Status of KEKB accelerator control system

KEKB control group
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Overview

- KEKB control system will use EPICS toolkit as a base of system. It provides an,
  - "OPEN",
  - Flexible,
  - and Extensible

  framework for a control system.

- Presentation Layer
  X-terminals are used as operator's console.
  Multi-screen X-terminal is being tested.

- Application Layer
  UNIX server is chosen as an application server. It also works as a database server for static/archive database.

- Database Layer
  - EPICS uses a distributed run time database for equipment control. Link-persons in hardware groups are responsible to design EPICS database templates.
  - A (relational) database provides,
    - Information of devices in the accelerators, such as interface address, calibration data etc,
    - Information on archived data.

- Equipment Control Layer
  - Field buses
    - ARCNET
    - CAMAC
    - VME-MXI-VXI
    - GP-IB
    - Serial
    - Modbus+
    - Reflective memory(?)
  - IOC CPU
    VME CPU based on MC68060 is used at the first stage.
    PowerPC based board was tested with EPICS R3.12 software. EPICS was ported

to the new platform without much difficulty. Our measurement shows that PowerPC based board runs EPICS 5 times faster than MC68040 based board.

- Network
  Switched FDDI is used as a backbone of KEKB control system network. The backbone network is connected to a switched Ethernet HUB at each control stations.

- Timing System
  - RF reference signal
  - Fast timing system
    Beam revolution signal and trigger signals will be distributed through fiber optics cables. Time delay module used in TRISTAN, TD2, is redesigned as VME board.
  - Synchronization based on EVENT.

- Safety
  Safety alarm/interlock system used in TRISTAN will also be used in KEKB with necessary modification.

- CATV
  We use the existing infrastructure for Lab-wide distribution of the KEKB status. The KEKB status can be accessed through a network.

Status of Development

- Availability of KEKB control system Hardware
  - A computer system for KEKB accelerator control system specification
  - Network installation is underway.
  - Server computer is installed. EPICS software is already running on the server.
  - VME CPU board is tested and confirmed to work.

- Test system
  Several small applications based on EPICS were used and tested in TRISTAN-AR operation.
  - Vacuum/temperature monitoring system, ARES temperature monitor.
    In AR high current study, EPICS was used to monitor vacuum/temperature status of the TRISTAN-AR. Several applications (medm, ALH, AR_cmd etc.) are used in the operation. A tool to convert EPICS archiver format to PAW format (column wise ntuple) was developed. This tool allows to use PAW as an archived data

retriever.

- Magnet field measurement system
  EPICS sequencer program controls the sequence of magnet field strength measurement using a rotating coil. Measured data are stored by archiver. CaMath interface is used to analyze Fourier components of the data.

- Gateway to LINAC control system.
  Portable channel Access server was tested by the LINAC control group. They have built a pilot system to monitor equipments in the LINAC. ["Operation of KEKB Linac and Ring with EPICS", Kaji M.* and Furukawa K. , http://maple.kek.jp/~mkaji/WWW/LinacKenkyu

- Software classification and availability
  - Level 0 : Each Device can be controlled over the control system. Software on this level Include
    - Run time database
    - Alarm Status Display
    - Data Archiver
    - New EPICS RECORD type
    - Device driver /Device Support
    - Interface Driver
      Most of software in this level are available now. Device/Driver support routine for serial interface and

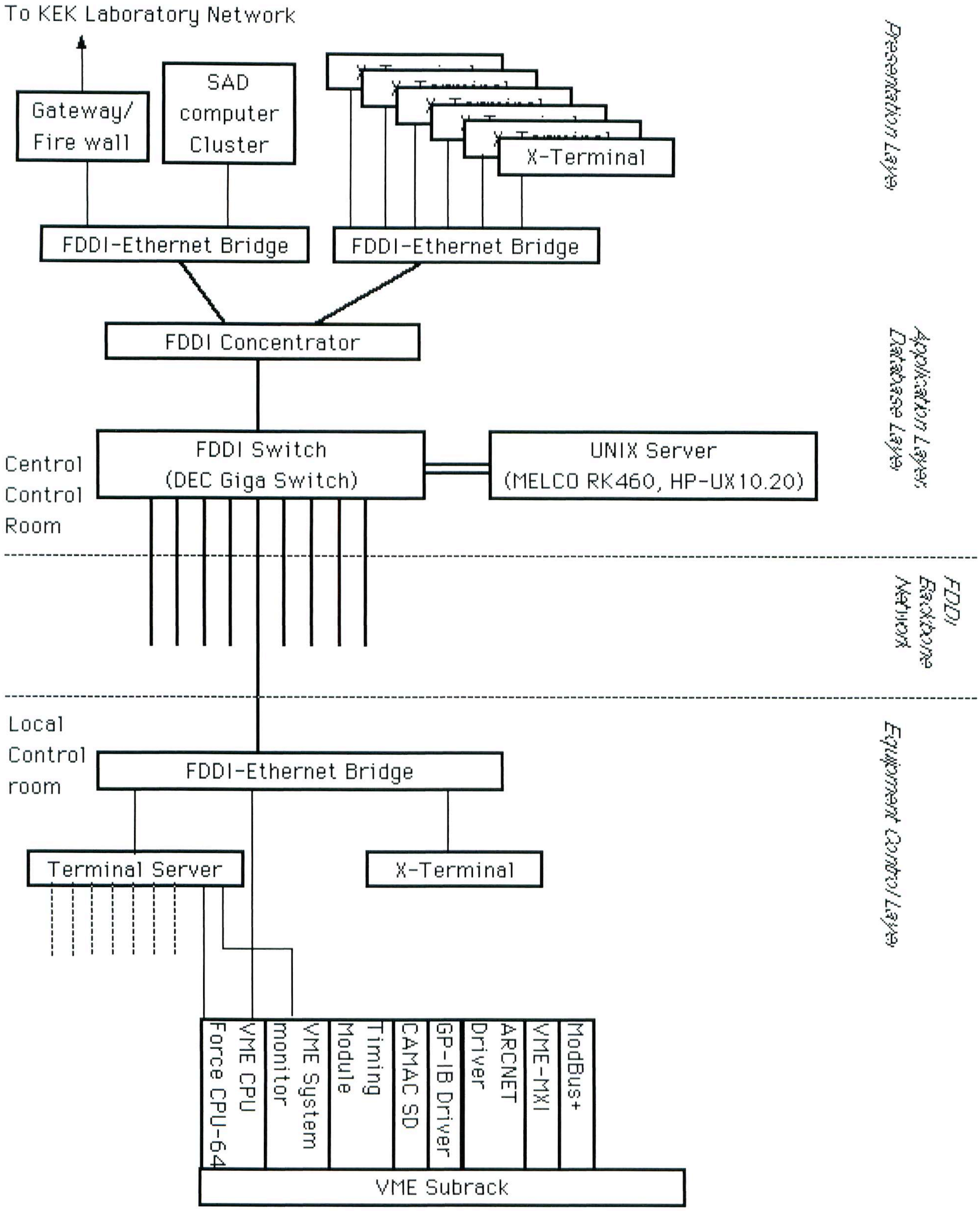
MXI-VXI will be available soon.

- Level 1 : Group of devices can be controlled as one device . In other word, Group of devices should be defined as a new device in the system. For the consistency of the system, this new device should be accessible by CA clients. "cdev" has a ability to define a new device which consists of group of devices. However, Not all the OPI tools support "cdev" yet.
  - Synchronization of the record processing on several IOC can be implemented using an EPICS event.
  - SAD can handle a set of channels in a natural way.
- Level 2 : Application programs to control accelerator as one device(or system). A modeling program should be tightly integrated with the control system. SAD is a modeling program developed in KEK and used for a design work of KEKB accelerators. An interface to the EPICS Channel Access) is implemented to the SAD. Way to send messages from the operator interface to SAD is also developed. Using these tools, sample of COD correction application is developed. This level of software should be available at the commissioning of the KEKB. Tools to develop these application is available

now.

    - □ SAD Interface
        - □ CaOpen/CaRead/CaWrite
    - □ COD correction sample
- ○ Level 3: Automation of accelerator operation.

Schematic configuration of KEKB control system



Field buses used in KEKB control system

- ARCNET
  KEKB control system has more than 1800 magnets to control. To simplify cabling between these power supplies and the control system, standard filed buses, such as CAN, was studied. Among the candidates ARCNET was chosen by the reasons;
    - Availability in JAPAN (Chips, support form the industry,...)
    - Performance consideration
    - etc.
- CAMAC
    - RF group reuses existing control system based on CAMAC.
- VME-MXI-VXI
    - Electronics for a beam position monitor(BPM) are developed as VXI modules. These electronics are controlled by VME-CPU(IOC) through MXI connection.
- GP-IB
    - Commercially available equipments, such as a digital volt-meter and a scanner, usually have GP-IB interface for communication with a computer.
    - A software tool to support a development

of GP-IB device support routine in EPICS is developed at KEK. (GDL, GP-IB Device description Language)

- Serial
  - Mass Analyzer to analyze contents of gas in the vacuum chamber.
- Modbus+
  - Safety/Alarm system in KEK uses Modbus+.
  - KEKB control system will read the status of Safety/Alarm system.
- Reflective memory(?)
  - Currently NO plan to use reflective memory.
  - Reflective memory or similar technology will be used only where high speed data transfer is required.
  - Injection bunch selection is a possible place for reflective memory. In KEKB, a beam from LINAC is added to the existing bunches in the ring. Too much unbalance in the bunch current can cause instability. Injection selection system should select the next injection bunch in the ring based on the profile of bunch current in the ring. This system requires bunch current of 5120 bunches every 1/50 second. In other words, it reads 2Mbits of data every second.

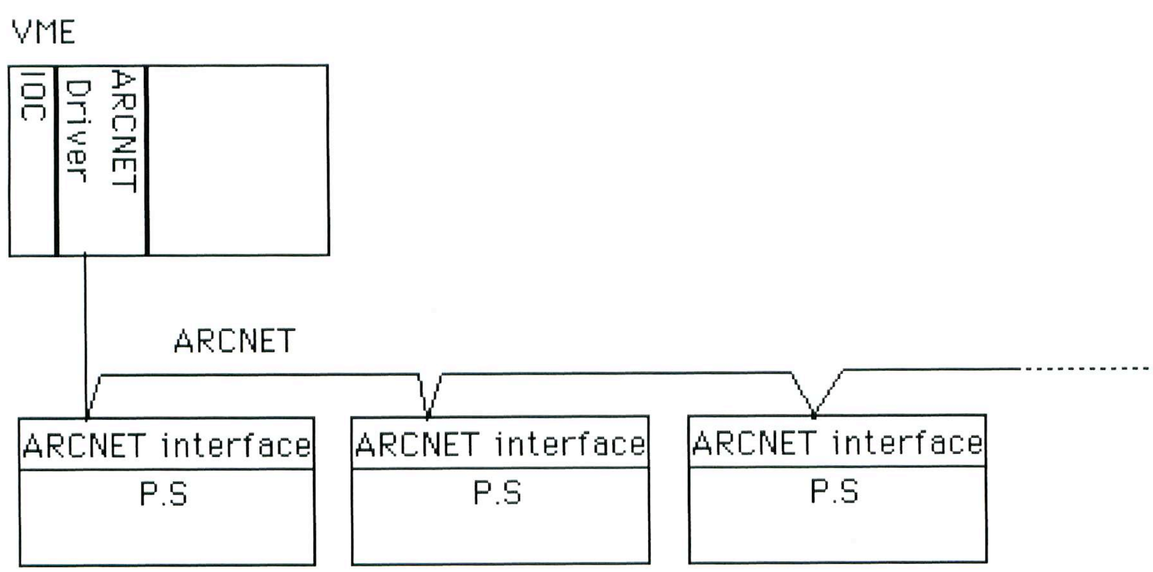
ARCNET

ARCNET is a standard of field bus widely used in Japanese and US industries.

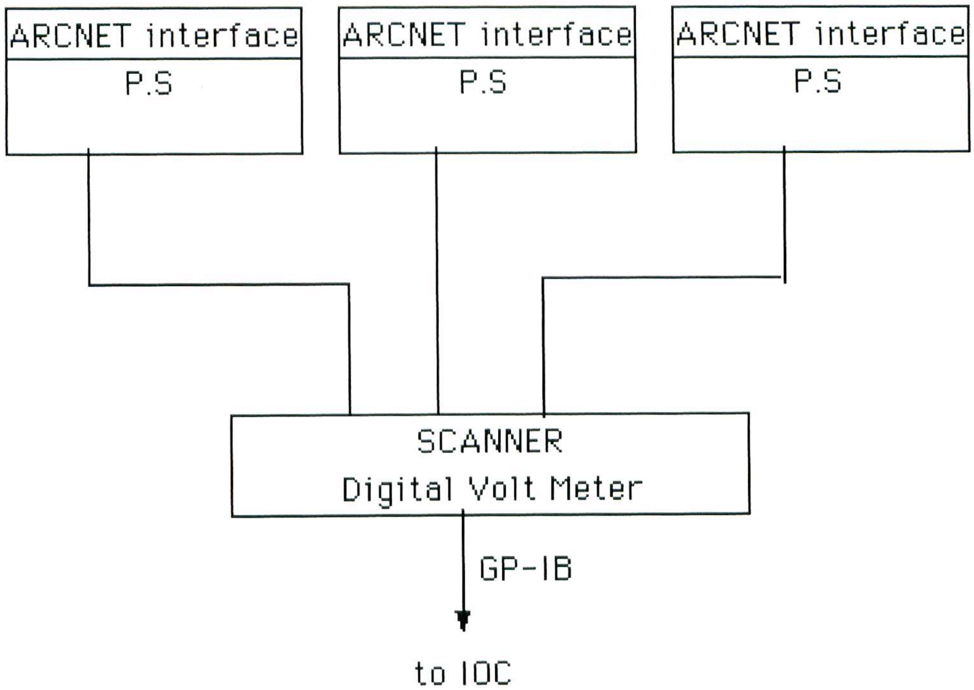
ARCNET is originally developed by Datapoint Corporation and is now ANSI standard.

Control of Magnet Power Supplies

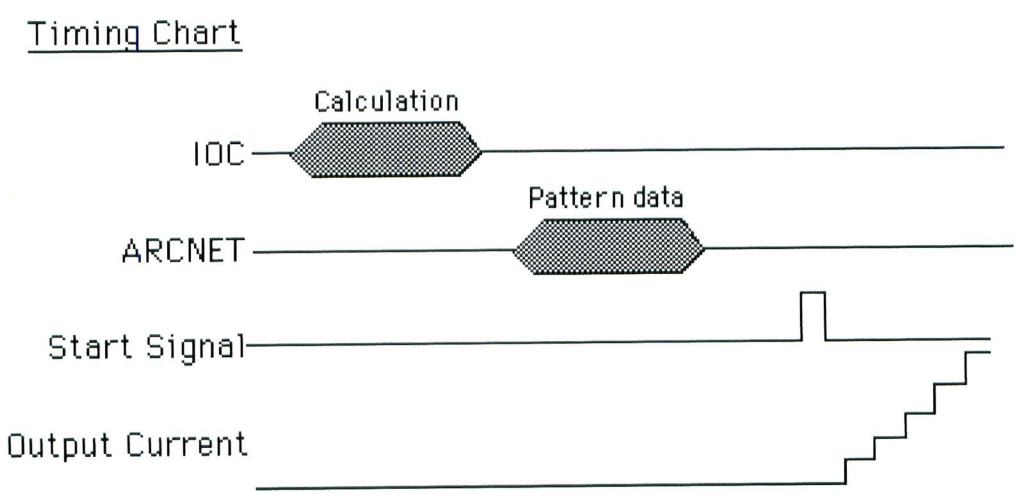
- Many(~ 2000) power supplies are used in the KEKB. Use of ARCNET reduces a number of lines to connect these power supplies and an IOC.



  - Prototype P.S.: Testing.
  - P.S. test using ARCNET will start soon.
- Output currents of P.S. are monitored by DVM.



Operation of Steering P.S.



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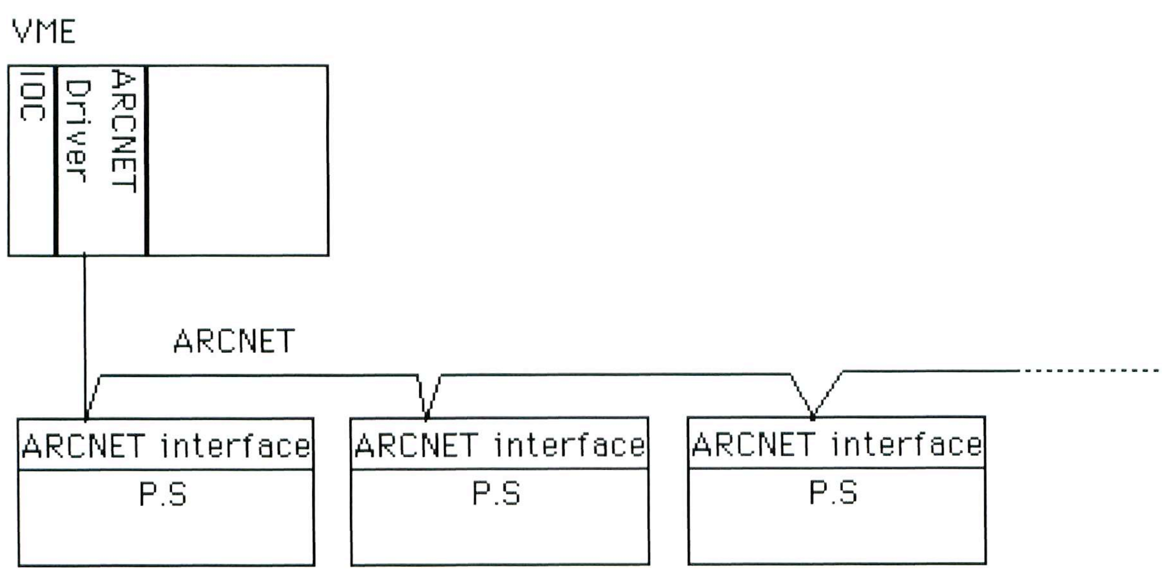

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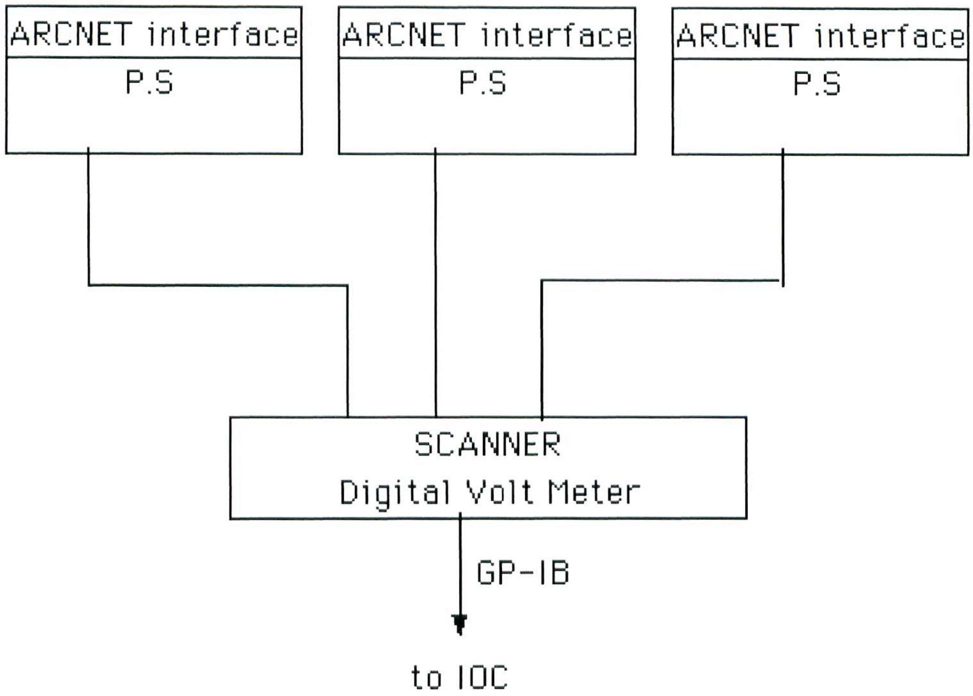

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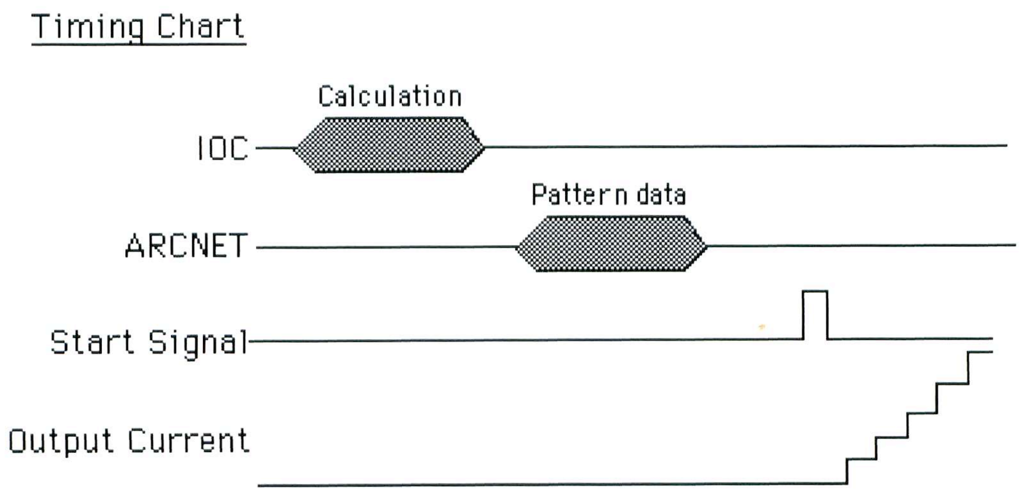


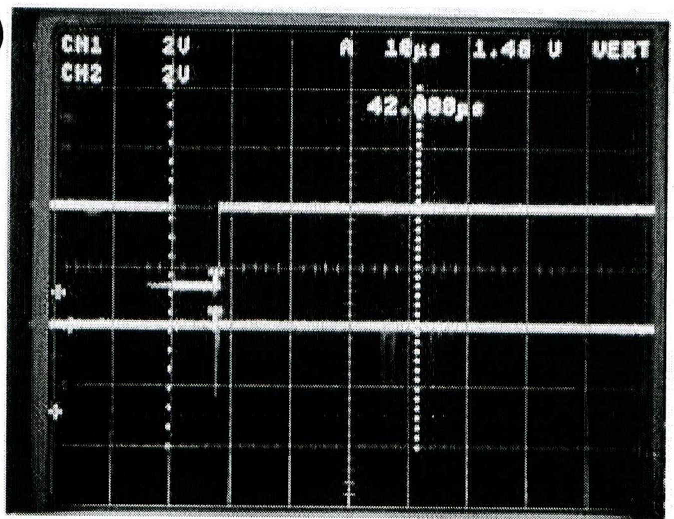
EPICS benchmark on a PPC board

- VME one board computer based on PowerPC chip was tested using EPICS software.
- CPU-604RT computer produced by FORCE.
  - CPU ： PowerPC 604 (100 MHz)
  - RAM ： 16MB
  - 2nd Cache ： None
  - OS ： VxWorks 5.3 (Beta) 2 , 3 (Wind River)
  - PowerPC CPU-604RT BSP(beta) by FORCE
  - GNU C compiler (Beta)
- EPICS database for a benchmark is designed by M.Kraimer at ANL/APS. 3000 records are processed every "Scan Period". One "medm" screen monitored database records.

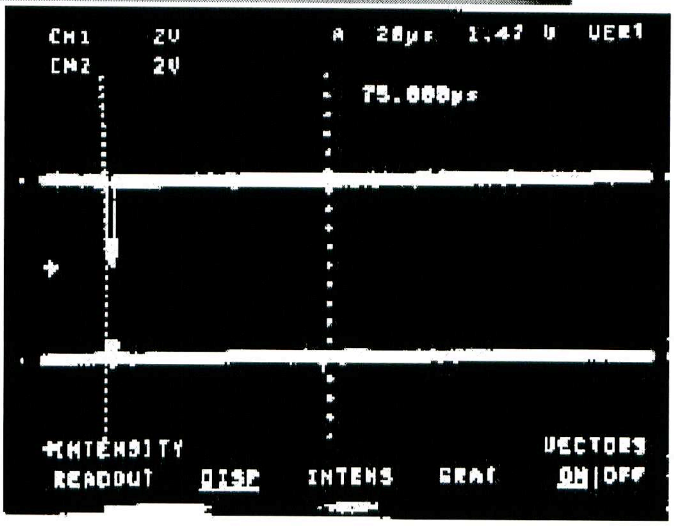
Scan Period (sec)	MC68040	PowerPC	PowerPC/MC68040 ratio
1	5.8 %	1.1 %	5.1
0.5	12 %	2.1 %	5.6
0.2	27 %	5.6 %	4.9
0.1	56 %	12 %	4.9

CPU usage of EPICS with Kraimer's database

(a)



(b)



Response to an external interrupt on PPC(a) and 68040(b)

Network in KEKB accelerator control system

Backbone

FDDI will be used as a backbone of KEKB accelerator control network. FDDI is chosen over 100BaseT, 100BaseAny and ATM because of mutuality in the technology.

Star configuration is used for the cabling of FDDI backbone network. It will reduce a cost of future re-cabling and boost overall bandwidth of the network.

FDDI-Ethernet bridges are placed at 26 local control rooms, including the LINAC control, and KEKB central control room.

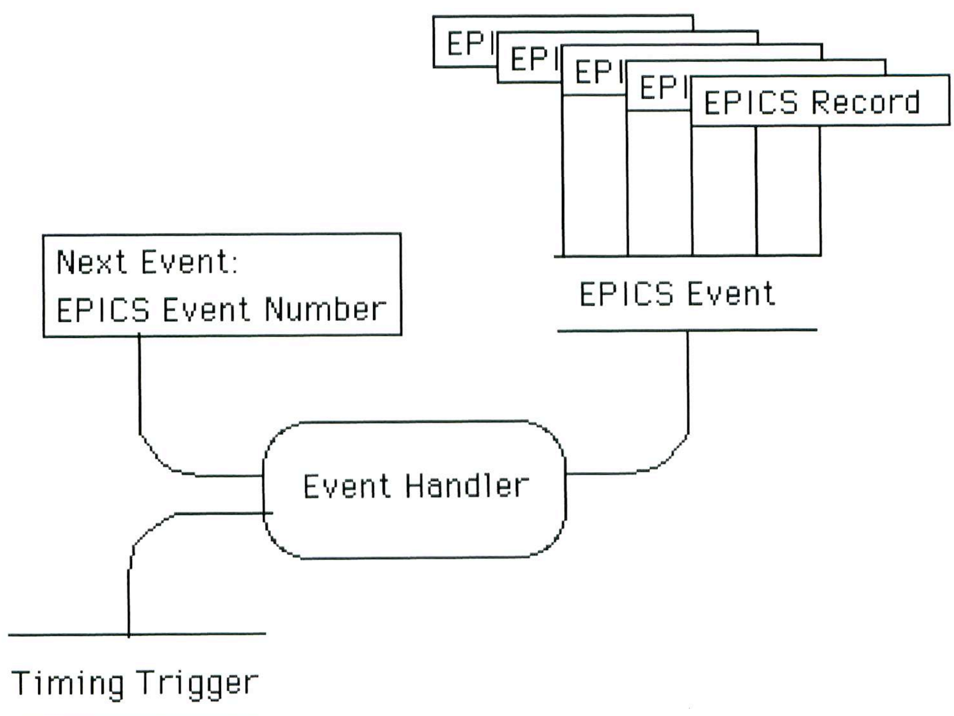
Network flow evaluation

KEKB control system will include more than 30,000 control points. Data flow rate to update status of these control points is estimated as 400KBytes/sec in total. Data flow from one IOC, estimated as 20Kbytes/sec, will fits in Ethernet bandwidth.

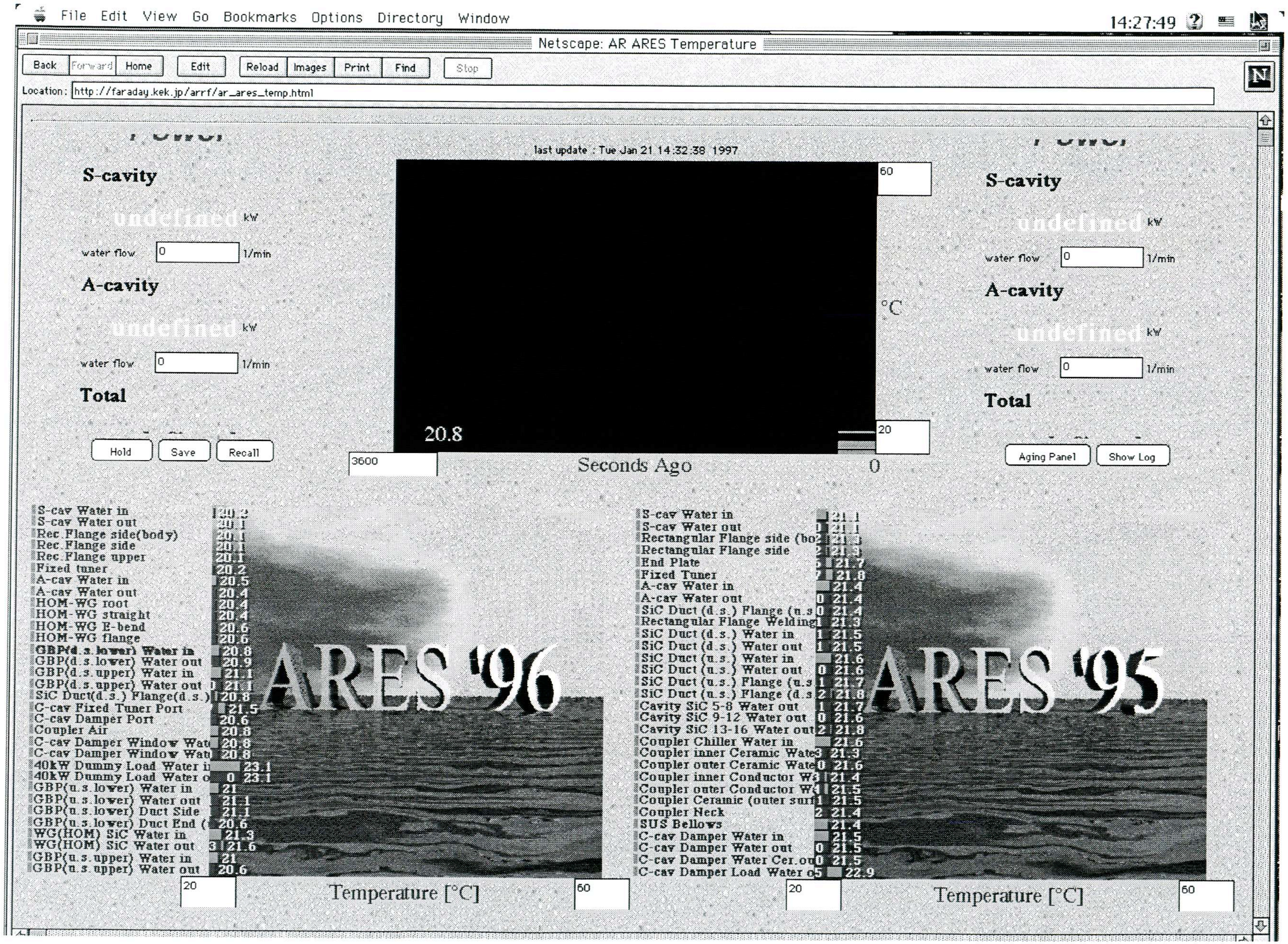
Rebooting of VME is followed by the downloading of the software from the server computer. Size of software is typically 2MB. If we reboot all 60 IOCs same time, 120MB of software will be downloaded. A booting process takes 30 to 60 seconds, resulting 4Mbytes/sec network traffic. Current design of the KEKB control system network can handle this level of network traffic.

Timing System

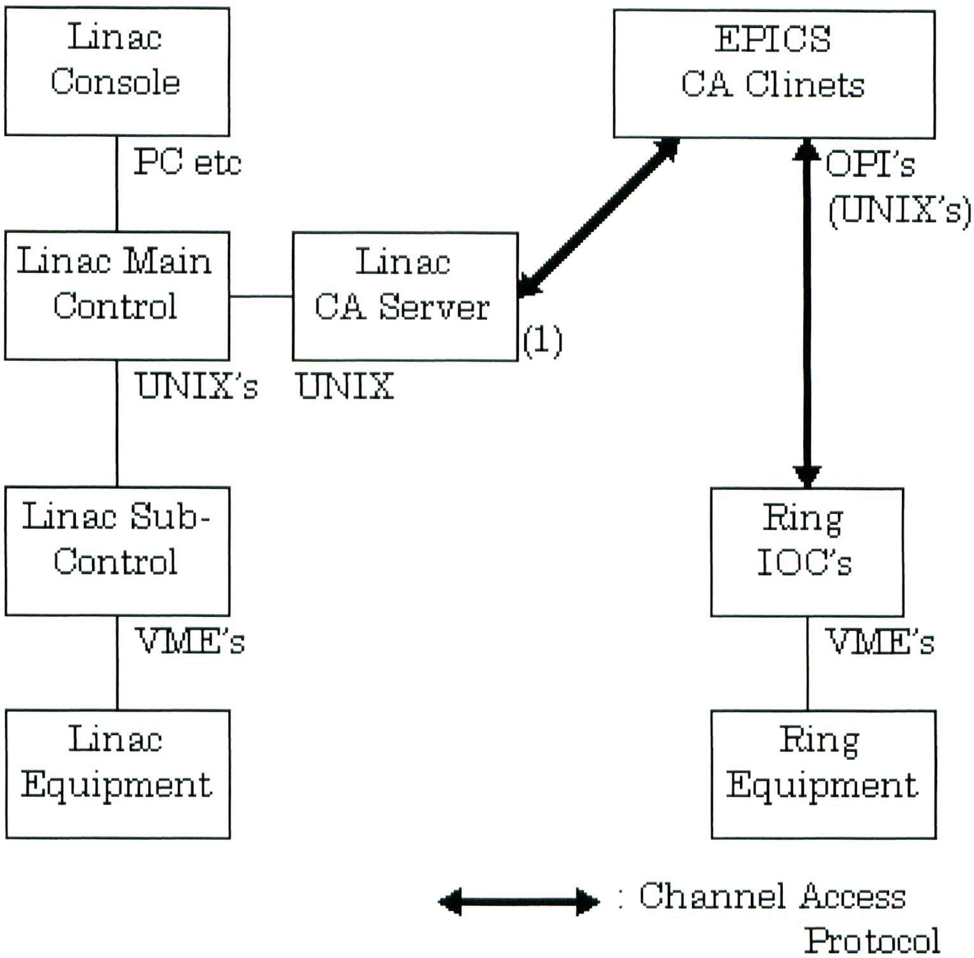
- RF reference signal (508MHz)
  - Use existing RF reference signal distribution system
- Fast Timing Signal
  - A beam revolution signal will be distributed over the fibber optic cable.
  - Trigger Signals over Fiber optic cable.
  - Trigger Signal/Delay Module based on TD2 module design.



Possible Implementation of Event Handler in EPICS


File Edit View Go Bookmarks Options Directory Window
14:27:49
Netscape: AR ARES Temperature
Back Forward Home Edit Reload Images Print Find Stop
Location: http://faraday.kek.jp/arrf/ar_ares_temp.html
last update : Tue Jan 21 14:32:38 1997
S-cavity
undefined kW
water flow 0 l/min
A-cavity
undefined kW
water flow 0 l/min
Total
Hold Save Recall
60
°C
20
20.8
3600
Seconds Ago
0
Aging Panel Show Log
S-cav Water in 20.2
S-cav Water out 20.1
Rec.Flange side(body) 20.1
Rec.Flange side 20.1
Rec.Flange upper 20.1
Fixed tuner 20.2
A-cav Water in 20.5
A-cav Water out 20.4
HOM-WG root 20.4
HOM-WG straight 20.4
HOM-WG E-bend 20.6
HOM-WG flange 20.6
GBP(d.s.lower) Water in 20.8
GBP(d.s.lower) Water out 20.9
GBP(d.s.upper) Water in 21.1
GBP(d.s.upper) Water out 21.1
SiC Duct(d.s.) Flange(d.s.) 20.8
C-cav Fixed Tuner Port 21.5
C-cav Damper Port 20.6
Coupler Air 20.8
C-cav Damper Window Wat 20.8
C-cav Damper Window Wat 20.8
40kW Dummy Load Water i 23.1
40kW Dummy Load Water o 23.1
GBP(u.s.lower) Water in 21
GBP(u.s.lower) Water out 21.1
GBP(u.s.lower) Duct Side 21.1
GBP(u.s.lower) Duct End (20.6
WG(HOM) SiC Water in 21.3
WG(HOM) SiC Water out 21.6
GBP(u.s.upper) Water in 21
GBP(u.s.upper) Water out 20.6
ARES '96
20 Temperature [°C] 60
S-cav Water in 21.1
S-cav Water out 21.1
Rectangular Flange side (bo 21.3
Rectangular Flange side 21.3
End Plate 21.7
Fixed Tuner 21.8
A-cav Water in 21.4
A-cav Water out 21.4
SiC Duct (d.s.) Flange (u.s 21.4
Rectangular Flange Welding 21.3
SiC Duct (d.s.) Water in 21.5
SiC Duct (d.s.) Water out 21.5
SiC Duct (u.s.) Water in 21.6
SiC Duct (u.s.) Water out 21.6
SiC Duct (u.s.) Flange (u.s 21.7
SiC Duct (u.s.) Flange (d.s 21.8
Cavity SiC 5-8 Water out 21.7
Cavity SiC 9-12 Water out 21.6
Cavity SiC 13-16 Water out 21.8
Coupler Chiller Water in 21.6
Coupler inner Ceramic Wate 21.3
Coupler outer Ceramic Wate 21.6
Coupler inner Conductor W 21.4
Coupler outer Conductor W 21.5
Coupler Ceramic (outer surf 21.5
Coupler Neck 21.4
SUS Bellows 21.4
C-cav Damper Water in 21.5
C-cav Damper Water out 21.5
C-cav Damper Water Cer.ou 21.5
C-cav Damper Load Water o 22.9
ARES '95
20 Temperature [°C] 60

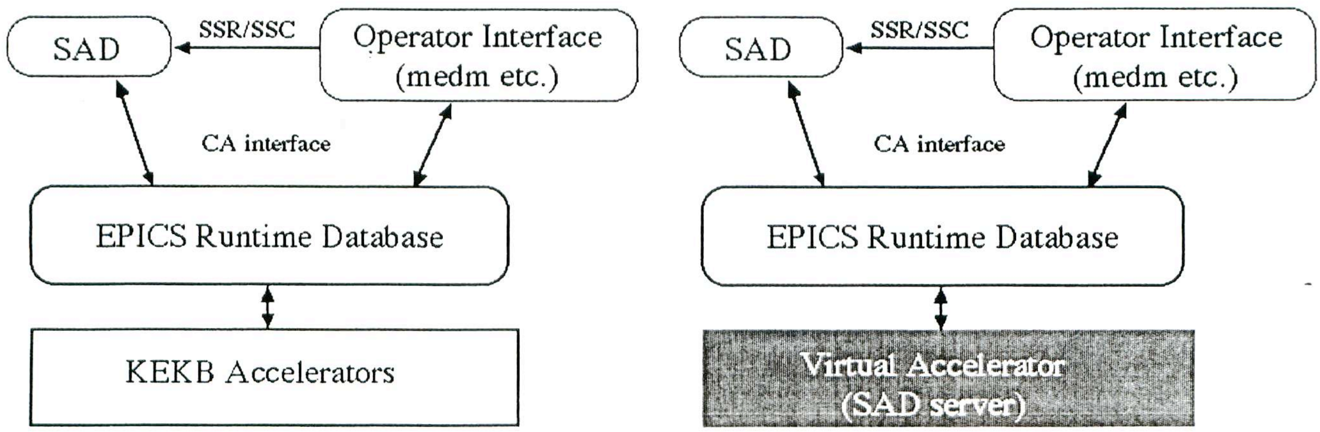
Portable CA server as a gateway between KEKB and LINAC control systems.



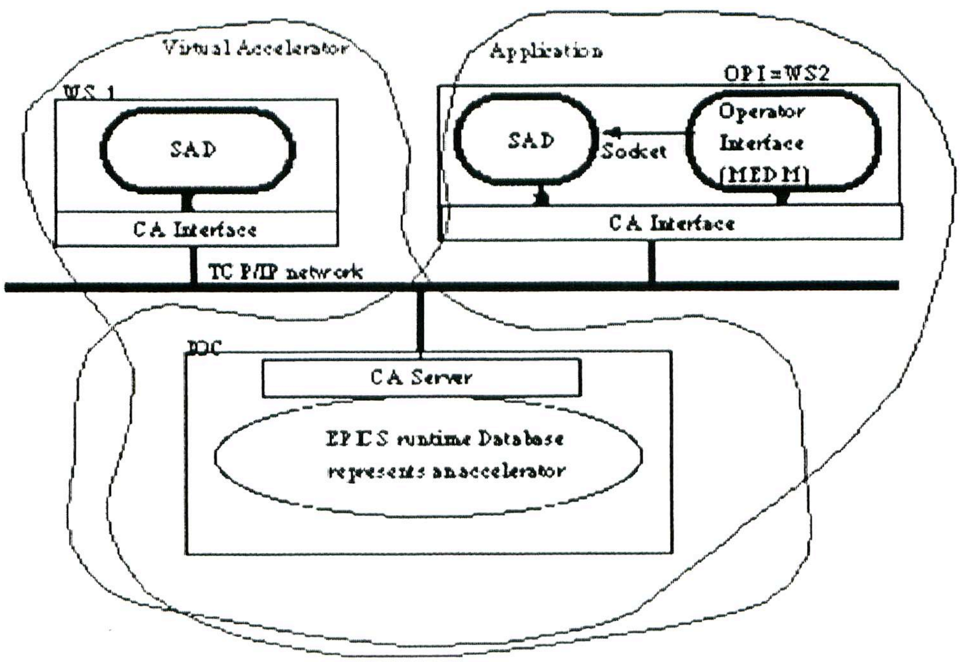
Sample screen of EPICS "medm" OPI to control magnets in the LINAC

ST2-14Y	-0.250	-0.259	-5.000	-0.250	5.000
ST2-20X	0.111	0.110	-5.000	0.111	5.000
ST2-20Y	-0.780	-0.774	-5.000	-0.780	5.000
ST2-23X	-0.070	-0.144	-5.000	-0.070	5.000
ST2-23Y	0.487	0.486	-5.000	0.487	5.000
ST2-31X	-0.031	-0.046	-5.000	-0.031	5.000
ST2-31Y	0.460	0.413	-5.000	0.460	5.000
ST2-33X	0.241	0.178	-5.000	0.241	5.000
ST2-33Y	-0.206	-0.210	-5.000	-0.206	5.000
ST2-41X	-0.096	-0.105	-5.000	-0.096	5.000
ST2-41Y	-0.580	-0.583	-5.000	-0.580	5.000
ST2-42X	-0.675	-0.762	-5.000	-0.675	5.000
ST2-42Y	-0.018	-0.046	-5.000	-0.018	5.000
ST2-43X	-0.556	-0.632	-5.000	-0.556	5.000
ST2-43Y	-0.302	-0.344	-5.000	-0.302	5.000
ST2-44X	-0.407	-0.417	-5.000	-0.407	5.000
ST2-44Y	-0.453	-0.444	-5.000	-0.453	5.000
QM2-61D	0.000	0.010	0.000	0.000	20.000
QM2-61F	0.000	0.010	0.000	0.000	20.000
QM2-62D	0.000	0.000	0.000	0.000	20.000
QM2-62F	0.000	0.010	0.000	0.000	20.000
QM2-63D	0.000	0.049	0.000	0.000	20.000
QM2-63F	0.000	0.029	0.000	0.000	20.000
QM2-64D	3.111	3.125	0.000	3.111	20.000
QM2-64F	3.346	3.379	0.000	3.346	20.0
QM2-72D	0.000	0.010	0.000	0.000	20.0
QM2-72F	0.000	0.010	0.000	0.000	20.0
QM2-74D	0.000	0.010	0.000	0.000	20.0
QM2-74F	0.000	-0.010	0.000	0.000	20.0
QM2-82D	0.000	0.010	0.000	0.000	20.0
QM2-82F	0.000	-0.020	0.000	0.000	20.0
QM2-84D	1.958	1.943	0.000	1.958	20.0
QM2-84F	2.017	2.012	0.000	2.017	20.0
ST2-61X	-0.106	-0.049	-5.000	-0.106	5.0
ST2-61Y	-0.057	-0.024	-5.000	-0.057	5.0
ST2-62X	-0.534	-0.264	-5.000	-0.534	5.0

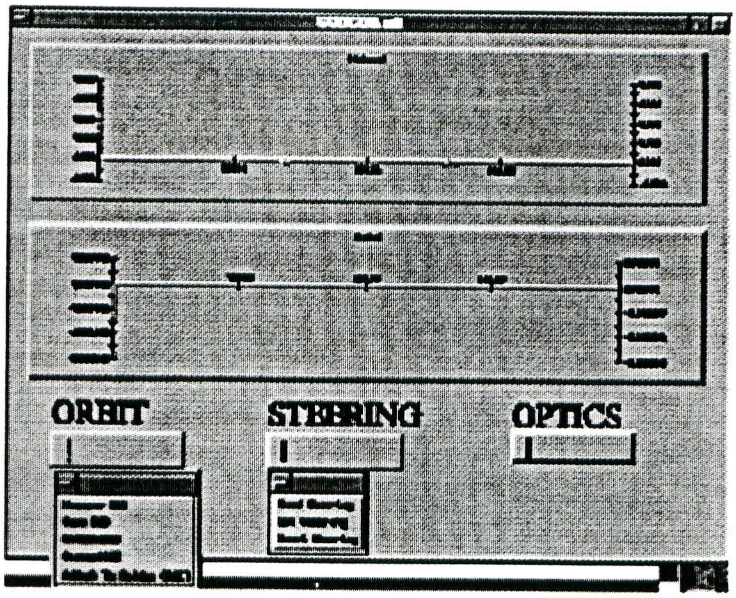
Control Systems for "REAL" and "VIRTUAL" Accelerators



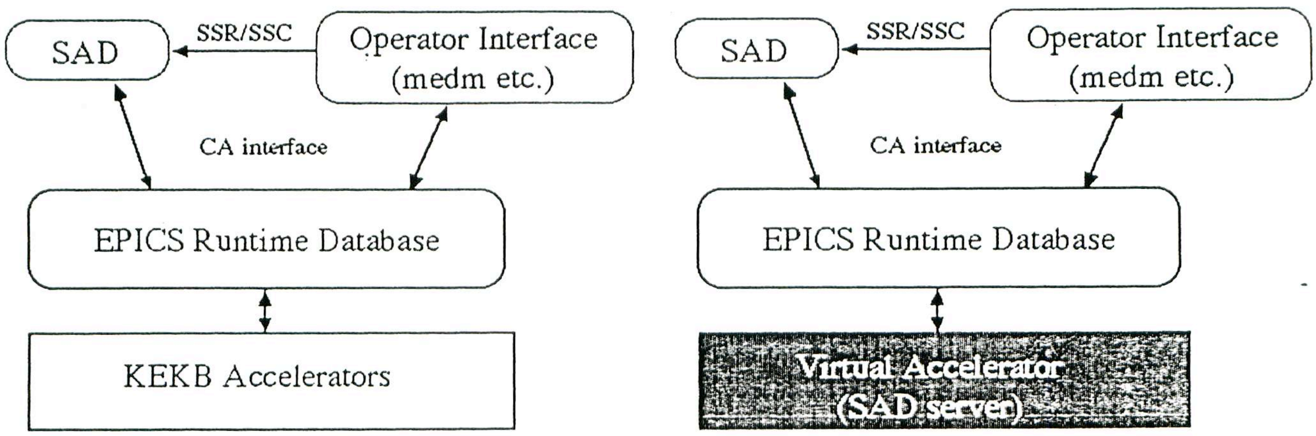
More on "VIRTUAL" Accelerator



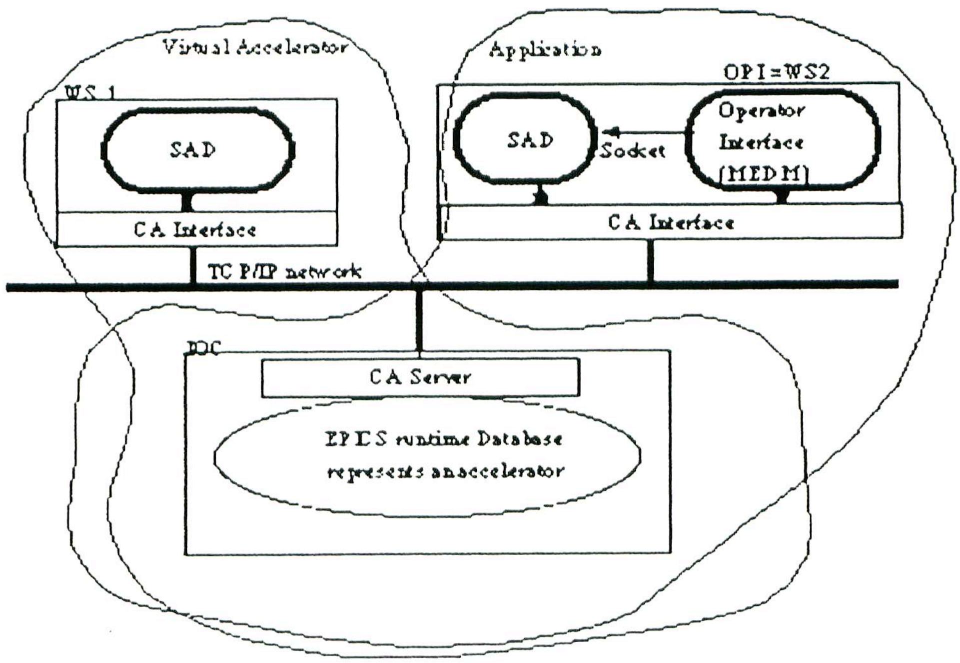
(SAMPLE) Operator interface of orbit correction application for a "VIRTUAL" accelerator.


ORBIT
STEERING
OPTICS

Control Systems for "REAL" and "VIRTUAL" Accelerators



More on "VIRTUAL" Accelerator



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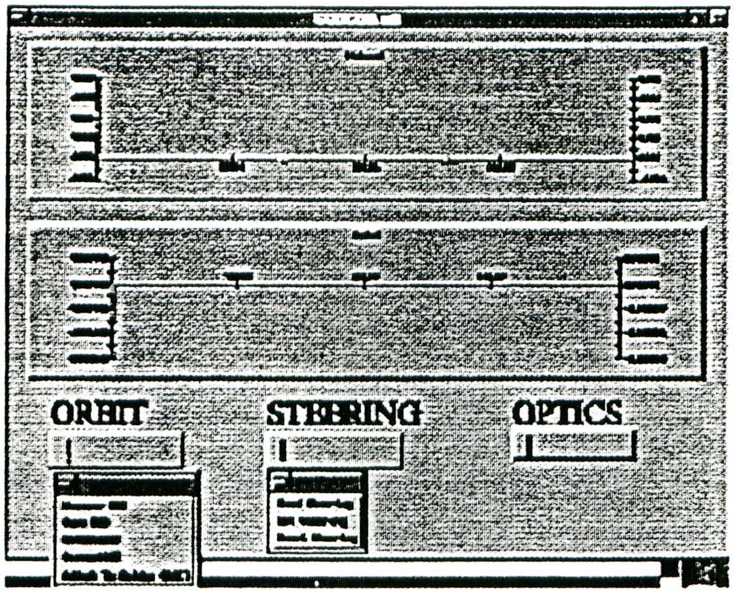
ORBIT
STEERING
OPTICS