DESIGN AND STATUS OF THE SUPERKEKB ACCELERATOR CONTROL NETWORK SYSTEM

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Abstract

We have upgraded the accelerator control network system for SuperKEKB, the next generation B-factory experiment in Japan. The designed network system has the higher performance based on the wider bandwidth data transfer, and more reliable and redundant configuration. For the SuperKEKB beamline construction and accelerator components maintenance, we have installed the new wireless network system consists with the Leaky Coaxial (LCX) cable antennas and collinear antennas into the 3 km circumference accelerator tunnel. In this paper, we describe the design and current status of the SuperKEKB accelerator control network system.

INTRODUCTION

SuperKEKB, the upgrade of the KEKB asymmetric energy electron-positron collider for the next generation B-factory experiment in Japan, was approved and 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 robust network under the 40 times higher luminosity operations. We have designed the SuperKEKB control network based on the 10 gigabit Ethernet (10GbE) for the wider bandwidth data transfer. Optical cable installation is also on going to construct the redundant network.

We reconfigure the network design to connect the SuperKEKB accelerator control network and the KEK network. It enhances the security of the accelerator control network.

It is also important to provide the convenient network environment for the efficient accelerator construction and maintenance of it. We install the new wireless network system based on the Leaky Coaxial (LCX) cable antennas and collinear antennas into the SuperKEKB 3 km circumference beamline tunnel.

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

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DESIGN OF THE SUPERKEKB CONTROL NETWORK SYSTEM

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

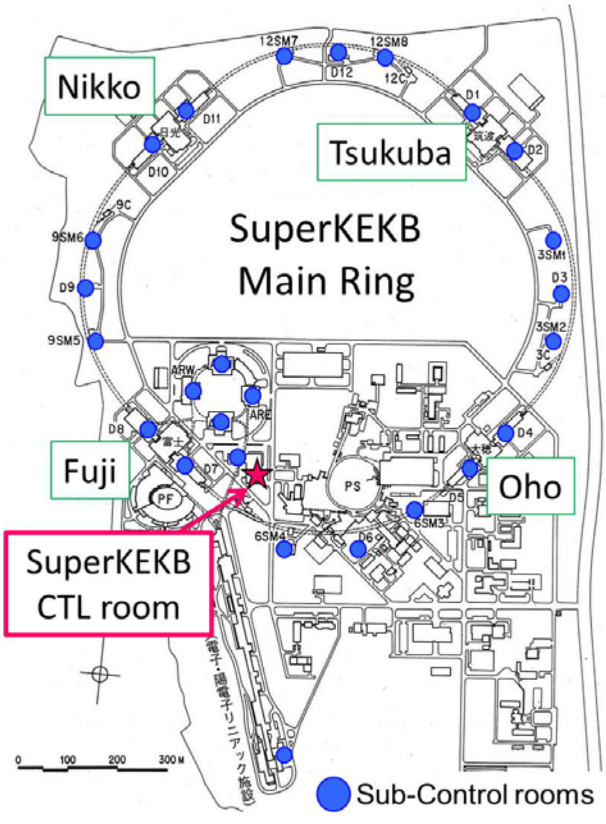

Figure 1: Schematic view of the SuperKEKB accelerator main ring. Red star indicates the SuperKEKB control room. Blue circles are the sub control rooms, located along the SuperKEKB main ring, Linac and AR

In KEKB, the network bandwidth of the edge switches at the sub control rooms were 100MbE or 1GbE. For historical reasons, there exist several 10MbE media convertors in the network line. Fig.2 shows the network connection between the KEKB control room and D1 and D2 sub control rooms, as an example. The 10MbE media convertor restricted the network bandwidth up to 10 MbE.

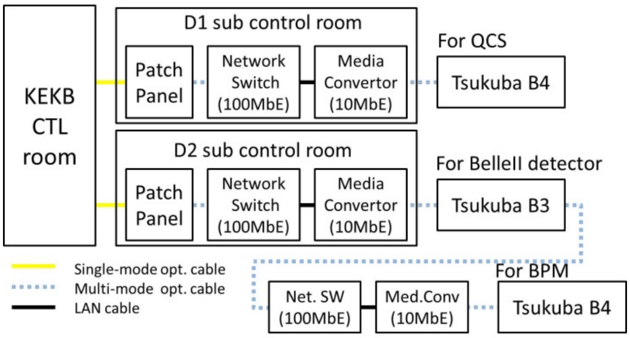

Figure 2: Network connections from KEKB control room to D1 and D2 sub-control rooms at KEKB. Yellow solid, blue dots, and black solid lines indicate the connection with a single-mode optical cable, a multi-mode optical cable, and a LAN cable, respectively.

For SuperKEKB, we're going to install the edge switches having both 1GbE and 10GbE connections into the all sub-control rooms along the SuperKEKB main ring and Linac. We have installed the single-mode optical cables to assure the 10GbE data transfer. As shown in the Fig.2, in the KEKB case, the KEKB control network and the Belle detector DAQ network at Tsukuba experimental building was not connected directly. For SuperKEKB, we'll install the 10GbE edge switches at Tsukuba B3 and B4 floors, and install the single mode optical cables to Tsukuba so that the SuperKEKB accelerator control network can be directly connected with the BelleII detector DAQ system located at B3, the SuperKEKB Superconducting final focusing Q-magnet system (QCS), the beam position monitors (BPM) for the interaction regions, and the cryogenic system for detector solenoid and QCS located at B4.

The SuperKEKB control network system is designed to have the redundant structure, where all edge switches are connected to the core switch via both 10GbE and 1GbE lines, employing the active-standby configuration. Here the 1GbE line will be active if the 10GbE one loses link.

The 10GbE edge switch installations and the optical cable laying to Tsukuba will be completed within this JFY.

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.

We have tested the VLAN segmentation, and confirm that the device with an Ethernet interface in the different VLAN operates properly in the new segmented VLAN configuration.

Network reconfiguration to connect with the KEK network

We reconfigure the network design, on the connection between the SuperKEKB accelerator control network and the KEK 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 KEK and KEKB-accelerator-control networks. Here the account system for SAD computers and the KEKB accelerator control computers were common, and all SAD account folders including the non-collaborators of KEKB could access to

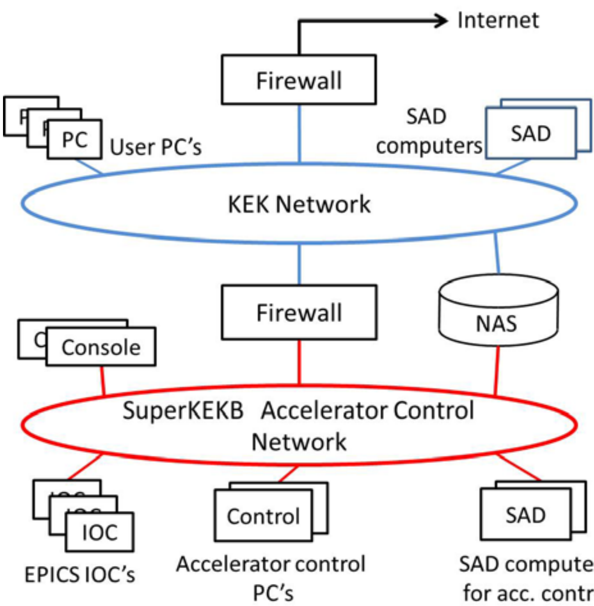

Figure 3: New configuration for the SuperKEKB accelerator control network and the KEK network connection.

the KEKB control network.

For SuperKEKB, we have changed the network configurations as shown in Fig.3. Here all computers in the accelerator control network do not connect to the KEK network. We also change the account system, and the only SuperKEKB collaborators logged into the computers in the accelerator control network. This summer, we changed and applied the new network configuration.

INSTALLATION OF THE WIRESS LAN SYSTEM INTO THE ACCELERATOR

It is important to provide the convenient network environment for the efficient accelerator components construction and maintenance of them. We install the new wireless network system based on the Leaky Coaxial (LCX) cable antennas and collinear antennas into the SuperKEKB accelerator tunnel.

As we described in the previous section, there are many UDP broadcast packets in the SuperKEKB accelerator control network. To chose the access point which can be operate under our network environment, the network speed was measured using the installed test 200m-length 20D-type LCX antenna, with the electric characters of a coupling loss of 70dB and a transmission loss of 7(dB/100m), in the SuperKEKB tunnel.

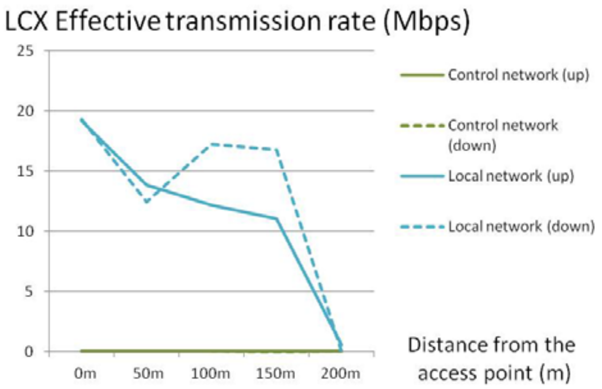

Figure 4: Measured network speed for access point A using a LCX antenna, with (green) or without (blue) connecting to the accelerator control network.

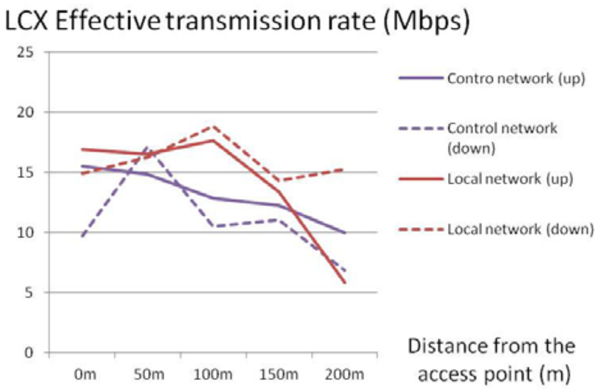

Figure 5: Measured network speed for access point B using a LCX antenna, with (purple) or without (red) connecting to the accelerator control network.

Figs 4 and 5 show the results of the network speed measurements in the SuperKEKB tunnel, for the access point A and B, respectively. As shown in the Fig. 4, the network speed in the SuperKEKB control network (green lines) is 10-30 kbps for the access point A. While, in the Fig. 5, there is little difference of the network speed between with (purple lines) and without (red lines) connecting to the SuperKEKB control network for the access point B. We then select the access point B for our wireless LAN system. In the area of >150m from the access point, the network speed degradation is observed. Then we design the length of the LCX antenna to 125m for our system. We also optimized the electric characters of the LCX antenna.

Fig.6 shows the layout of the wireless LAN components, access points, LCX antennas and collinear antennas. The figure is for the 1/4 of the SuperEKKB 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.

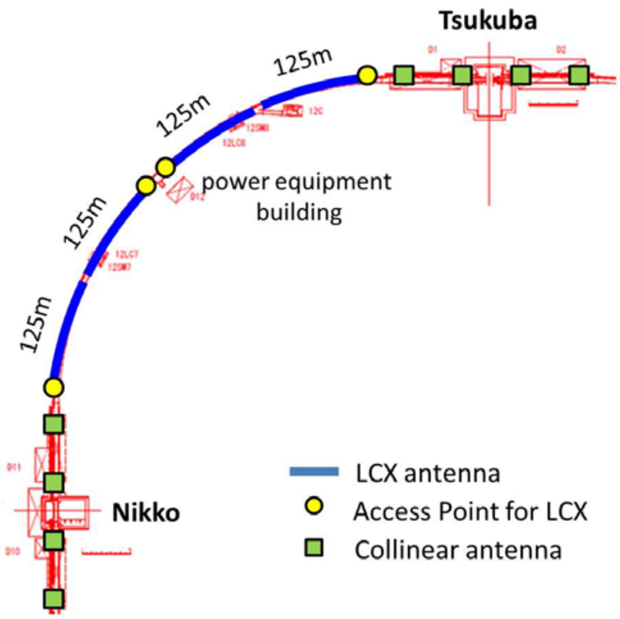

Figure 6: Layout of the wireless LAN components in the SuperKEKB tunnel. Blue lines, yellow circles, green squares indicate the LCX antennas, access points for LCX, and collinear antennas, respectively. The figure is for the 1/4 of the SuperKEKB main ring.

The installed 20D LCX has the electric characters of a coupling loss of 65dB and a transmission loss of 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 7 and 8 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).

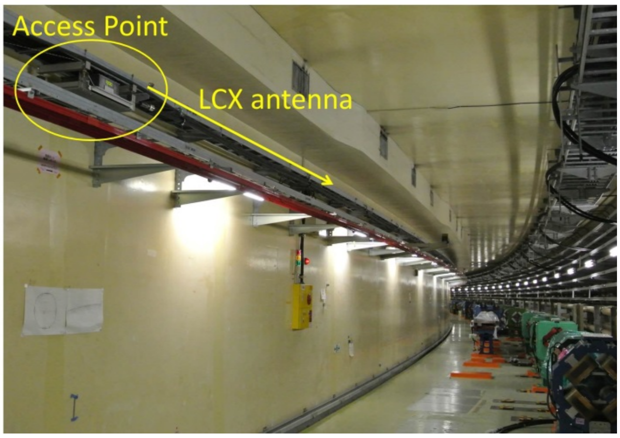

Figure 7: An access point and a 125m length LCX antenna installed at the SuperKEKB arc section. The access point is located in a lead box.

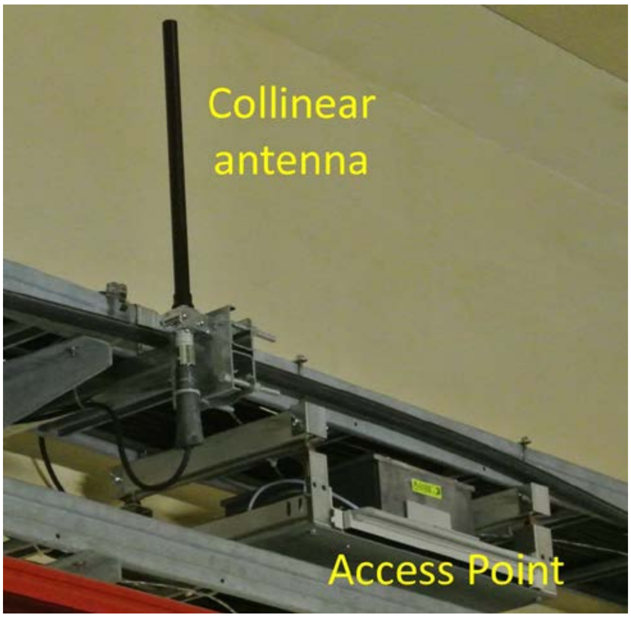

Figure 8: An access point and a collinear antenna installed at the SuperKEKB straight section. The access point is located in a lead box.

After the installation, we tested the wireless LAN system. Fig. 9 shows the measured effective transmission rate for LCX antennas in the arc section between Tsukuba and Oho. We obtain the good performance of about 18Mbps effective transmission rate in the SuperKEKB tunnel. In the figure, the performance degradation is found around Tsukuba area. It is due to the interference from the other wireless networks.

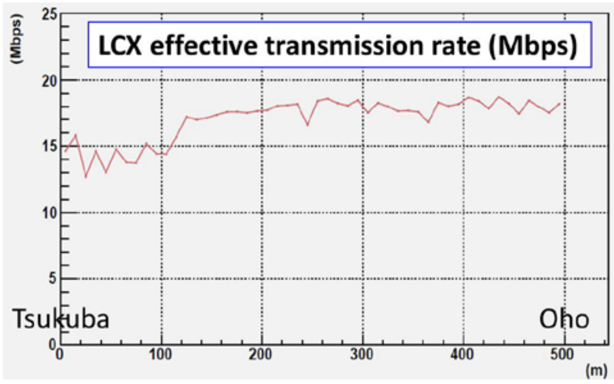

Figure 9: Effective transmission rate for LCX antennas in Mbps measured in the arc section between Tsukuba and Oho. Performance degradation around Tsukuba area is due to the interference from the other wireless networks.

In addition to the 32 access points installed in the SuperKEKB main ring, we also install 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.

SUMMARY

We have upgraded the accelerator control network system for SuperKEKB. The designed network system has the higher performance based on the wider bandwidth data transfer, and more redundant configurations. We change the network configuration on the connection of the KEKB network to enhance the security.

For the SuperKEKB beamline construction and accelerator components 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.

REFERENCES

[1] SuperKEKB Task Force, Letter of Intent for KEK Super B Factory, KEK-REPROT-2004-4, Jun. 2004. Belle II Collaboration, KEK-REPORT-2010-1, Nov. 2010.

[2] EPICS, http://www.aps.anl.gov/epics/