ChimeraTK.
ChimeraTK ApplicationCore in a nutshell.

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Martin Hierholzer

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Accelerator Middle Layer Workshop
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ChimeraTK — **C**ontrol system and **H**ardware **I**nterface with **M**apped and **E**xtensible **R**egister-based device **A**bstraction **T**ool **K**it

What does a control application do?

Task 1

- Talk to the hardware
- ChimeraTK DeviceAccess

Task 2

- Run the business logic / algorithm
- ChimeraTK ApplicationCore

Task 3

- Interface to the control system
- ChimeraTK ControlSystemAdapter

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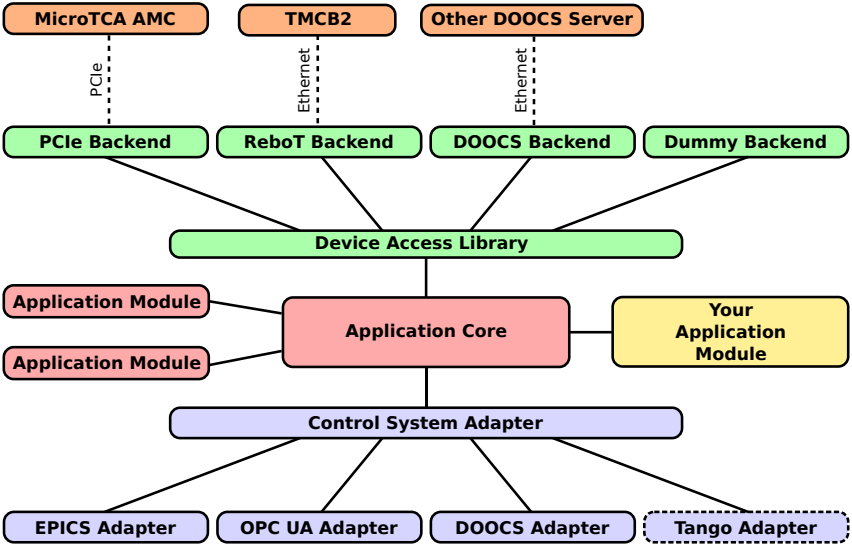
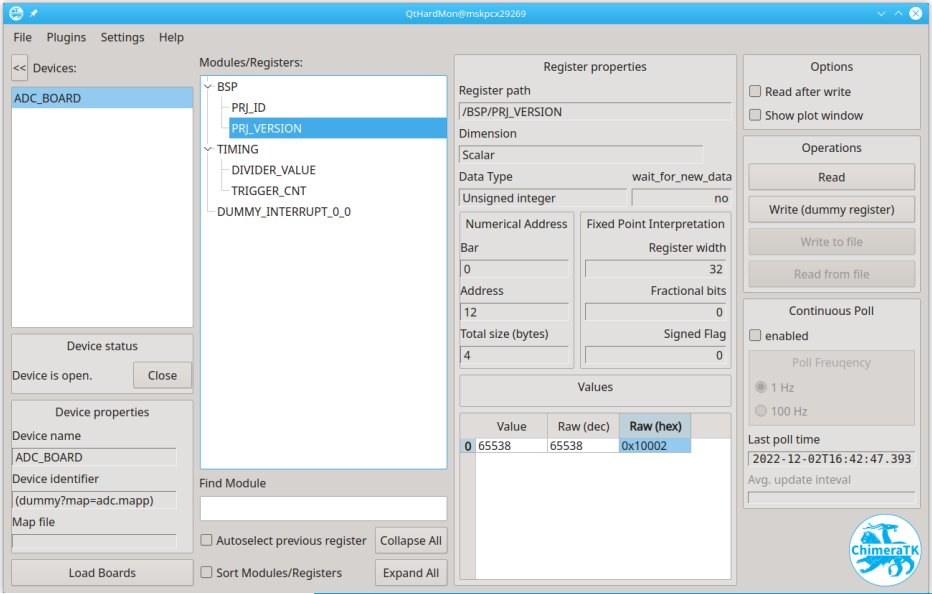
ChimeraTK Overview



QtHardMon: A graphical user interface for DeviceAccess



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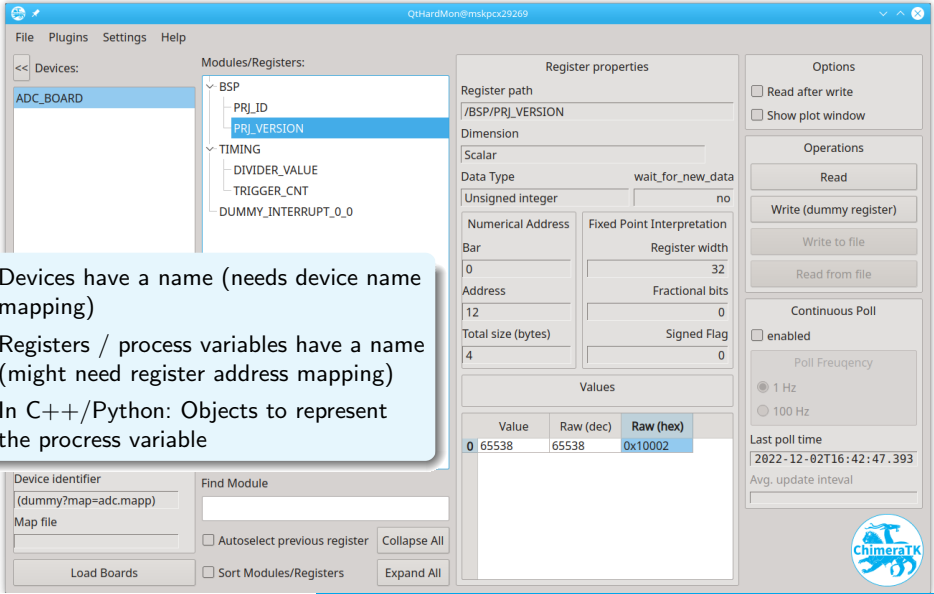
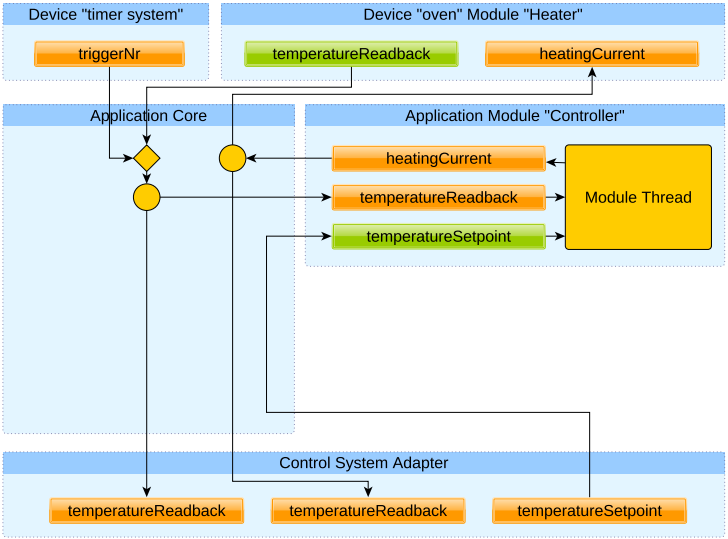


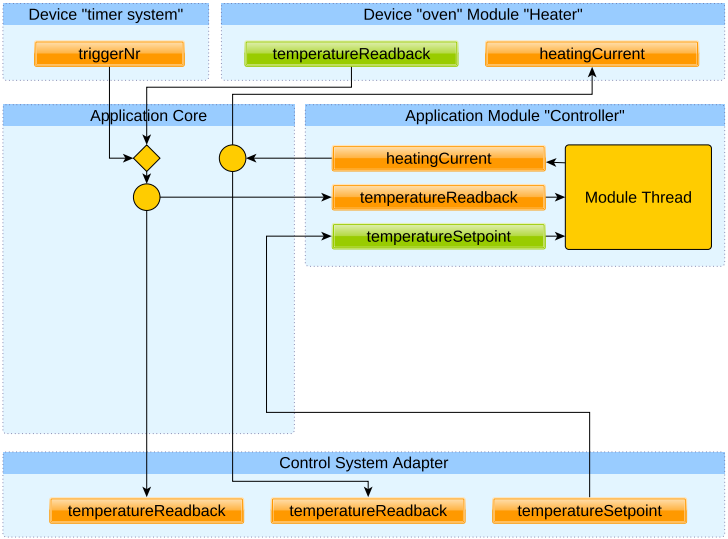
- Devices have a name (needs device name mapping)
- Registers / process variables have a name (might need register address mapping)
- In C++/Python: Objects to represent the procress variable



Modules

- Input/output variables
- Application Modules
  - One thread per module
- Special “modules”
  - Device module
  - Control system adapter

ApplicationCore



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- Modern multithreading: lock-free communication between modules ("for free")

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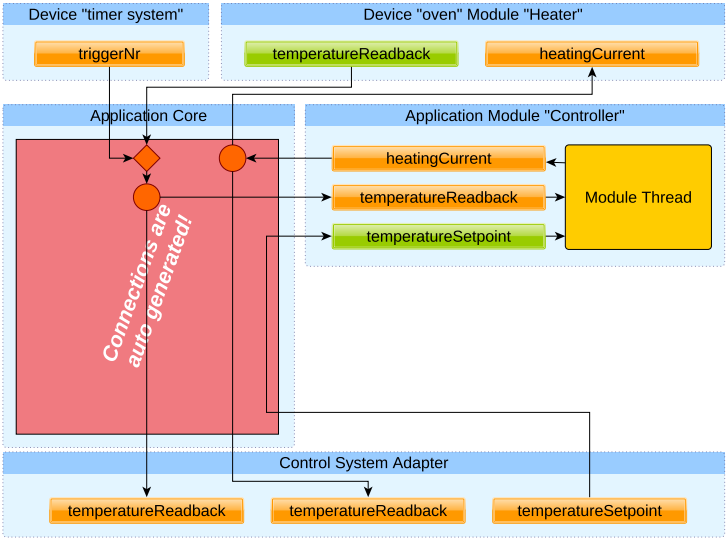

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- Connections are auto-genegated

Writing an ApplicationModule (Header Example)

Taken from the API dokumentation:
https://chimeratk.github.io/ApplicationCore/master/conceptual_overview.html

Application module

An application module represents a relatively small task of the total application, e.g. one particular computation. The task will be executed in its own thread, so it is well separated from the rest of the application. Ideally, each module should be somewhat self-contained and independent of other modules, and only ApplicationCore process variables should be used for communication with other parts of the application.

An application module is a class deriving from **ChimeraTK::ApplicationModule**, e.g.:

```
19 class Controller : public ctk::ApplicationModule {
20   using ctk::ApplicationModule::ApplicationModule;
21
22   ctk::ScalarPollInput<float> temperatureSetpoint{
23       this, "temperatureSetpoint", "degC", "Setpoint for the temperature controller"};
24   ctk::ScalarPushInput<float> temperatureReadback{
25       this, "temperatureReadback", "degC", "Actual temperature used as controller input"};
26   ctk::ScalarOutput<float> heatingCurrent{this, "heatingCurrent", "mA", "Actuator output of the controller"};
27
28   void mainLoop() override;
29 };
```

Writing an ApplicationModule (Main Loop)

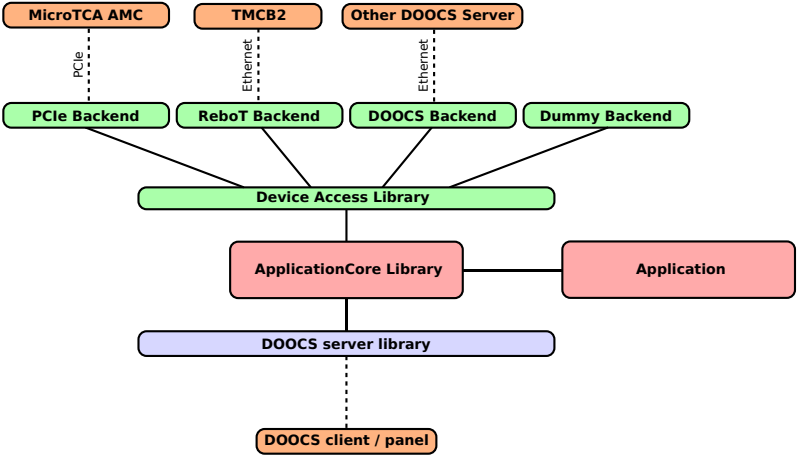
The code processing the data needs to go into the implementation of the ApplicationModule::mainLoop() function implementation. In our small example, we implement a simple, fixed-gain proportional controller like this:

```
18 void Controller::mainLoop() {
19   const float gain = 100.0F;
20   while(true) {
21     heatingCurrent = gain * (temperatureSetpoint - temperatureReadback);
22     writeAll(); // writes any outputs
23
24     readAll(); // waits until temperatureReadback updated, then reads temperatureSetpoint
25   }
26 }
```

The ApplicationModule::mainLoop() function litteraly needs to contain a loop, which runs for the lifetime of the application. Any preparations which need to be executed once at application start should go before the start of the loop.

Fully functional code from a working example!

Control system integration



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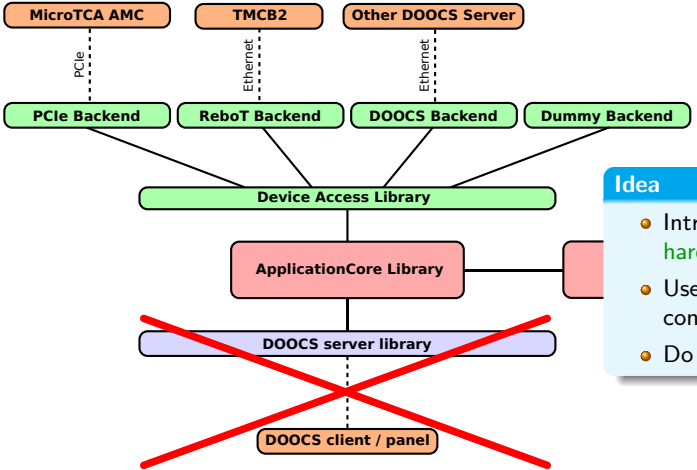

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- Introduce similar abstraction as for the hardware access
- Use ChimeraTK applications with various control system middlewares
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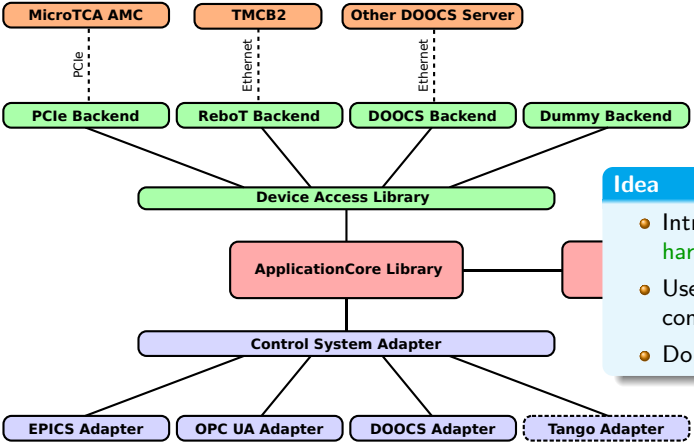

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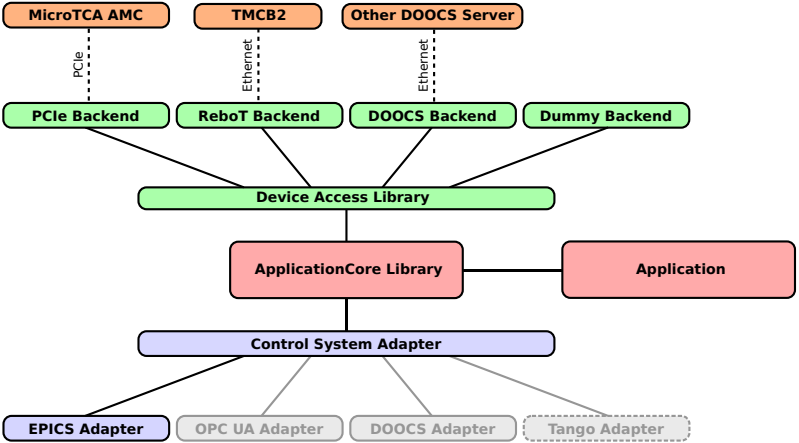

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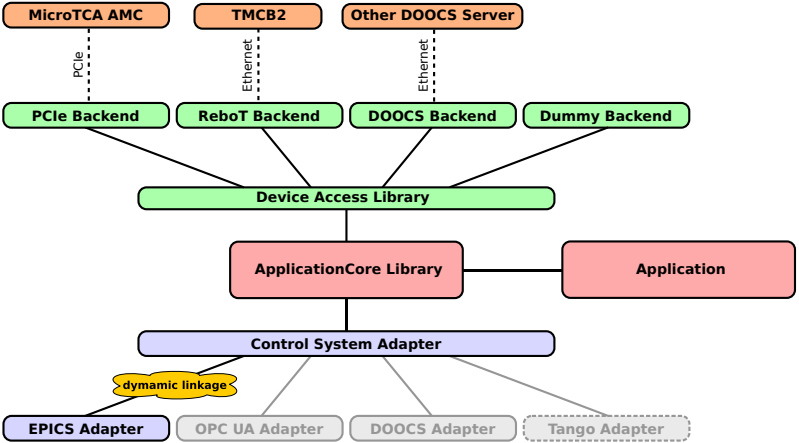

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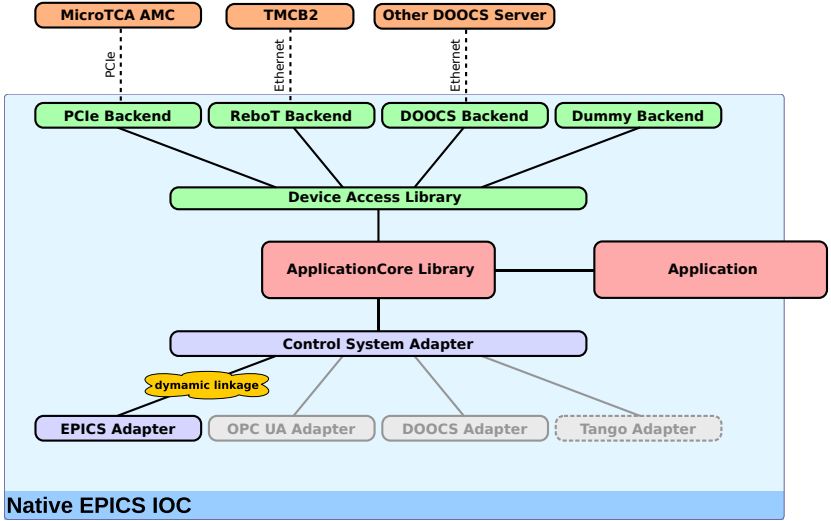

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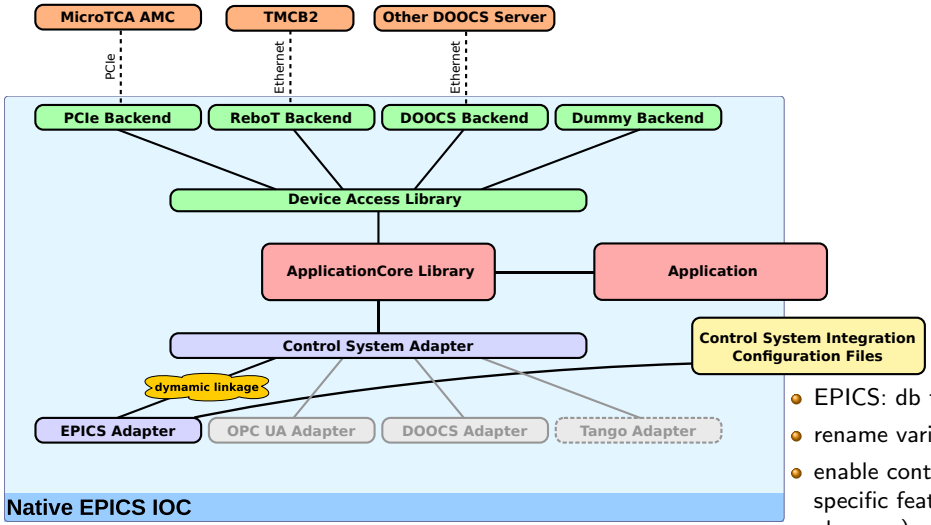

- EPICS: db files etc.
- rename variables
- enable control system specific features (histories, alarms...)

Generic Server Application

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  - Rename registers
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- Future plan: plug-in ApplicationModules written in Python

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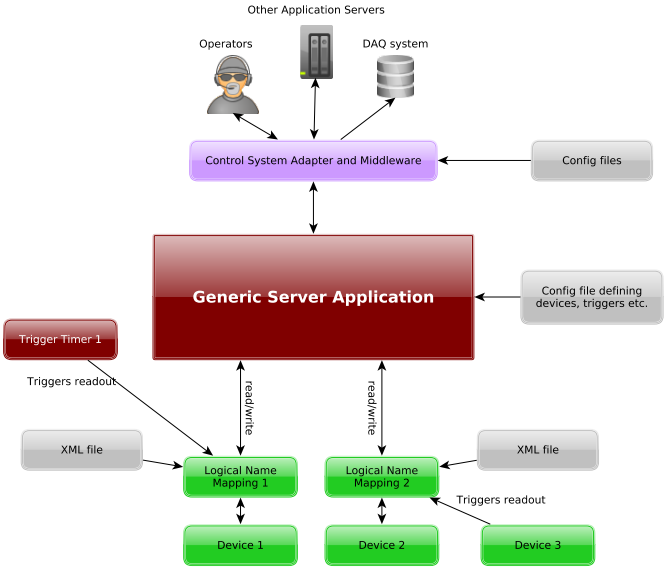


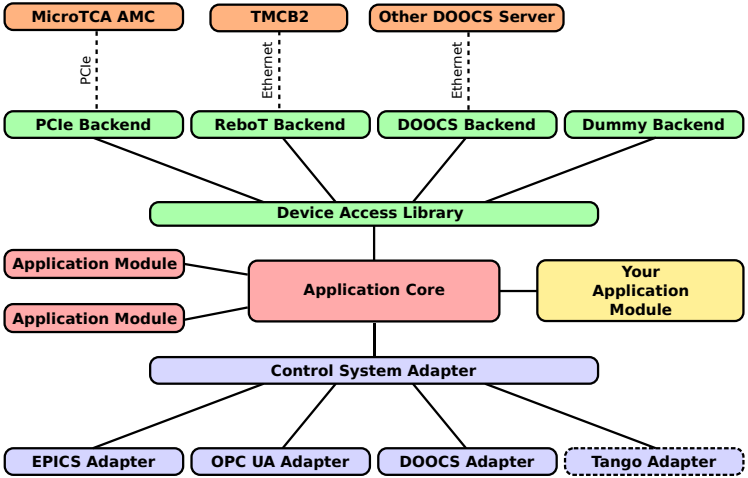
Planned: Python Bindings for ApplicationCore

Idea:

- Write individual ApplicationModules in Python
  - Syntax similar to C++
  - Inputs and output
- Run the Python ApplicationModules in addidion to C++ modules
- Let ApplicationCore do the connection to DeviceAccess, ControlSystem and other ApplicationModules
- Run the Python ApplicationModules in the Generic Server

- Implementation is planned for next year
- Should we increase the priority?

Summary


MicroTCA AMC
TMCB2
Other DOOCS Server
PCIe
Ethernet
Ethernet
PCIe Backend
ReboT Backend
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Dummy Backend
Device Access Library
Application Module
Application Module
Application Core
Your Application Module
Control System Adapter
EPICS Adapter
OPC UA Adapter
DOOCS Adapter
Tango Adapter

Software Repositories

All software is published under the GNU GPL or the GNU LGPL.

- ChimeraTK source code: https://github.com/ChimeraTK
- Ubuntu 20.04 and 24.04 packages are available in the DESY DOOCS repository.

Documentation and Tutorials

- API documentation https://chimeratk.github.io/
- Tutorials on the MicroTCA Workshop Indico page
- e-mail support: chimeratk-support@desy.de

Backup.

Example C++ code

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#include <ChimeraTK/Device.h>

int main(){
  // Setup section
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  ChimeraTK::Device d("ADC_BOARD");
  d.open();

  auto projectVersion =
    d.getScalarRegisterAccessor<uint32_t>("BSP/PRJ_VERSION");

  // Business logic
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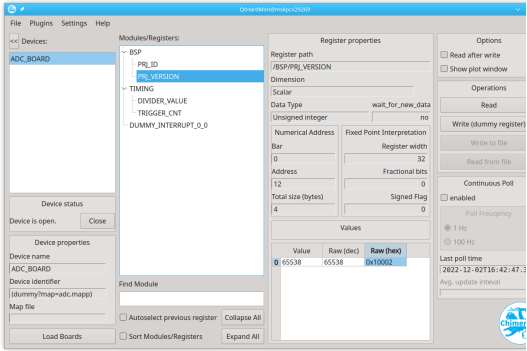


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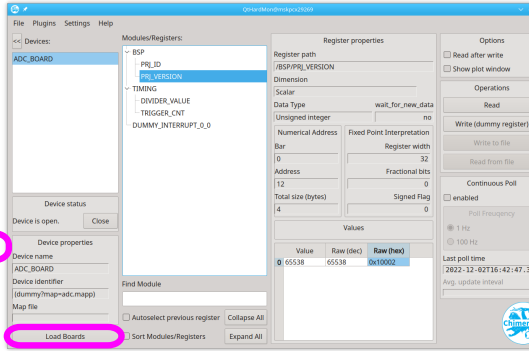


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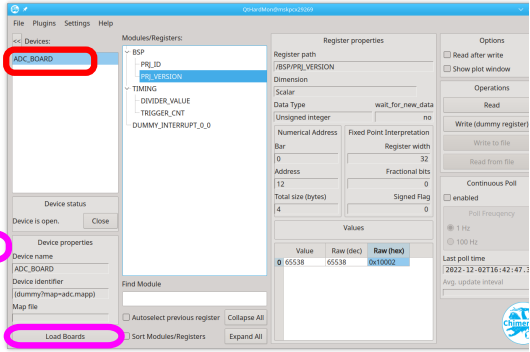


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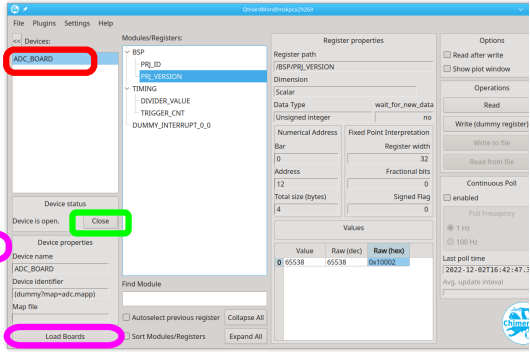


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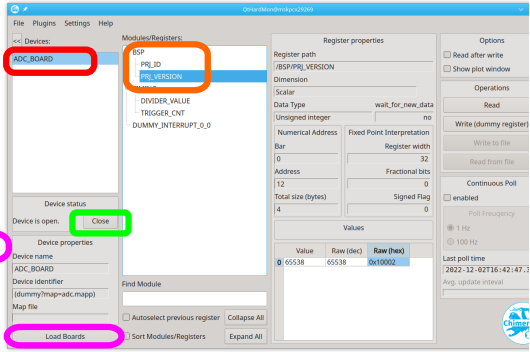


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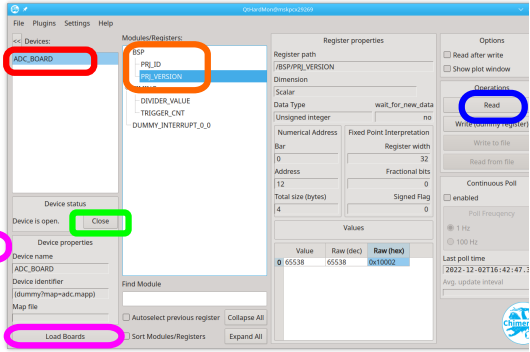

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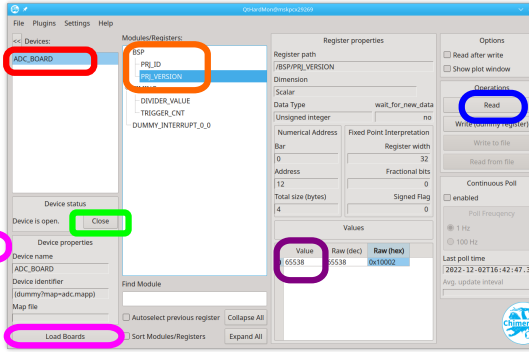


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NEW! Python bindings have a syntax similar to C++

```
import deviceaccess as da
import numpy as np

# Setup section
da.setDMapFilePath('devices.dmap')
d = da.Device('ADC_BOARD')
d.open ()

# For technical reasons ScalarRegisterAccessor inherits from np.ndarray
projectVersion = d.getScalarRegisterAccessor(np.uint32,'BSP/PRJ_VERSION')

#Business logic
projectVersion.read ();
if projectVersion[0] > 0x010000 :
    print('Compatible version '+ hex(projectVersion[0]))
```

What can I do with Logical Name Mapping?

Arrange the register content to logically match your application

- Rename registers
- Add constant registers or dummy registers
- Extract channels from 2D registers and give it a name
- Extract scalars from 1D registers and give it a name
- Extract bits from a scalar register

Math plugin

- Apply conversion formulas, e.g. ADC counts to physical units