Operation Experience and Migration of I/O controllers for J-PARC Main Ring

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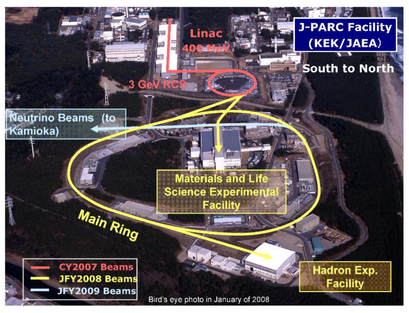
Abstract

- The control system for J-PARC Main Ring (MR) was constructed in 2007-2008, followed by the first beam in May, 2008.
- In 2007, the VME-bus computers were selected as I/O controllers (Epics IOC). The number of them in 2008 was about 80.
- In 2016, we have non-VME IOCs: a) Customized PC with serial ports (microIOC), b) Yokogawa F3RP61 (Linux-based CPU with PLC I/O modules), c) vioc (Epics IOC on a virtual machine), and d) commercial micro-server, "Saba taro". Characteristics of VME and non-VME IOCs are explained.
- Based on operation experience since 2008, following issues are discussed: (1) Reliability of VME-bus computers. Failures of memory cards are reported. (2) Possible IOC distributions around 2020, followed by ideas for new IOC types.

J-PARC and MR Control

J-PARC accelerators : LI, RCS, and MR (Main Ring)



- J-PARC is located in Tokai-mura, Ibaraki, Japan

Operation online: http://j-parc.jp/researcher/Acc/bi/totalstatus.html

Details of J-PARC control is given in Icalepcs 2011

J-PARC MR Control

- Control for J-PARC MR was constructed in 2007-2008.
- J-PARC is one of big users of EPICS in Japan.
- In 2007, VME-bus computers were selected as highly reliable IOCs. About 80 pieces were used at the initial beam commissioning in 2008.

J-PARC MR

- J-PARC MR is a slow-cycle synchrotron, delivers high-intensity proton beams to neutrino and hadron experiments.
- Upgrades and modifications are very often. Thus, flexibility and extendability are important in its controls.

IOC Chronicle 2008-2020

Past | NOW | Future

2008
- VME-IOC (ioc) ~80
- pcioc (uioc), 3

2011
- VME-IOC (ioc) ~90
- pcioc (uioc), 3
- PLC-IOC (pioc) ~30

2013
- VME-IOC (ioc) ~90
- pcioc (uioc), 3
- PLC-IOC (pioc) ~40
- Virtual IOC (vioc) ~30

2008-2009: PLC-IOC ~10 in trial

2010-2011: Virtual IOC a few in test

2014-2015: "Saba" IOC a few in trial

June, 2016
- VME-IOC (ioc) 79 — 54 for network-devices, 25 for timing
- pcioc (uioc), 3
- PLC-IOC (pioc) 45
- Virtual IOC (vioc) 25
- "Saba" IOC (sioc) 11

Future in 2020
- "Saba" IOC (sioc) ~50
- VME-IOC (ioc) ~40
- PLC-IOC (pioc) ~60
- Virtual IOC (vioc) ~30

Discussion – Imagine 2020

IOC distributions in 2020

- The number of "Saba" IOCs will be 50
- It will becomes a new standard IOC for network-based devices
- VME-IOCs will be still used, but the number will be half
- PLC-IOC will be the dominant IOC with signal I/O; increases every year
- pcioc will be replaced by PLC-IOC
- Virtual IOCs will be used as well

Possible New IOC types

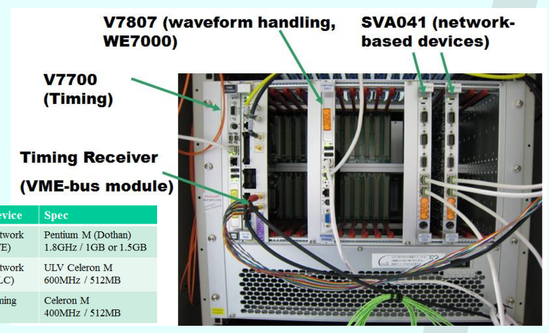
- Compact card-size IOC
  - Need only a few I/O (Dio/Aio/serial)
  - Raspberry pi? BBB?
- High-performance processor at IOC side
  - FPGA board with I/O, EPICS embedded
  - TCA.4 or Zynq-based board ?

In fact, these are not future plans. Pioneer works have started already. But not standardized in J-PARC yet.

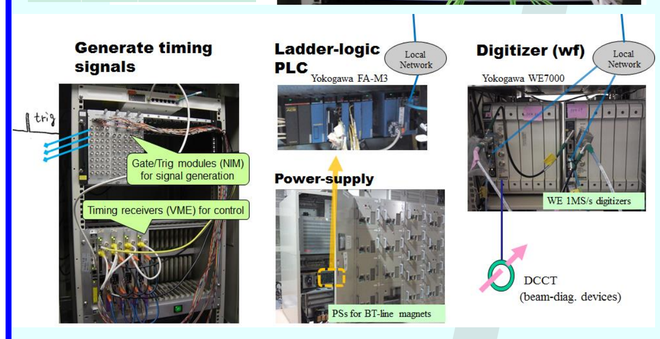
IOC Types: VME and non-VME

VME-IOC and usage

- In the construction phase (~2007), a VME-bus computer was selected as a standard platform
- Intel-based chip and the Linux OS
- Three models (SVA041, V7807, V7700)
  - ∗ after 2009, V7865 instead of V7807

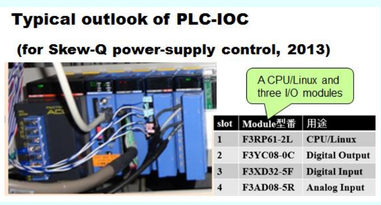


Model	Device	Spec
VMIC V7807	Network (WE)	Pentium M (Dothan) 1.8GHz / 1GB or 1.5GB
Sanritz SVA041	Network (PLC)	ULV Celeron M 600MHz / 512MB
VMIC V7700	Timing	Celeron M 400MHz / 512MB

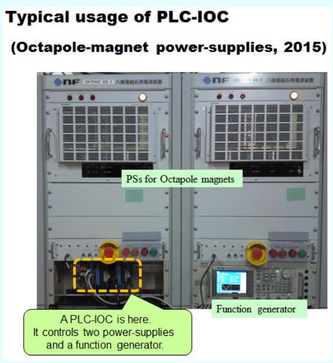


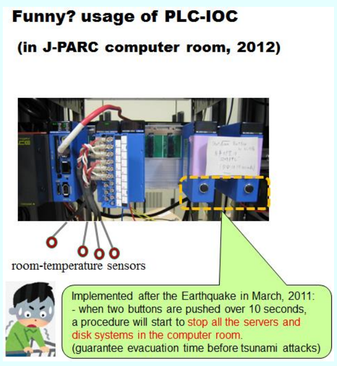
PLC-IOC and usage

- In 2008, EPICS implementation into F3RP61 (a Yokogawa's PLC-CPU running Linux OS) was carried out in KEK
- Many PLC-IOCs, each consists of a F3RP61 CPU/Linux and suitable I/O modules, have been introduced in J-PARC MR



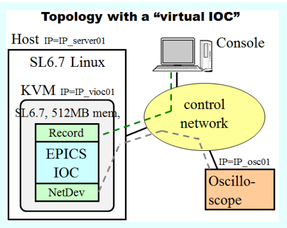
slot	Module型番	用途
1	F3RP61-2L	CPU/Linux
2	F3YC08-0C	Digital Output
3	F3XD32-5F	Digital Input
4	F3AD08-5R	Analog Input

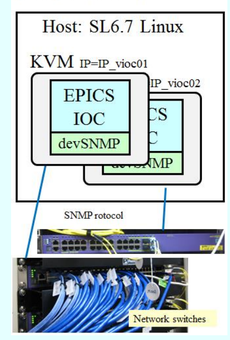


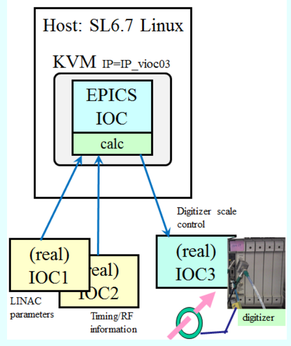


Virtual IOC and usage

- "Virtual IOC" is an Epics-IOC running on a virtual machine.
- Three blade-type servers, with Scientific Linux 6.7 and KVM, have been used as host machines.
- Since 2011, "Virtual IOCs" have been used for network-based devices, and for soft-IOCs of management purposes.



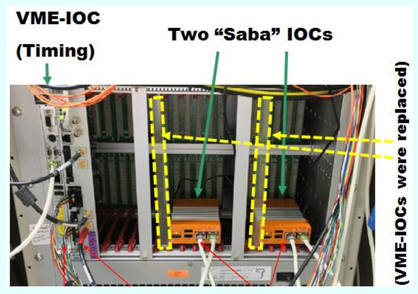




"Saba" IOC and usage

- "Saba Taro" is a commercial micro-server for administrative purposes (i.e. DNS, Web, DHCP, etc.).
- "Saba" IOC is an EPICS-IOC, using a "Saba Taro" server.
- Lower cost and smaller size than VME-IOC.
  - Cost: V7807 ¥400k, SVA041 ¥250k, Saba ¥80k
- Since 2014, we started to test a few "Saba" IOCs.

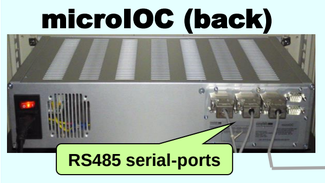
種別	CPU	Memory	OS
サバ太郎 Saba Taro	Celeron J1900 2~2.42GHz/4コア	8GB	SL6.8 SSDブート
V7807 (VME SBC)	Pentium M 1.8GHz	1GB ~1.5GB	SL6.3 ネットブート
SVA041 (VME SBC)	Celeron M 600MHz	512MB	SL6.3 ネットブート



- A VME-IOC for network-based devices can be replaced with a "Saba" IOC.
- In 2016, we start multi-year plan to replace VME-IOCs (models: V7807 and SVA041) with "Saba" IOCs.

pcioc and usage

- "microIOC", is a customized PC provided by CosyLab. The model with RS485 ports has been used for vacuum controllers since 2008.



Discussion – Reliability of VME-IOCs

Failures of on-board memory card

- During 2008-2011, VME-IOCs worked without troubles.
- Since 2011, each time after a scheduled power-outage, a few of VME-IOCs did not run. On-board memory card was broken. After replacing a memory with a spare, a VME-IOC worked well.
- Broken models are SVA041 and V7807; V7700 has no trouble.
- Number of broken memory cards are shown below.

Nov. 2011	Aug. 2012	Sept. 2013	Dec. 2013	July 2014	July 2015	Sept. 2015	Jul. 2016
1	2	2	2	3	11	1	5

Until 2016, 27 pieces broken in total

- Later we knew that all the broken memories are **the products in the middle of 2007**.
- We introduced 20(22) pieces of SVA041(V7807) VMEs in 2007. Until 2016, 20 memories of 33 SVA041 (7 of 22 V7807) were broken.

- In 2015, Micron company announced a defect in DRAM chips which were shipped before December 2010.

> ... under certain usage conditions over extended time periods, may ↓
> result in the inability of a small percentage of the devices ↓
> to properly power on after a power cycle event.↓
> The issue affected a limited subset of 95nm DDR1 and DDR2 products ↓
> manufactured before December 2010.↓
> ↓
> The root cause of the (長いので一部編集して略) failure is the degradation of a single transistor on the silicon chip.↓

<https://www.micron.com/~/media/documents/products/customer-service-note/csn37_95nm_legacy_dram.pdf>

Observed our memory failures are well understood.

Was VME reliable ?
- **No trouble on main boards of SVA041 and V7700.**
  Few pieces of V7807 boards had troubles.
  => reliable enough
- **Memory failures have made us discouraged so much**
  => very un-reliable

This experience pushes us to:
- migrate VME-IOC into "Saba" IOC if possible
- try no mass-introduction in the same product lot