15 years of operation of the J-PARC Main Ring controls and its future plan

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Abstract

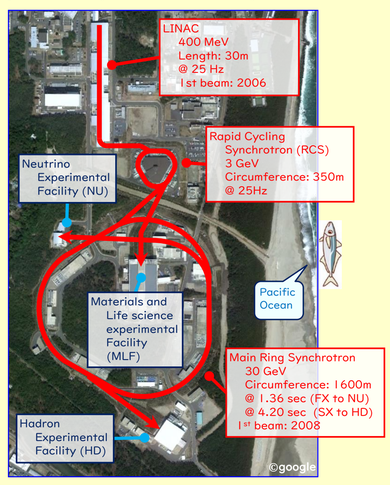
The accelerator control system of the J-PARC MR started operation in 2008. Most of the components of the control computers, such as servers, disks, operation terminals, front-end computers and software, which were introduced during the construction phase, have went through one or two generational changes in the last 15 years. Alongside, the policies for the operation of control computers has changed. This paper reviews the renewal of those components and discusses the philosophy behind the configuration and operational policy. It is also discussed the approach to matters that did not exist at the beginning of the project, such as virtualization or cyber security.

Japan Proton Accelerator Research Complex (J-PARC)

- Jointly planned, developed, and operated by KEK and JAEA.

J-PARC Accelerator Control System

- Two control systems for two machine cycles working closely together:
  - LI&RCS (25Hz) : JAEA
  - MR (1.36s, 4.24s) : KEK

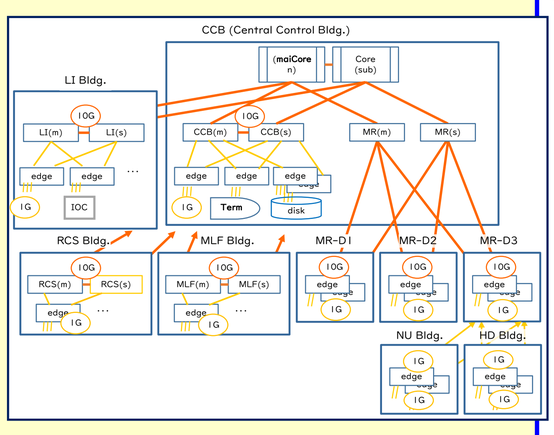


- Common Infrastructures:
  - Network
  - Storage
  - EPICS
  - Timing
  - (PPS, MPS)
- Individual Items:
  - Servers
  - Terminals
  - Front-end computers
  - Operating system
  - Archive system

Accelerator Control Network

- Redundant configuration.
  - 250 edge switches in total.
  - MR uses 12 edges + ~ 70 SOHO hubs (for cost).
- VLAN segments : 3 accelerators, 3 experimental facilities, and CCR.
- Maintenance contract : high reliability (but expensive).

2018) Chassis End-of-Life.
2020) One of the chassis failed.



Gradual renewal every 7-8 years

- 2005-2007) Installation
  - 10 Gbps backbone,
  - 1 Gbps inter-building connection.
- 2011-2015) 1st Renewal
  - 40 Gbps backbone,
  - 10 Gbps inter-building connection.
- 2019-2024) 2nd Renewal (underway)
  - 100 Gbps backbone,
  - 10 Gbps inter-building connection.

2011-2016) 25 units will not boot after annual power outage.
・Found to be manufacturing defect of memory chips.

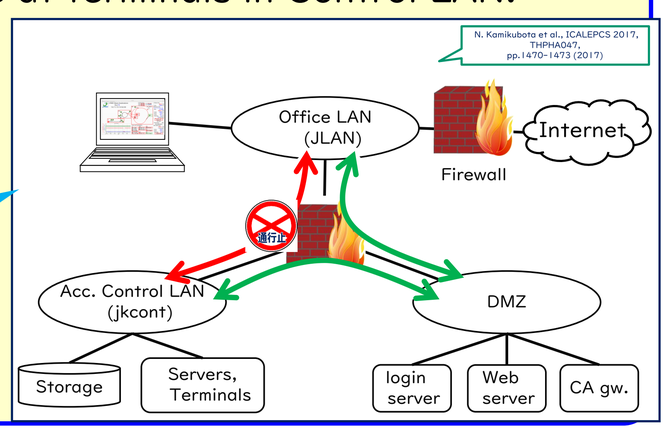
2011-2013) 29 unexpected stoppage of edge switches after 5-6 yrs. of operation.
・Found to be manufacturing defect of capacitors in P/S.

2022) Network disconnection.
・Optical fibers damaged by rats.

Network and Security

- Separate control LAN and office LAN by a Firewall.
  - No direct communication between Control LAN and office LAN.
  - From office LAN: SSH or CA from authorized host, or HTTP.
  - From Control LAN: HTTP via proxy with white list.
- USB storage not available at terminals in Control LAN.
- Install antivirus software.
- No out-of-support OS.

Prevent malware and viruses from entering Control LAN



Storage System

- Basic idea: store everything in one place.
  - operation data, operation programs, and home directories
- File server appliances (NetApp)
  - Highly available and reliable (but expensive)
  - Redundant network and disks
  - Expandable by adding shelves and disks
  - ~ 500 NFS clients

History of disk system

- 2008) IBM N3600, 9 TB → 2012) expand to 28 TB
- 2013) NetApp FAS2240, 48 TB → 2014) expanded to 84 TB
- 2022) Lenovo DM3000H, 192 TB

Later, purpose-specific storages ware introduced

- 2012) 1U server (Linux) for old waveform data (>1 yr.)
- 2016) 1U server (Linux) for EPICS Archiver

Servers

- 2006) Started w/ 1 chassis + 5 blades (IBM BladeCenter E)
  - As CPU for running accelerator control applications.
- 2007) Installed 2nd chassis, more blades as needed.
- 2010) Introduced virtual machines.
- 2021-2022) 22 blades migrated to 12 rack-mount servers.
  - Diverting to VM hosts from CPU for apps.

Terminals

- 2007) diskless thin-client (HP):
  - Used as X-terminals.
- 2014) Migrated to Standard PC (Intel NUC):
  - Run applications locally.

Front-end Computers (IOCs)

- 2007) diskless VME-SBCs (~90 units at max):
  - Most of control targets were found to be network devices.
- 2008) Introduced Linux-based PLC-CPU (Yokogawa; currently 70 units).
- 2010) Introduces Virtual IOCs (currently 45 units).
- 2014) Introduced fan-less micro server (currently 80 units).
- 2023) Retirement of VME-SBCs w/o bus access.

Operating system and EPICS

Use same versions of OS and EPICS for servers, IOCs and terminals.

- 2008) Scientific Linux 4 + EPICS R3.14.7
  - MEDM/EDM/Strip-tool, EPICS Channel Archiver.
- 2012-2014) Scientific Linux 6 + EPICS R3.14.12.3
  - 2014) Introduced CS-Studio.
  - 2017) Introduces Archiver Appliance
- 2019-2020) CentOS7 + EPICS R3.15.5
- 2023-2024) Alma Linux 9 + EPICS R7.0.7 (underway)

Continuous R&D is essential to maintain the entire control system

- Software and computers need to be updated in tandem.
- The approach that testing new OS and software on spare machines and deploying them in production environment has worked well so far, and will continue to do so in the future.