Construction of New Data Archive System in RIKEN RI Beam Factory

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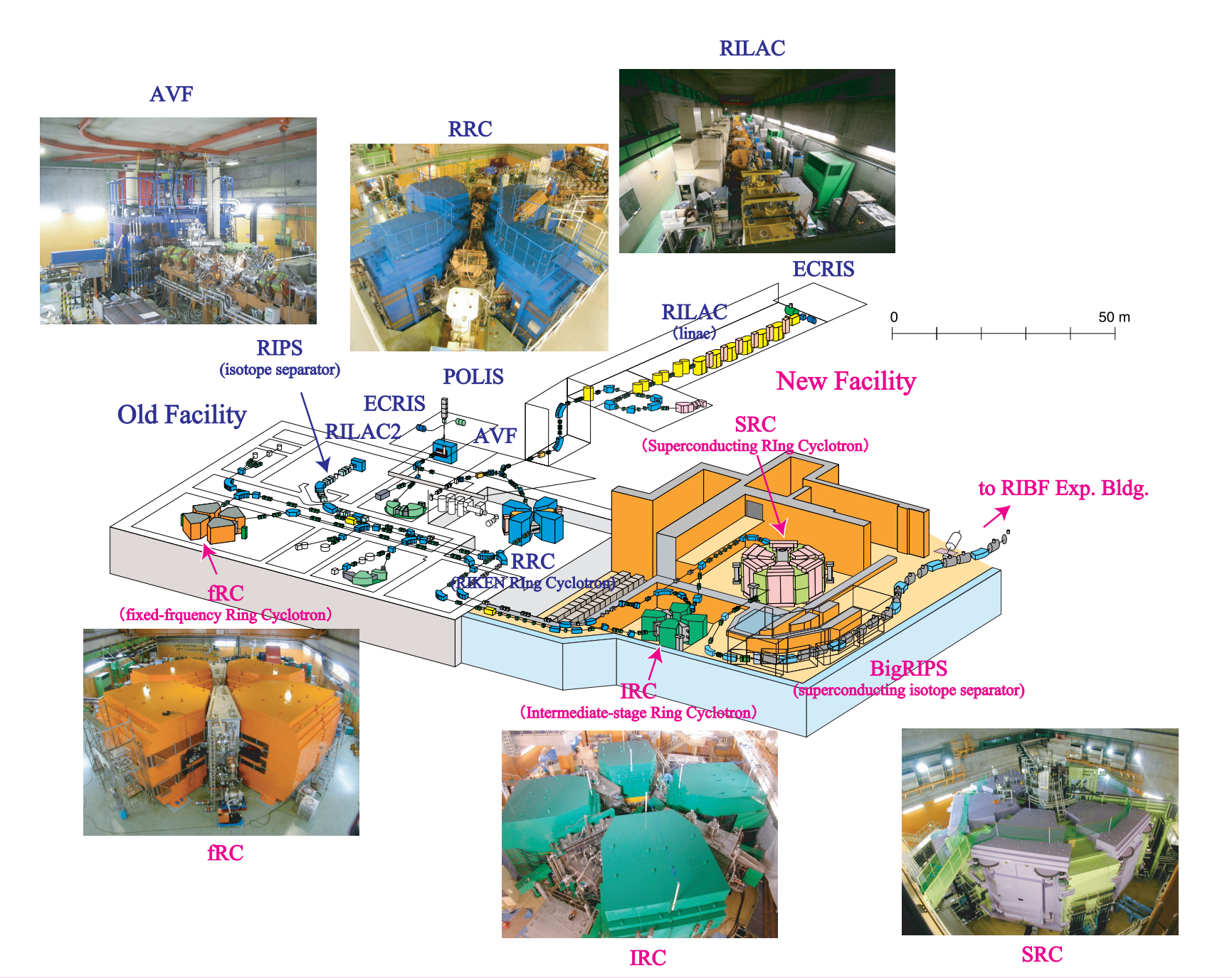
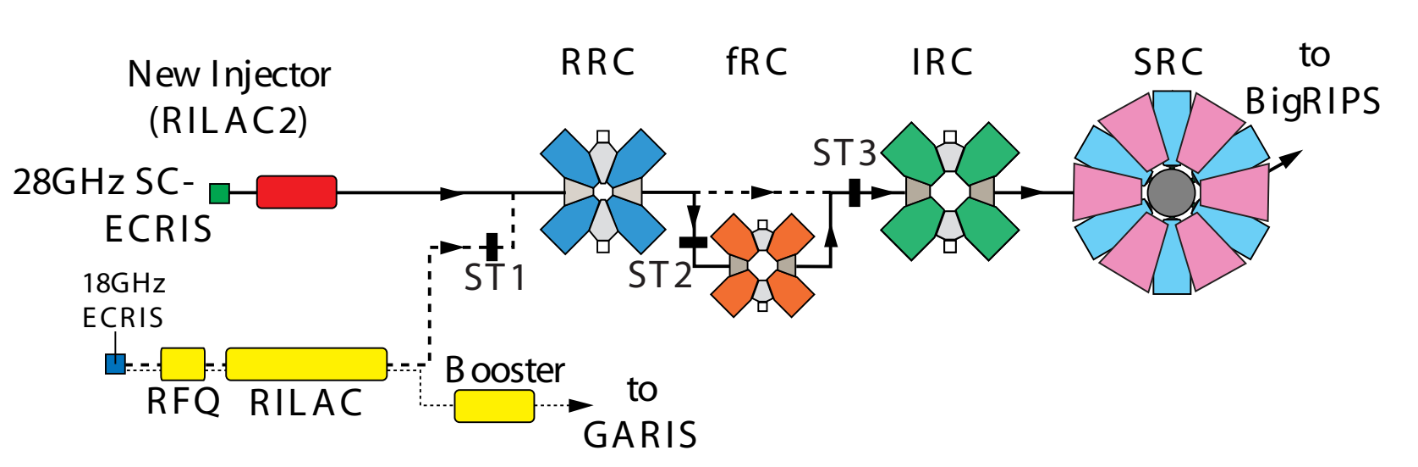
What is Radioactive Isotope Beam Factory (RIBF)?


RILAC
AVF
RRC
ECRIS
RIPS (isotope separator)
POLIS
RILAC (linac)
New Facility
Old Facility
ECRIS
RILAC2
AVF
SRC (Superconducting Ring Cyclotron)
to RIBF Exp. Bldg.
fRC (fixed-frequency Ring Cyclotron)
RRC (RIKEN Ring Cyclotron)
IRC (Intermediate-stage Ring Cyclotron)
BigRIPS (superconducting isotope separator)
fRC
IRC
SRC

Layout of RIBF



Conceptual layout of the accelerator chain of RIBF

Ion	Energy (MeV/u)	Intensity	Date
^{4}He	320	1 pμA	09/10/31
^{18}O	345	1 pμA	10/06/17
^{48}Ca	345	0.23 pμA	10/05/31
^{86}Kr	345	33 pnA	07/11/04
^{238}U	345	0.8 pnA	09/12/19

Beam intensities achieved at RIBF

RIBF Accelerators :
- Frequency-variable RIKEN heavy-ion linac (RILAC)
- New linac injector (RILAC2) <- New (2010) !
- K70-MeV AVF Cyclotron (AVF)
- K540-MeV RIKEN Ring Cyclotron (RRC)
- K570-MeV Fixed frequency Ring Cyclotron (fRC)
- K980-MeV Intermediate stage Ring Cyclotron (IRC)
- K2600-MeV Superconducting RIng Cyclotron (SRC) <- World's First!

* $E(\mathrm{MeV/u})=K(q/M)^2$

◎ RIBF is a cyclotron-based in-flight facility.
◎ RIBF accelerators can supply RI beams at energies hundreds of MeV/u over the entire range of atomic masses.
◎ In 2009, RIBF succeeded in providing heavy ion beams of ^{238}U with 0.8 pnA at an energy of 345 MeV/u (Injector : RILAC).
The beam intensity of ^{238}U beam acceleration in the RIBF is expected to become 100 times larger than the presentbeam intensity with the use of RILAC2.

Development of RIBF Control Data Archive System (RIBFCAS)

Background of the development of RIBFCAS :

RIBF uses two types of control systems :
- an experimental physics and industrial control system (EPICS)-based system
- a group of several non-EPICS-based systems

For each control system there is a corresponding data archiving system in operation:
- Channel Archiver for EPICS-based system
- MyDAQ2 for non-EPICS-based systems

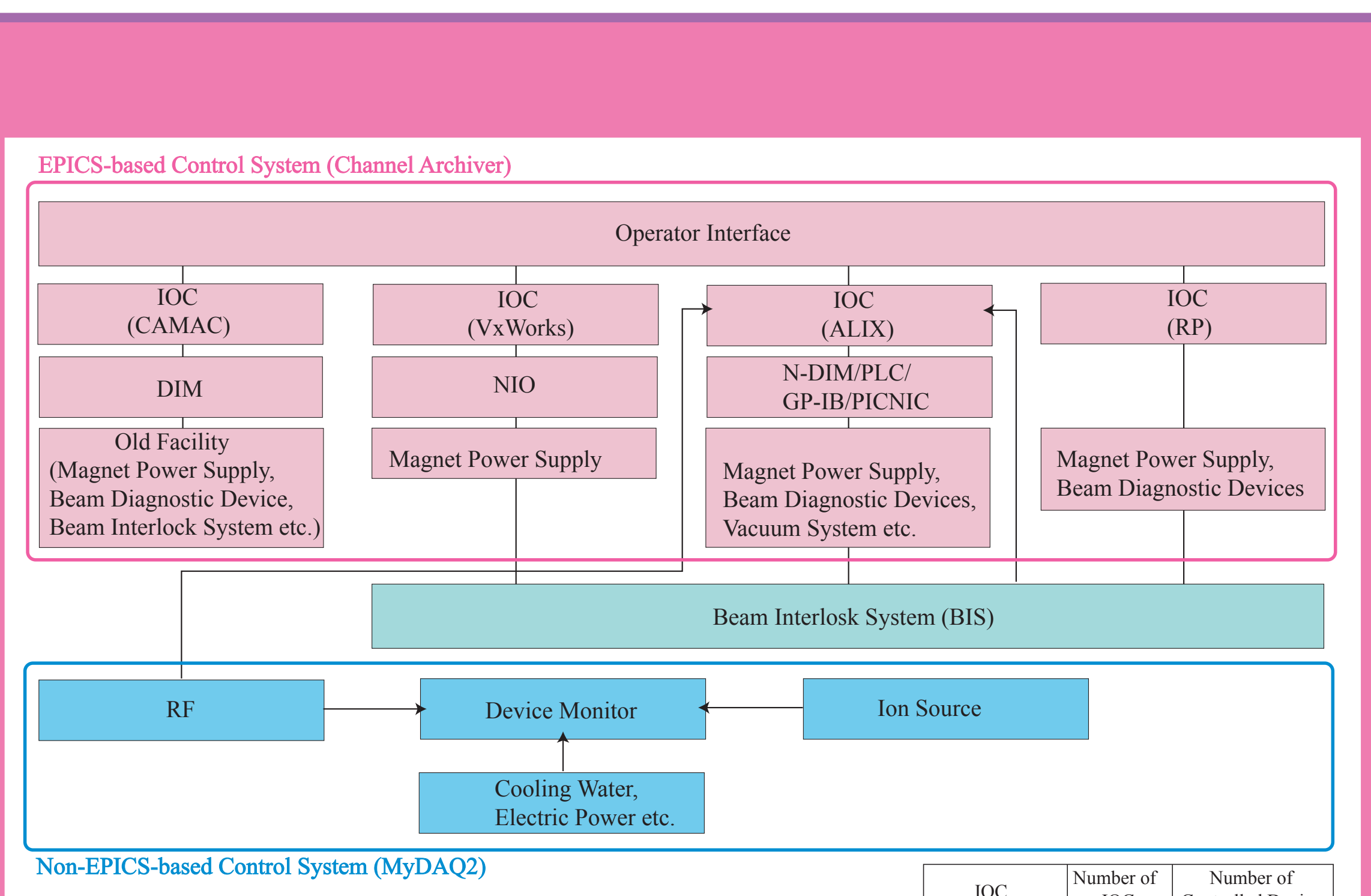
* Channel Achiver is supported by EPICS collaboration.
MyDAQ2 was developed by the SPring-8 control group.

Drawback of the coexistence of two data archives :
- Data pocessing is necessary to investigate correlations in the stored data.
  e.g.) Notice a gradual decrease in beam intensity
  -> Investigate the correlation between operation parameters (e.g. temperature of cyclotron magnets and beam intensity)
  -> Since beam intensity data are stored in the Channel Archiver and magnet temperature data are stored in MyDAQ2, data processing is needed for comparison between the data.

Unify the data archive systems!

Requirement for a unified data archive system :
- Acqire all parameters essential for the stable operation of RIBF accelerators at the required sampling rates.
- Retrieve stored data and monitor real-time data.

However, △ Difficult to apply Channel Archiver to our non-EPICS-based systems.
△ Difficult to apply MyDAQ2 to eitire control system of RIBF (means handling vast amount of data).

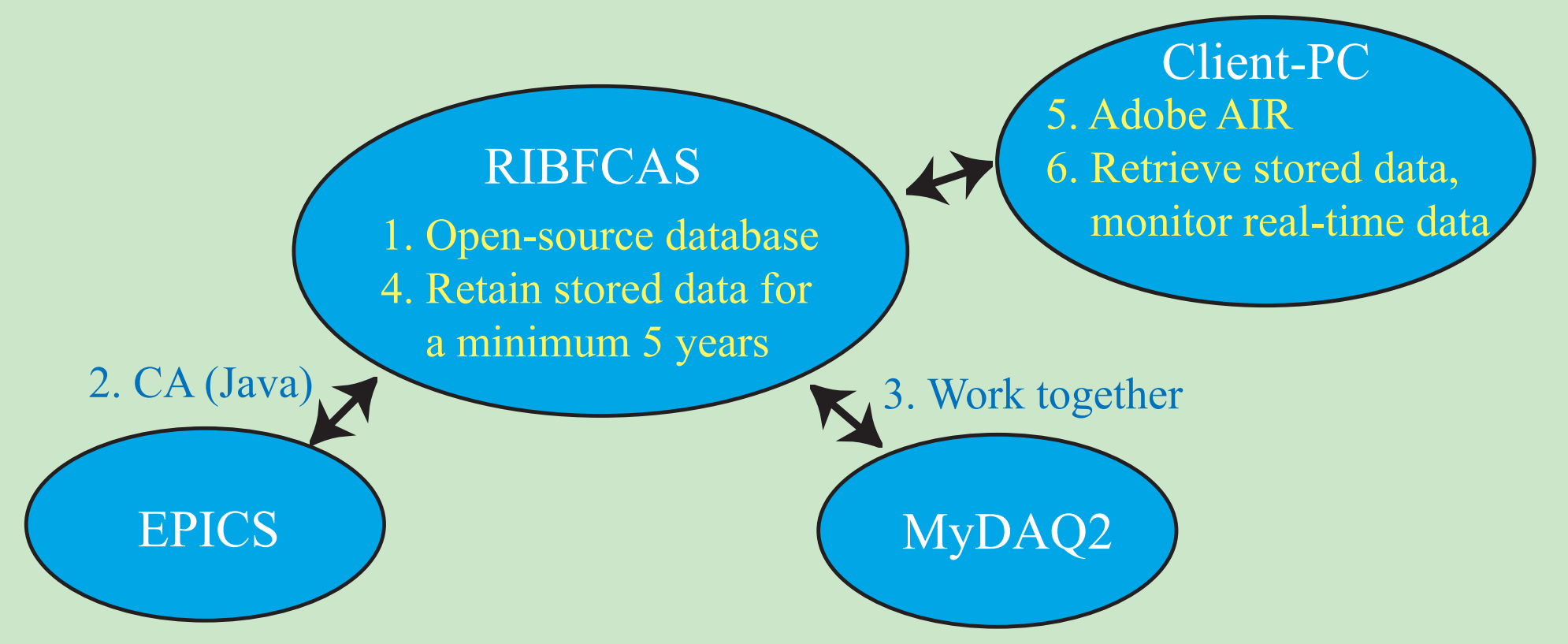

EPICS-based Control System (Channel Archiver)
Operator Interface
IOC (CAMAC)
IOC (VxWorks)
IOC (ALIX)
IOC (RP)
DIM
NIO
N-DIM/PLC/ GP-IB/PICNIC
Old Facility (Magnet Power Supply, Beam Diagnostic Device, Beam Interlock System etc.)
Magnet Power Supply
Magnet Power Supply, Beam Diagnostic Devices, Vacuum System etc.
Magnet Power Supply, Beam Diagnostic Devices
Beam Interlosk System (BIS)
RF
Device Monitor
Ion Source
Cooling Water, Electric Power etc.
Non-EPICS-based Control System (MyDAQ2)

IOC	Number of IOCs	Number of Controlled Devices
CC/NET	6	~500
VME	6	~400
ALIX	13	~350
RP (F3RP61-2L)	9	~50

Schematic of RIBF Control System

Develop a new data archive system !

Outline of RIBFCAS :


Client-PC
5. Adobe AIR
6. Retrieve stored data, monitor real-time data
RIBFCAS
1. Open-source database
4. Retain stored data for a minimum 5 years
2. CA (Java)
3. Work together
EPICS
MyDAQ2

1. PostgreSQL 8.4.1 as a RIBFCAS database.
2. For the EPICS-based system, a Java-encoded data acquisition program was newly developed to communicate with IOCs.
3. For the non-EPICS-based system, RIBFCAS works together with MyDAQ2.
4. Retain stored data for a minimum of 5 years.
   Data from up to two years previously can be searched immediately from client-PCs at all times; however, older data are retrieved from a backup.
5. The client application was developed on Adobe AIR.
6. The client application has an ability to show both past and rea-time data.

Performance test of CA libraries :

Purpose : to evaluate data acquisition speeds

Target : Java Channel Access (JCA)
Java Channel Access Light Library (JCAL)
An adopter library for JCA API (JCA-JCAL)

- Performance of the libraries was examined by writing programs with each such that all data could be processed for three chosen IOC types, having approximately 200 parameters apiece.
- One process of the test programs attempted to obtain data every 1 s and a test was concuded by obtaining five successive failures or successes.
- The JCA program was implemented for a single thread, whereas the JCAL program was implemented for multiple threads.

* JCA is supported by the EPICS collaboration.
JCAL and JCA-JCAL were developed by the J-PARC control group.

		JCA			JCA-JCAL			JCAL		
IOC	Number of Parameters	Execution Time (ms)	Average (ms)		Execution Time (ms)	Average (ms)		Execution Time (ms)	Average (ms)	
CC/NET	187	49830	43	Fail	5102	2	Fail	5035	2	Fail
ALIX	198	46986	42	Pass	5104	2	Pass	5042	2	Pass
VME	192	45540	42	Pass	5101	1	Pass	5037	2	Pass

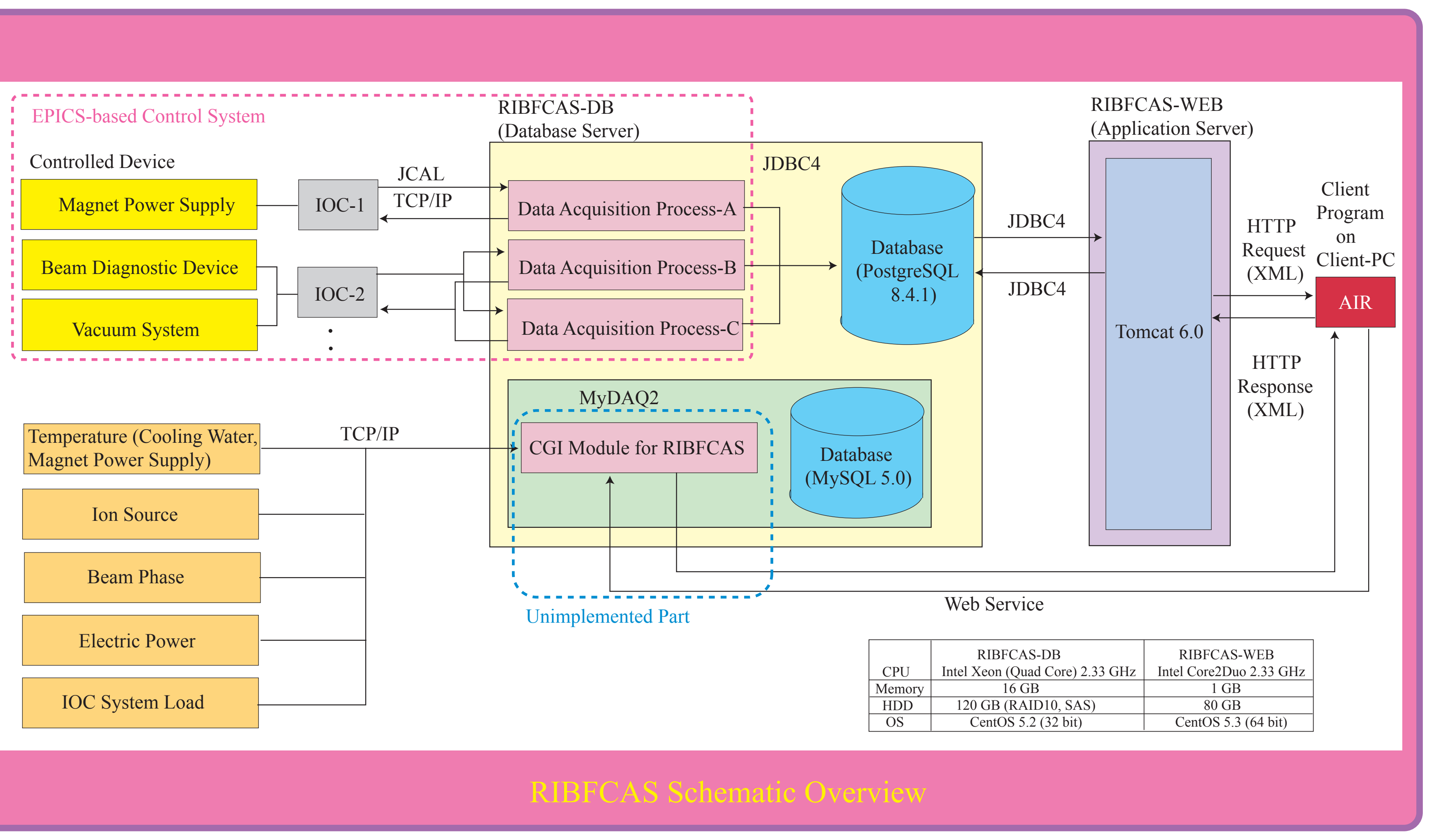
- A longer data acquisition time was found for the JCA program due to the introduction of a delay time in order to establish a safe connection between the program and an IOC.
  If the JCA program attempts to process data from any chanel of an IOC following a JCA-API call to establish chanel connection, the program receives signals indicating an unconnected status and returns a failure message.
  To avoid this scenario, it was necessary to wait for 40 ms after each connection was establoshed. For the case of CC/NET IOC, this delay was increased 100 ms.

- As a consequence, we selected JCAL as the CA library for RIBFCAS.

Structure of RIBFCAS :

◎ Consists of a database server, an application server, and client-PCs.
◎ RIBFCAS-DB executes a JCAL-based data acquisition program to collect EPICS data.
◎ MyDAQ2 currently runs on RIBFCAS-DB and the MySQL database is also managed on this server.
◎ RIBFCAS-WEB implements Tomcat version 6.0.
◎ Tomcat executes tasks in response to requests from client PCs, and returns retrieved data to client-PCs in XML format.
◎ On client PCs, applications are executed on Adobe AIR runtime.
◎ MyDAQ2 data will be marged with the data from the EPICS-based system by using a client application.

Features of the data acquisition program :
- The data collection program is devided into several processes and multi-thread technology is used to execute these processes simultaneously.
  The program structure gives the flexibility to divide existing processes into segments or to add new threads for devices introducted to RIBF accelerator complex in future upgrades.
- A list containing a large amount of information collected by RIBFCAS is managed within the XML framework in the program, making it easier to change device data.
- The system has an organized multilayer structure; components such as the database, data collection processes and data collection logic in the database server, Web service and client services are isolated from each other.



	RIBFCAS-DB	RIBFCAS-WEB
CPU	Intel Xeon (Quad Core) 2.33 GHz	Intel Core2Duo 2.33 GHz
Memory	16 GB	1 GB
HDD	120 GB (RAID10, SAS)	80 GB
OS	CentOS 5.2 (32 bit)	CentOS 5.3 (64 bit)

RIBFCAS Schematic Overview

Operational status :

- The main RIBFCAS system was completed in FY2010 and performance tests commenced in FY2011.
- The program acquires values for approximately 3000 various component parameters of RIBF from 22 IOCs every 10 s by using 9 separate processes.
- We have succeeded in continuous data acquisition without significant problems occurring.
- The EPICS-based section of RIBFCAS collects 76 GB of data in 2.5 months.
- The client program successfully monitors real-time data and can retrieve data for any period stored in the database.
- The client program displays data over a 24 h interval for a parameter within 10 s, and data over 1 h within 0.3 s.
  Even more, only 0.05 s is required to recall 24 h data of a parameter once it has been referred to.

Future plan :

- Develop an additional client application that processes the data stored by MyDAQ2.
- Management of the vast amounts of data.
  Selection of appropriate hardware is now in progress.

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