Introduction to the Control System of the PAL-XFEL Beamlines

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Abstract

The PAL-XFEL beamlines are composed of two different types of beamlines: a hard X-ray beamline and a soft X-ray beamline, The hard X-ray beamline generates free electron lasers with pulse energies ranging from 2-15 keV, pulse lengths of 10-35 fs, and arrival time errors of less than 20 fs from 4-11 GeV electron beams for X-ray Scattering & Spectroscopy (XSS) and Nano Crystallography & Coherent Imaging (NCI) experiments. On the other hand, the soft X-ray beamline generates free electron lasers with photon energies ranging from 0.25-1.25 keV, and with more than 10^{12} photons, along with 3 GeV electron beams for soft X-ray Scattering & Spectroscopy (SSS) experiments. To conduct experiments using the XFEL, precise beam alignment, diagnostics, and control of experimental devices are necessary. The devices of the three beamlines are composed of control systems based on the Experimental Physics and Industrial Control System (EPICS), which is a widely-used open-source software framework for distributed control systems. The beam diagnostic devices include QBPM (Quad Beam Position Monitor), photodiode, Pop-in monitor, and inline spectrometer, among others. Additionally, there are other systems such as CRL (Compound Refractive Lenses), KB mirror (Kirkpatrick-Baez mirror), attenuator, and vacuum that are used in the PAL-XFEL beamlines. We would like to introduce the control system, event timing, and network configuration for PAL-XFEL experiments.

Introduction of PAL-XFEL

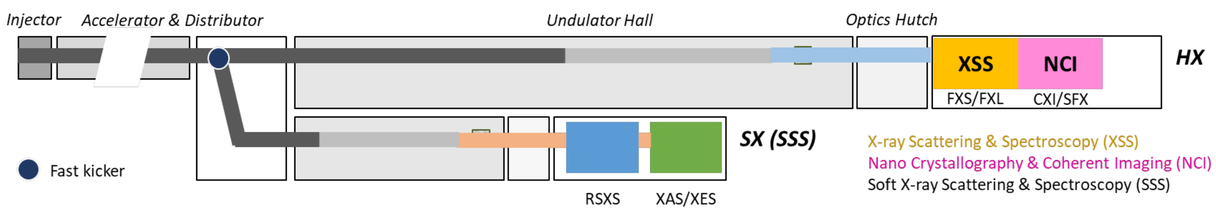

Fig 1. Schematic diagram of PAL-XFEL beamlines

- Provide intense ultrashort X-ray pulses.
- X-ray Free-Electron Laser (XFEL) is characterized by strong pulse-to-pulse fluctuations

	Hard X-ray	Soft X-ray
Photon energy	**2.0 ~ 15 keV** (0.6 ~ 0.08 nm)	**250 ~ 1250 eV** (5 ~ 1 nm)
Repetition rate	10 Hz, 30 Hz, 60 Hz	10 Hz, 30 Hz, 60 Hz
Band width of pink beam (ΔE/E)	~ 0.4 %	~ 0.5 %
Photon flux (pink beam)	> 1.0 × 10^{11} phs/pulse	> 1.0 × 10^{12} phs/pulse @ 800eV

Table 1. Conditions of Hard X-ray and Soft X-ray

Event Timing System

- Receives event timing signals and connects to devices that require synchronization.

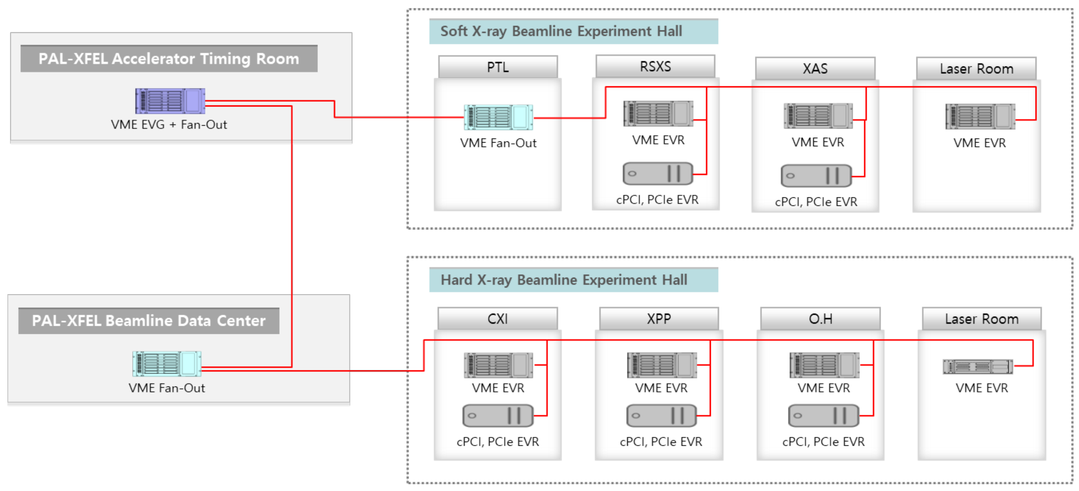

Fig 2. Event Timing System configuration diagram

Network

- Network area related to control such as device control, diagnosis, and remote control.

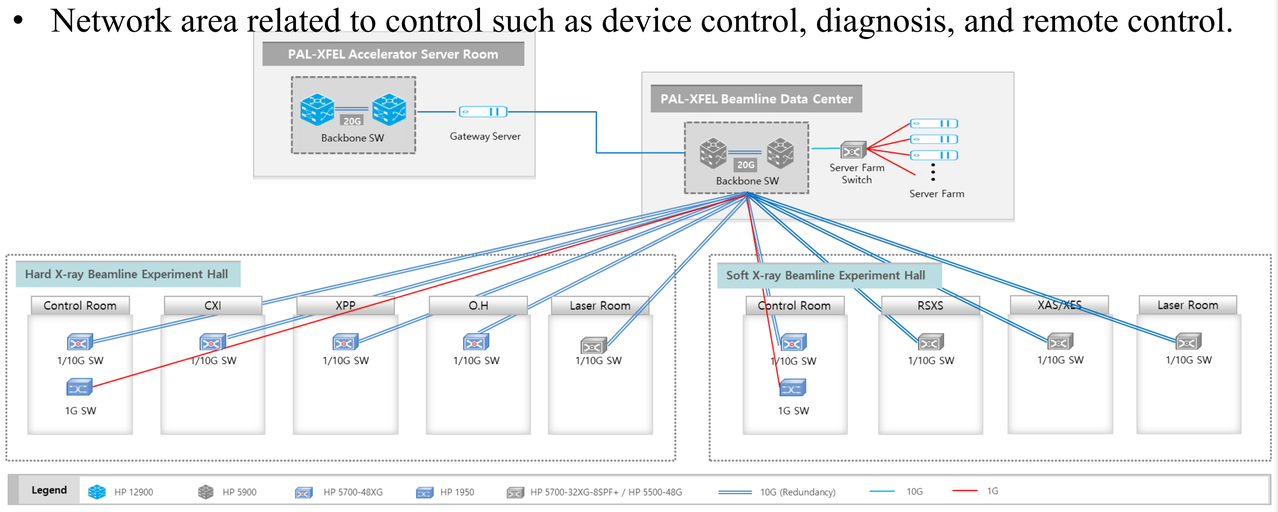

Fig 3. XFEL Beamline control network configuration diagram

- Dedicated data network to transmit large amounts of data generated from user experiments of the PAL-XFEL

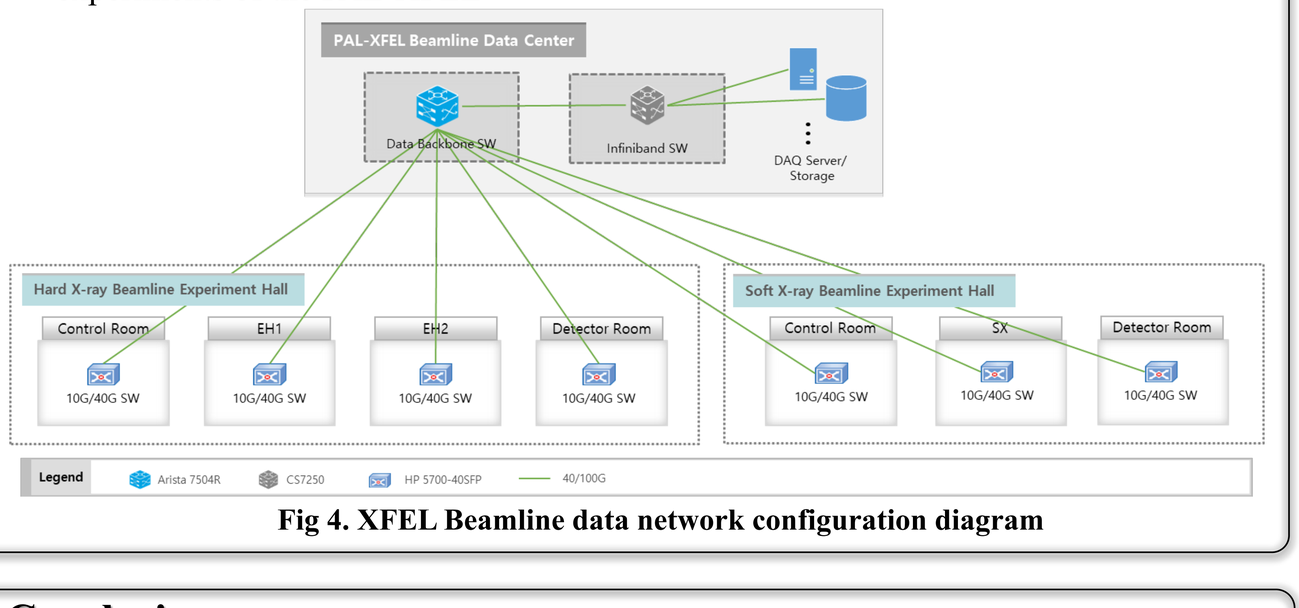

Fig 4. XFEL Beamline data network configuration diagram

Control System

- Configuring the system layer on each device.

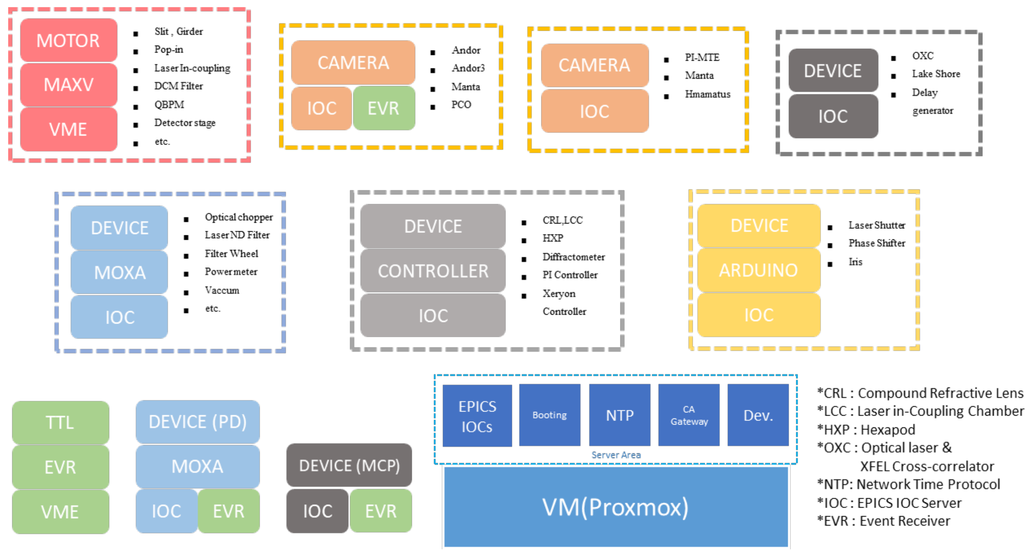

Fig 5. System configuration diagram for each equipment

- Shows the control system configuration of the entire beamline.

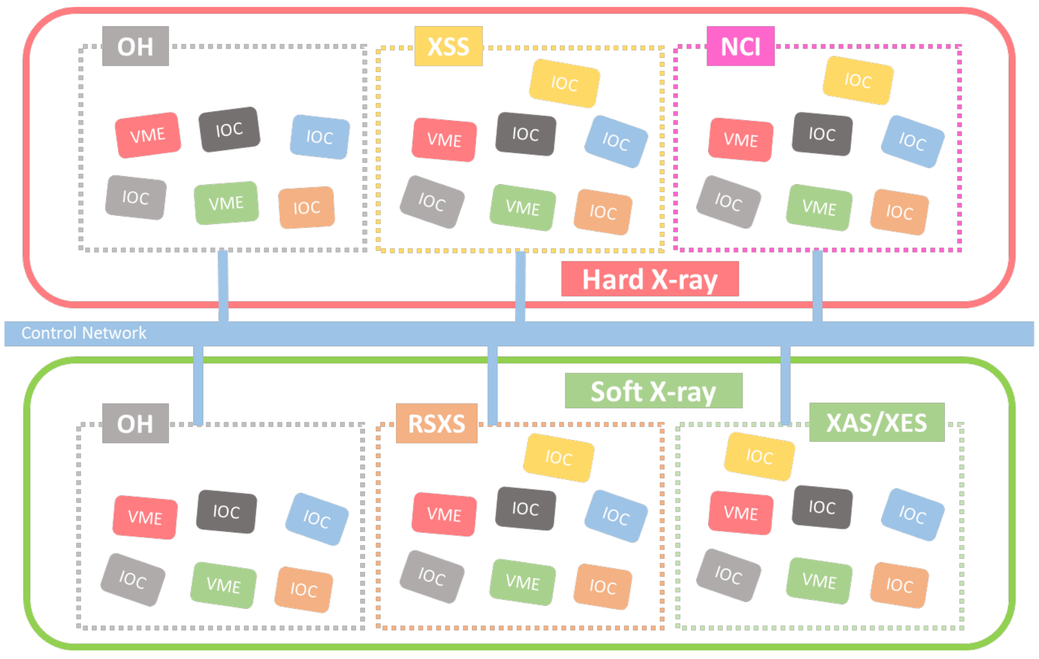

Fig 6. XFEL beamline control system configuration diagram

Conclusions

We introduced the event timing, network, control system, and monitoring system for the PAL-XFEL beamline experiment. In particular, reliability and stability were improved by building a separate data network to transmit large amounts of data.

Acknowledgments

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