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# GROWTH OF CONTROL TRANSACTIONS OF THE KEK LINAC DURING THE KEKB COMMISSIONING

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## Abstract

The number of control transactions handled by an accelerator control system and the load of control computers are fundamental parameters for long-term maintenance of the control system. This article gives detailed information on such parameters of the KEK electron/positron linac. In addition, the growth of transactions and loads in recent years is discussed with respect to the KEKB commissioning activities.

## 1 INTRODUCTION

How many control transactions are handled by an accelerator control system? How much computer load exist during accelerator operation? Their amount and their changes over several years are fundamental parameters for long-term maintenance of the control system.

In this article, we discuss the control transactions of the KEK electron/positron linac in recent years. As a part of the KEKB project during 1994-1998, the KEK electron/positron linac has been upgraded to provide single-bunch beams of 3.5-GeV positrons and 8-GeV electrons directly to the KEKB rings. It is worth noting that the period covered by this report completely overlaps the period of the KEKB accelerator commissioning. The observed control transactions and network traffic in recent years are given in Section 2. The growth of the control transactions due to the KEKB commissioning activities and the extension of the control system to follow the growth are discussed in Section 3.

## 2 TRANSACTION STATISTICS

### 2.1 Control System Overview

The KEK linac has provided electron/positron beams to the rings: a) 3.5-GeV positrons to the KEKB LER (KEK B-factory Low-energy ring), b) 8-GeV electrons to the KEKB HER (High-energy ring), c) 2.5-GeV electrons to the PF ring, and d) 2.5-GeV electrons to the PF-AR ring. The present control system has been used since 1993 [1, 2]. The base of the control system comprises UNIX workstations, VME computers with the OS-9 operating system, PLC (Programmable logic controller) controllers, and CAMAC interfaces with direct network ports. The home-made RPC (remote procedure call), based on the TCP and/or UDP protocols, are used for communication between them.

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A simplified view of the control system is shown in Fig. 1. The numbers of important control devices are summarized in Table 1.

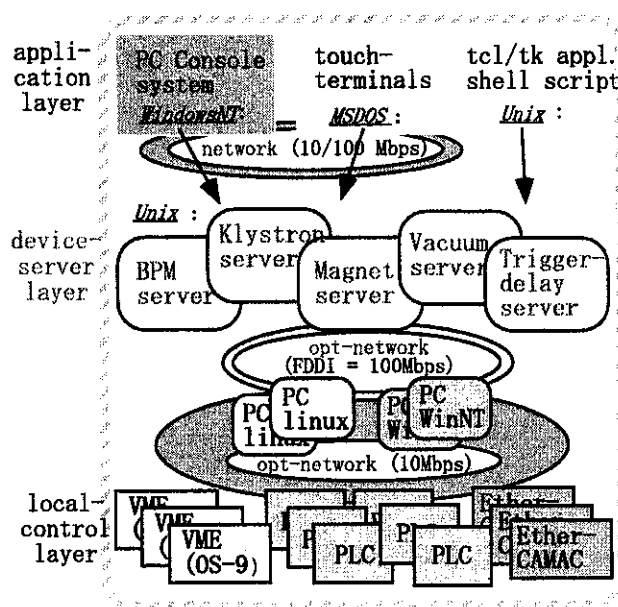


Figure 1: Simplified view of the control system.

As shown in Fig. 1, all of the control transactions (monitor and/or control) from the application layer are managed by device servers, i.e. no direct access from the application layer to the local-control layer is allowed. Thus, the number of transactions of each device can be deduced by analyzing the access log-files of the device servers.

Table 1: Devices at the KEK linac

Device	total number	Front-end
beam-position monitor (BPM)	89	19 x VME
klystron	69	69 x PLC
magnet power-supply	499	45 x PLC
vacuum (ion pump)	284	17 x PLC
trigger-delay (timing signal)	141	5 x VME 11 x CAMAC

## 2.2 Transactions in June 2001

The total control transactions in June of 2001 were studied<sup>1</sup>, and are given in Table 2. In 1999, we developed on-memory cache areas for the BPM, klystron, and vacuum (see Section 3). From that time on, read-only applications use cached data, rather than accessing the device server. The amounts of cache accesses are also shown in Table 2<sup>2</sup>.

Table 2: Transactions in June 2001

Device [transactions/s]	Total (Cache)	Server <i>plum</i> <i>lychee</i> <i>grape</i>	Client <i>KEKB-ring</i> <i>Windows</i>
beam-position monitor (BPM)	299 tr./s (257)	36 6 0	34 none
klystron	27 tr./s (25)	0.007 0.4 0.4	2.5 0.1
magnet power-supply	23 tr./s (none)	10 10 3	3 0.006
vacuum (ion pump)	2.1 tr./s (2.1)	0.0004 0 0	0 0
trigger-delay (timing)	1.6 tr./s (none)	0.3 0.9 0.4	0.004 0

Actually, there are three server workstations (with node names *plum*, *lychee*, and *grape*). The *plum* has been used as the primary server for miscellaneous transactions, while the *lychee* has been dedicated to slow-feedback applications [3, 4]. The *grape*, the oldest workstation, (purchased in 1993) has been used for transactions from the Windows-based console system [5] and other supplementary controls. The transactions for each workstation are separately given in Table 2. In addition, the transaction requests from the KEKB-ring control and from the Windows-based console system are also given in Table 2.

## 2.3 Changes of Transactions in 1998-2001

An analysis of the control transactions have been carried out since 1998. Table 3 gives the control transactions from 1998 to 2001.

A considerable growth of the BPM transaction is discussed in Section 3. A clear decrease in the magnet power-supply between 1999 and 2000 corresponds to an improvement of the surveillance program during the summer of 1999. The monitoring method was changed from one-by-one polling to event-driven base. Another obvious decrease in the vacuum transactions between 2000 and 2001 came

<sup>1</sup>In fact, the values are averages during June 10–16.

<sup>2</sup>In Table 2, the Total counts include the Cache counts.

from a change of the vacuum application. This application sends vacuum data to 69 klystron controllers (PLC) at 2 second intervals. In the summer of 2000, the application moved to a PC Linux in the local-control layer (see Fig. 1) in order not to access the vacuum server, but to use local cached data at the PC.

Table 3: Total transactions in 1998-2001

Device [transactions/s]	total Jun.98	total Jun.99	total Jun.00	total Jun.01
beam-position monitor	32 tr./s	158	252	299
klystron	5.3 tr./s	4.6	18	27
magnet power-supply	63 tr./s	70	24	23
vacuum	no data	no data	45 tr./s	2.1
trigger-delay	0.028 tr./s	0.035	0.035	1.6

## 2.4 Network Capacity

The network system for our control system, as shown in Fig. 2, consists of the main backbone (FDDI, 100Mbps) and about 50 local segments (10Mbps). Each segment is linked to the backbone; however, it is isolated from unnecessary network traffic by using switching-hubs.

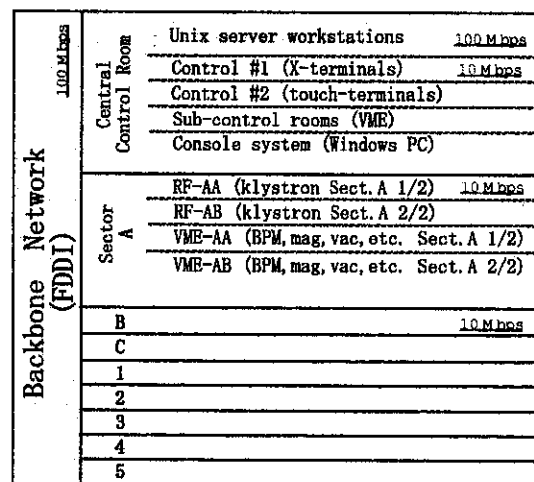


Figure 2: Network segments for the linac control.

In order to study the capacity of the control network, the network traffic of typical local segments was measured in October, 1998. The results are given in Table 4. The observed network traffic in all four segments are 2–3 orders smaller than the maximum capacity of the local segment. The higher traffic observed at the *RF-CB* came from the klystron waveform monitor, which was occasionally running to observe a troublesome klystron.

Table 4: Traffic of typical network segments

network segment	network traffic frames/s (Mbps)	devices
RF-1A	29 (0.04)	klystron (1sector 1st-half)
RF-CB	170 (0.26)	klystron (Csector 2nd-half)
VME-1B	35 (0.05)	BPM, mag, vac, etc. (1sector 2nd-half)
VME-CA	26 (0.04)	BPM, mag, vac, etc. (Csector 1st-half)

### 3 DISCUSSION

The KEKB commissioning started at the end of 1997 [8, 9]. The commissioning group includes both the linac and ring staff members. The commissioning, even for the linac, has been made by using ring-side Unix workstations. It was a new experience for the linac to accept control transactions from the KEKB-ring control workstations. Table 5 shows the 4-year transition of the control transactions from the KEKB-ring workstations.

Various commissioning activities have produced a considerably greater amount of control transactions than before. A noticeable growth is found in the BPM transactions. The BPM has been newly developed in the KEKB project as a key device for advanced beam studies of the linac [6, 7]. The observed growth implies that the BPM system has been successfully used in commissioning studies. It is worth noting that most of the BPM transactions come from the KEKB-ring workstations.

Table 5: Transactions from the KEKB-ring

Device [transactions/s]	total Jun.98	total Jun.99	total Jun.00	total Jun.01
beam-position monitor	20 tr./s (57%)	134 (85%)	174 (69%)	34 (11%)
klystron	3.5 tr./s (66%)	1.8 (39%)	2.5 (14%)	2.5 (9%)
magnet power-supply	10 tr./s (16%)	8 (11%)	19 (79%)	3 (13%)

In December, 1998, the CPU load of the *plum* reached 100%. This is because many slow-feedback applications were developed at *plum* in order to suppress various beam instabilities. The analysis showed that the klystron server consumed a very large fraction of the CPU resource. We thus prepared on-memory cache areas to keep updated klystron data in order to decrease the total CPU consumption by network communications. In addition, we introduced a new server workstation, *lychee*, in the summer of 1999 to improve total CPU resources.

In the following years, we have proceeded to prepare on-

memory cache areas for BPM and vacuum data in addition to klystron. The total amount of control transaction becomes 2-3 times larger in the recent 3 years (Table 3), however, no problem on the CPU availability has occurred.

### 4 CONCLUSION

The number of control transactions at the KEK linac has been studied. In June, 2001, the number of BPM transactions (klystron, magnet power-supply) was 299 (27, 23) per second, respectively. The present network system with a FDDI backbone and several local segments has sufficient capacity. Since 1998, the control transactions, especially the BPM transactions, have increased very rapidly, which have originated from the KEKB commissioning activities. This increase caused a crisis of the CPU availability in December, 1998. However, by introducing on-memory cached data on the server workstations, we succeeded to suppress the total CPU consumption.

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