Application of Embedded EPICS to SuperKEKB Vacuum Control System

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Overview of SuperKEKB Vacuum Control System

Component	Analogue Input	Analogue Output	Digital Input	Digital output
Temperature	4000 ch			
Ion Pump	600 ch		600 ch	600 ch
Vacuum Gauge	600 ch		600 ch	600 ch
Gate Valve			80 ch	80 ch
NEG Heater	550 ch	50 ch	50 ch	50ch
Flow Meter	500 ch			500 ch

SuperKEKB is a two-ring electron-positron collider with asymmetric energies

Needs for Upgrading Control System

* Vacuum Control System of KEKB Accelerator had been operated successfully based on:
  * VME-based IOC
  * CAMAC (scanning ADC and DI/DO)
* SuperKEKB is expected to be in operation for decades from 2014
  * Availability of CAMAC modules will be a serious issue
* We decided to apply Embedded EPICS ("Channel-Access-Everywhere") concept to upgrading the system with up-to-date controllers and data loggers

Successor of VME-based IOC

* We chose Embedded EPICS on F3RP61
* A new FA-M3 PLC's CPU running Linux
  * Can work as IOC
  * Can work with wide variety of I/O modules for FA-M3 PLC
  * Can work with ordinary PLC's CPU side-by-side on the same PLC-bus

Reason of adopting F3RP61

* Well before F3RP61 became available, FA-M3 PLCs had been being used as front-end controller for the protection of various vacuum components of the KEKB accelerator
* Consolidation of IOC and PLC makes the configuration of front-end control considerably simpler
* Tens of F3RP61-based IOCs have been serving for various different controls at both Tsukuba- and Tokai-sites of KEK for years without any serious problems

Successor of CAMAC

* We chose CompactRIO (cRIO) for monitoring analogue and digital input channels
  * Can run CA-Server on cRIO
  * High analogue I/O channel density in compact chassis (32ch/module)
  * Can execute high speed data acquisition on built-in FPGA

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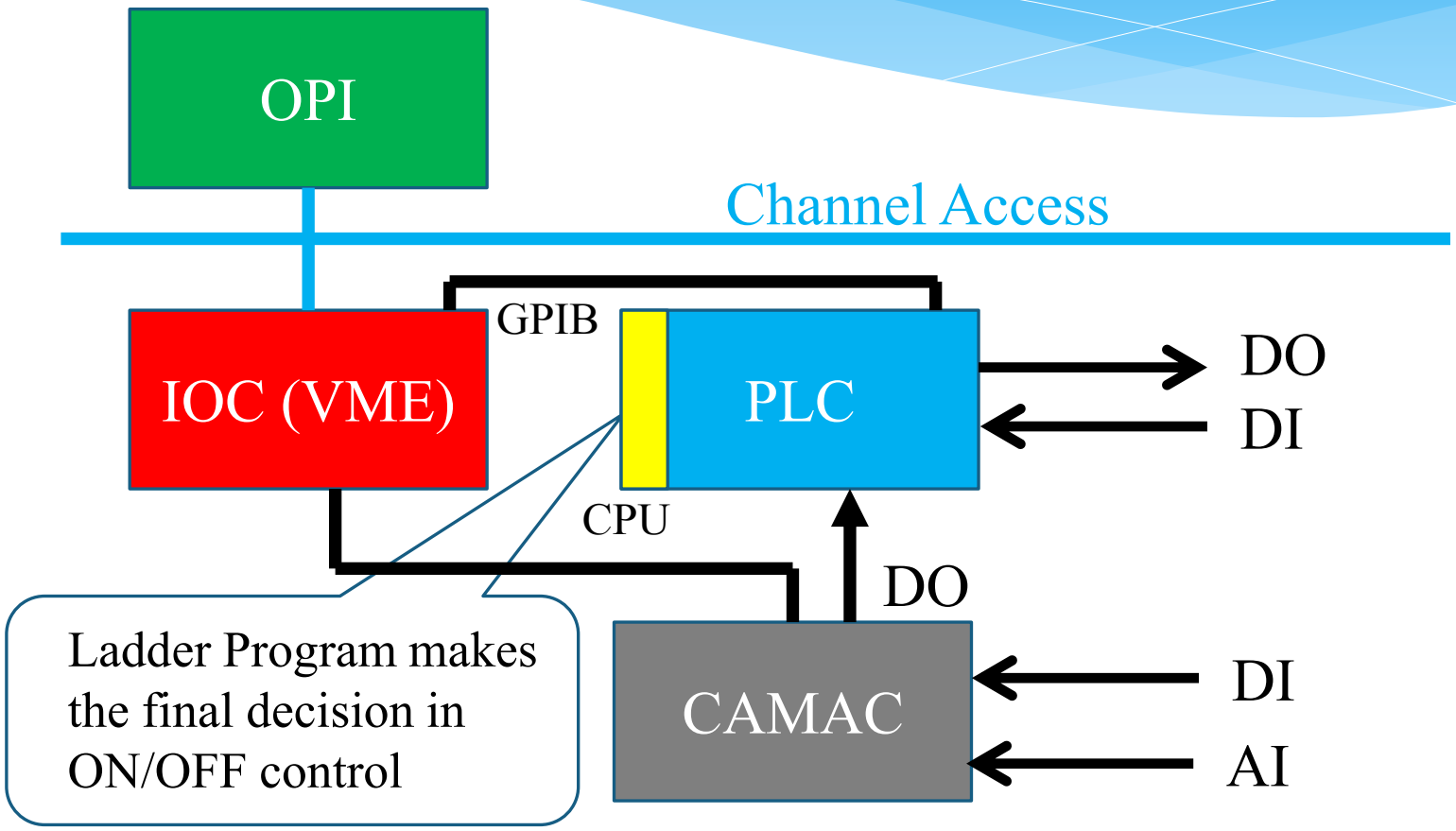
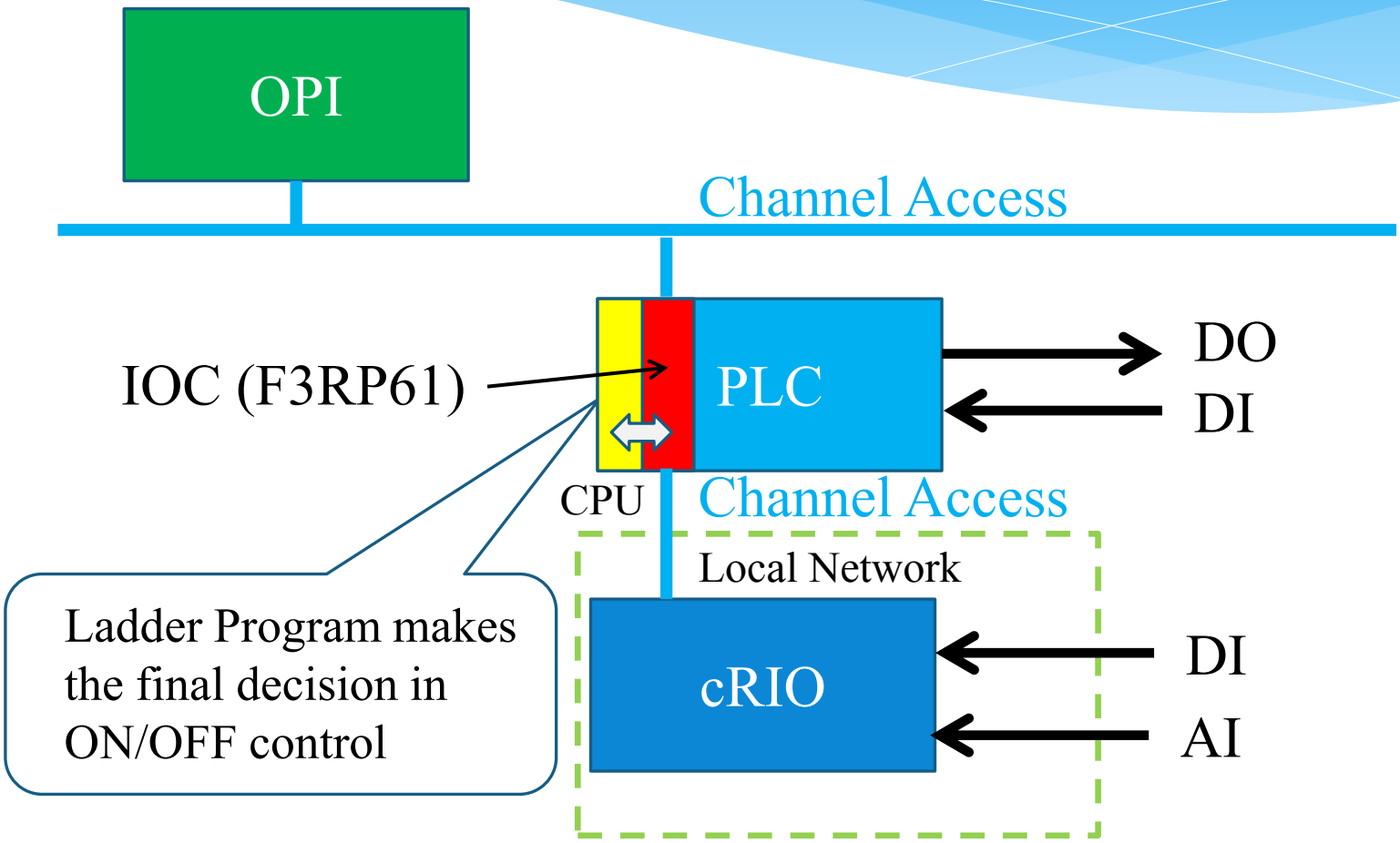
16bits

Old System Configuration

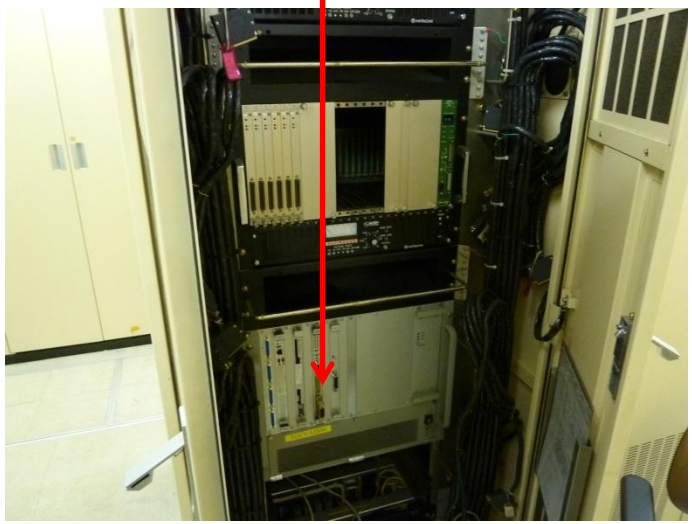


New System Configuration

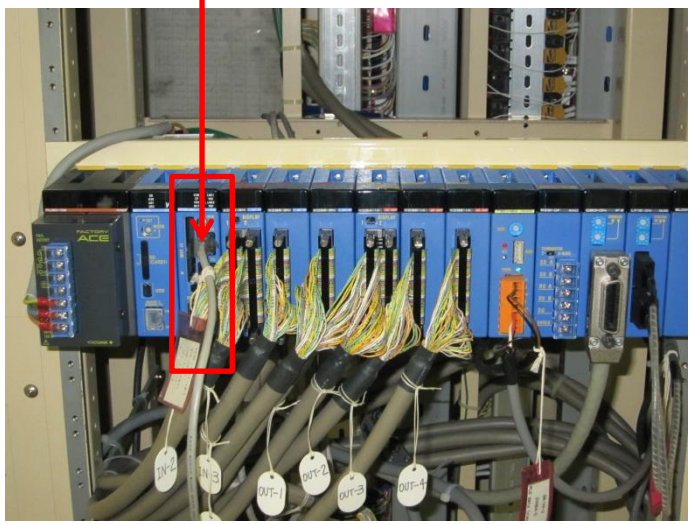


IOC Upgrade (Downsize)

IOC (VME)



IOC (F3RP61)



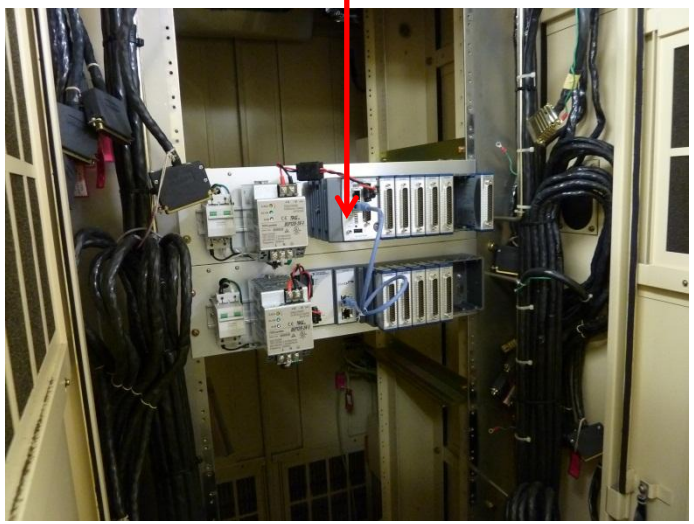
Before

After

Data Logger Upgrade (Downsize)

CAMAC

cRIO



Before

After

Placing cRIO on Local Network

* Graphical programming takes a lot of time and effort when the number of channels is huge
* By placing cRIO on a local network, we can use the same set of Process Variable names for all of local control rooms

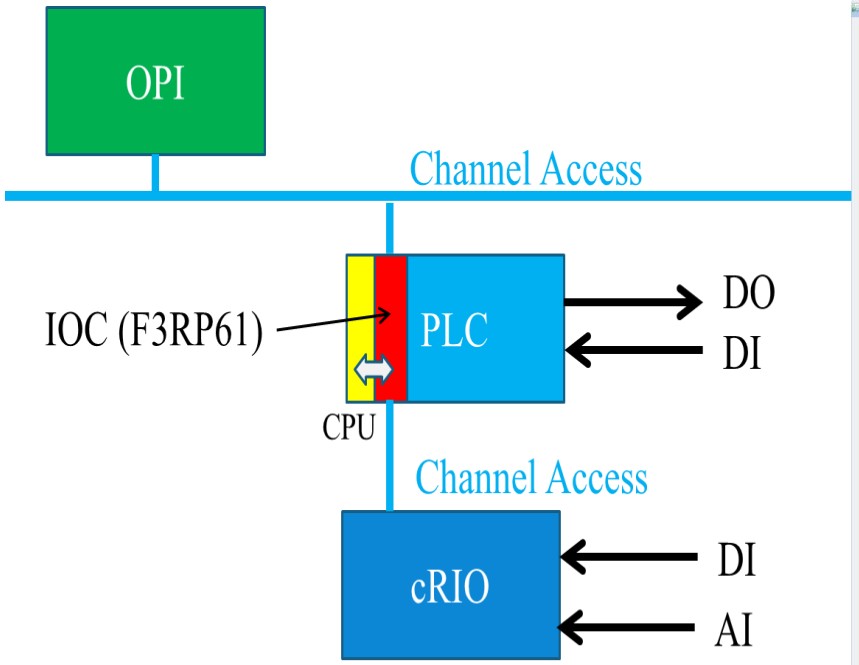
```
record (ai, "VALIP:D01_IP_L01:SADC"){
    field(INP,"crio:c1:s01:ai00 CP")
}
```

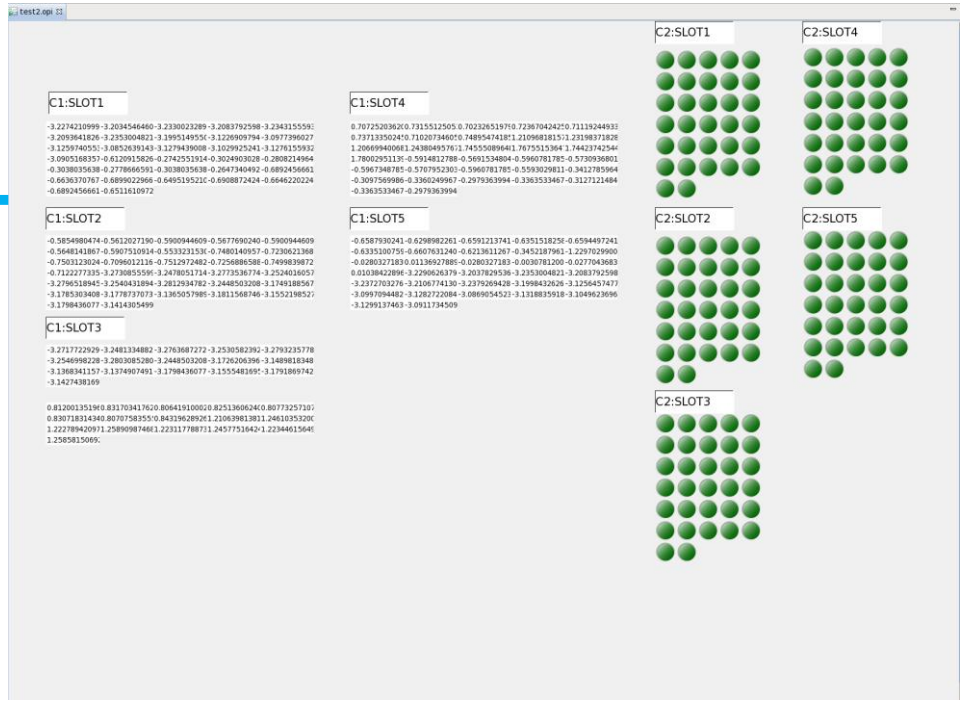
* Can reduce unnecessary traffic on the control network

Evaluation of CA-Server on cRIO

* Overload tests were carried out in order to confirm the reliability of the CA-Server running on cRIO
  * Rapid cycle (Most quickly: about 10K cycle/second) creation and destruction of CA connections between a cRIO and an OPI
    * No problem was found at all
  * Breaking off CA connections between a cRIO and an OPI by imposing bandwidth-consuming packets on the network (100 Mbps)
    * CA connections were automatically recovered successfully as expected when the disturbance was removed

Prototyping System with Full Channels





OPI (BOY) for test

Conclusions

* Embedded EPICS (“Channel-Access-Everywhere”) on PLC-based IOC was applied to upgrading the vacuum control system of SuperKEKB
* Consolidation of IOC and PLC considerably simplified the configuration of front-end control
* Overload test of CA-Server on cRIO has been carried out to prove it’s good stability
* A prototype system has been constructed and being under evaluation at a local control system