Partner ---

Or

EPICS – It Has Industry In Its Name.

Bob Dalesio - Short Bio

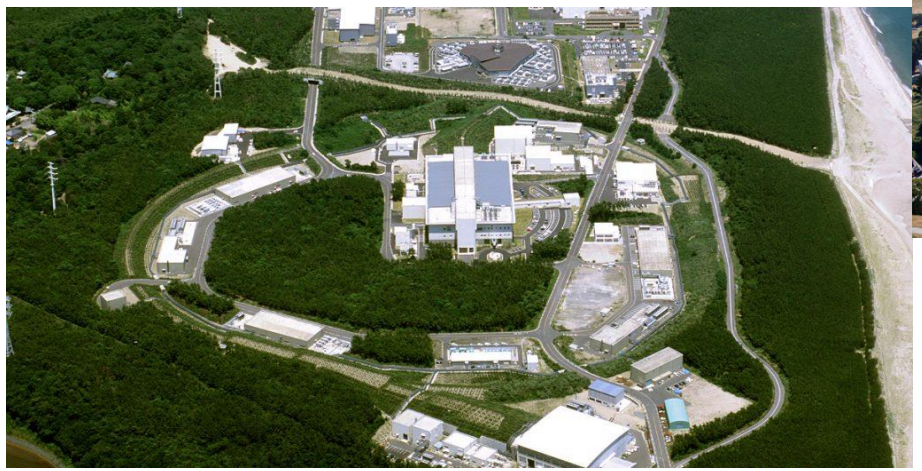
- Team Developed and applied the EMC Controls Emcon D3 Control System: Steel Plant Provo, Utah, Oil Refinery, Puerto Rico Early 80s

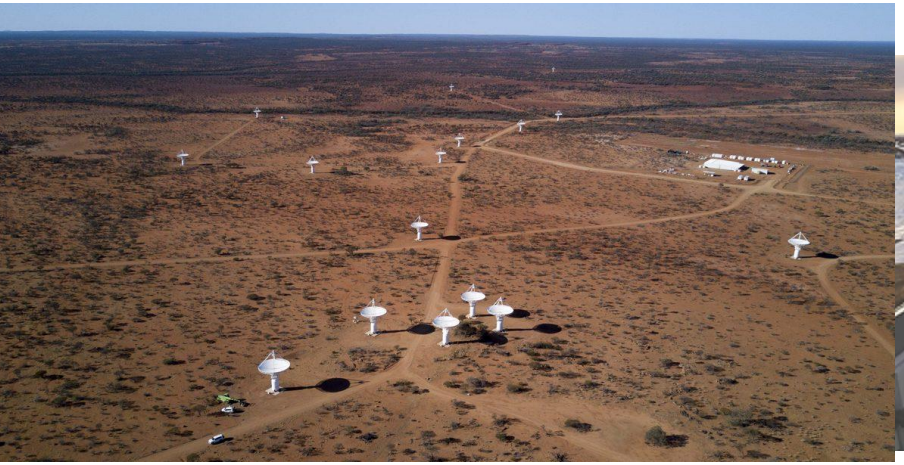
  This company was started by a group that split off from Foxboro
- Team Developed and applied the Computer Products Industry Control System: UTC Fuel Cell, %$# and ^%$ Laser Control Systems Mid 80s
- Team Developed and deployed the Ground Test Accelerator Control System aka Low Energy Development Accelerator in the late 80's
- Team Developed and supported the deployment of The Experimental Physics and Industrial Control System from 1990's to the present.

The Experimental Physics and Industrial Control System (EPICS)

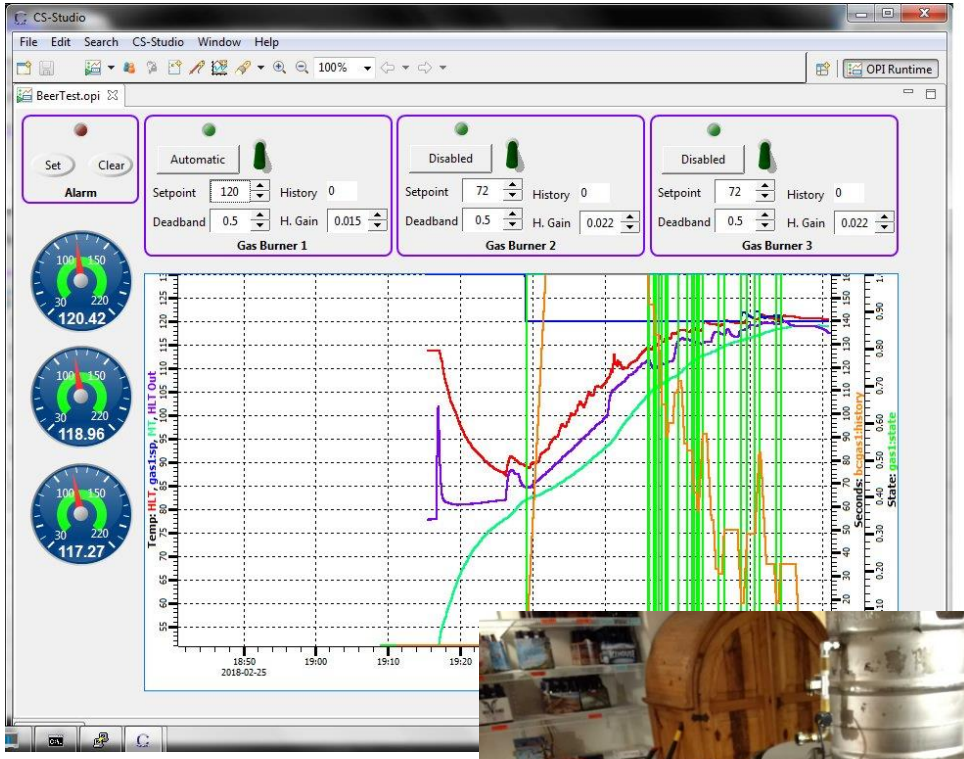
- Was developed to provide tools for process control engineers with no programming.
- EPICS is widely used in Industrial and Research Applications of all Sizes.
- Architectural Features of EPICS support Industrial and Research Control
- Interfaces to support extensions and high-resolution timing
- Support from Commercial Companies for tools and application

EPICS at Large Facilities On All Continents





EPICS Scales Down to PCs and Raspberry Pi's



Industrial IO is 60% of all IO at Accelerators

- Vacuum Control – Vacuum Controllers and PLC IO
- Cryo Control – CEBAF was the first facility to use EPICS for this
- Vibration Monitoring
- Cooling Water Control
- Temperature Monitoring
- Power Supplies: high voltage RF, regular and pulsed magnets
- Access Control into restricted areas
- Facility Control – Sverdrup used EPICS for SNS facility with AB PLCs
- Power Distribution and rack monitoring

Hardware Architecture

Industrial I/O Controller

I/O Controller
Data Acquisition Computer

Console Server

Ethernet for EPICS Channel Access or pvAssess

Ethernet instrumentation bus

Ethernet pvAccess for DAQ

Mitigation Node

Cell Controller

Cell Controller

Cell Controller

Cell Controller

Signal

PLC

Deterministic Ring Communication

Deterministic Timing Distribution Network

Master Pattern / EVENT Generator

Non-Industrial Instrumentation

- Beam Diagnostics (>300 MHz)
- Radio Frequency Field Control (>300 MHz)
- Fast Orbit Feedback (10 kHz)
- RF Phase Control (>300 MHz)
- Triggered acquisition (<10 psec jitter, <1nsec resolution)
- Fast corrector magnet power supplies (10 kHz)
- Beam Loss Detection (<3 usecs latency)
- Beam Loss Mitigation (<10 usec)
- Data Correlation (1 nsec)

Commercial Research and Development Agreements Yielded Three Partners in the 90’

- Baltimore Gas & Electric - LNG terminal, Pipeline compressors (3)
- LOF - Float glass manufacturing, Glass coating (3)
- NASA - Satellite ground station instrument monitoring
- WLSSD - Sewage treatment & incineration
- S. Nevada - Water treatment, pumping & storage
- Citgo - Refinery tank farm automation, Product movement
- AMD - Chip ‘fab’ environmental controls/HVAC
- SAIC - Automated/portable weapons disposal plant’ (2)
- LosAlamos - Particle accelerator vacuum system control
- California ISO - Power grid monitoring, metering and AGC
- San Diego Gas & Electric – SCADA/Remedial Action System
- City of N. Wales - Water pumping & distribution
- City of Milwaukee - Sewage treatment & Water treatment (5)
- Nippon Sheet Glass - Glass coating line
- Anne Arundle Co. - Waste treatment, Water treatment/distribution (6)
- Austin Regional - Sewage treatment and collection/pumping
- Tong Yang - Cement plant automation
- S. Nevada - Water distribution/pumping system expansion
- Citgo Lake Charles - Tank farm automation
- Northwest Indiana - Water treatment, storage and distribution
- River Mtn. Treatment Plant - Water treatment, and distribution
- San Diego Gas & Electric - Distribution SCADA & load shedding

Hathaway
Industrial Automation, Inc.

Non-Traditional (Distributed) SCADA and DCS systems:

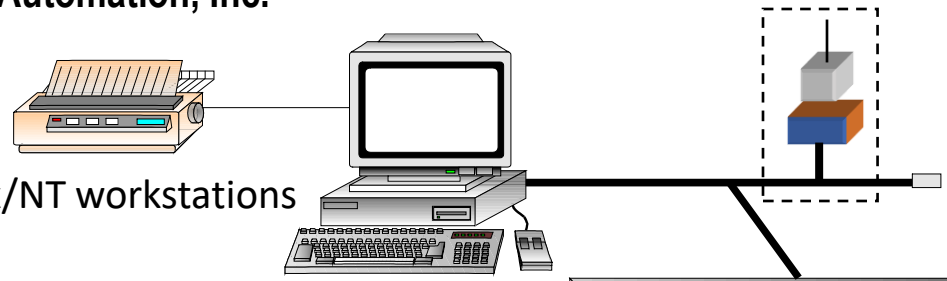
- Designed to provide for Inter/Intra/ExtraNet communications
- **Incorporates SSL layer TCP/IP plus digital "certs"/VPN technology**
- Uses "digital" communication systems
- Works well at 56Kbps and better with more bandwidth
- Uses a "publish and subscribe" data exchange methodology
- Co-exists with other traffic (video, VoIP, data, FTP, etc.)
- **Can be part of a "hybrid" system (traditional plus distributed)**

"REPLACE IN PLACE" was the marketing approach to integrate existing systems

…… and then upgrade incrementally

Hathaway
Industrial Automation, Inc.

TIS-4000 Systems

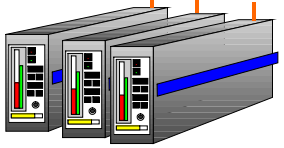


Unix/Linux/NT workstations

10/100baseT, FDDI,
ATM, Frame Relay, etc.

I/O Scanning
Calculations
Interlocks
Regulatory control
Sequence Control
BATCH processing

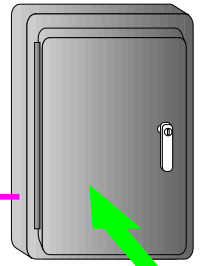
Interface HW and drivers for
numerous “smart” instruments
and controllers



VMEbus or ISAbus
iNTEL/Motorola CPU
VxWorks O.S. 128Mbytes
Up to 32 serial ports

Modbus+
Datahighway+
Profibus
Echelon
Interbus-S
RS-xxx

Process I/O



1024 I/O
2048 blocks

Unit controller
PCU configuration

Up to 1Km
total length

Distributed I/O

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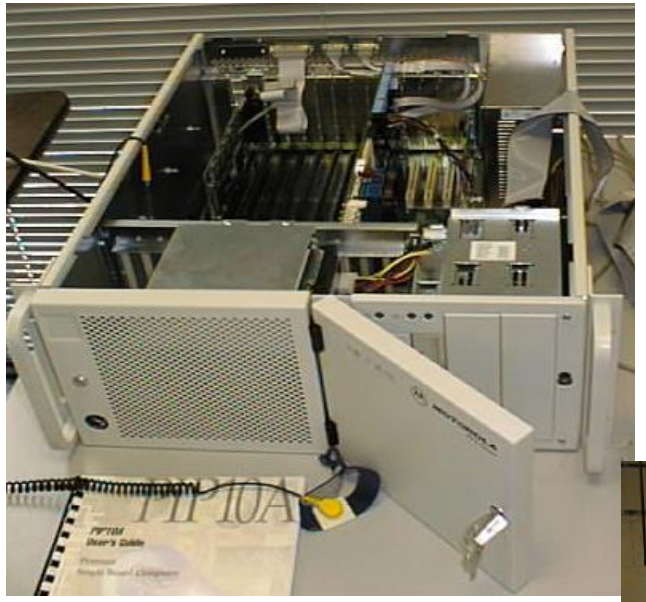
TIS-4000 Systems

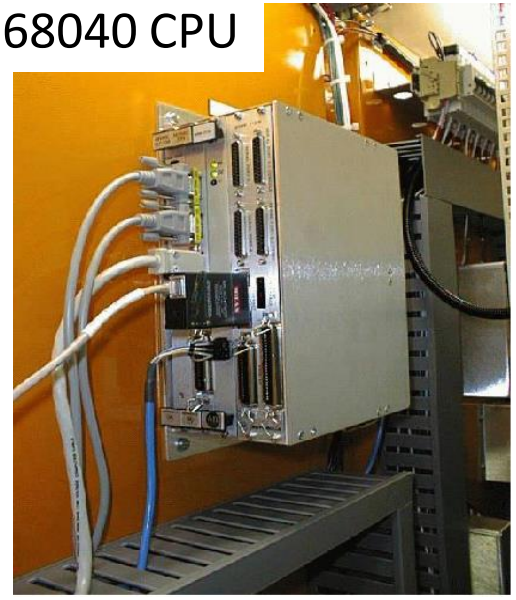


ISAbus RSU
Pentium II CPU

PLC remote unit

Floor mounted
“Smart” RTU

VMEbus RSU
M68040 CPU



Pole-top RMS900
“Smart” RTU

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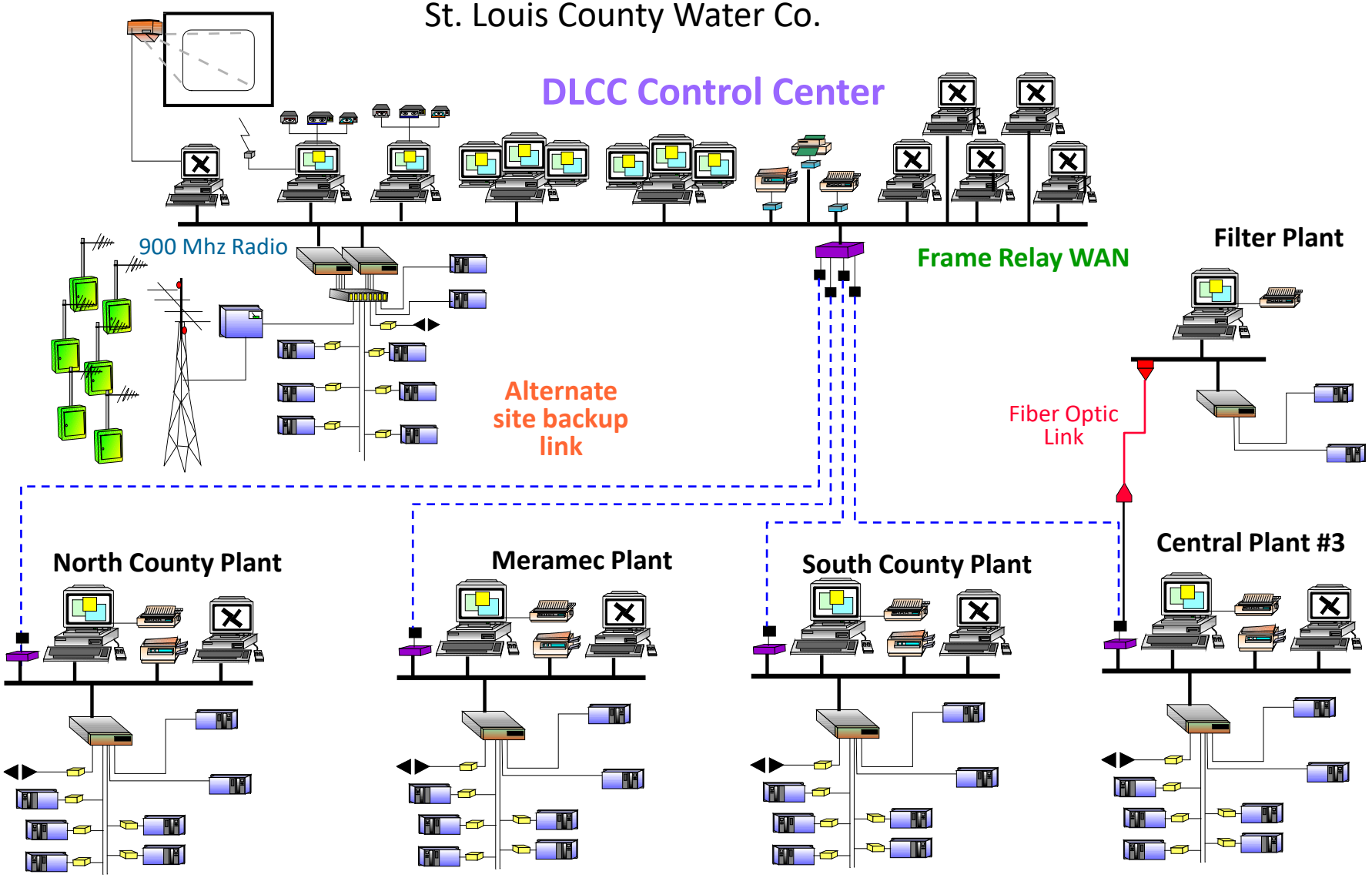
TIS-4000 Systems

St. Louis County Water Co.



Hathaway

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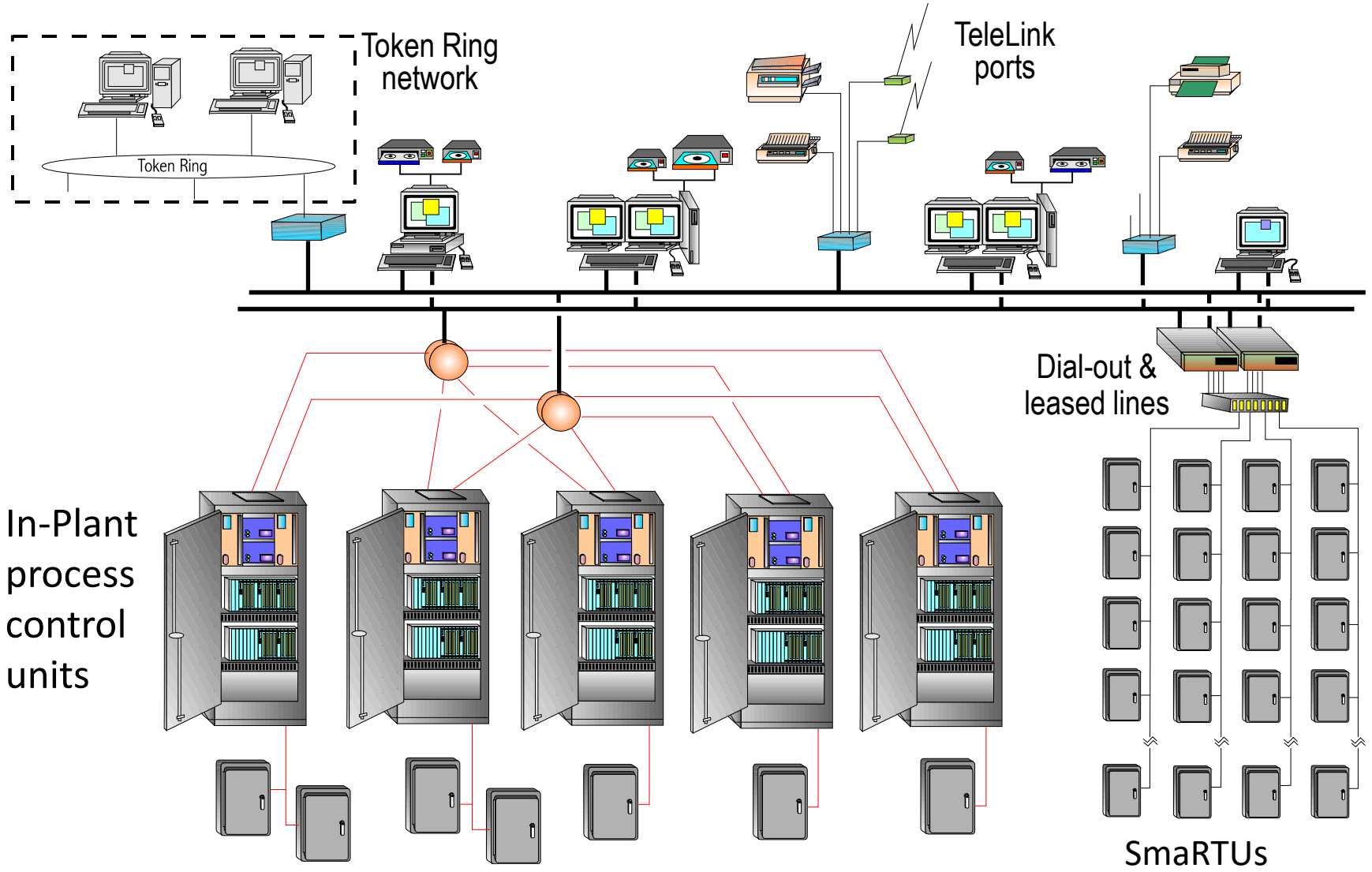
TIS-4000 Systems

Western Lake Superior Sanitary District



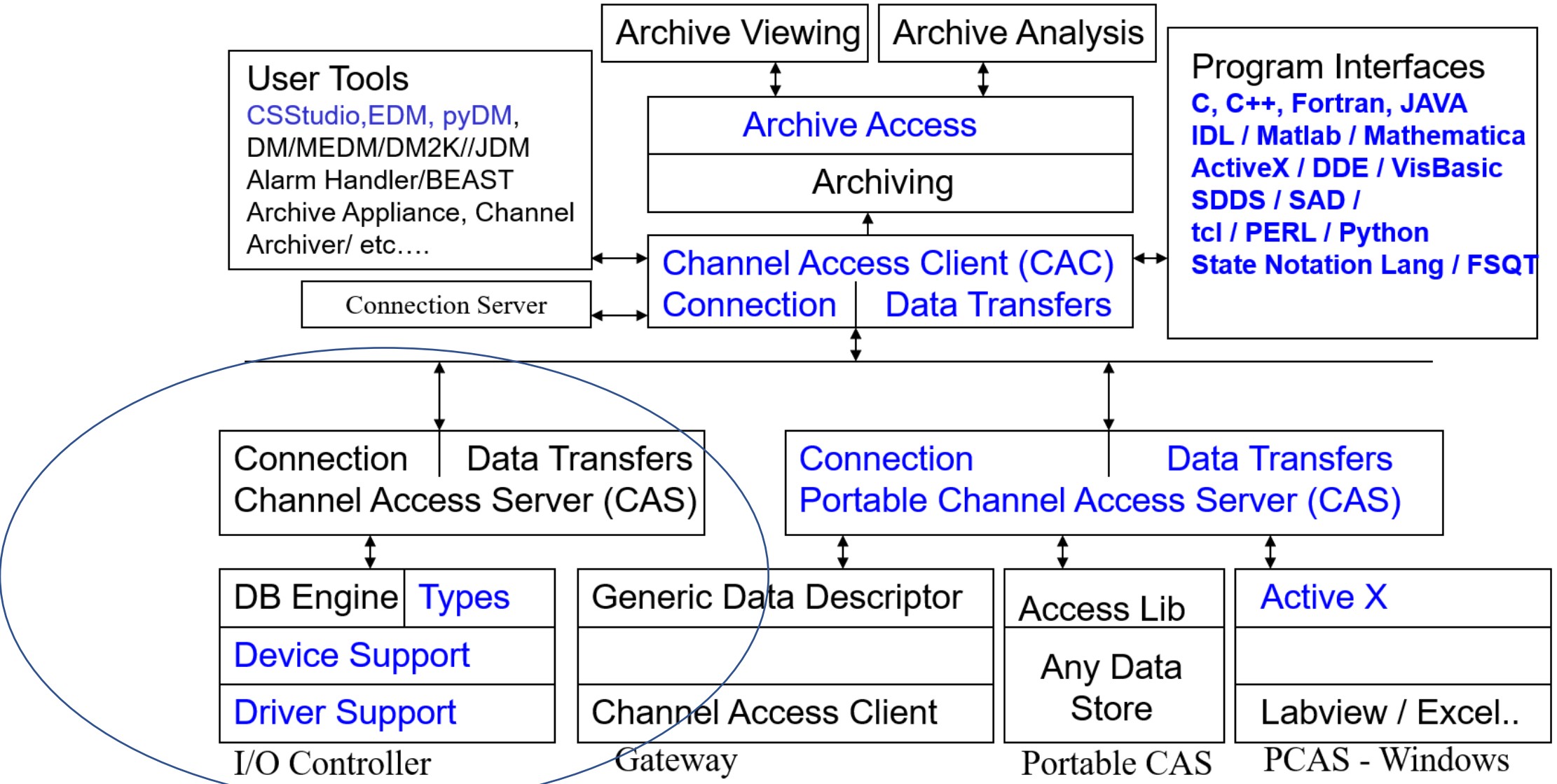
EPICS Is an Established Standard Toolkit

- The Experimental Physics and Industrial Control System is used successfully in both Industry and Research Facilities since the late 1990’s
- EPICS is a set of tools (not a solution) that have been applied to small and large systems worldwide.
- Domain Expertise Applies Tools to Effectively, Efficiently and Reliably Solve a wide variety of Process Control Problems.
- Commercial Companies have a lot more time to create marketing material.

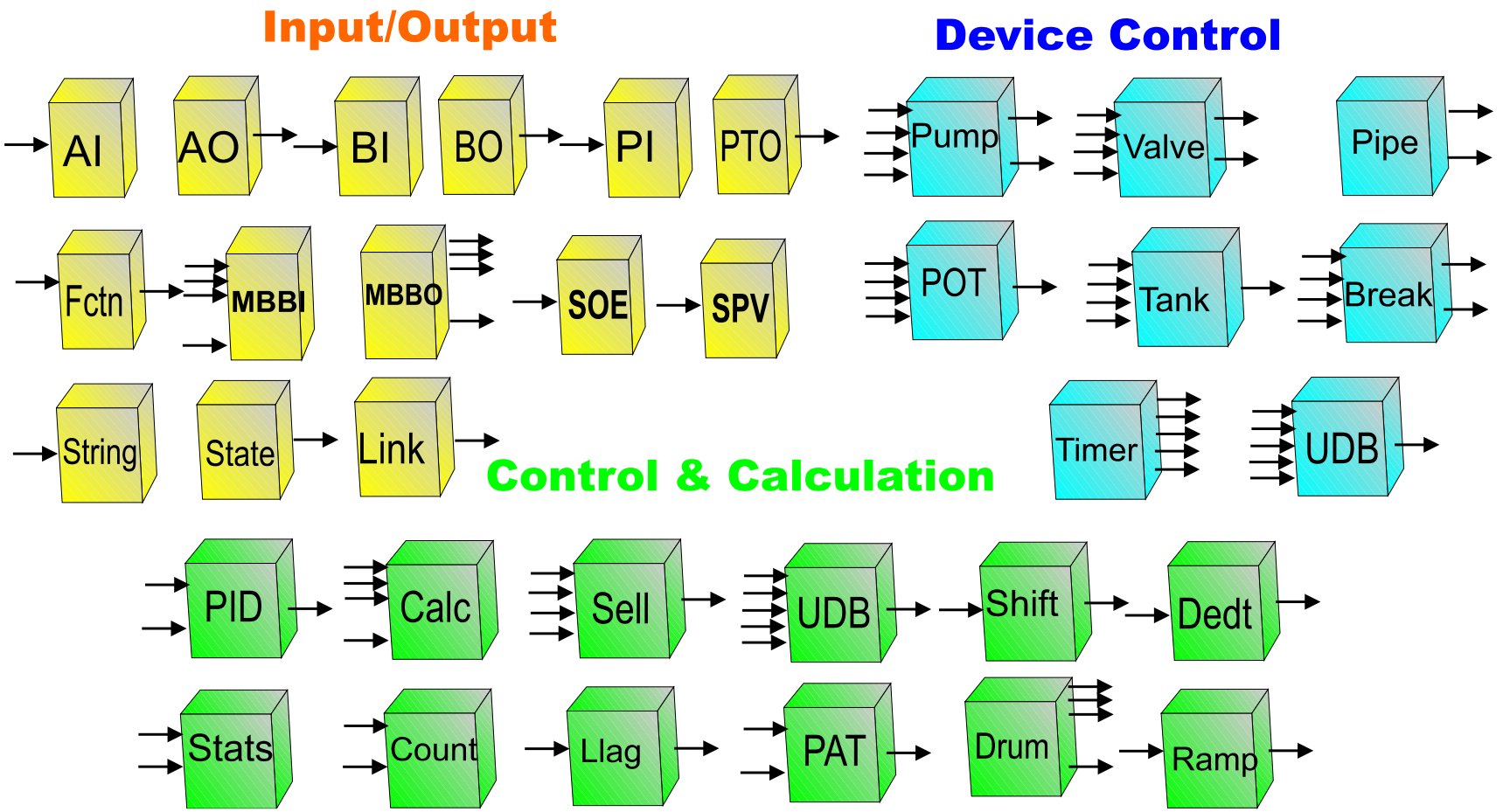
EPICS Architecture has Significant Differences compared to Industrial Control Systems

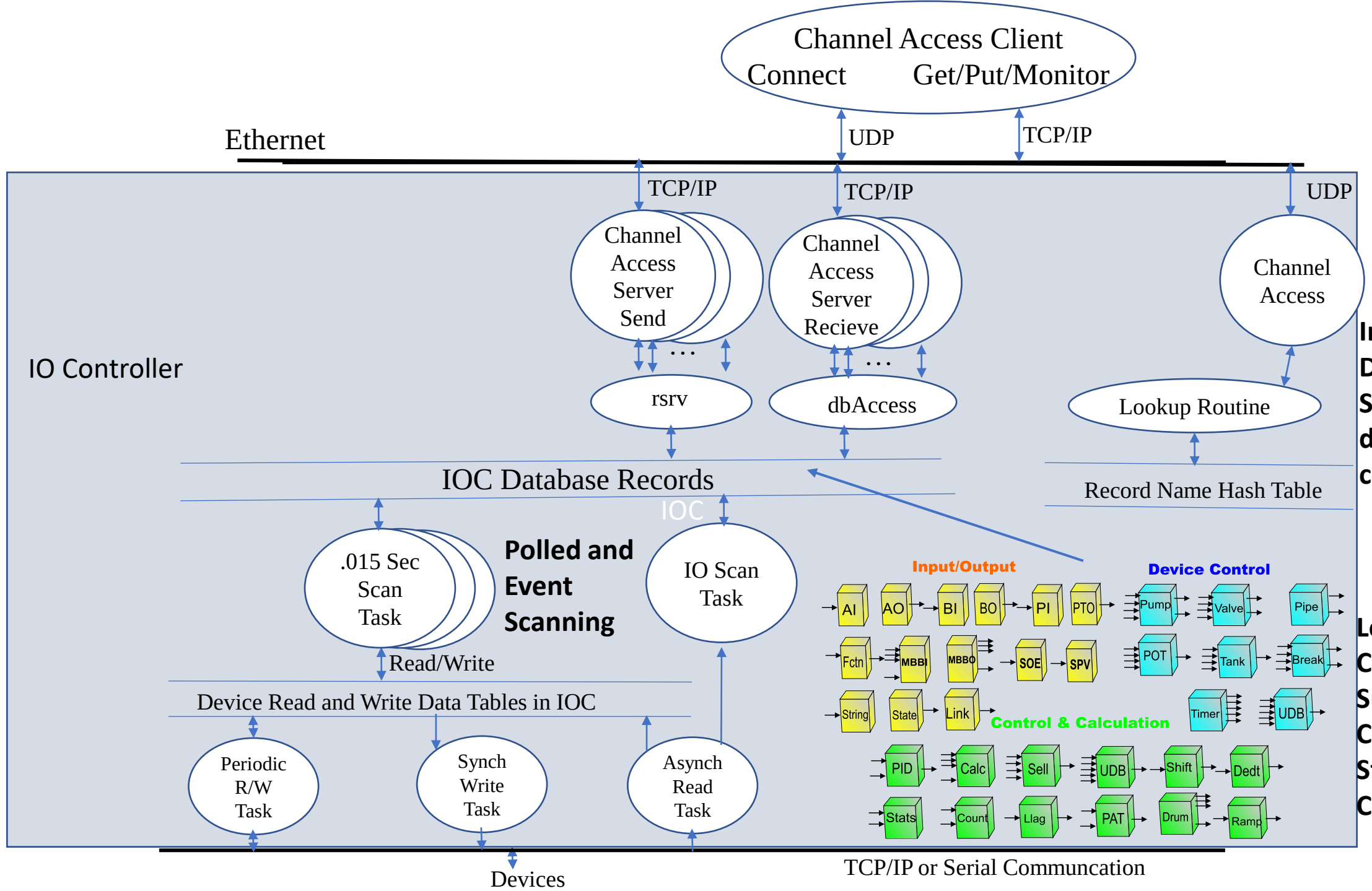
- A three-tier architecture was deemed the “standard model” for control systems: Field IO/Instrumentation, Computer Front End as Data Servers and Client Applications
- **The unique feature of EPICS was to create well defined interfaces at all level of the software to support the independent development and extensions to EPICS base (Channel Access Protocol and the Process Database).**
- Configuration tools are provided to reduce the programming time and risk. The same EPICS core runs at all facilities.
- The open source collaboration worked cooperatively or individually to extend the functionality as needed.

Interfaces Support Independent Development



Process Database Configuration of DBTypes – Building Blocks that form atomic operations





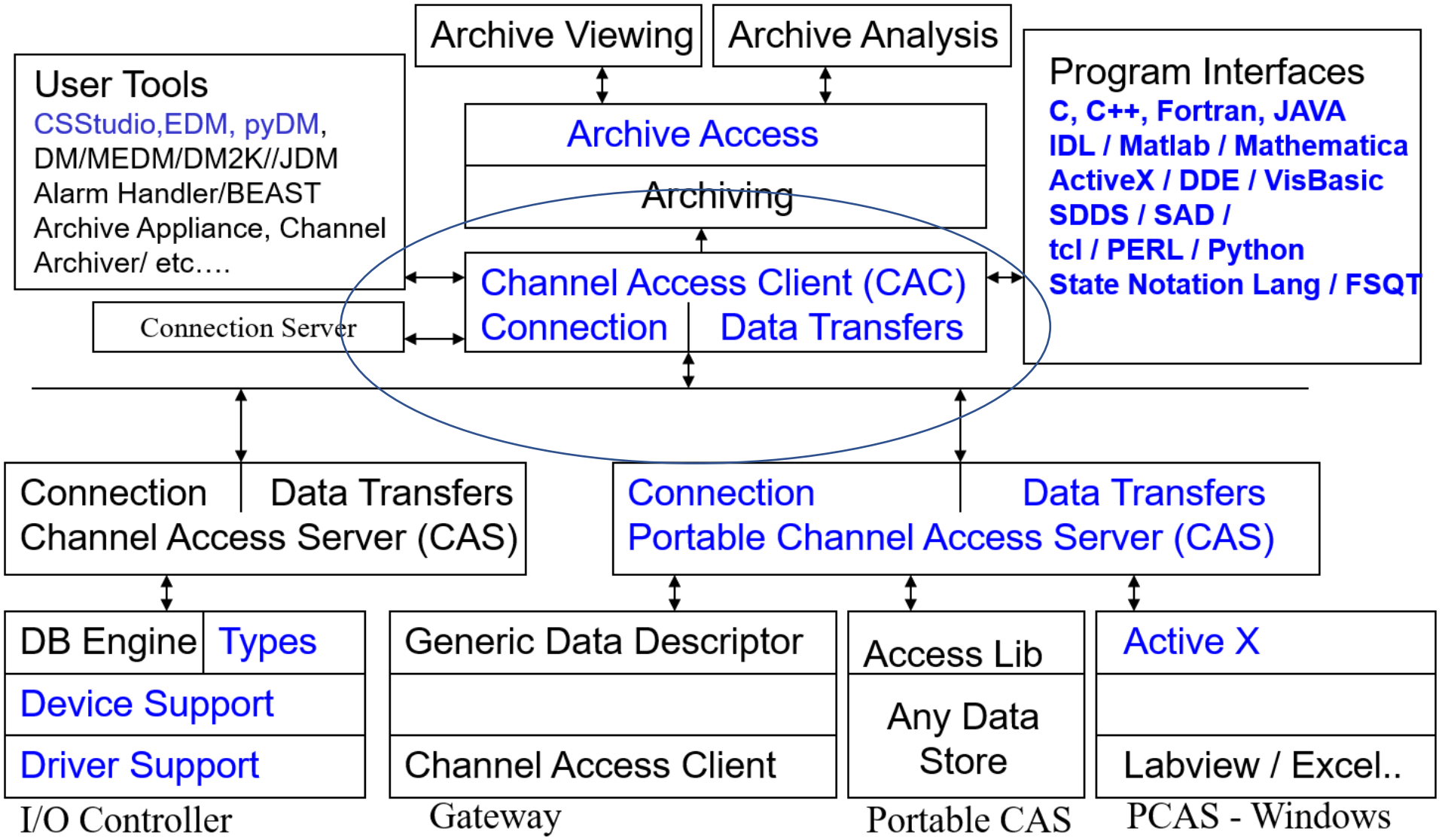
Independent Directory Service that is discovered at connect time

Logic Blocks Configured for Supervisory Control and Steady State Control

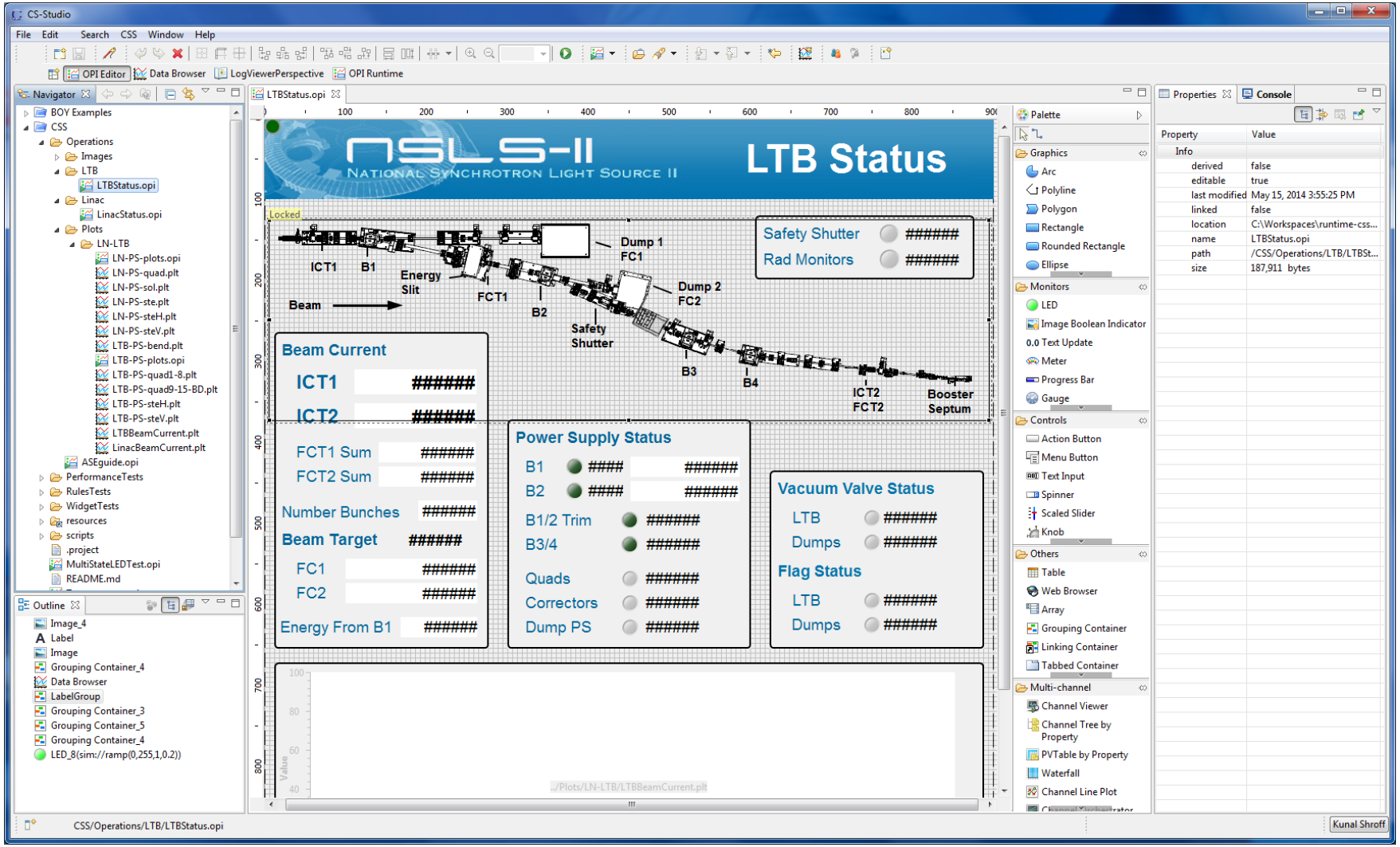
Getting the time stamp into a record

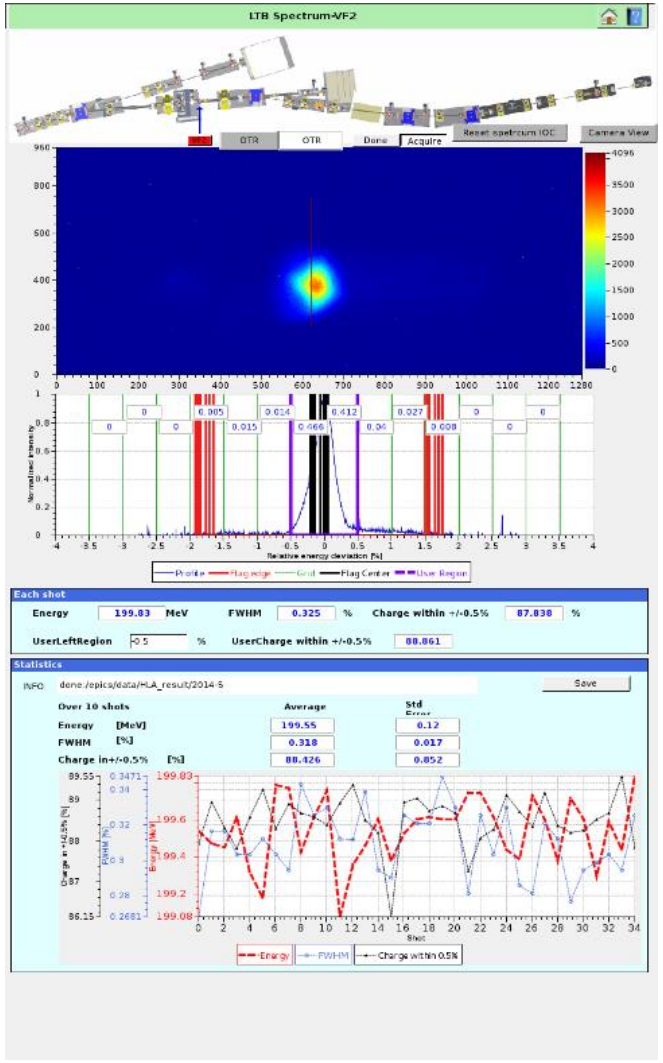
- Allow the device support to provide the timestamp from the Device.
- Get the time stamp from the local time server NTP or PTP
- Use the time stamp of the Record from which a value was read

Interfaces Support Independent Development

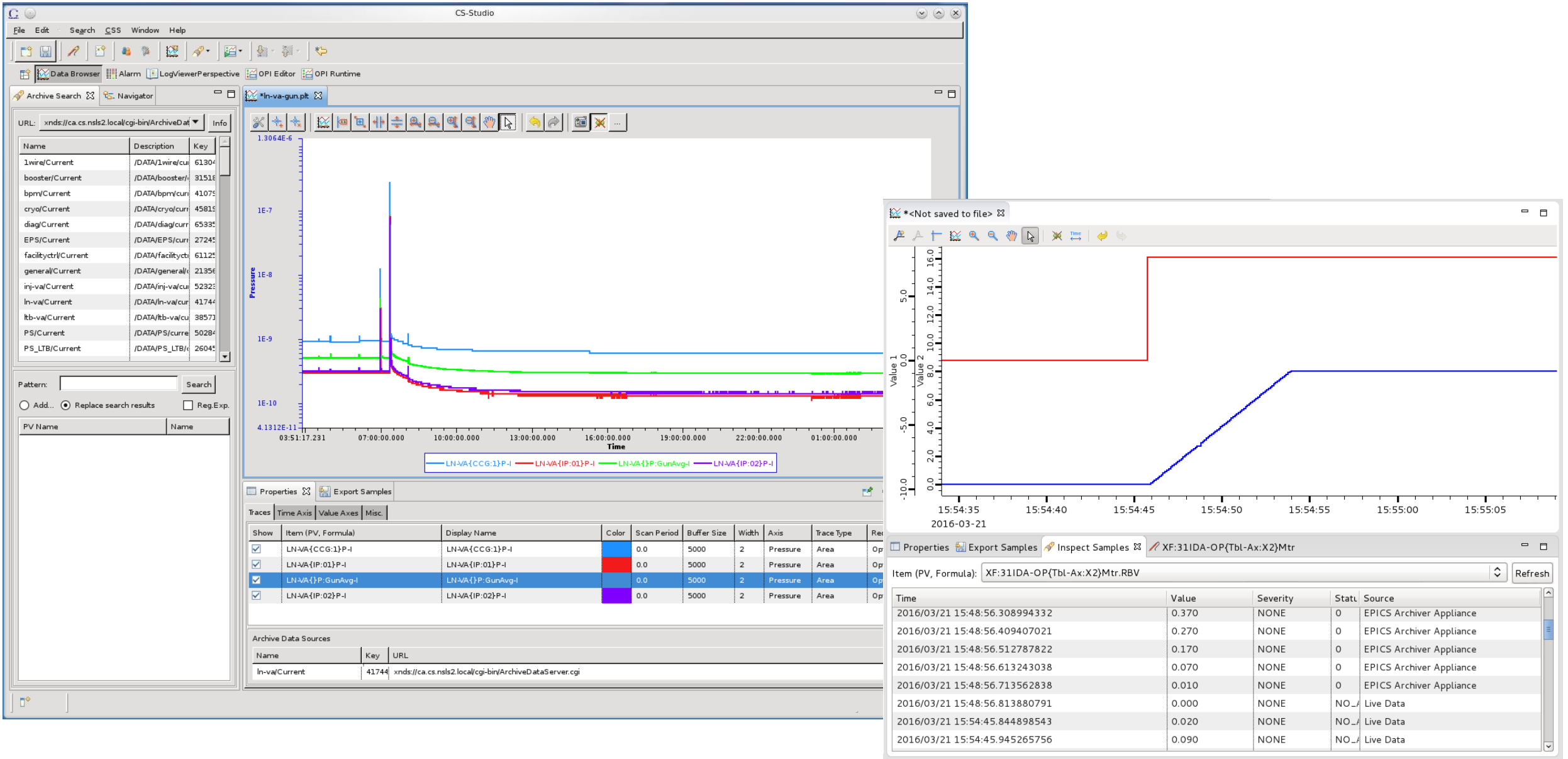


Synoptic Editor and Runtime

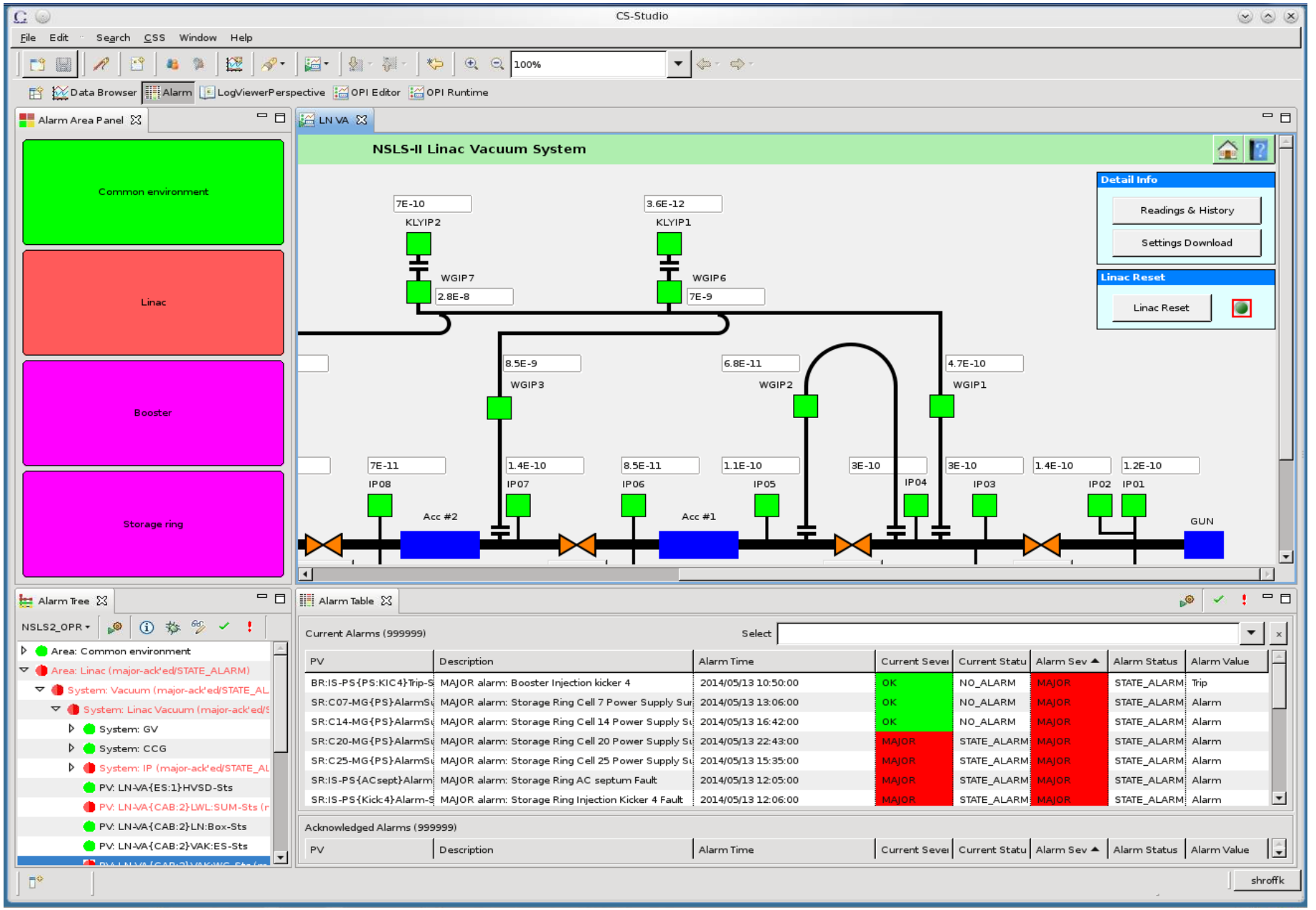




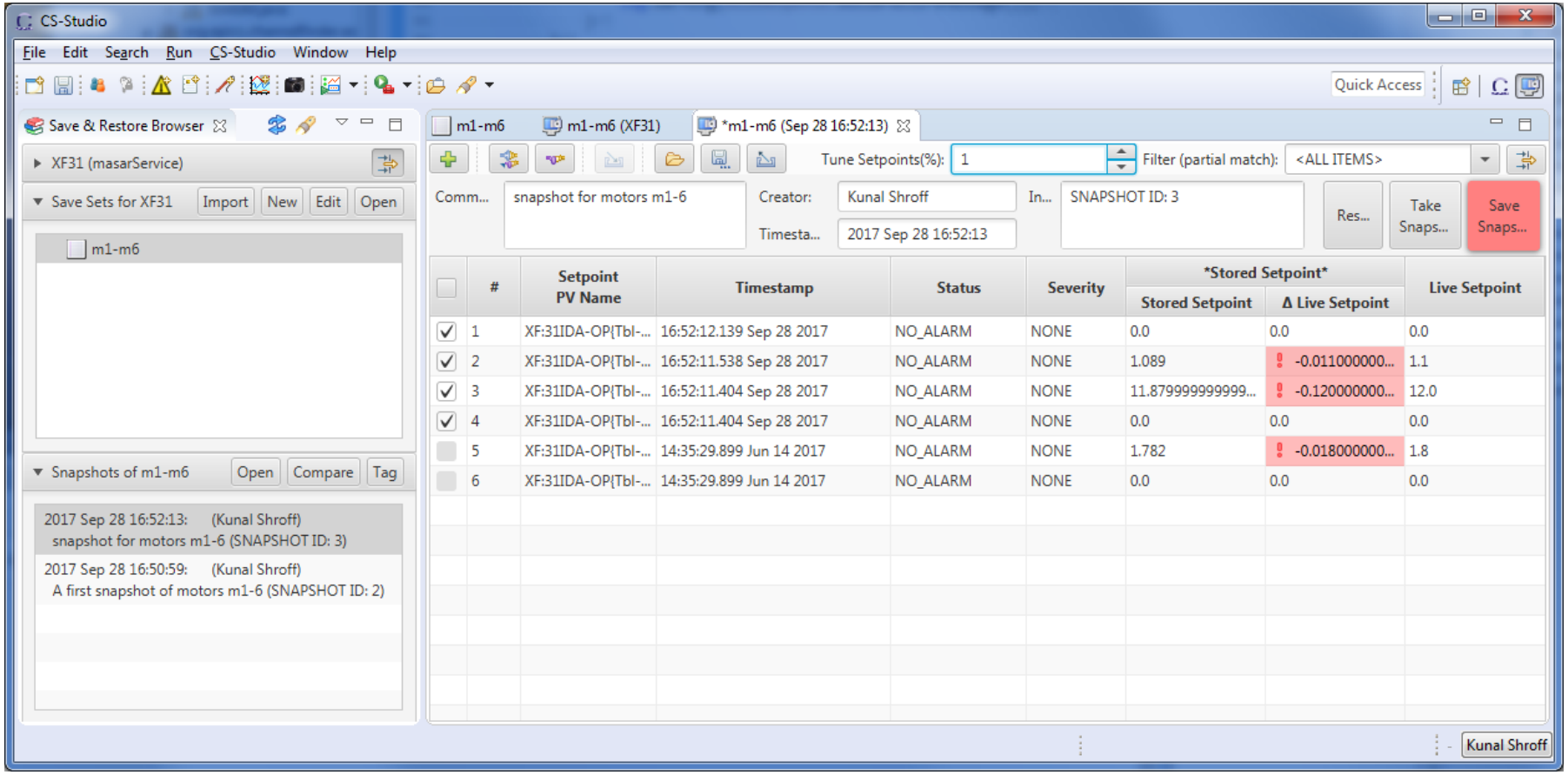
Archive Appliance



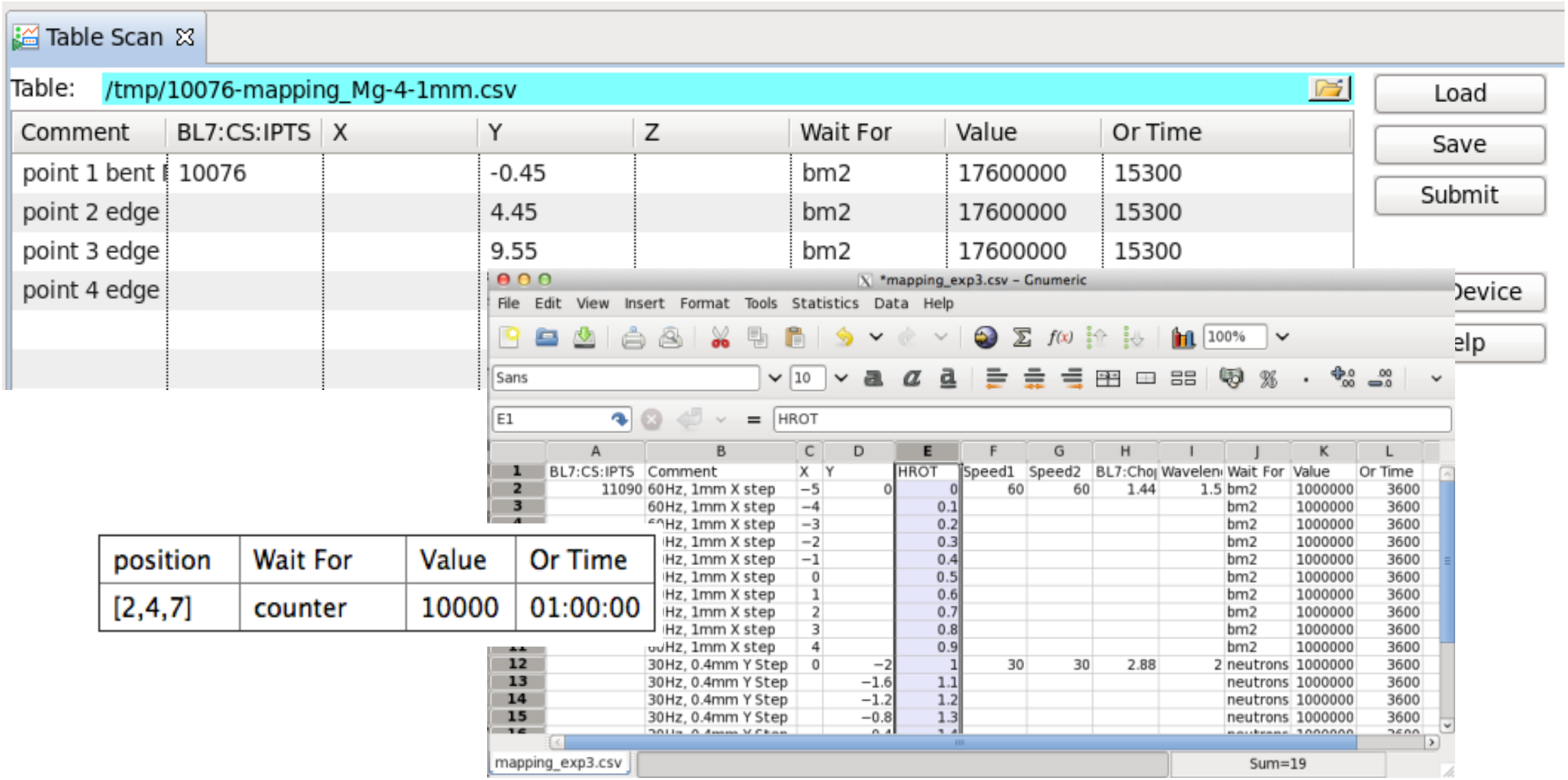
Alarm Viewer



Save/Compare/Restore

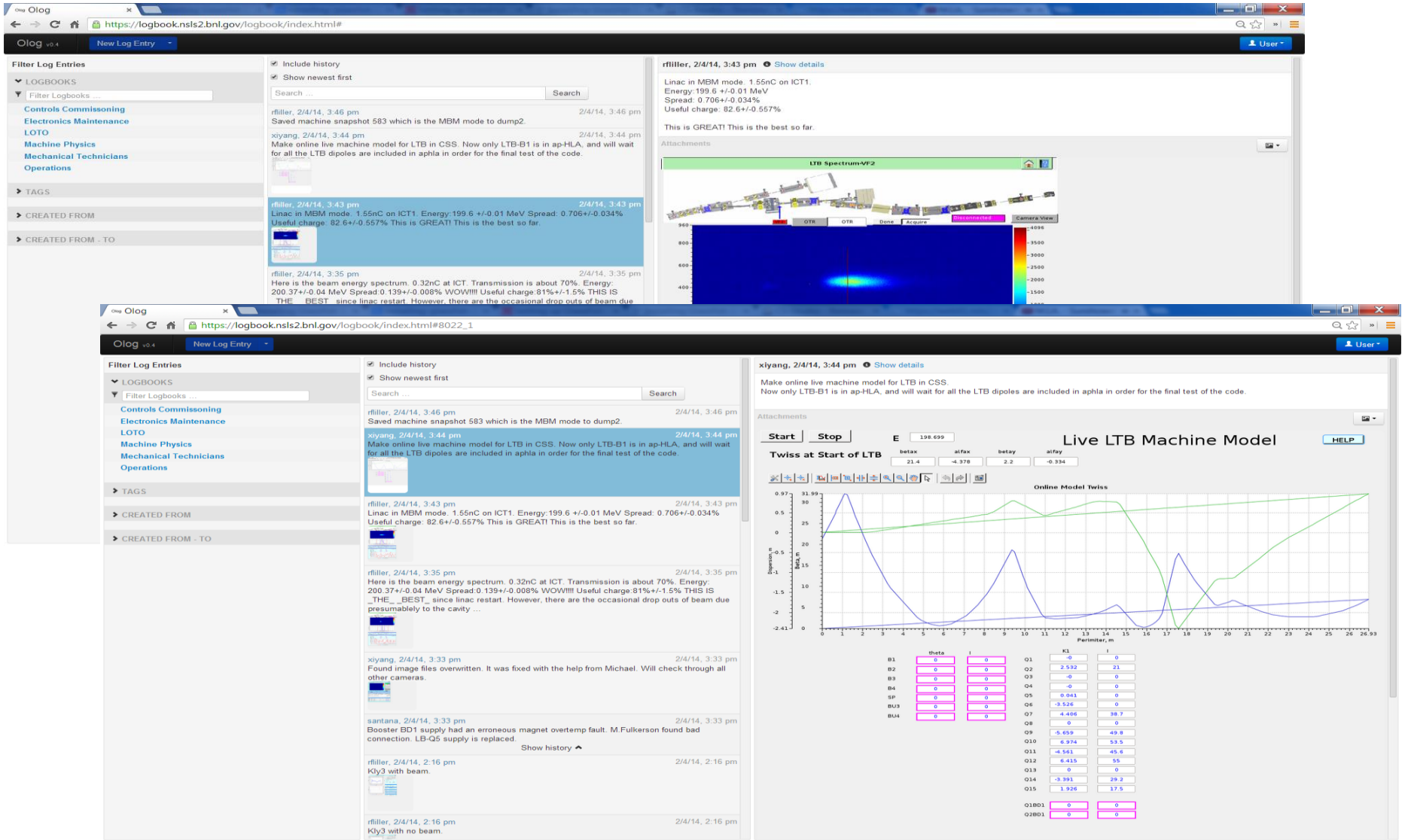


Scan Service



position	Wait For	Value	Or Time
[2,4,7]	counter	10000	01:00:00

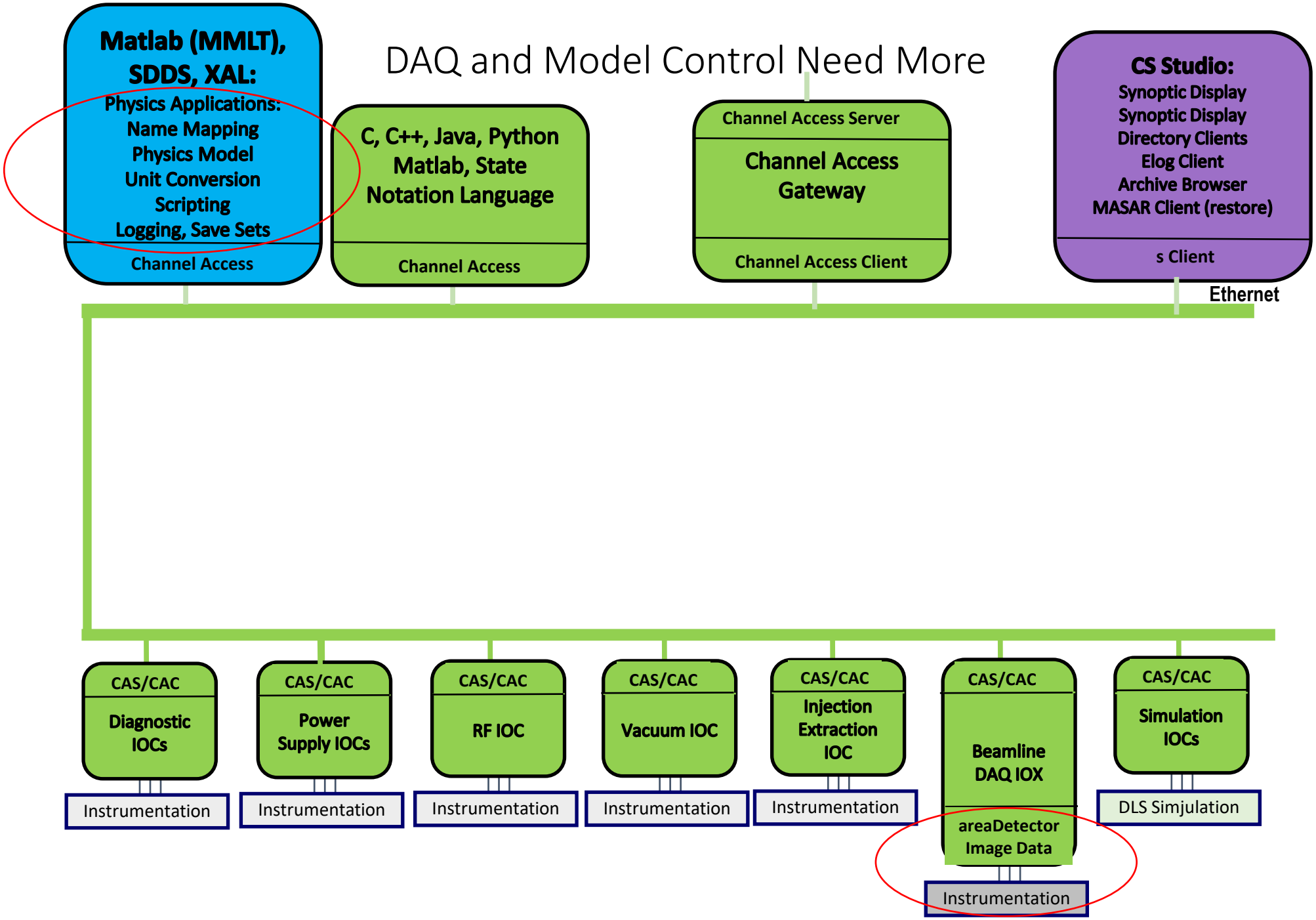
Operator Logbook – Web Viewer



EPICS Architecture V3 (1991 – present)

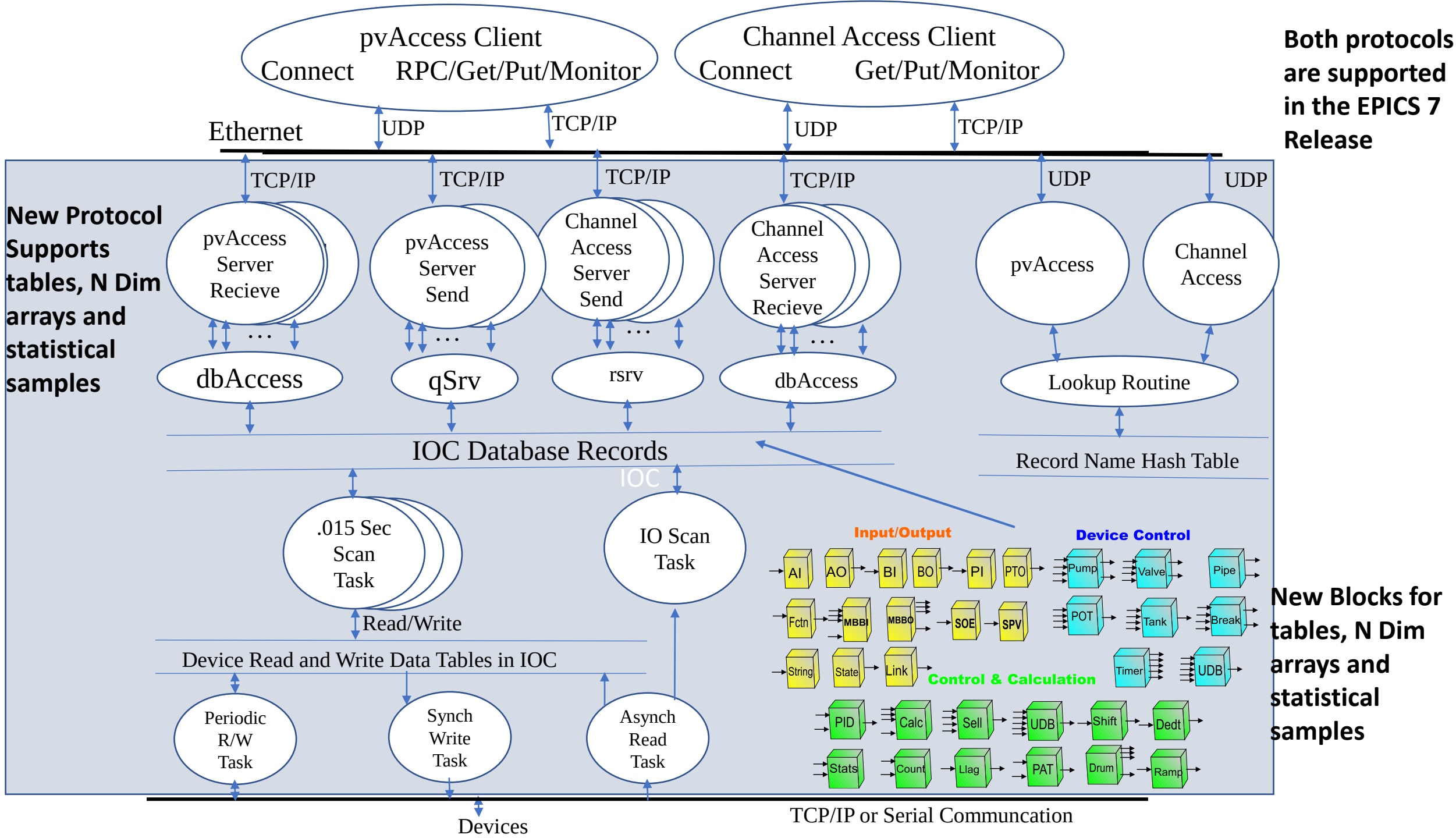
- Has been successfully deployed internationally for a wide variety of facilities over a wide range of domains.
- The Configuration tools for SCADA and DCS have been demonstrated.
- A multitude of facilities have integrated a wide range of I/O.
- The Channel Access Interface has been used on all platforms and programming languages to develop general purpose and application specific clients.
- Scalar data is well supported in V3, however, faster ADCs and real time access to SQL and non-SQL databases provide new opportunities.

DAQ and Model Control Need More



New Standards Create Opportunities to Improve Capabilities

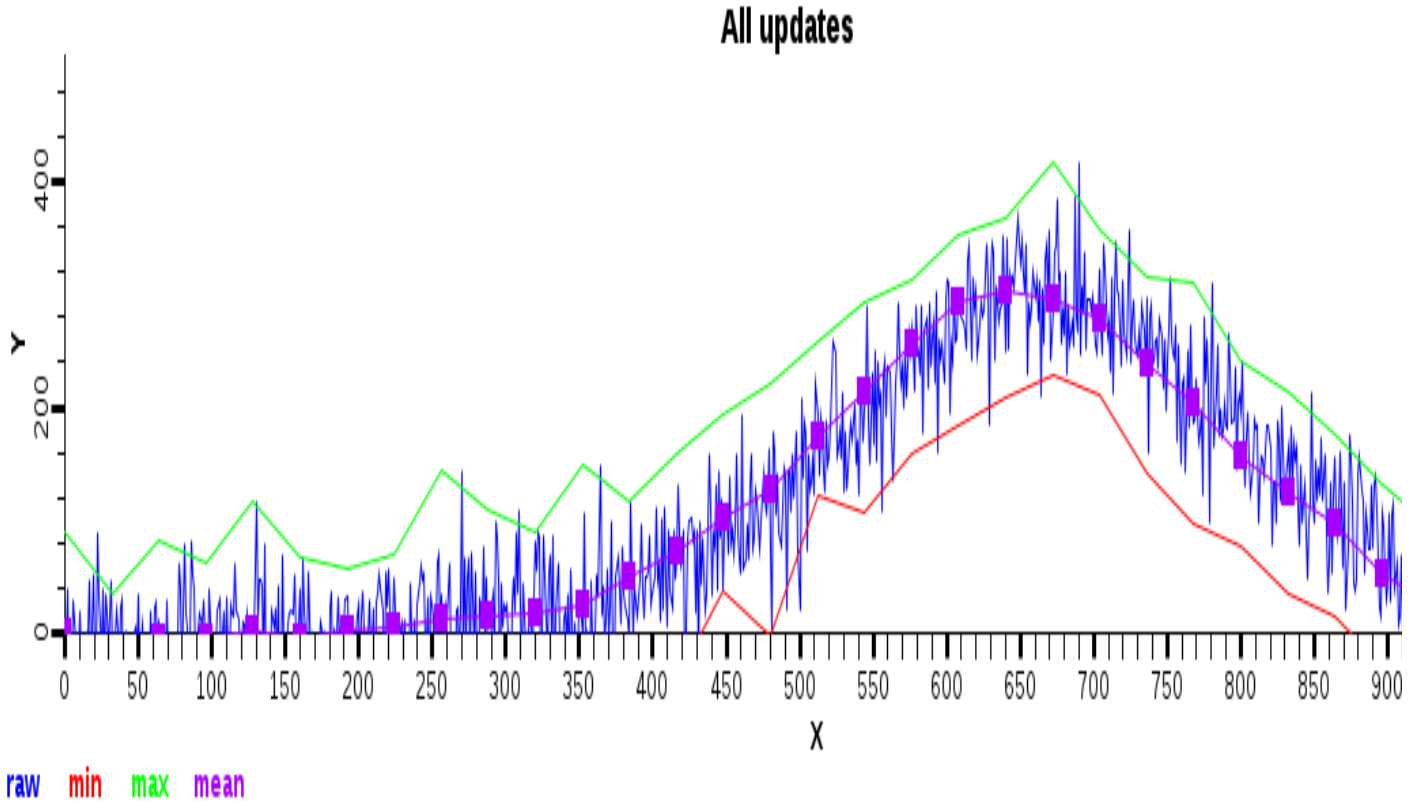
- Expand Process Database
  - N Dimensional Arrays
  - Tables
  - Statistical Samples
- Middle Layer Services Improve capabilities
  - Directory Service – hierarchical views of 1M Process Variables
  - Aggregate Alarm Data
  - Snap shot data
- Phoebus /CS Studio
  - Data passing between client applications
- Data Management Tools from configuration to snapshot data
  - Inventory, Device Types, electronic travelers, machine design

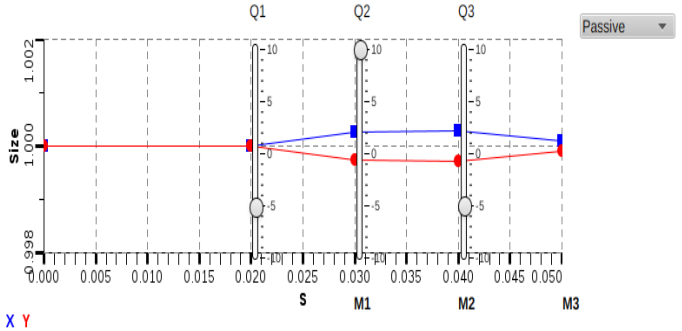


Both protocols are supported in the EPICS 7 Release

New Blocks for tables, N Dim arrays and statistical samples

Client Viewer for statistics and Table Data





X Y

sec	ns	M1X	M1Y	M2X	M2Y	M3X	M3Y
1603141226	765062686	1.0002622065798652	0.9997378163355621	1.0002925650424335	0.9997071991852091	1.0000849847268154	0.9999142530780648
1603141226	665122230	1.0002622065798652	0.9997378163355621	1.0002925650424335	0.9997071991852091	1.0000849847268154	0.9999142530780648
1603141226	565074401	1.0002622065798652	0.9997378163355621	1.0002925650424335	0.9997071991852091	1.0000849847268154	0.9999142530780648
1603141226	464971846	1.0002622065798652	0.9997378163355621	1.0002925650424335	0.9997071991852091	1.0000849847268154	0.9999142530780648
1603141226	365205607	1.0002622065798652	0.9997378163355621	1.0002925650424335	0.9997071991852091	1.0000849847268154	0.9999142530780648
1603141226	265059730	1.0002622065798652	0.9997378163355621	1.0002925650424335	0.9997071991852091	1.0000849847268154	0.9999142530780648
1603141226	165069099	1.0002622065798652	0.9997378163355621	1.0002925650424335	0.9997071991852091	1.0000849847268154	0.9999142530780648
1603141226	65138234	1.0002622065798652	0.9997378163355621	1.0002925650424335	0.9997071991852091	1.0000849847268154	0.9999142530780648
1603141225	965105451	1.0002622065798652	0.9997378163355621	1.0002925650424335	0.9997071991852091	1.0000849847268154	0.9999142530780648
1603141225	865097427	1.0002622065798652	0.9997378163355621	1.0002925650424335	0.9997071991852091	1.0000849847268154	0.9999142530780648
1603141225	764951385	1.0002622065798652	0.9997378163355621	1.0002925650424335	0.9997071991852091	1.0000849847268154	0.9999142530780648
1603141225	664930303	1.0002622065798652	0.9997378163355621	1.0002925650424335	0.9997071991852091	1.0000849847268154	0.9999142530780648
1603141225	565014047	1.0002622065798652	0.9997378163355621	1.0002925650424335	0.9997071991852091	1.0000849847268154	0.9999142530780648
1603141225	465091000	1.0002622065798652	0.9997378163355621	1.0002925650424335	0.9997071991852091	1.0000971825976501	0.9999020607099068
1603141225	365117716	1.0002622065798652	0.9997378163355621	1.0002925650424335	0.9997071991852091	1.0000971825976501	0.9999020607099068
1603141225	265165692	1.0002622065798652	0.9997378163355621	1.0002925650424335	0.9997071991852091	1.000054490266667	0.9999447342152903
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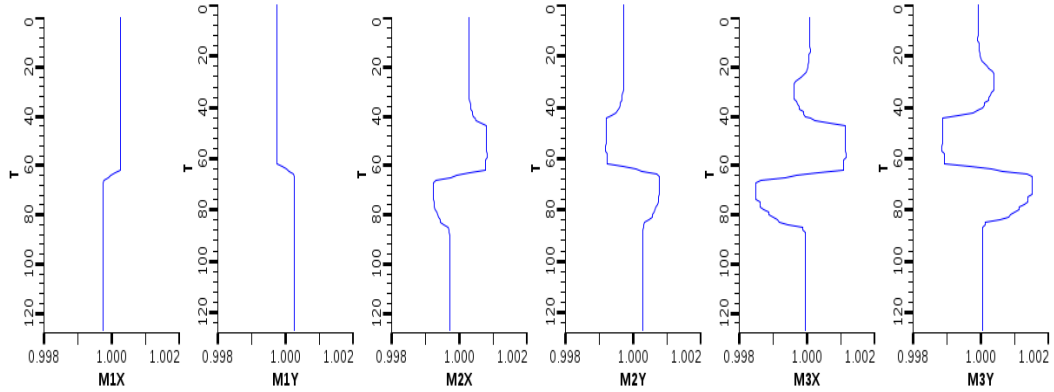
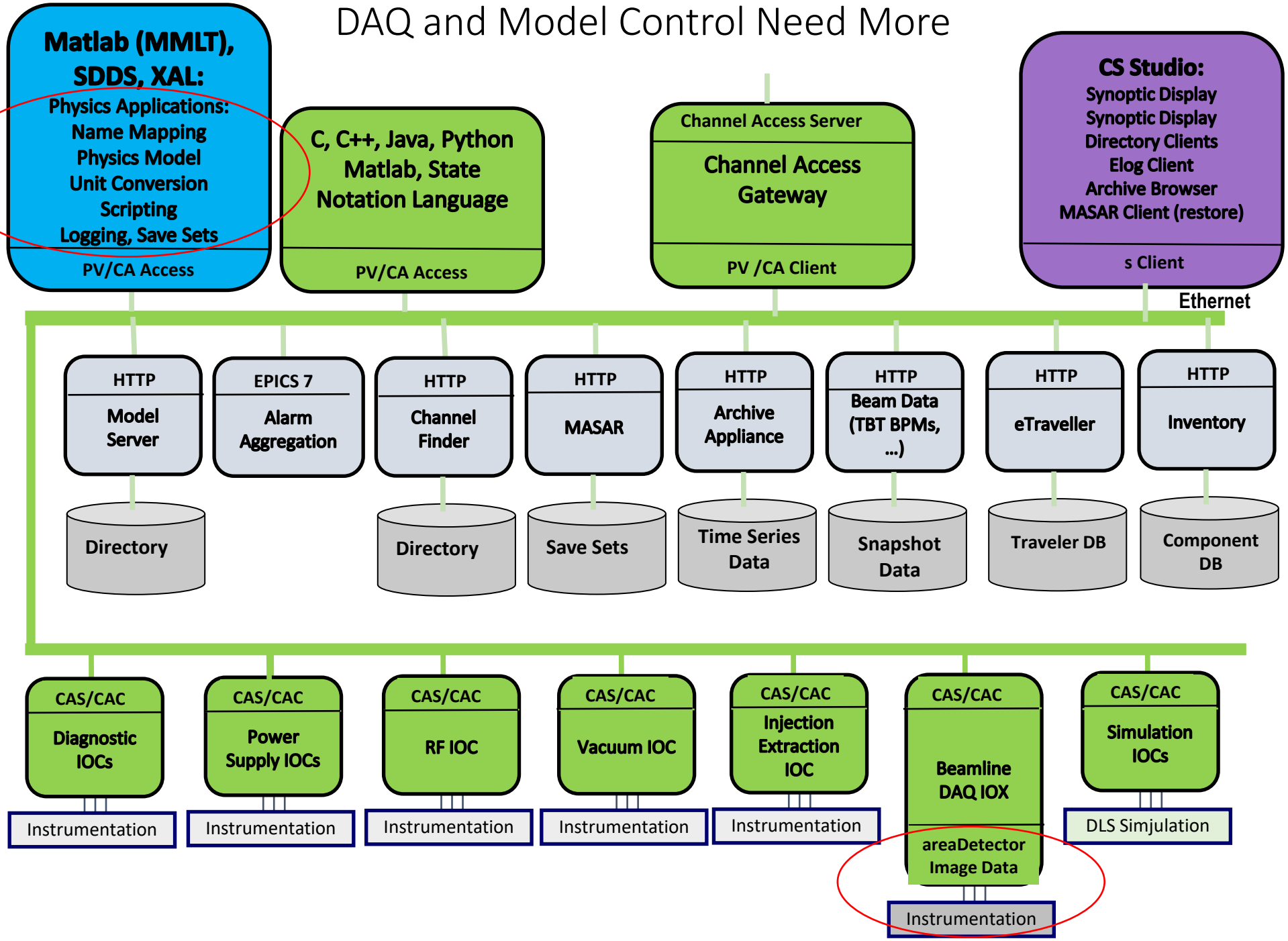


DAQ and Model Control Need More



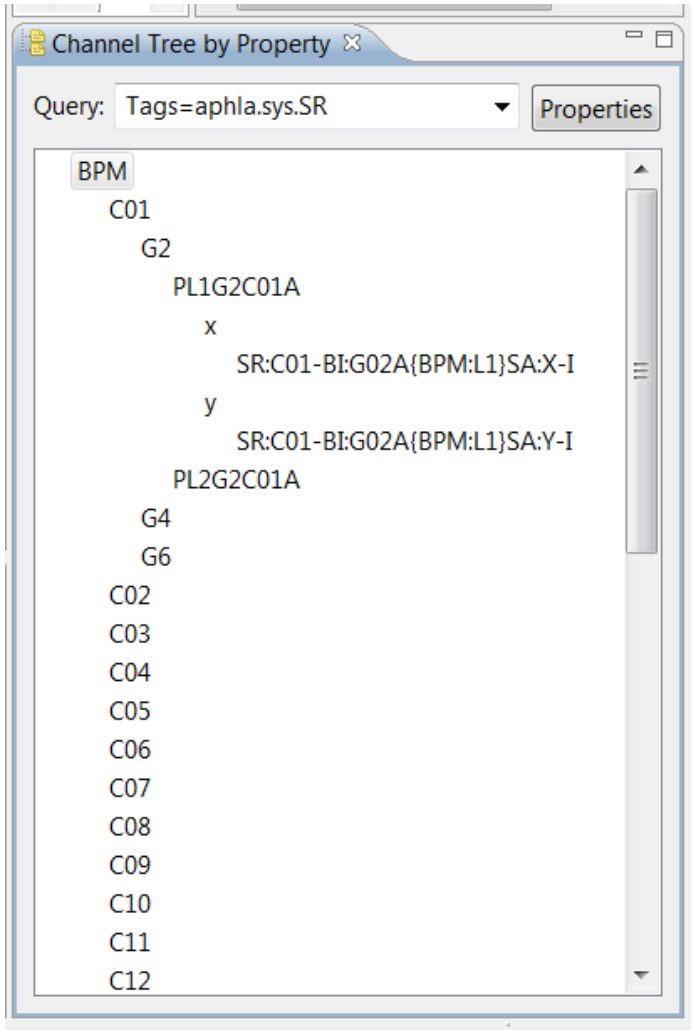
Directory Service - Alias Properties

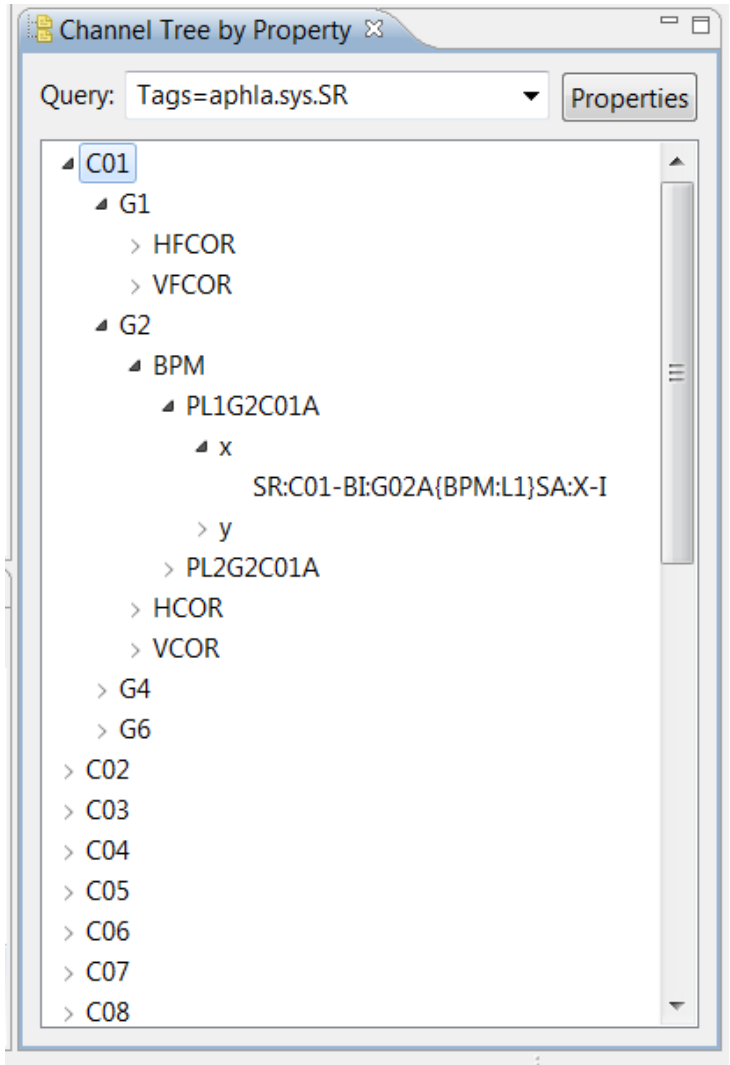
Channels | MultiChannel View

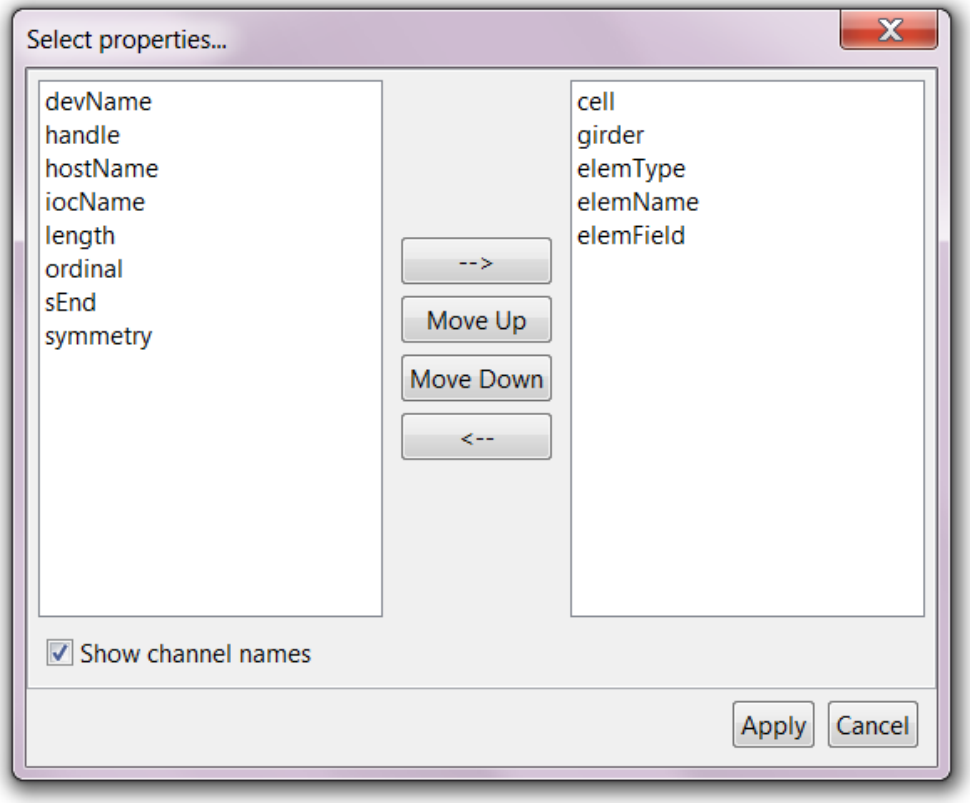
SR:C0* elemType=HCOR,BPM Tags=aphla.sys.SR — Search

Channel Name	Owner	handle	girder	cell	ordinal	devName	elemName	elemField	elemType	sEnd	length
SR:C01-BI:G02A...	cf-update	READBACK	G2	C01	120	PL1G2C01A	PL1G2C01A	x	BPM	29.9886	0.0
SR:C01-BI:G02A...	cf-update	READBACK	G2	C01	120	PL1G2C01A	PL1G2C01A	y	BPM	29.9886	0.0
SR:C01-BI:G02A...	cf-update	READBACK	G2	C01	120	PL1G2C01A	PL1G2C01A		BPM	29.9886	0.0
SR:C01-BI:G02A...	cf-update	READBACK	G2	C01	120	PL1G2C01A	PL1G2C01A		BPM	29.9886	0.0
SR:C01-BI:G02A...	cf-update	SETPOINT	G2	C01	120	PL1G2C01A	PL1G2C01A		BPM	29.9886	0.0
SR:C01-BI:G02A...	cf-update	SETPOINT	G2	C01	120	PL1G2C01A	PL1G2C01A		BPM	29.9886	0.0
SR:C01-MG:G02...	cf-update	SETPOINT	G2	C01	125	CL1G2C01A	CXL1G2C01A	x	HCOR	30.6673	0.2
SR:C01-MG:G02...	cf-update	READBACK	G2	C01	125	CL1G2C01A	CXL1G2C01A	x	HCOR	30.6673	0.2
SR:C01-MG:G02...	cf-update	READBACK	G2	C01	133	CL2G2C01A	CXL2G2C01A	x	HCOR	32.1047	0.2
SR:C01-MG:G02...	cf-update	SETPOINT	G2	C01	133	CL2G2C01A	CXL2G2C01A	x	HCOR	32.1047	0.2
SR:C01-BI:G02A...	cf-update	READBACK	G2	C01	138	PL2G2C01A	PL2G2C01A	y	BPM	32.5523	0.0
SR:C01-BI:G02A...	cf-update	READBACK	G2	C01	138	PL2G2C01A	PL2G2C01A	x	BPM	32.5523	0.0
SR:C01-BI:G02A...	cf-update	SETPOINT	G2	C01	138	PL2G2C01A	PL2G2C01A		BPM	32.5523	0.0
SR:C01-BI:G02A...	cf-update	SETPOINT	G2	C01	138	PL2G2C01A	PL2G2C01A		BPM	32.5523	0.0
SR:C01-BI:G02A...	cf-update	READBACK	G2	C01	138	PL2G2C01A	PL2G2C01A		BPM	32.5523	0.0
SR:C01-BI:G02A...	cf-update	READBACK	G2	C01	138	PL2G2C01A	PL2G2C01A		BPM	32.5523	0.0
SR:C01-MG:G04...	cf-update	READBACK	G4	C01	150	SQMG4C01A	CXMG4C01A	x	HCOR	36.7222	0.2
SR:C01-MG:G04...	cf-update	SETPOINT	G4	C01	150	SQMG4C01A	CXMG4C01A	x	HCOR	36.7222	0.2
SR:C01-BI:G04A...	cf-update	SETPOINT	G4	C01	161	PM1G4C01A	PM1G4C01A		BPM	38.3018	0.0
SR:C01-BI:G04A...	cf-update	SETPOINT	G4	C01	161	PM1G4C01A	PM1G4C01A		BPM	38.3018	0.0
SR:C01-BI:G04A...	cf-update	READBACK	G4	C01	161	PM1G4C01A	PM1G4C01A	x	BPM	38.3018	0.0
SR:C01-BI:G04A...	cf-update	READBACK	G4	C01	161	PM1G4C01A	PM1G4C01A		BPM	38.3018	0.0
SR:C01-BI:G04A...	cf-update	READBACK	G4	C01	161	PM1G4C01A	PM1G4C01A		BPM	38.3018	0.0
SR:C01-BI:G04A...	cf-update	READBACK	G4	C01	161	PM1G4C01A	PM1G4C01A	y	BPM	38.3018	0.0
SR:C01-BI:G04B...	cf-update	SETPOINT	G4	C01	171	PM1G4C01B	PM1G4C01B		BPM	40.5345	0.0
SR:C01-BI:G04B...	cf-update	SETPOINT	G4	C01	171	PM1G4C01B	PM1G4C01B		BPM	40.5345	0.0
SR:C01-BI:G04B...	cf-update	READBACK	G4	C01	171	PM1G4C01B	PM1G4C01B		BPM	40.5345	0.0

Directory Service – Configures Hierarchy







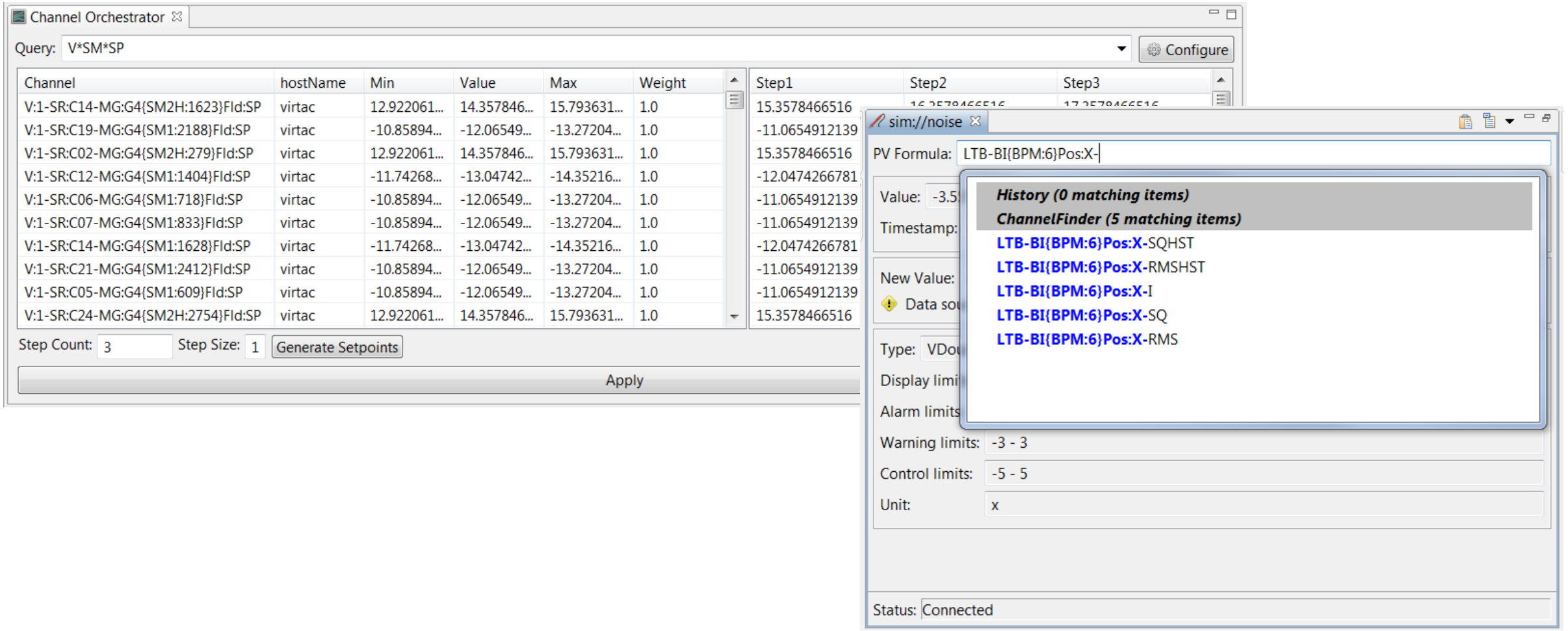
Directory Service – Used to provide parameter displays

PVTable by Property

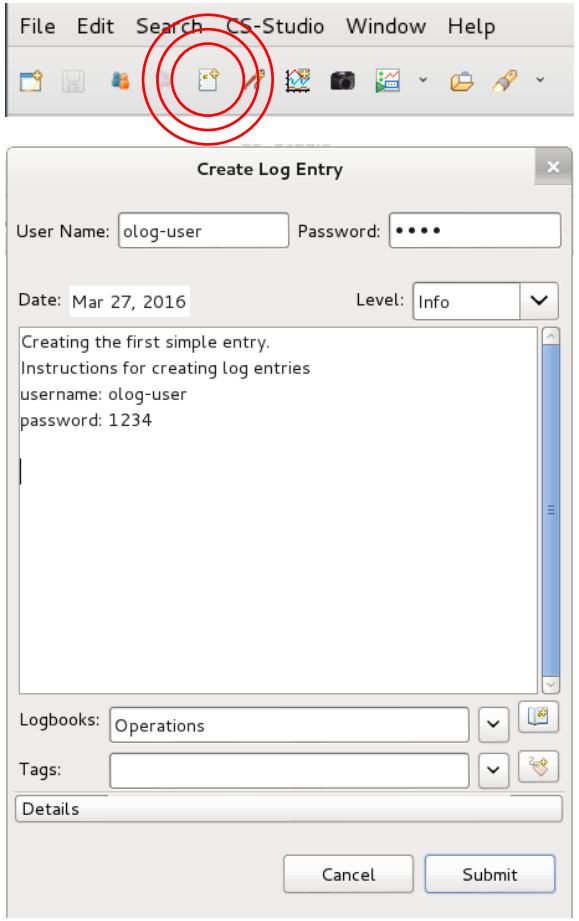
Query: Tags=aphla.sys.SR cell=C01 Row: devName Column: elemField

devName \ elemField	x	y
CH1G6C01B	0.0	0.0
CH2G6C01B	0.0	0.0
CL1G2C01A	0.0	0.0
CL2G2C01A	0.0	0.0
CM1G4C01B	0.0	0.0
FL1G1C01A	0.0	0.0
FL2G1C01A	0.0	0.0
FM1G4C01A	0.0	0.0
PH1G6C01B	-7.216569742425744E-7	0.0
PH2G6C01B	-2.1431258791651994E-7	0.0
PL1G2C01A	-1.500986653185494E-6	0.0
PL2G2C01A	-1.806087679109317E-6	0.0
PM1G4C01A	1.6492499142893348E-6	0.0
PM1G4C01B	1.3008445367347664E-6	0.0
SQMG4C01A	0.0	0.0

Phoebus uses Directory Service to improve workflow

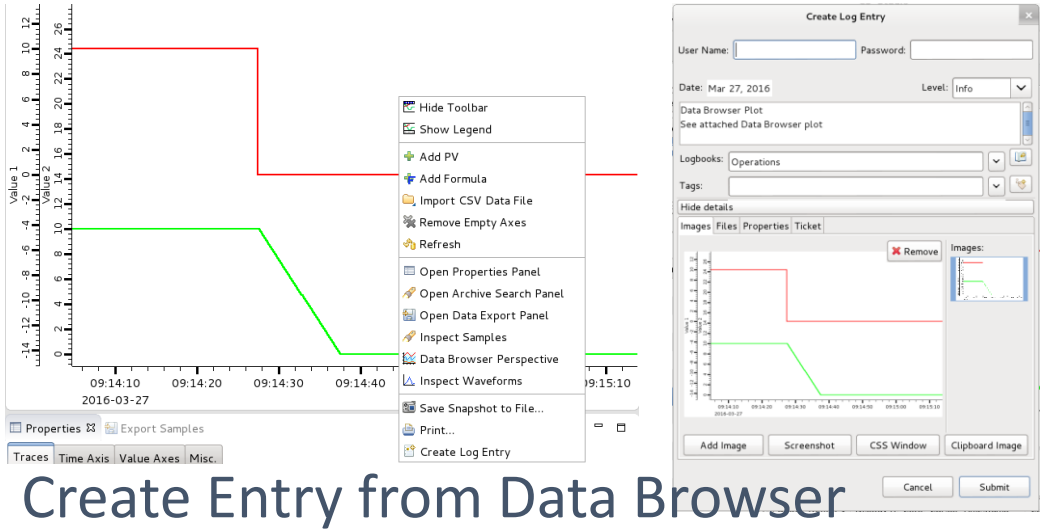


Operator Log – Entry Creation

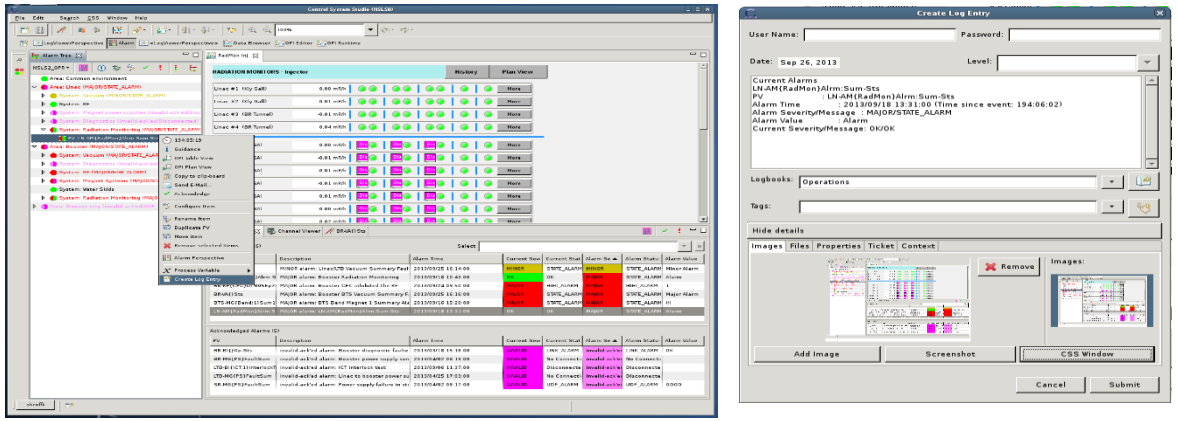


Create Entry

Time
Owner
Text
Attachments
Logbooks
Tags
Properties

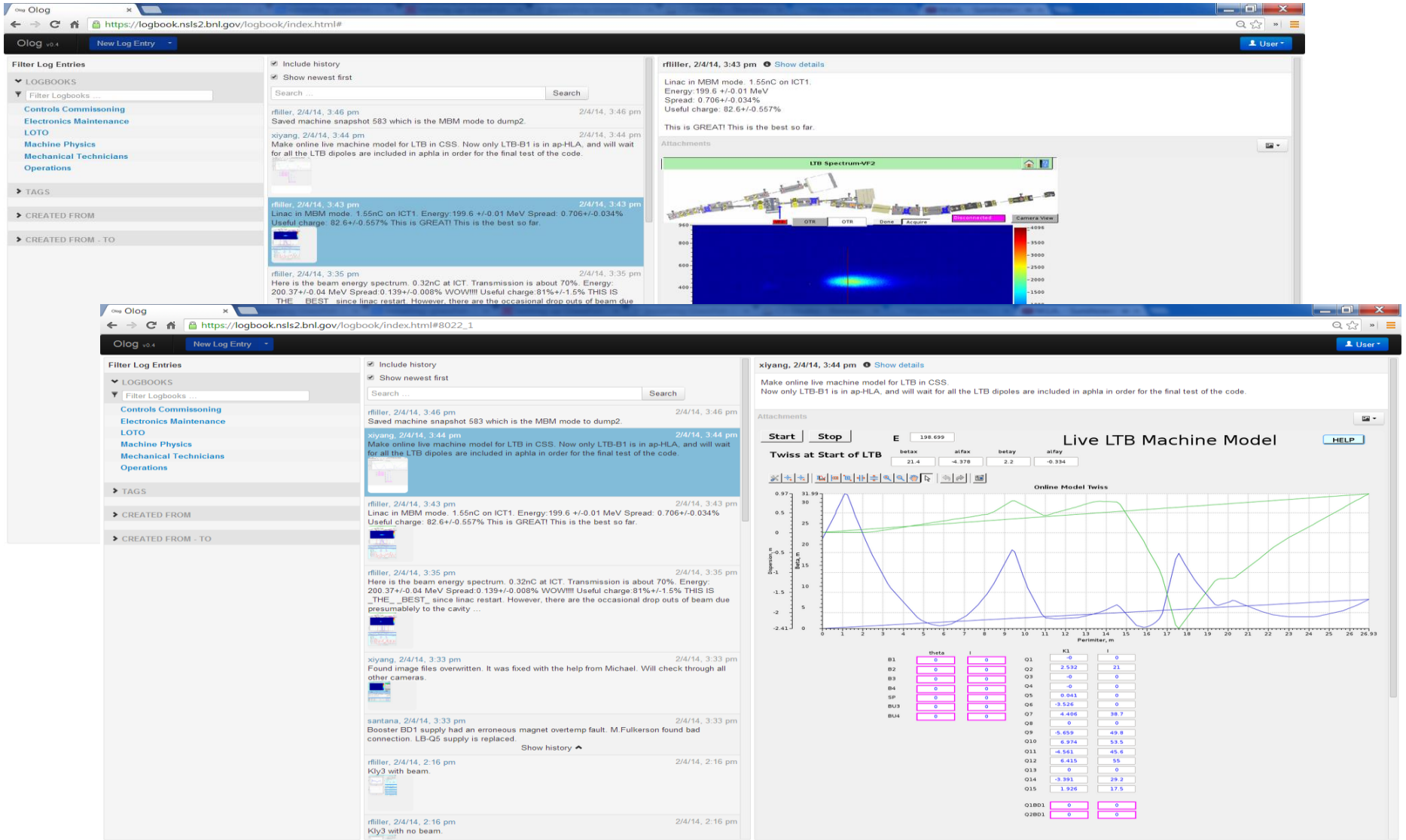


Create Entry from Data Browser



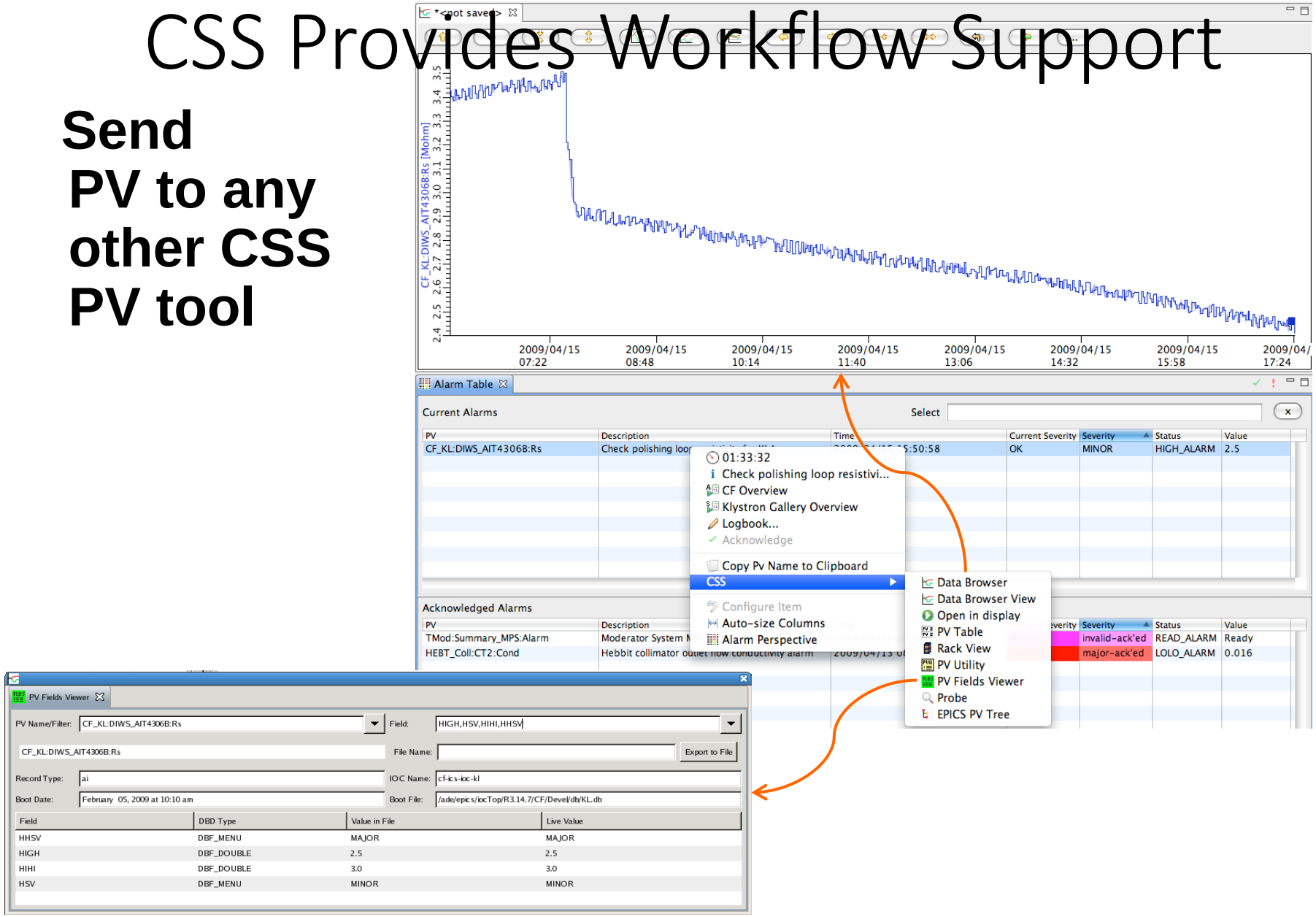
Create Entry from Alarm Viewer

Operator Log – Web Viewer

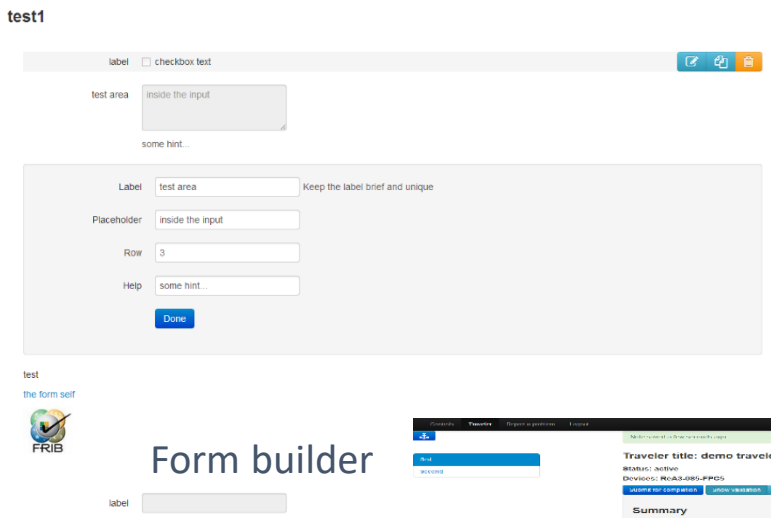


CSS Provides Workflow Support

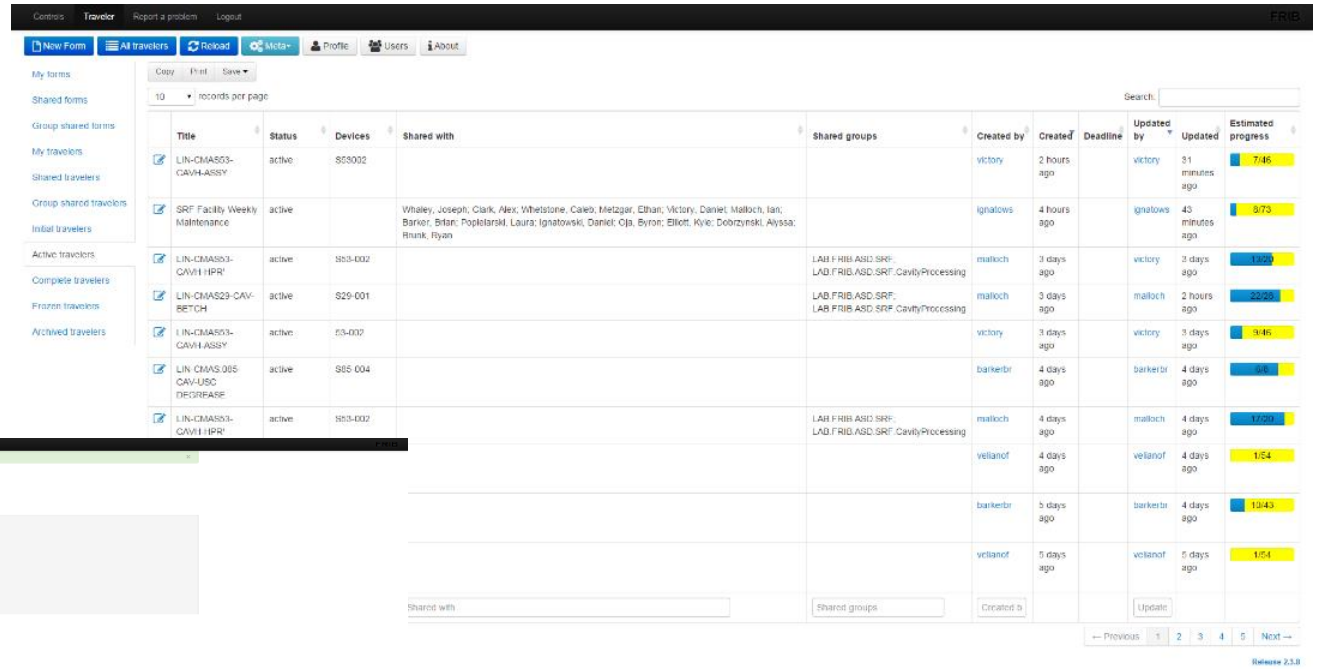
Send PV to any other CSS PV tool

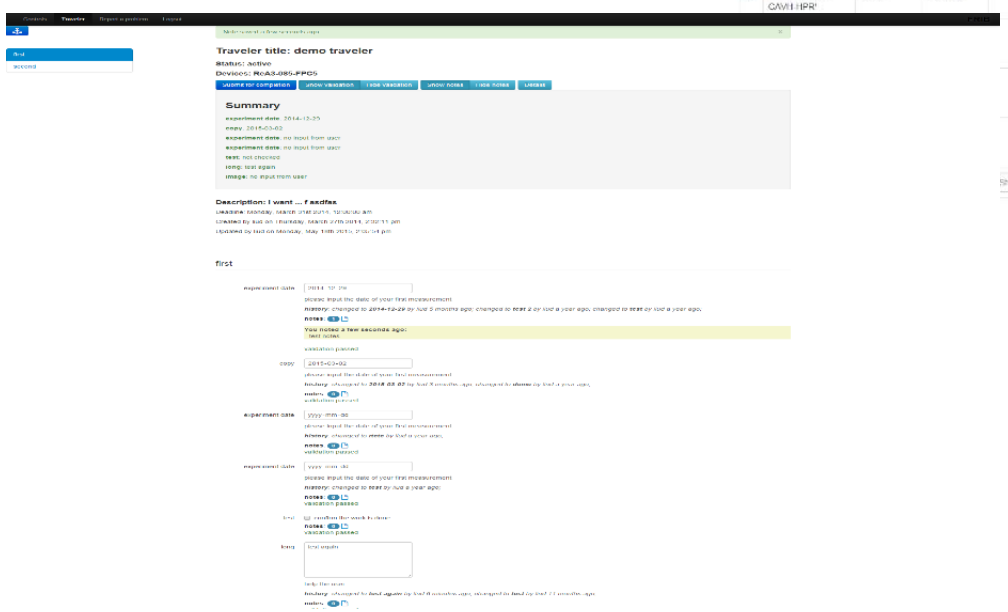


Data Management Tools – electronic traveler



Form builder





Traveler Page

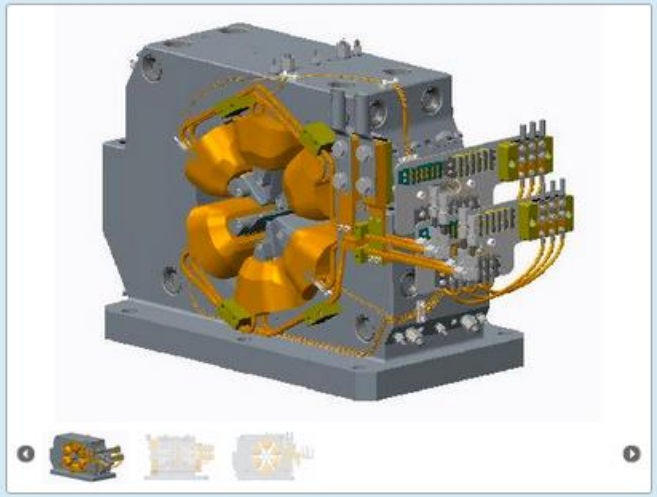
Data Management Tools – inventory/installation

Component Instance Details

QR Id	000 000 108
Component	DMM SEXTUPOLE S1A001 [Sextupole:Magnets]
Tag	S1A001
Serial Number	-
Location	314
Location Details	-
Description	Sectupole magnet for DMM instance 105

More Info | Return

Gallery



Component Instance Properties

Type	Tag	Value	Units	Dynamic	Actions
Traveler Instance (Electronic)		EAA to 314			
Traveler Instance (Electronic)		S1A001 EAA to 314			
Traveler Instance (ICMS)		APSU_1694686			
Traveler Instance (Electronic)		314 to EAA			

Component Properties

Type	Tag	Value	Units	Dynamic	Actions
PDMLink Drawing	Yoke	U221020202-112000.drw			
Purchase Requisition		F5-013070			
Image	Iso View				
PDMLink Drawing	Magnet Assembly	U221020202-112100			
Image	Front View				
Image	Upstread View				
Component Design	Reference Design	DMM SEXTUPOLE U221020202-112100			
Traveler Template (Electronic)		APS-U Rigging Daily Lift Checklist			

EPICS 7 Enables New Solutions

- EPICS 7 is the EPICS 3 and EPICS 4 protocols running simultaneously where V4 has new capabilities in Normative Data Types and Communication Mechanisms.
- The Middle Layer Services provides an aggregation layer allows for use in multiple user interfaces tools.
- New Tools are developed to improve control system development
- The collaboration continues to contribute to this open source control system with concern for the large installed base.

Commercial Support for EPICS

- There are commercial applications that use EPICS.
- There are a number of companies that sell their instrumentation with EPICS support such as drivers or a full implementation provided
- Companies are providing support for EPICS develop or use in applications: Observatory Sciences, CosyLab and Osprey Distributed Control Systems.
- As EPICS is open source, anyone could be using it and there could be more that are not listed here.

Conclusions

- Architectural Features of EPICS support Industrial and Research Control Systems.
- EPICS is used in Industrial Applications and Research Successfully for over 30 years.
- The open source community continues to support and extend EPICS to support new technology in control applications.