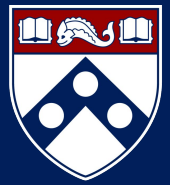
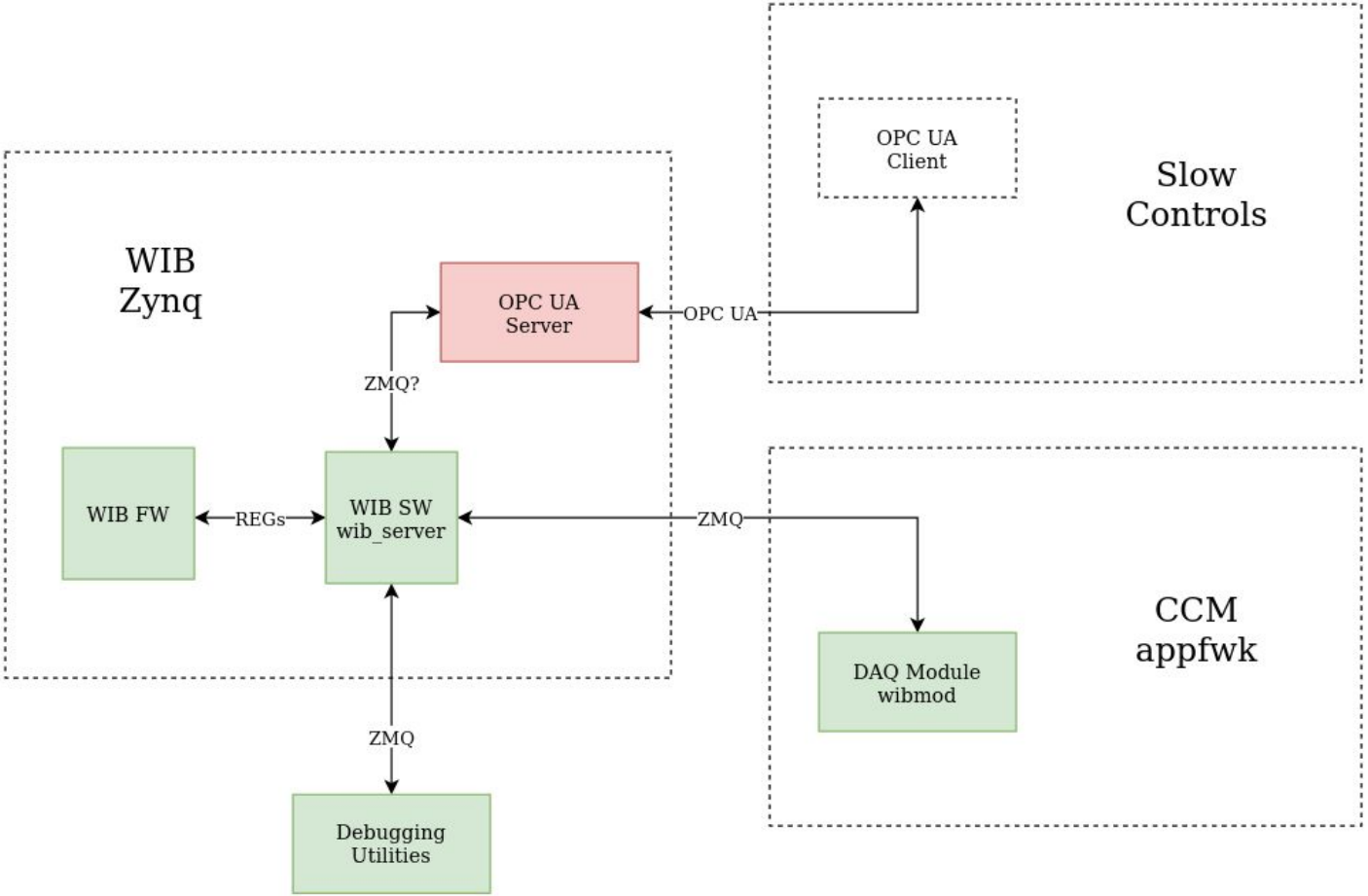


Penn
University of Pennsylvania

WIB OPC UA Server

Ben Land
July 20, 2021


OPC UA
Client
Slow
Controls
WIB
Zynq
OPC UA
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OPC UA
ZMQ?
WIB FW
REGs
WIB SW
wib_server
ZMQ
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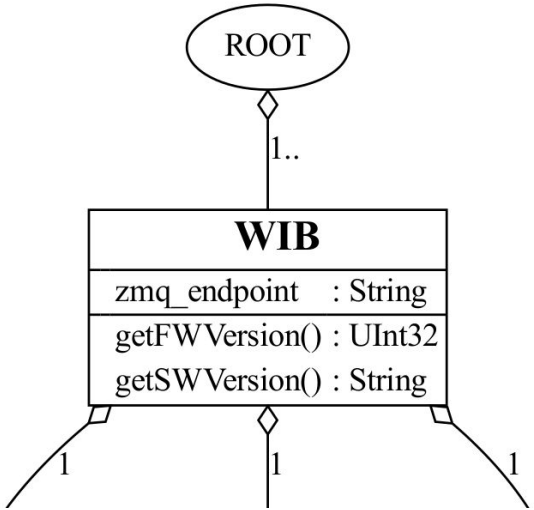
Debugging
Utilities

Overview

- OPC UA is a protocol for clients (control software) and servers (hardware) to interface for commands and status updates
- Giovanna recommended QUASAR for generating OPC UA servers
  - Wraps open62541 (most popular free / open source OPC UA implementation)
  - Used (exclusively) by CERN / one primary developer
- Quasar has some quirks, but easier than using open62541 directly
  - Only serious project documentation is a series of youtube videos on basic topics
  - Complex build system (Python+CMake) that isn't well documented
  - Significant code generation → relatively simple interface to implement
- Generates skeleton of a OPC UA server from XML schema
  - Define "classes" encapsulating different subsystems
  - Define "variables" and "methods" for each class
  - Implement logic in generated C++ code

Server Layout

- WIB class interfaces with wib_server via ZMQ
  - zmq_endpoint specified in the configuration
- Server supports any number of WIBs
  - ROOT represents a server process
  - If running on the WIB, probably just one WIB object
  - If running off the WIB, one process could be several
- Has methods for querying WIB metadata
  - Software and firmware versions
- Contains three child classes
  - FEMBPower, Sensors, and TimingEndpoint

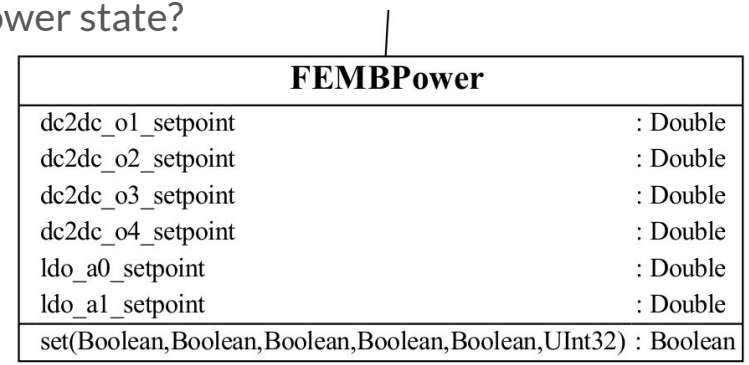


```
<d:class name="WIB">
    <d:devicelogic></d:devicelogic>
    <d:hasobjects instantiateUsing="configuration" class="FEMBPower"
        maxOccurs="1" minOccurs="1">
    </d:hasobjects>
    <d:hasobjects instantiateUsing="configuration" class="Sensors"
        maxOccurs="1" minOccurs="1">
    </d:hasobjects>
    <d:hasobjects instantiateUsing="configuration"
        class="TimingEndpoint" maxOccurs="1" minOccurs="1">
    </d:hasobjects>
    <d:configentry dataType="UaString" name="zmq_endpoint"
        storedInDeviceObject="true">
    </d:configentry>

    <d:method name="getFWVersion"
        executionSynchronicity="synchronous">
        <d:returnvalue dataType="OpcUa_UInt32" name="version"></d:returnvalue>
        <d:documentation>
            Return the firmware build timestamp register
        </d:documentation>
    </d:method>

    <d:method name="getSWVersion"
        executionSynchronicity="synchronous">
        <d:returnvalue dataType="UaString" name="version"></d:returnvalue>
        <d:documentation>
            Return the software git commit hash
        </d:documentation>
    </d:method>

    <d:documentation>
        Interface to the wib_server control software
    </d:documentation>
</d:class>
```

```
/* delegators for methods */
UaStatus DWIB::callGetFWVersion (
    OpcUa_UInt32& version
)
{
    wib::GetTimestamp req;
    wib::GetTimestamp::Timestamp rep;
    if (wib.send_command(req,rep,10000)) {
        version = rep.timestamp();
        return OpcUa_Good;
    } else {
        return OpcUa_Bad;
    }
}
UaStatus DWIB::callGetSWVersion (
    UaString& version
)
{
    wib::GetSWVersion req;
    wib::GetSWVersion::Version rep;
    if (wib.send_command(req,rep,10000)) {
        version = rep.version().c_str();
        return OpcUa_Good;
    } else {
        return OpcUa_Bad;
    }
}
```

Server Layout

- FEMBPower class controls FEMB power regulators
- Contains variables for each regulator setpoint
  - Read/Write by OPC UA clients
- Contains a “set” method to change power state of FEMBs
  - Loads setpoints, changes FEMB power state (4 boolean parameters)
  - Also sets the “warm” or “cold” parameter sets (last boolean parameter)
  - Runs wib_server’s init sequences for different power-on stages (uint32)
- TODO: current power state?

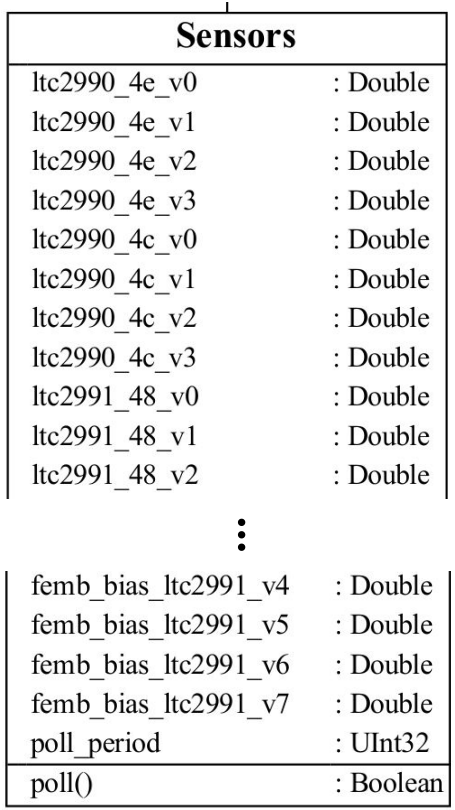


```
<d:class name="FEMBPower">
    <d:devicelogic></d:devicelogic>
    <d:cachevariable initializeWith="configuration"
        dataType="OpcUa_Double" name="dc2dc_o1_setpoint"
        nullPolicy="nullForbidden" addressSpaceWrite="regular">
        <d:documentation>
            Voltage setpoint for DC2DC O1 to be used for next set command
        </d:documentation>
    </d:cachevariable>
    <d:cachevariable initializeWith="configuration"
        dataType="OpcUa_Double" name="dc2dc_o2_setpoint"
        nullPolicy="nullForbidden" addressSpaceWrite="regular">
        <d:documentation>
            Voltage setpoint for DC2DC O2 to be used for next set command
        </d:documentation>
    </d:cachevariable>
    <d:cachevariable initializeWith="configuration"
        dataType="OpcUa_Double" name="dc2dc_o3_setpoint"
        nullPolicy="nullForbidden" addressSpaceWrite="regular">
        <d:documentation>
            Voltage setpoint for DC2DC O3 to be used for next set command
        </d:documentation>
    </d:cachevariable>
    <d:cachevariable initializeWith="configuration"
        dataType="OpcUa_Double" name="dc2dc_o4_setpoint"
        nullPolicy="nullForbidden" addressSpaceWrite="regular">
        <d:documentation>
            Voltage setpoint for DC2DC O4 to be used for next set command
        </d:documentation>
    </d:cachevariable>
    <d:cachevariable initializeWith="configuration"
        dataType="OpcUa_Double" name="ldo_a0_setpoint"
        nullPolicy="nullForbidden" addressSpaceWrite="regular">
        <d:documentation>
            Voltage setpoint for LDO A0 to be used for next set command
        </d:documentation>
    </d:cachevariable>
    <d:cachevariable initializeWith="configuration"
        dataType="OpcUa_Double" name="ldo_a1_setpoint"
        nullPolicy="nullForbidden" addressSpaceWrite="regular">
        <d:documentation>
            Voltage setpoint for LDO A0 to be used for next set command
        </d:documentation>
    </d:cachevariable>
    <d:method name="set" executionSynchronicity="synchronous">
        <d:argument dataType="OpcUa_Boolean" name="femb0_on"></d:argument>
        <d:argument dataType="OpcUa_Boolean" name="femb1_on"></d:argument>
        <d:argument dataType="OpcUa_Boolean" name="femb2_on"></d:argument>
        <d:argument dataType="OpcUa_Boolean" name="femb3_on"></d:argument>
        <d:argument dataType="OpcUa_Boolean" name="cold"></d:argument>
        <d:argument dataType="OpcUa_UInt32" name="stage"></d:argument>
        <d:returnvalue dataType="OpcUa_Boolean" name="success"></d:returnvalue>
        <d:documentation>
            Set the power state of the FEMBs on the WIB using the
            current voltage settings
        </d:documentation>
    </d:method>
    <d:documentation>
        Control the FEMB power subsystem on the WIB
    </d:documentation>
</d:class>
```

```
/* delegators for methods */
UaStatus DFEMBPower::callSet (
    OpcUa_Boolean femb0_on,
    OpcUa_Boolean femb1_on,
    OpcUa_Boolean femb2_on,
    OpcUa_Boolean femb3_on,
    OpcUa_Boolean cold,
    OpcUa_UInt32 stage,
    OpcUa_Boolean& success
)
{
    auto *as = getAddressSpaceLink();
    wib::ConfigurePower conf_req;
    conf_req.set_dc2dc_o1(as->getDc2dc_o1_setpoint());
    conf_req.set_dc2dc_o2(as->getDc2dc_o2_setpoint());
    conf_req.set_dc2dc_o3(as->getDc2dc_o3_setpoint());
    conf_req.set_dc2dc_o4(as->getDc2dc_o4_setpoint());
    conf_req.set_ldo_a0(as->getLdo_a0_setpoint());
    conf_req.set_ldo_a1(as->getLdo_a1_setpoint());
    wib::Status conf_rep;
    if (getParent()->wib.send_command(conf_req,conf_rep,10000)) {
        if (!conf_rep.success()) return OpcUa_Bad;
    } else {
        return OpcUa_Bad;
    }

    wib::PowerWIB req;
    req.set_femb0(femb0_on);
    req.set_femb1(femb1_on);
    req.set_femb2(femb2_on);
    req.set_femb3(femb3_on);
    req.set_cold(cold);
    req.set_stage(stage);
    wib::Status rep;
    if (getParent()->wib.send_command(req,rep,10000)) {
        success = rep.success();
        return OpcUa_Good;
    } else {
        return OpcUa_Bad;
    }
}
```

Server Layout

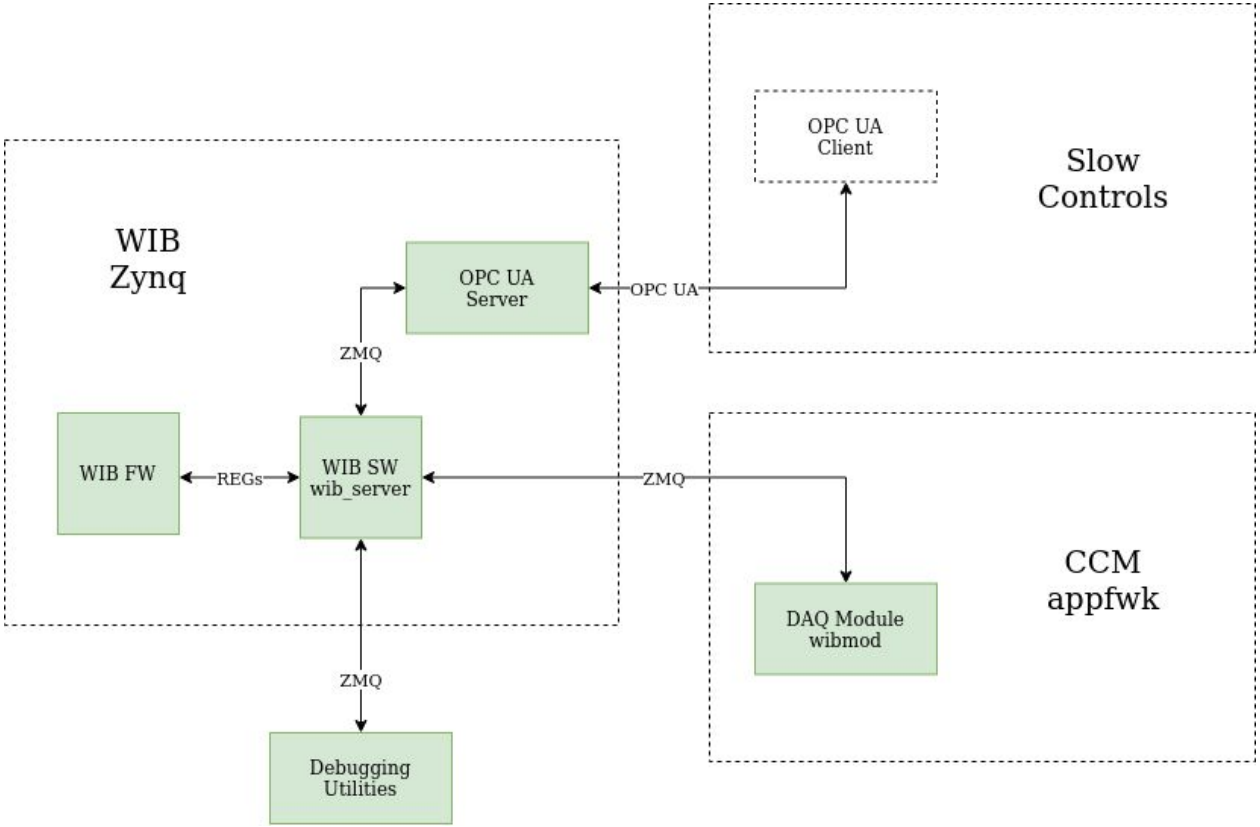
- Sensors class provides access to onboard monitoring
- Contains variables for each sensor value
  - Typically in raw volts
    - i.e. before/after sense resistors
  - Quasar supports “calculated variables”
    - To add scale factors, compute current
    - Only useful if SC needs this
    - Clients can calculate their own scaled values
- Values updated by polling the i2c sensors via wib_server
  - By calling “poll” method as needed
  - By setting an auto poll period (handled by server)



PetaLinux Integration

- QUASAR documentation suggested this worked out-of-the-box
  - Realistically, hadn't been tested in years, and dev doesn't use it
  - Quasar builds and runs nicely within its development environment, not much baked in support for actually installing it
- Spent a couple of days trial/error debugging build system
  - Stripped out several unnecessary parts of Python build code
  - Added several non-existent required dependencies in Petalinux (Yocto)
  - Kludged together an installer script
- Now working on my ARM64 emulator with WIB linux distro
  - Will deploy to UPenn WIB later this week (or soon…)
  - For now, testing with simulated wib_server on x86_64 host

Live Demo!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