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DESIGN AND STATUS OF THE SUPERKEKB ACCELERATOR CONTROL NETWORK SYSTEM

M. Iwasaki#, K. Furukawa, T. T. Nakamura, T. Obina, S. Sasaki, M. Satoh, KEK, Ibaraki, Japan
T. Aoyama, T. Nakamura, Mitsubishi Electric System & Service Co. Ltd, Japan

Abstract

We have upgraded the accelerator control network system for SuperKEKB, the next generation B-factory experiment in Japan. The new network system has the higher performance based on the wider bandwidth data transfer, and more reliable and redundant network configuration. For the SuperKEKB construction, the new wireless network system has installed into the whole 3 km circumference accelerator tunnel.

INTRODUCTION

SuperKEKB, the upgrade of the KEKB asymmetric energy electron-positron collider for the next generation B-factory experiment in Japan, is currently under construction [1]. The designed luminosity is 8×10^{35} $cm^{-2}s^{-1}$, 40 times higher than the world highest luminosity record at KEKB. For SuperKEKB, we have upgraded the accelerator control network system.

For SuperKEKB, the accelerator control network system with the higher performance of the wider bandwidth data transfer, and more reliable and redundant network configuration is required to ensure the stable operations under the 40 times higher luminosity environment. We have designed the SuperKEKB control network based on the 10 gigabit Ethernet (10GbE) for the wider bandwidth data transfer. Additional optical cables were installed to form the redundant network system. To enhance the network security, we change the network configurations. For the accelerator construction and maintenance, we install the new wireless network system based on the Leaky Coaxial (LCX) cable antennas and collinear antennas into the SuperKEKB 3 km circumference accelerator tunnel.

This paper describes the design and status of the SuperKEKB accelerator control network system.

SUPERKEKB CONTROL NETWORK SYSTEM

Fig. 1 shows the schematic view of the SuperKEKB accelerator main ring. The SuperKEKB accelerator control network system is based on a star network topology. The main network switch (core switch) is located at the SuperKEKB control room. All network switches (edge switches) located at 26 sub control rooms along the 3 km circumference main ring, the injector linac (Linac), and AR, are connected to the core switch with optical cables.

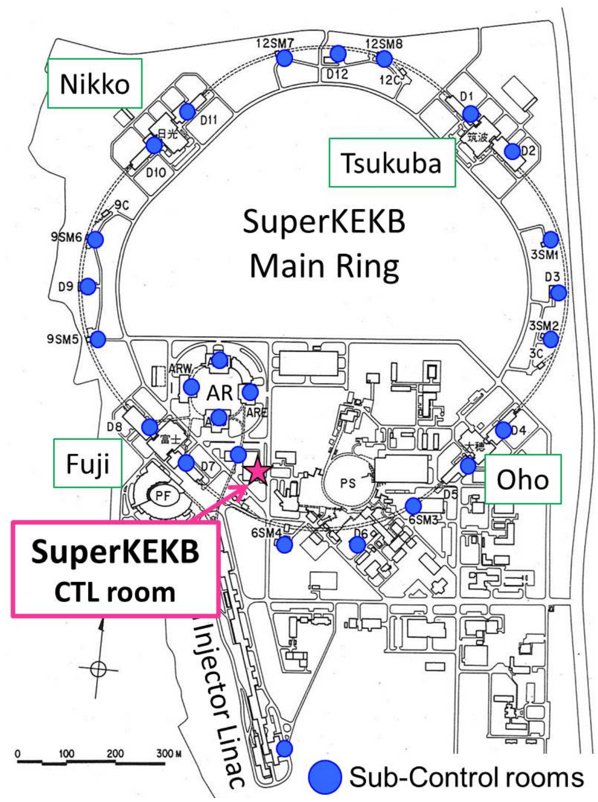

Figure 1: Schematic view of the SuperKEKB accelerator main ring. Red star indicates the SuperKEKB control room. Blue circles are the sub control rooms, located along the SuperKEKB main ring, injector Linac and AR.

In KEKB, the network bandwidth of the edge switches at the sub control rooms were 100MbE or 1GbE. For SuperKEKB, we installed the 30 edge switches having both 1GbE and 10GbE connections into the all sub-control rooms along the SuperKEKB main ring and Linac, in Feb. 2014. The additional single-mode optical cables are also installed, so that the network system has the redundant network structure, where all edge switches are connected to the core switch via both 10GbE and 1GbE lines, here the 1GbE line will be active if the 10GbE one loses link.

Network Connection between Accelerator and the Belle II Detector

Fig.2 shows the old network connection between the KEKB control room and the Belle detector area located at the Tsukuba experimental hall. For historical reasons,

#masako.iwasaki@kek.jp

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there exist several 10MbE media convertors in the network line, which restricted the network performance.

In JFY2013, we have installed the 10GbE edge switches at Tsukuba B3 and B4 floors, and install the single mode optical cables from SuperKEKB accelerator control room to Tsukuba area so that SuperKEKB can be directly connected with the BelleII detector DAQ system located at Tsukuba B3. The SuperKEKB superconducting final focusing Q-magnet system (QCS), the beam position monitors (BPM) for the interaction regions, and the cryogenic system for the BelleII detector solenoid and QCS located at B4 are also directly connected to the SuperKEKB control room.

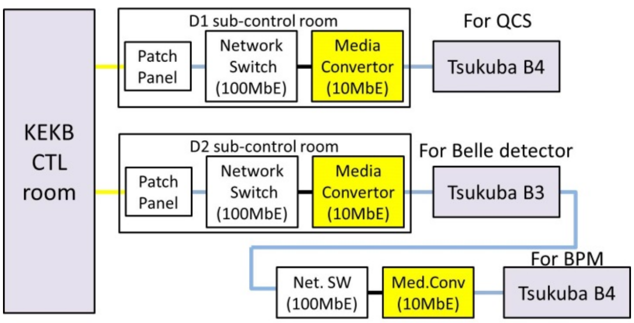

Figure 2: Old network connections between the KEKB control room and Tsukuba. Yellow, blue, and black lines are the connection with a single-mode optical cable, a multi-mode optical cable, and a LAN cable, respectively.

VLAN segmentation for the SuperKEKB control Network

In the KEKB operations, we used EPICS [2] as the main software to control the accelerator components. Based on the experience of the KEKB operations, we have continued to employ the EPICS software tools to control the SuperKEKB accelerator. In EPICS, the UDP broadcast is used to communicate between Operator Interfaces (OPIs) and Input/Output Controllers (IOCs). Therefore, there are many UDP broadcast packets in the accelerator control network.

In SuperKEKB, the number of the controlled devices, which have the Ethernet interface to connect with the IOCs, increases, and these devices also receive the UDP broadcasts in the accelerator control network. Several devices cannot properly operate under the high rate UDP broadcast environment.

To prevent such UDP broadcast effects to the accelerator components, we apply the VLAN-based network segmentation to the SuperKEKB control network. Here IOCs and the accelerator components with Ethernet interfaces are in the different VLANs. The core switch of the SuperKEKB control network takes care of the routing task among the VLANs.

In Feb. 2014, we have applied the new VLAN segmentation into the SuperKEKB control network. Here the control network consists with the EPICS network which is for the EPICS IOCs and OPIs, and the device networks. We have checked the device with an Ethernet interface in the device network can be controlled from IOCs in the EPICS network and operates properly in the new segmented VLAN configuration.

Network reconfiguration to connect with the KEK laboratory network

In 2013 summer, we reconfigure the network design, on the connection between the SuperKEKB accelerator control network and the KEK laboratory network. The new network design enhances the reliability and security of the SuperKEKB accelerator control network.

In KEKB, there were many computers, including the SAD computers, the accelerator control computers, and consoles, connecting to both the KEK laboratory and the KEKB-accelerator-control networks. Here the SAD computers are for the optics calculations with the SAD program [3], and these SAD computers are used by the KEKB and the other project users. Since the account system for the SAD computers and the KEKB accelerator control computers were common, all SAD account folders including the non-collaborators of KEKB could access to the KEKB control network.

The new network configuration is shown in Fig.3. Here all computers in the accelerator control network do not connect to the KEK laboratory network. We also change the account system, and the only SuperKEKB collaborators logged into the computers in the accelerator control network.

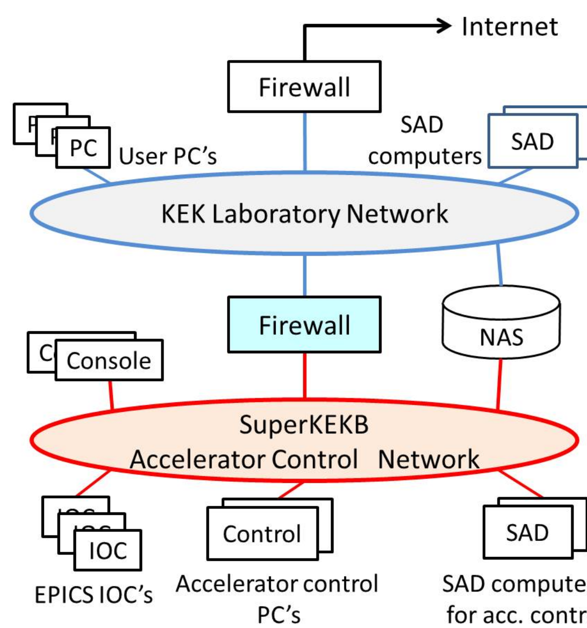

Figure 3: New configuration for the SuperKEKB accelerator control network and the KEK laboratory network connection.

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Wireless LAN installation into the accelerator tunnel

For the accelerator components construction and maintenance of them, we installed the new wireless network system based on the Leaky Coaxial (LCX) cable antennas and the collinear antennas into the SuperKEKB accelerator tunnel, in JFY2012 and 2013.

For the SuperKEKB main ring, the 16 125m-length 20D-type LCX antennas, 2000m length in total, are installed into the 4 arc sections, and 16 collinear antennas are installed into the 4 linear sections covering 1000m length area. The installed 20D LCX has the electric characters of a coupling loss 65dB and a transmission loss 9(dB/100m). The gain of the collinear antenna is 6dBi.

There are little power supplies in the arc sections. Then power supply for the access points at the middle of the arc sections is provided from the PoE modems at power equipment buildings.

For SuperKEKB, we have selected the LCX and collinear antennas which have good radiation hardness of more than 1MGy. Figs 4 and 5 show the installed LCX antenna and collinear antenna into the SuperKEKB arc section and the straight section, respectively. As shown in the figures, all access points, as well as PoE modems for power supply in the accelerator tunnel are installed within the lead boxes. All connector connections are wrapped with lead sheets and fixed with cable ties made with polyetheretherketone (PEEK).

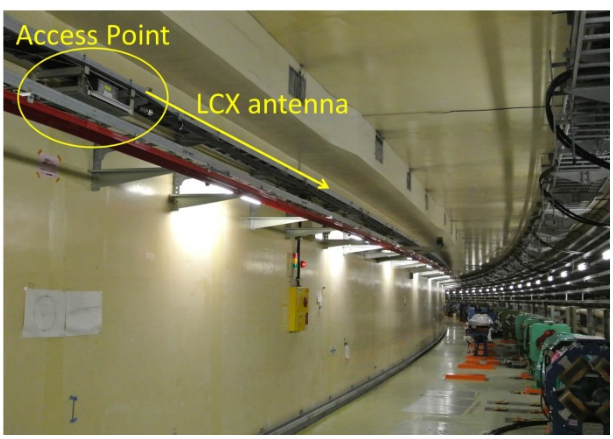

Figure 4: An access point and a 125m length LCX antenna installed at the SuperKEKB arc section. The access point is located in a lead box.

After the installation, we tested the wireless LAN system and obtained the good performance of about 18Mbps effective transmission rate in the SuperKEKB tunnel.

We also installed the access points into AR, Linac, SuperKEKB sub control rooms, and power equipment rooms at the power equipment buildings. Total 70 new access points are controlled by an access-point controller.

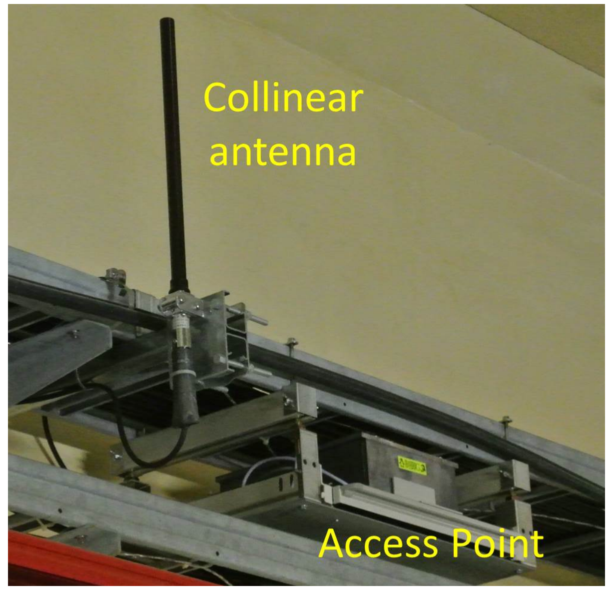

Figure 5: An access point and a collinear antenna installed at the SuperKEKB straight section. The access point is located in a lead box.

SUMMARY

We have upgraded the accelerator control network system for SuperKEKB. The new network system has the higher performance based on the wider bandwidth data transfer, and more redundant configurations. We have changed the network configuration on the connection of the KEKB network to enhance the security. We also introduced the VLAN segmentation into the system.

For the SuperKEKB construction and maintenance, we have installed the new wireless network system consists with the LCX antennas and collinear antennas into the 3 km circumference accelerator tunnel. The wireless LAN system has the sufficient effective transmission rate over the whole accelerator area.

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