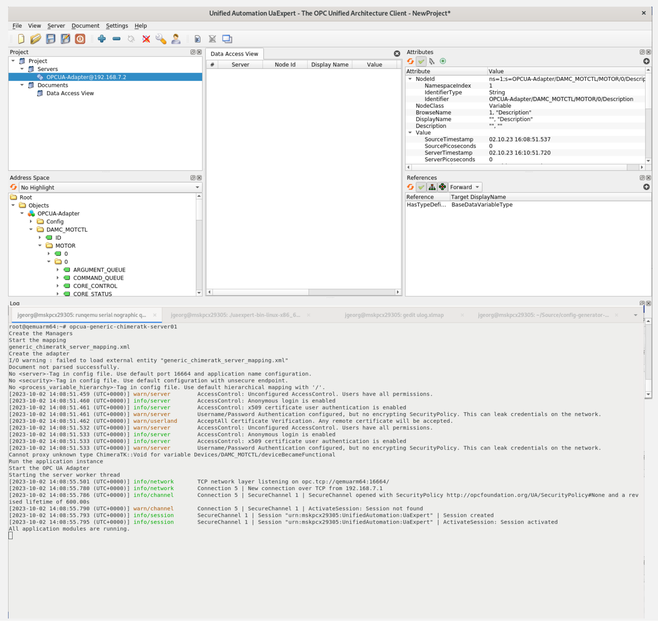
The DESY FWK is the heart of FGPA development. It provides Board Support Packages, reusable IP blocks for recurring tasks and machine consumable description of required hardware access.

ChimeraTK bridges hardware access with DeviceAccess to control system middleware using ApplicationCore and its control system adapters.

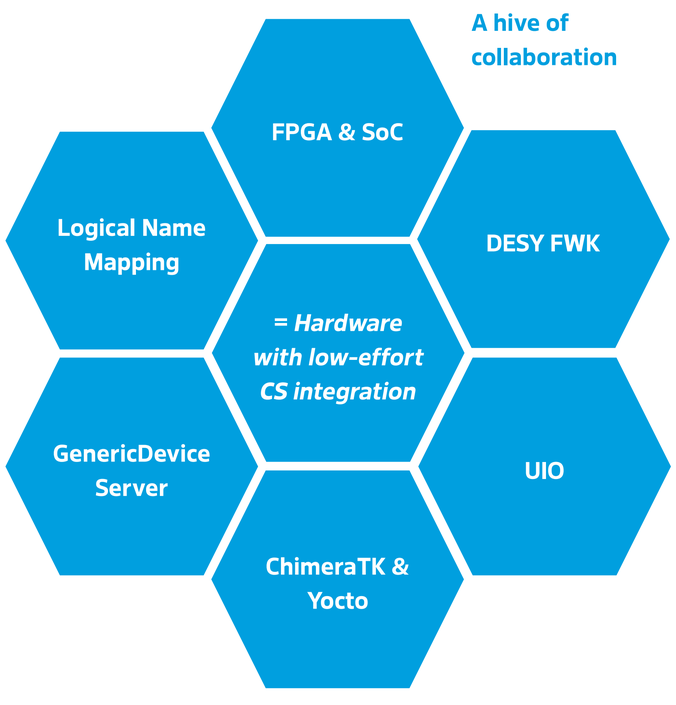
Yocto provides an extensive platform for creating your own Linux distribution. Based on the OpenEmbedded build tooling and software build descriptions, the user can create a distribution that is tailored specifically to the underlying use-case.

- By using DESY FWK to implement the FPGA firmware, we get instant integation of the device into ChimeraTK.
- ChimeraTK provides access to a variety of sources through DeviceAccess and its backends.
- ApplicationCore gives the user building blocks for writing their own control software.
- ControlSystemAdapters provide a generic interface for exposing data to different control system middlewares.
- It also provides robustness against temporary failure of data sources through automatic recovery procedures.
- DESY FWK integrates ChimeraTK into the SoC firmware through its newly developed OpenEmbedded layers.
- The result is an embedded Linux that contains the register description and our software out of the box.
- The user can simply start a server consuming the register description as provided by DESY FWK.

UaExpert accessing GenericDeviceServer on Yocto



Laying the foundation for rapid development turn-around



Userspace I/O

A common communication channel on SoC is Linux's UIO kernel interface for memory-mapped registers. We have written a new backend for DeviceAccess to support these devices, which includes the FPGA-to-SoC communication

Generic Server Software

Faced with the repetitive challenge of many hardware devices that just needed periodic read-out of monitored values and configuration parameters, we have written the GenericDeviceServer.

Through simple configuration it can expose a device to the control system. Narrowing down its variable household and complex value transformations are possible as well through logical name mapping.

If necessary, the step for implementing more customized algorithms is a small one, taking the GenericDeviceServer as a starting point and adding one's own ApplicationCore modules.

Conclusion

- Introducing UIO as an additional interface has vastly increased our range of supported devices.
- Providing OpenEmbedded layers for ChimeraTK has made our framework much more accessible to the embedded community.
- Our embedded Linux with GenericDeviceServer and DESY FWK enable users to jump start their own developments.
- GenericDeviceServer has already proven itself in the XFEL and FLASH facilities

This setup can provide a quick platform for jump-starting user feedback and shortening development cycles during the initial phase, but in many cases can be carried over to the actual production setup, as demonstrated by the operation of the FLASH master oscillator.

Deutsches Elektronen-Synchrotron DESY
A research centre of the Helmholtz Association