F3RP61-based Embedded IOCs for Accelerator Controls at KEK

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For KEKB and Linac Control Groups

KEK: Accelerator Facilities for Particle & Nuclear Physics, Material Structure Science

Mt. Tsukuba

J-PARC (at Tokai Site)
(Initial) PLC usage at KEK

◆ At e⁻/e⁺ Linac
  ❖ We enforced that all the new controllers should be connected over IP/Ethernet since 1993 (instead of other field networks)
  ❖ PLC was much cost-effective compared with VME
    ✤ if the speed requirement allows
  ❖ Products from OMRON, Mitsubishi, Yokogawa, etc. were installed
    ✤ Only Yokogawa (FAM3) remained and others were removed, because maintenance capability over network was better
      ✤ Ladder software downloadable over IP/Ethernet, etc.
      ✤ (Recently Mitsubishi also added that feature)
  ❖ 170 PLCs (with Ethernet) used for RF, Magnets, Vacuum, (Safety), etc

◆ At J-PARC
  ❖ Many installations with the same reasons as e-Linac

◆ At KEKB
  ❖ Used indirectly at many devices, over serial or GPIB links

◆ Even custom hardware modules can be designed (I/O Open)
Vacuum Controller Internal  Magnet Controller Internal  RF Controller Internal

Safety Controller  Touch Panel Display for RF
Software management with PLCs

◆ Ideal at the beginning
  ❖ Separate software development at control group, at equipment group, or at industrial company
  ❖ Later, integration test with IP/Ethernet

◆ Logic management, however
  ❖ Same logics could be placed at ladder software, in EPICS database/sequencer (or in high-level applications)

◆ Speed requirement
  ❖ Closed loop over Ethernet was slow, sometimes un-reliable
  ❖ Interrupts were possible, but slow and complicated

◆ Thus, hoped to run EPICS on PLC
EPICS on PLC

◆ VxWorks CPU was available on PLC (Yokogawa, Mitsubishi)
  □ Besides normal sequence / ladder CPU
◆ Yokogawa starts to provide Linux (2.6) on PLC CPU (F3RP61)
  ▶ Brave enough to choose open source environment
  □ We negotiate with Yokogawa to remove any license issues
  ▶ Odagiri/KEK, Uchiyama/SHI-RIKEN, Yamada/KEK made much effort to realize EPICS implementation, (but no need for asynchronous records)
  ▶ Takuya-Nakamura/MSC-KEK, et al, tailored the environment for KEKB
    □ Procserv, pcmon, NFS, ...
◆ Four F3RP61-based IOCs are used in KEKB operation
  ▶ Three since September 2008, and another later, four in total
  ▶ Beam mask controllers and Pulsed-quad controllers
  ▶ No trouble at all, they run more than 8 months
◆ ~20 new IOCs are also used in J-PARC operation now
F3RP61 (e-RT3 2.0)

- Linux 2.6.24
- PPC 533MHz
- 128Mbyte RAM
- 100BaseTx x2
- USB
- IEEE1394
- Serial
- PCI

I/O Bus for FAM3 Module Interface

- can access to mature FAM3 I/O Modules
- Can be combined with conventional ladder CPU
- Software development environment (ELDK)

KEKB Beam mask controller
Simple Usage under EPICS

Conventional PLC usage

- OPI CA Clients
- IOC (Logics)
- Ladder CPU (Logics)
- FAM3 PLC I/O Modules

with asynchronous access

PLC usage with F3RP61

- OPI CA Clients
- F3RP61 IOC
- FAM3 PLC I/O Modules

with only synchronous access and maybe with sequencer

If necessary, we can combine

- OPI CA Clients
- F3RP61 IOC
- Ladder CPU
- FAM3 PLC I/O Modules

Device Support

◆ No need for asynchronous access
  ◆ Direct access to all I/O modules
◆ Can access to registers on ladder CPU
  ◆ If necessary
◆ Interrupts also possible
◆ Logics can be database links or sequencers
◆ Did extend the number of EPICS developers

◆ Source code and documents
  ◆ http://www-linac.kek.jp/cont/epics/f3rp61/
  ◆ Local development, PREEMPT_RT realtime (Yamada, et al)
Other EPICS Development Activities at KEK

◆ By A. Akiyama, et al
  ❖ Embedded IOC on FPGA-based controller

◆ By M. Satoh, et al
  ❖ Embedded IOC on oscilloscopes

◆ By A. Kazakov, et al
  ❖ Redundant IOC (RIOC with OSI supports)
  ❖ Redundant caGateway
  ❖ ATCA IOC with HPI/SAF support for RIOC
    ✳ ATCA for STF/ILC-LLRF and µTCA for ERL-LLRF
  ❖ Automatic test system environment

◆ By K. Zagar, et al
  ❖ Wireshark protocol analyzer for CA

◆ By K. Furukawa, et al
  ❖ Event-based fast control system
Summary

◆ Many PLC systems are used at KEK

◆ PLC-embedded IOCs simplified the EPICS control architecture at KEK

◆ FAM3-RP61 will replace some of VME IOCs
  ❖ RP61s behave like VME with embedded IOC and IO open modules
Thank you