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Porting VME-Based Optical-Link Remote I/O Module to a PLC Platform

- an Approach to Maximize Cross-Platform Portability Using SoC

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SPring-8

Outline

- Background
  - Optical-linked remote I/O system
  - Platform consideration
- Development of module
  - Design policy
  - Hardware implementation
  - Software implementation
  - Implementation of FPGA logic
- Summary

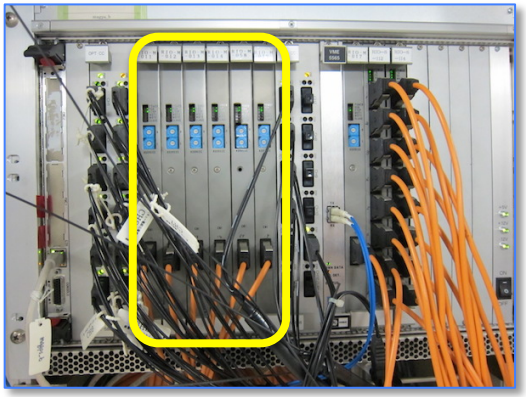
Background

- VME
  - employed at SPring-8 as FE computers.
- Optical-linked Remote I/O systems
  - utilized to cover widely distributed accelerator equipment.
  - consist of **VME-based** master boards and several kinds of slave boards.
  - two types of optical-linked remote I/O system
    - *RIO system*
    - *OPT-VME system*

Background

- *RIO system*
  - developed by Mitsubishi Electric Co.
  - used since 1997, already **discontinued**.
  - employ **over 1,400 slave boards** in SPring-8.
    - mainly for SR magnet power supplies control.
    - many of them can be replaced with *OPT-VME system*.
      - developed the compatible slave boards.

RIO Master boards

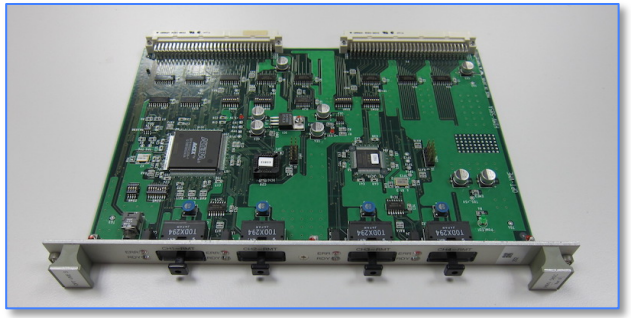


RIO Slave boards

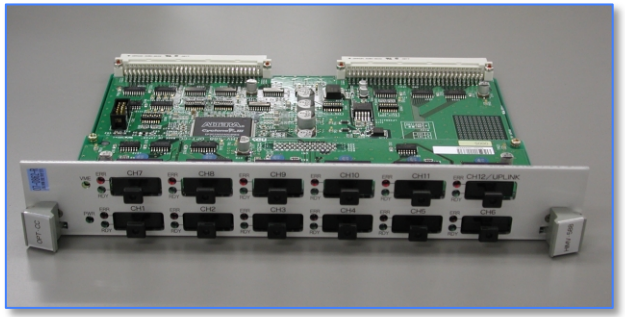
Background

- *OPT-VME system*
  - developed by SPring-8 at 2001.
  - two types of **VME-based** master boards.
    - OPT-VME
    - OPT-CC

OPT-VME: *4ch single-slot VME board*



OPT-CC: *12ch dual-slot VME board*



Background

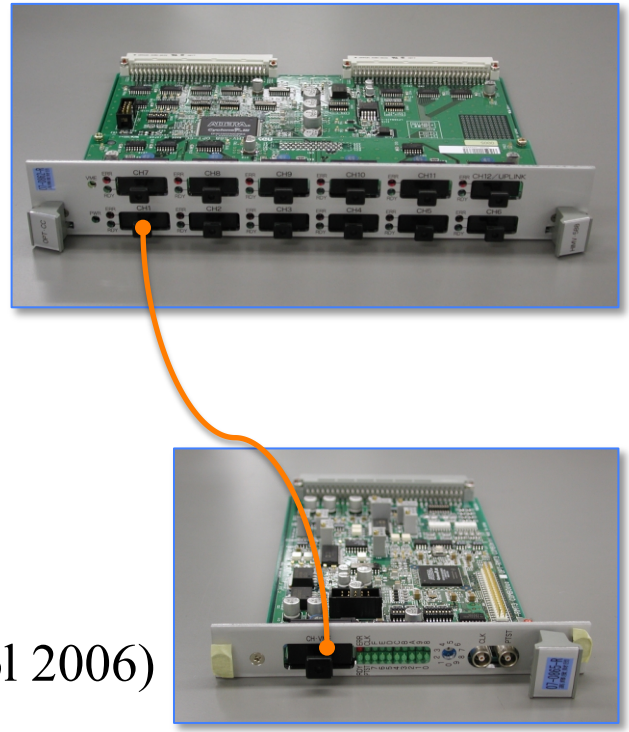
- *OPT-VME system*
  - developed by SPring-8 at 2001.
  - two types of **VME-based** master boards.
    - OPT-VME
    - OPT-CC
  - employ **over 400 slave boards** in SPring-8.
    - 10 types of slave boards are available.

a kind of slave board

Used for steering magnet PSs control at the booster ring.

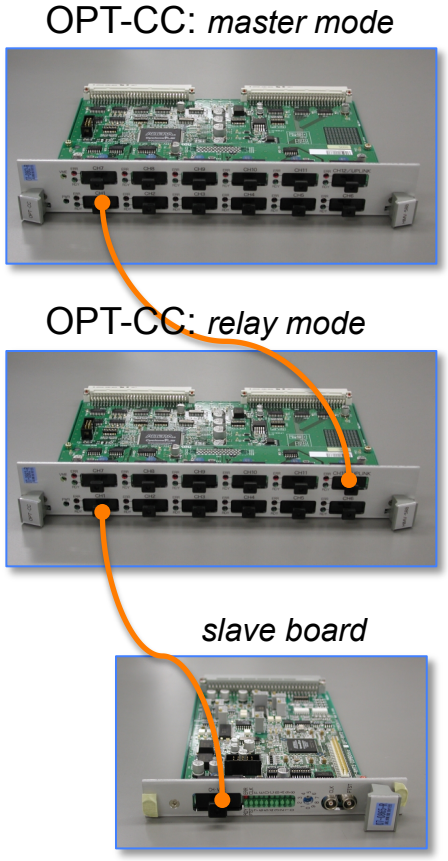
Background

- *OPT-VME system*
  - developed by SPring-8 at 2001.
  - two types of **VME-based** master boards.
    - OPT-VME
    - OPT-CC
  - employ **over 400 slave boards** in SPring-8.
    - 10 types of slave boards are available.
  - original communication protocol (OPT-Protocol 2006)
    - Only support point-to-point connection.



Background

- *OPT-VME system*
  - OPT-CC
    - also available in the relay-mode.
      - max. 132 slave boards can be controlled from a master.



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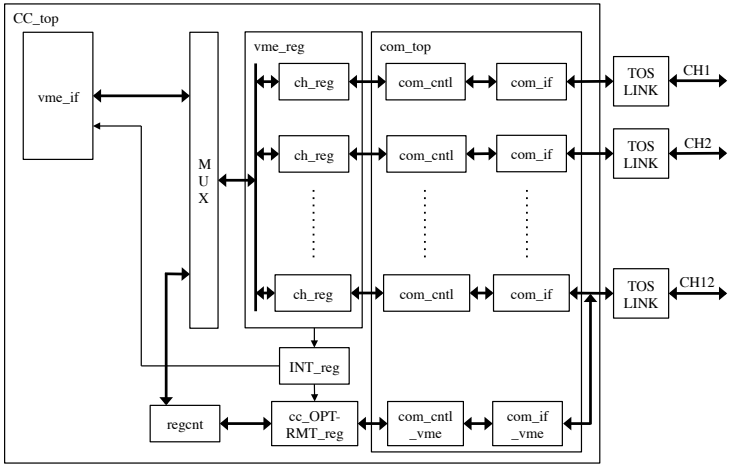

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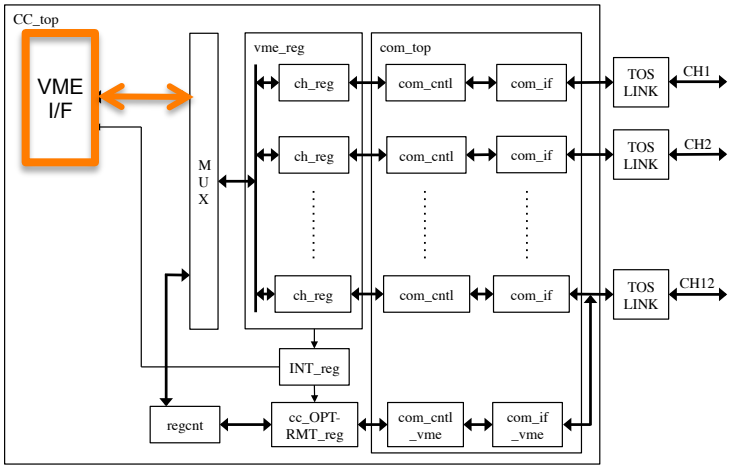
In a master mode



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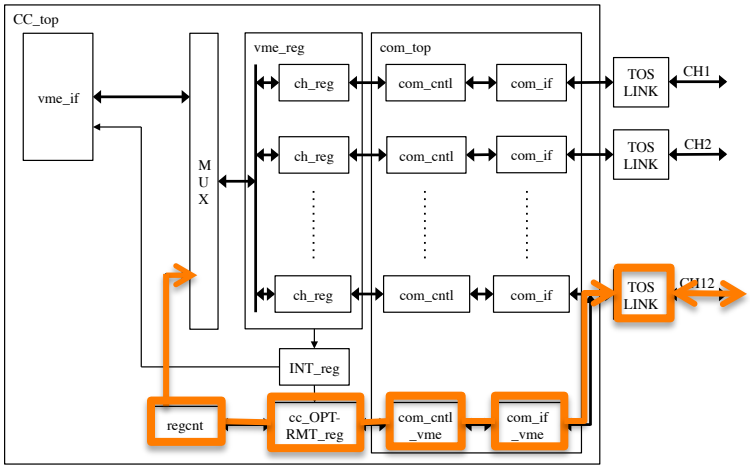

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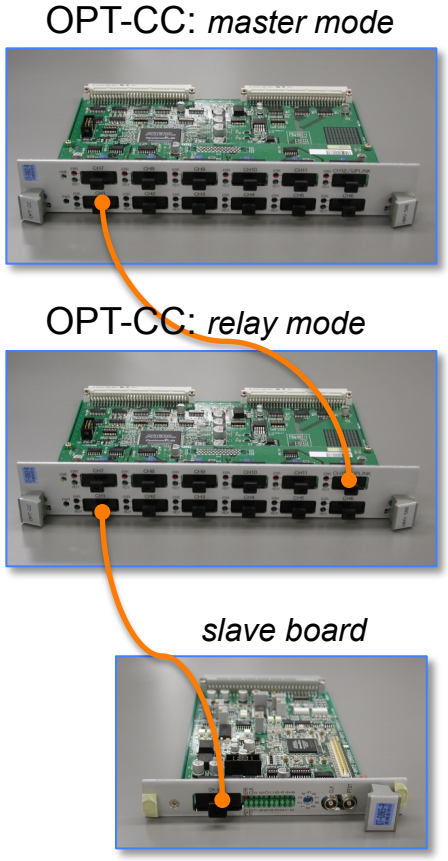

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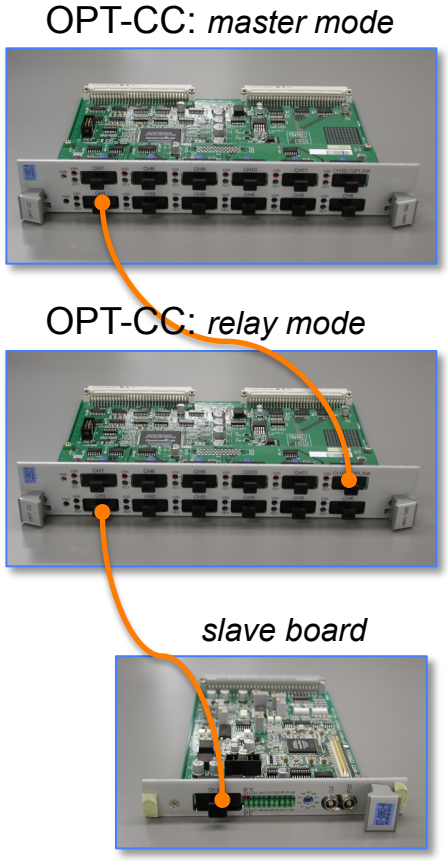
The device driver is responsible for the high-level communication procedures including the remote slave control.



Platform Consideration

- **VME**
  - Passed over 30 years, become out-of-date.
  - Two major issues;
    - Lack of bandwidth.
    - **Discontinued the de-fact standard bus-bridge chip *Tsi148*.**

      → *This has been a big problem for VME users.*
- considering the next-generation alternative platform.

Platform Consideration

- **MTCA.4**
  - Decided to introduce MTCA.4 **as a high-end platform**.
  - Analog-based old SR LLRF system controlled by VME is planed to be replaced with MTCA.4-based digital LLRF system.

Platform Consideration

- MTCA.4
  - Decided to introduce MTCA.4 as a high-end
  - Analog-based old SR LLRF system controlled by VME is planed to be replaced with MTCA.4-based digital LLRF system.
- **Linux PLC (Programmable Logic Controller)**
  - one of the candidate to **cover a low-end side**.
  - e.g. e-RT3 (FA-M3) by Yokogawa Electric Co.
    - already applied as front-end computers in both SPring-8 and SACLA.

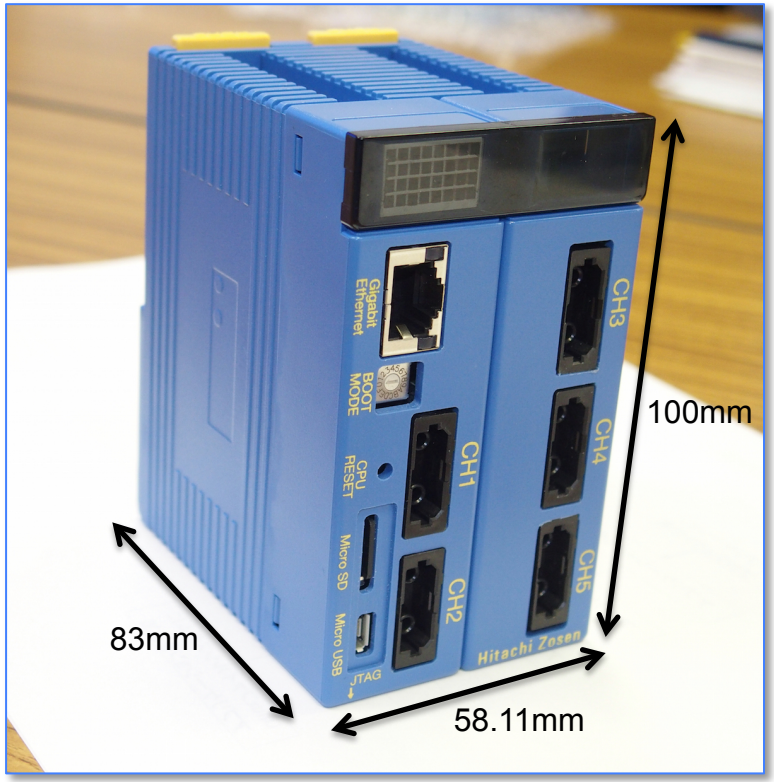
Background

- Developed the new master module of the OPT-VME system based on the e-RT3 platform.
  - To effectively utilize the resources of large amount of *OPT-VME* slave board (~400).
    - RIO slave boards (~1,400) are also integrated by replacing OPT-VME based compatible slave boards.
  - Considering alternative platform portability such as a PCI Express (MTCA.4)

Development of the new master module

- **OPT-PLC**
  - e-RT3-based new master module for the *OPT-VME system*.

SoC	Xilinx Zynq 7015 : XC7Z015-1CLG485C
Memory	1GB DDR3-SDRAM 128MB QSPI Flash
LAN	1 port (RJ-45 Connector)
MicroSD	1 port (Micro-SD socket)
UART	1 port (Micro-USB connector)
High-Speed Serial I/F	4 pairs x 6.25GBps in a 70pins stacking connector (Molex 53625-0774)
JTAG	1 port
Power	+5V±5%



OPT-PLC module

- Design Policies
  1. Equip with as many optical channels as possible.
  2. Separate an I/O unit from a logic control unit.
  3. Control the module using the e-RT3 general-purpose device driver.
  4. Control the module from a sequence CPU in addition to a Linux CPU.

OPT-PLC module

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  1. **Equip with as many optical channels as possible.**
  2. **Separate an I/O unit from a logic control unit.**
  3. Control the module usin → Hardware Implementation driver.
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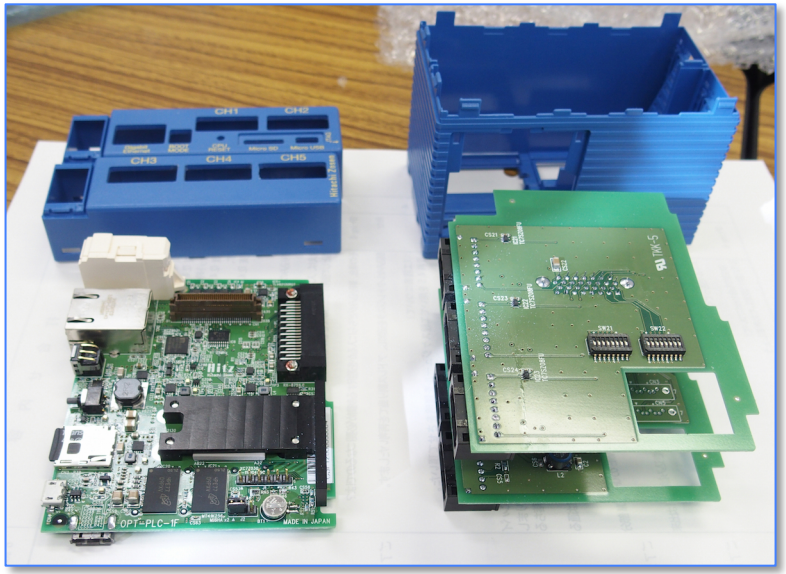
Hardware Implementation

- Consists of three PCBs.
  - Separate two I/O boards from the control logic board.
  - Connected using 70 pins stacking connector each other.
    - *PCB is a little small to mount the FMC.*
- Equipped with 5 optical channels.



control logic board I/O boards

OPT-PLC module

- Design Policies
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→ Implementation of Software & FPGA logic

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  4. Control the module fr
     CPU.

→ Implementation of Software & FPGA logic

Keyword : SoC

e-RT3 General-Purpose Device Driver

- supplied and supported by Yokogawa Electric Co.
- primitive device driver to handle memory access and interrupt.

e-RT3 General-Purpose Device Driver

- supplied and s
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  interrupt.

Background

- *OPT-VME system*
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    - also available in the relay-mode.
      - max. 132 slave boards can be controlled.
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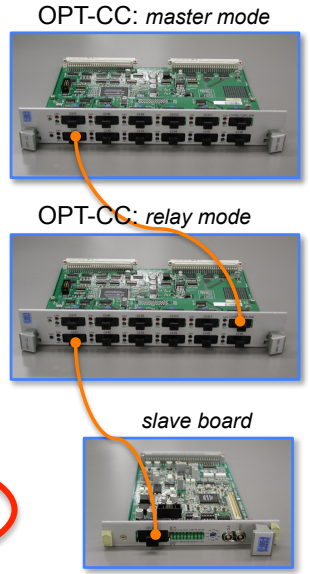
    - communication procedure with the remote slave board is **implemented in the device driver** for the master board.

The device driver is responsible for the high-level communication procedures including the remote slave control.



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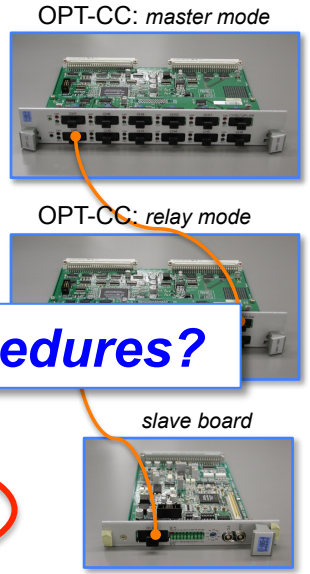

How do we implement this high-level communication procedures?

board is **implemented in the device driver** for the master board.

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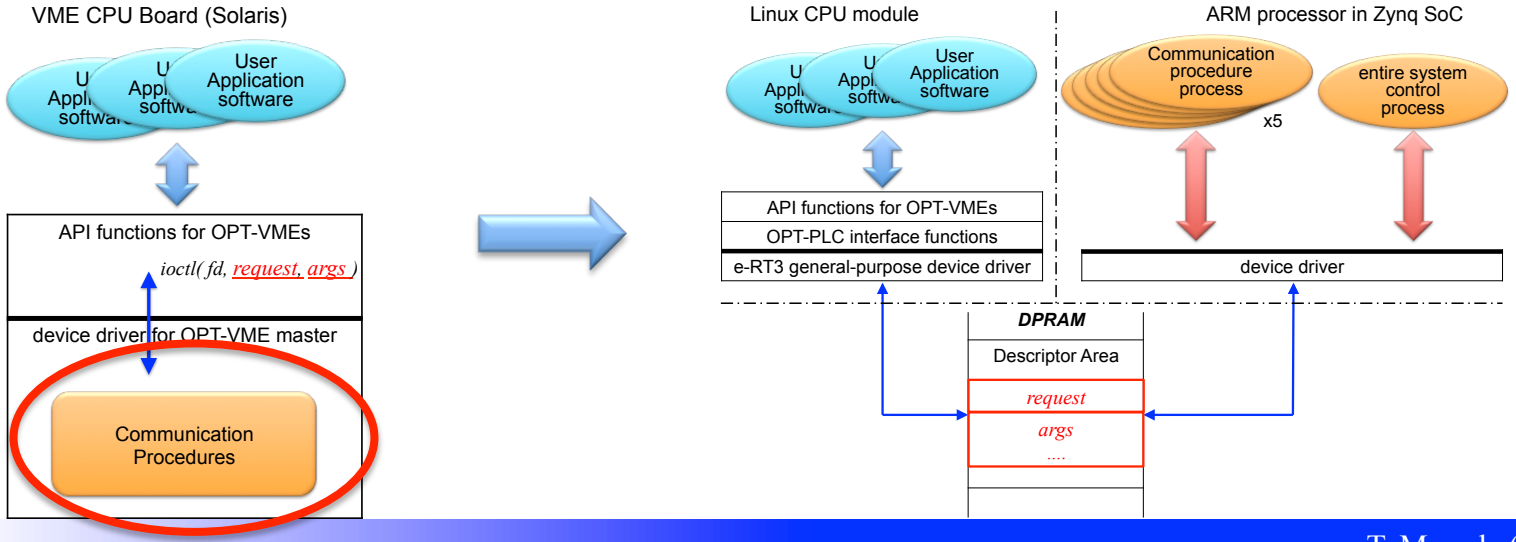
Software Implementation

- Adopt SoC (Xilinx Zynq 7000)
- Implement the high-level communication procedures as application software running on ARM Linux in SoC.



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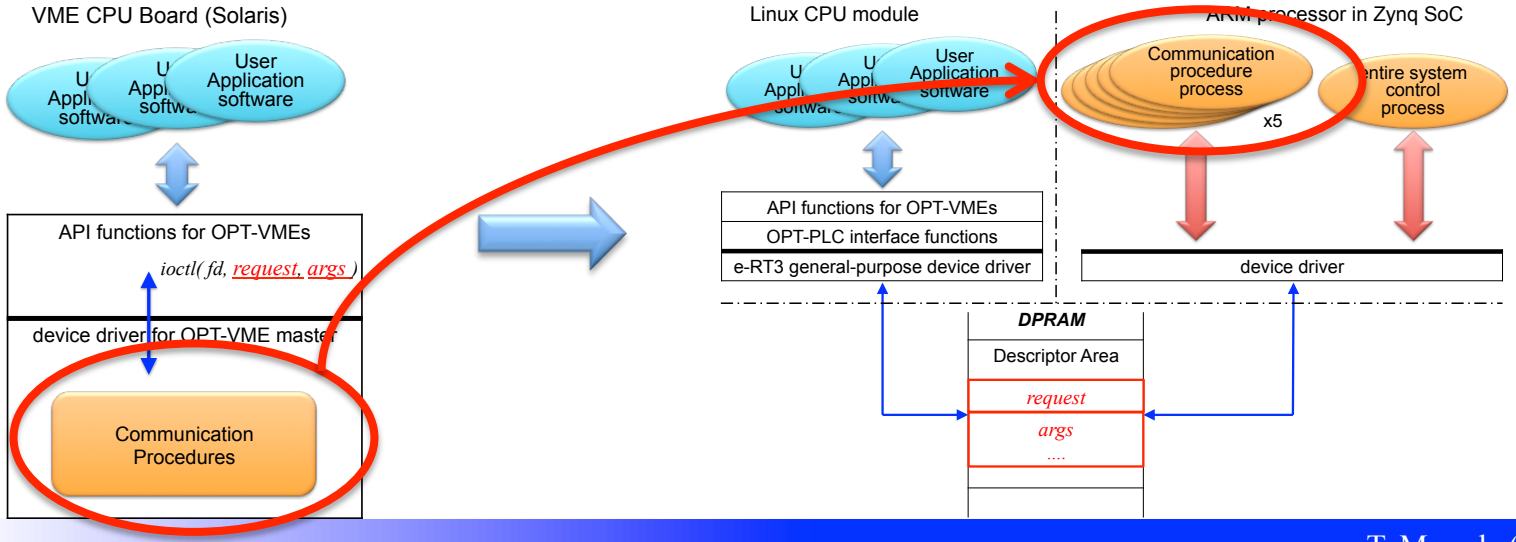

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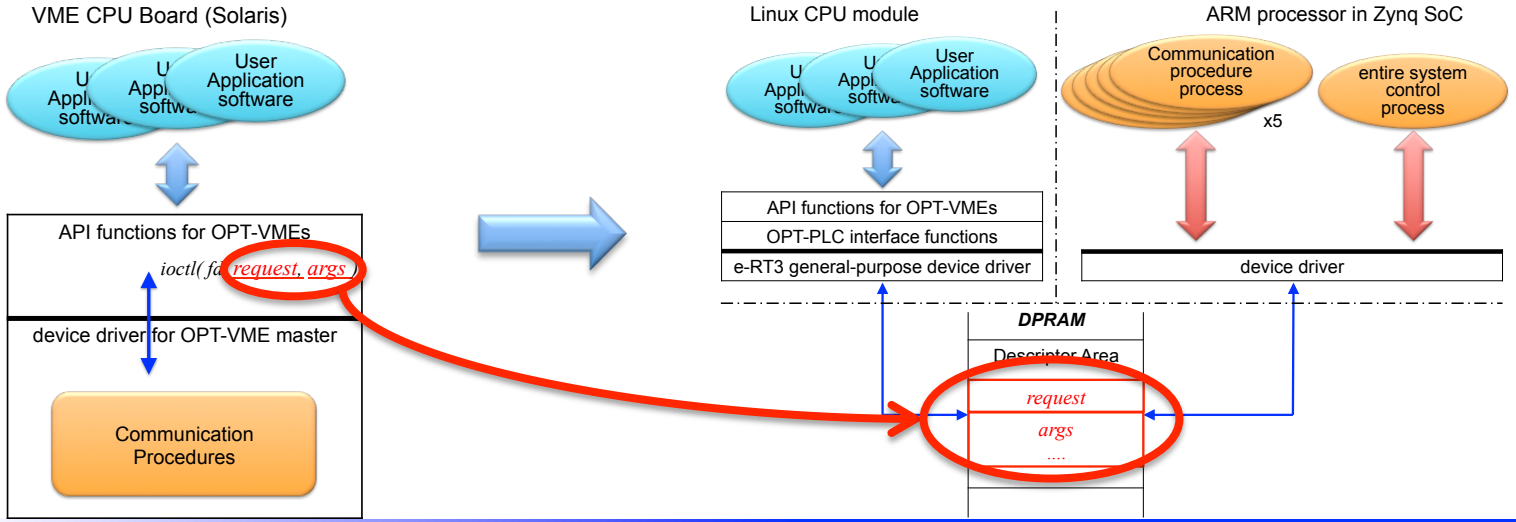

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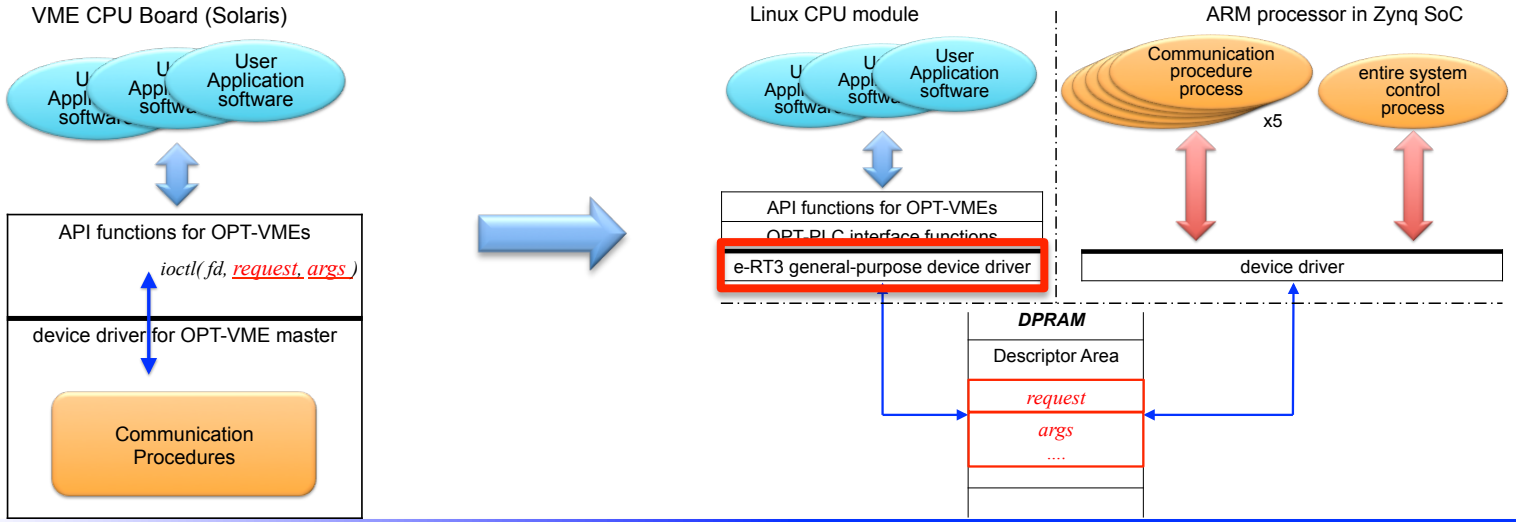
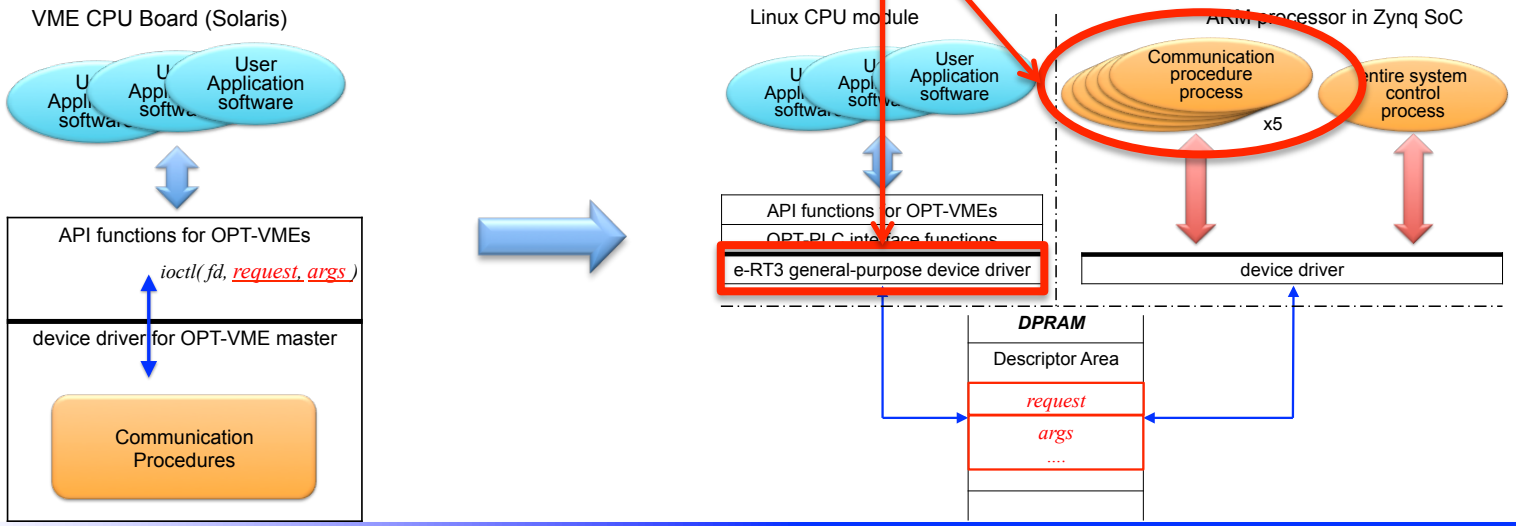


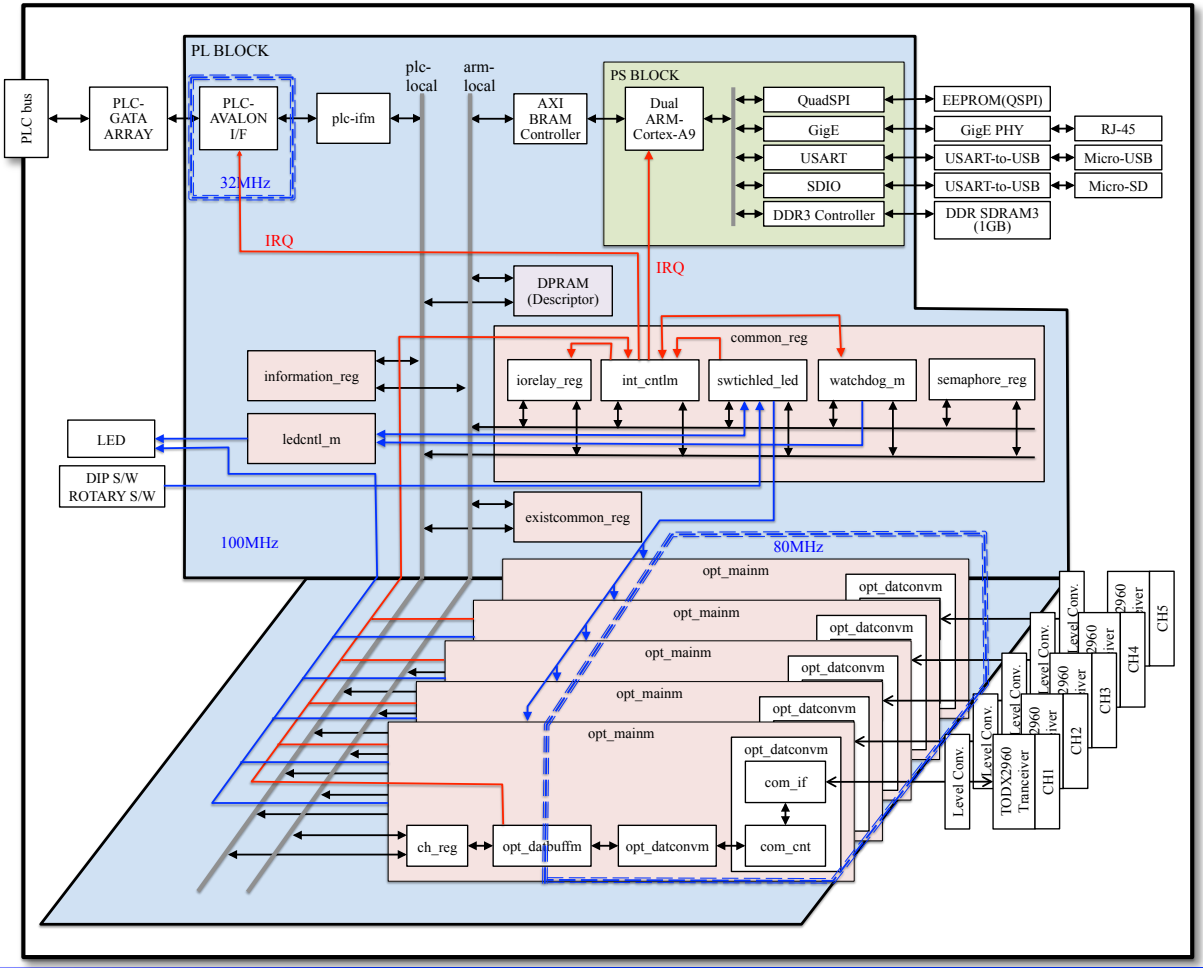
Software Implementation

- Adopt SoC (Xilinx
- Implement the high-level communication procedures as application software running on ARM Linux in SoC.

As a result the device driver of platform side is simplified, the module portability to other platform is enhanced.



Implementation of FPGA Logic



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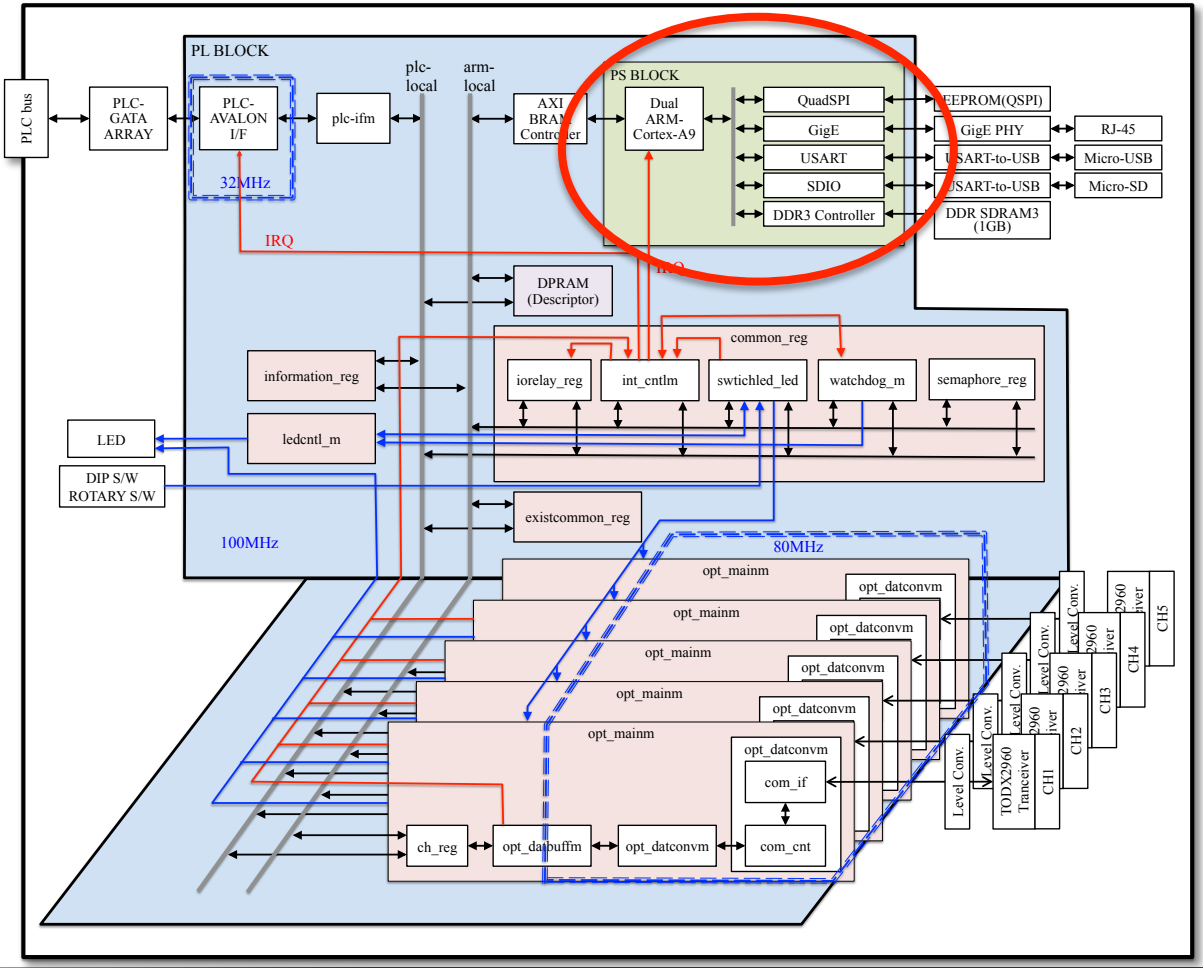

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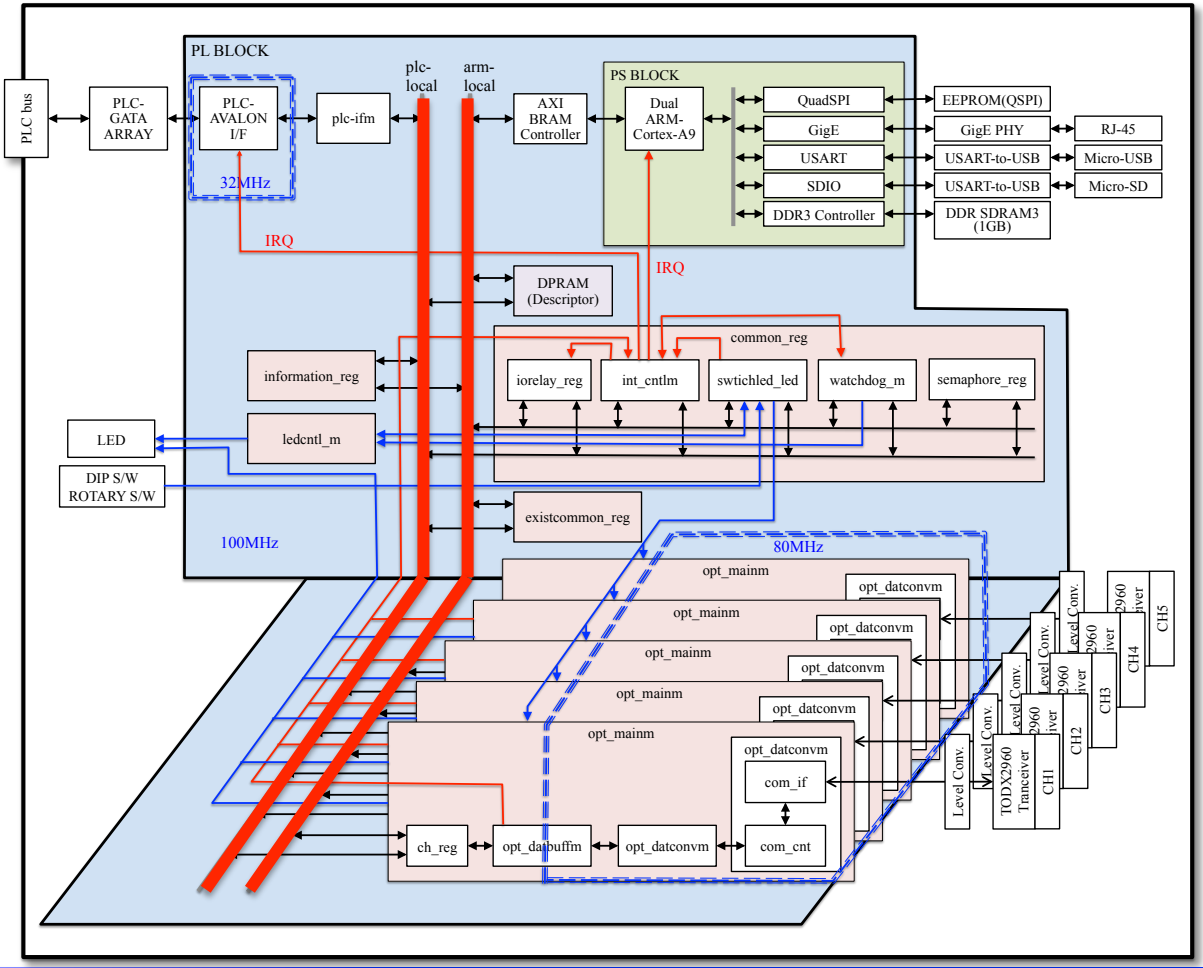
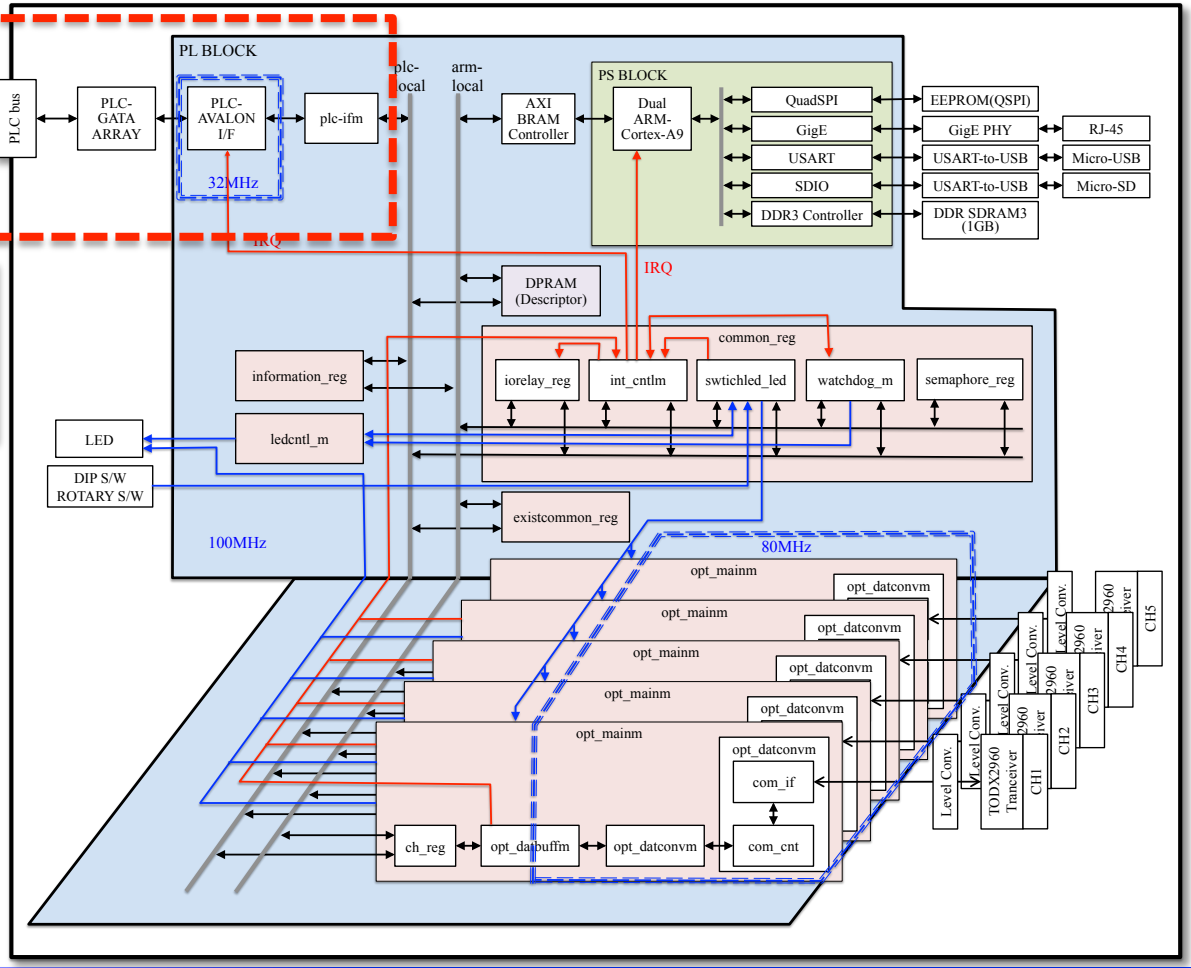


Implementation of FPGA Logic

We can port the FPGA logic to an alternative bus by replacing this part.



Summary

- We have successfully ported the VME-based optical-link remote I/O module to the e-RT3 platform.
- The developed module OPT-PLC is equipped with Zynq 7000 SoC to build the communication procedures as the application S/W on the ARM Linux.
  - the interface with the PLC bus is simplified and the e-RT3 general-purpose device driver is available.
- We can port the developed FPGA logic to an alternative bus e.g. the PCI express by replacing the PLC bus interface block in the PL part.
- **The interface simplification enhances portability.**

Thank you for your attention.