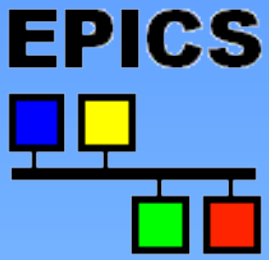

LabIOC

EPICS-LabVIEW Interface

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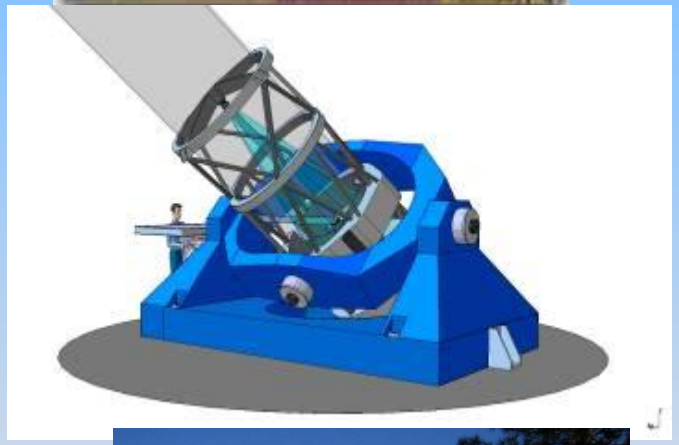
Presented by Philip Taylor

Observatory Sciences Ltd, Cambridge UK

NI Big Physics Summit CERN 11-12 February 2016

Observatory Sciences: LabVIEW Telescope Control Systems

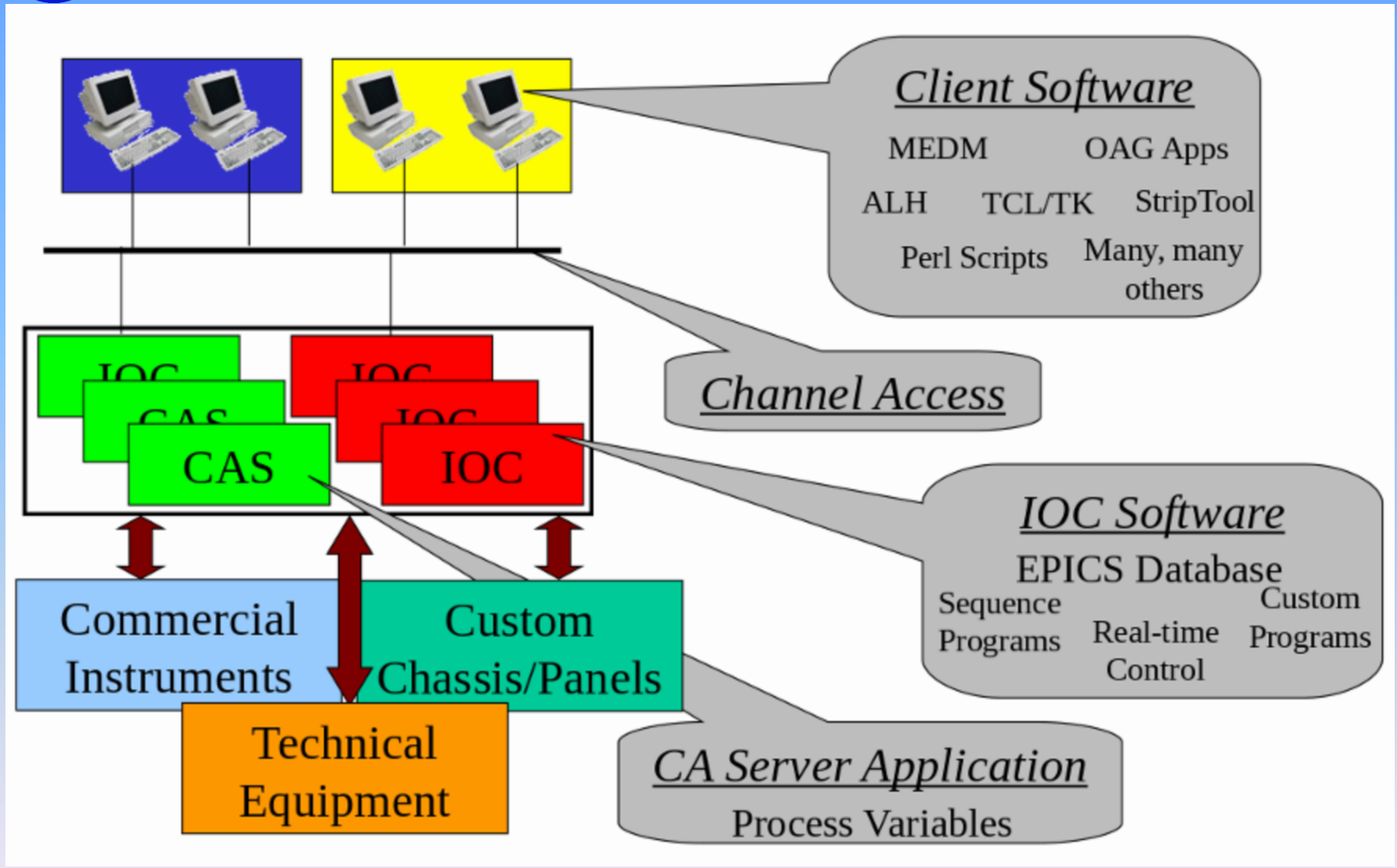


1. The **Multi-Application Solar Telescope (MAST)** is a 0.5m advanced solar telescope, commissioning 2013-14 in Udaipur, India.
2. The **ARIES telescope** will be a 3.6 meter diameter optical telescope, the largest in Asia. It will be sited at Devesthal Peak, India. On-site commissioning 2015.
3. The **Magdalena Ridge Optical Interferometer** (MROI) will be sited on Magdalena Ridge in New Mexico, USA. Awaiting completion.
4. The **Discovery Channel Telescope** is a 4.2 meter optical telescope built in Arizona, USA by the Lowell Observatory. Completed in 2012, now in full operation.
5. **Observatory Astrofisico de Javalambre** includes a 2.5m wide-field survey telescope sited in the Aragon region of Spain. Factory Commissioning on-site 2014-15

Introduction to EPICS

- Experimental Physics and Industrial Control System (EPICS).
- Control System Architecture and Software Toolkit.
- Open source software used by hundreds of sites, with many collaborators including
  - The Advanced Photon Source at Argonne National Laboratory
  - Australian Synchrotron
  - Berlin Electron Synchrotron (BESSY II)
  - Deutches Elektronen Synchrotron (DESY)
  - Diamond Light Source
  - European Spallation Source (ESS)
  - Extreme Light Infrastructure (ELI)
  - Fermilab (FNAL)
  - ITER
  - Jefferson Laboratory (JLAB)
  - Keck Observatory
  - Laboratori Nazionali di Legnaro (INFN-LNL)
  - Lawrence Berkeley National Laboratory (LBL)
  - Los Alamos National Laboratory (LANL)
  - Swiss Light Source (SNS)
  - Stanford Linear Accelerator Center (SLAC)
- See NI whitepaper for introduction to EPICS and current NI implementation of EPICS/LabVIEW interface: http://www.ni.com/white-paper/14144/en/

EPICS Control System



EPICS IOC

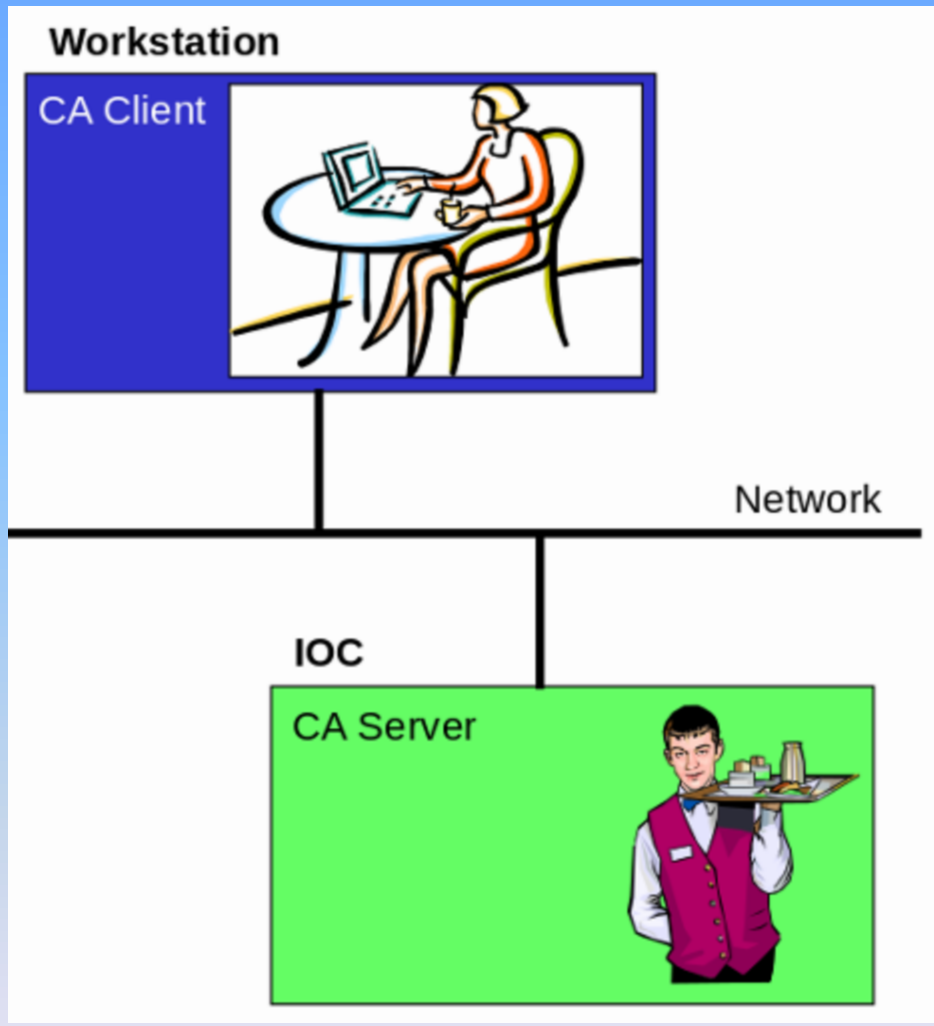
- IOC = Input Output Controller.
- The computer running the IOC can be:
  - PC running Windows, Linux
  - VME based CPU, running vxWorks, RTEMS, Linux
  - Mac running OSX
  - Embedded processor running Linux, RTEMS
  - Raspberry Pi
- Usually has Input and/or Output devices attached
- An EPICS control system must consist of at least on Channel Access Server (usually an IOC).
- An IOC has one or more databases loaded. The database tells the IOC what to do.

EPICS Channel Access

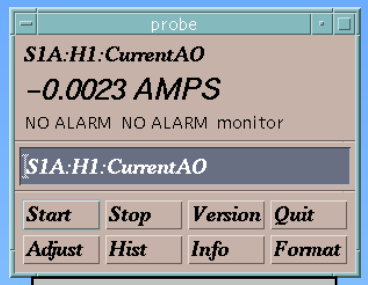
- Allows other programs (CA Clients) to see and change values of Process Variables in an IOC (CA Server)
- CA Clients may:
  - Put (write)
  - Get (read)
  - Monitor (wait for event)

data of Process Variables

- IOCs are both CA clients and CA servers. They can interact with data in other IOCs
- A CA Client can connect to many servers
- A CA Server may serve many clients
- A very efficient and reliable protocol in operational use for over 25 years



EPICS Channel Access in One Slide



Channel Access Client

"connection request" or "search request"

"get" or "caGet"

"put" or "caPut"

"set a monitor"

Who has a PV named "S1A:H1:CurrentAO"?

What is its value?

Change its value to 30.5

Notify me when the value changes

CA Client

CA Server

Channel Access Server

Process Variables:

S1A:H1:CurrentAO

S1:P1:x

S1:P1:y

S1:G1:vacuum

I do.

25.5 AMPS

OK, it is now 30.5

It is now 20.5 AMPS

It is now 10.5 AMPS

It is now -0.0023 AMPS

"put complete"

or

30.5 is too high. It is now set to the maximum value of 27.5.

or

You are not authorized to change this value

"post an event" or "post a monitor"

EPICS Databases

- Use common, proven, objects (*records*) to collect, process and distribute data
- Provide a common toolkit for creating applications
- They contain a collection of EPICS records, including processing and data links between records.
- Interface to process instrumentation
- Distributed processing
- Provide external access to all process information

What are EPICS records?

- A record is an object with...
  - A unique name e.g. BL:V5:MVM1:Current
  - Controllable properties (fields) e.g. EGU
  - A behaviour – defined by its record type
  - Optional associated hardware I/O (device support)
  - Links to other records
- Each field can be accessed individually by name e.g. BL:V5:MVM1:Current.EGU
- A record name and field name combine to give the name of a process variable
- A process variable name is what Channel Access needs to access data

Where does LabVIEW fit?

- LabVIEW is a tool for producing applications faster and more effectively
- LabVIEW offers integration with unprecedented quantities of hardware
- Many hardware manufacturers provide LabVIEW drivers and LabVIEW test applications
- LabVIEW offers multi-platform support, inherent parallel programming, many pre-existing libraries for data acquisition, processing, analysis...

LabVIEW – EPICS Integration

- Many solutions exist with various advantages and disadvantages*

1. Shared memory on VxWorks (LANL)
2. Hypervisor shared memory – Hyppie (LNLS)
3. ActiveX CA (ORNL-SNS)
4. CaLab Win DLL (HZB-BESSYII)
5. DCOM Win API via EPICS driver (STFC-ISIS)
6. DIM Interface (GSI + CERN)
7. LV – native EPICS implementation (ORNL-SNS)

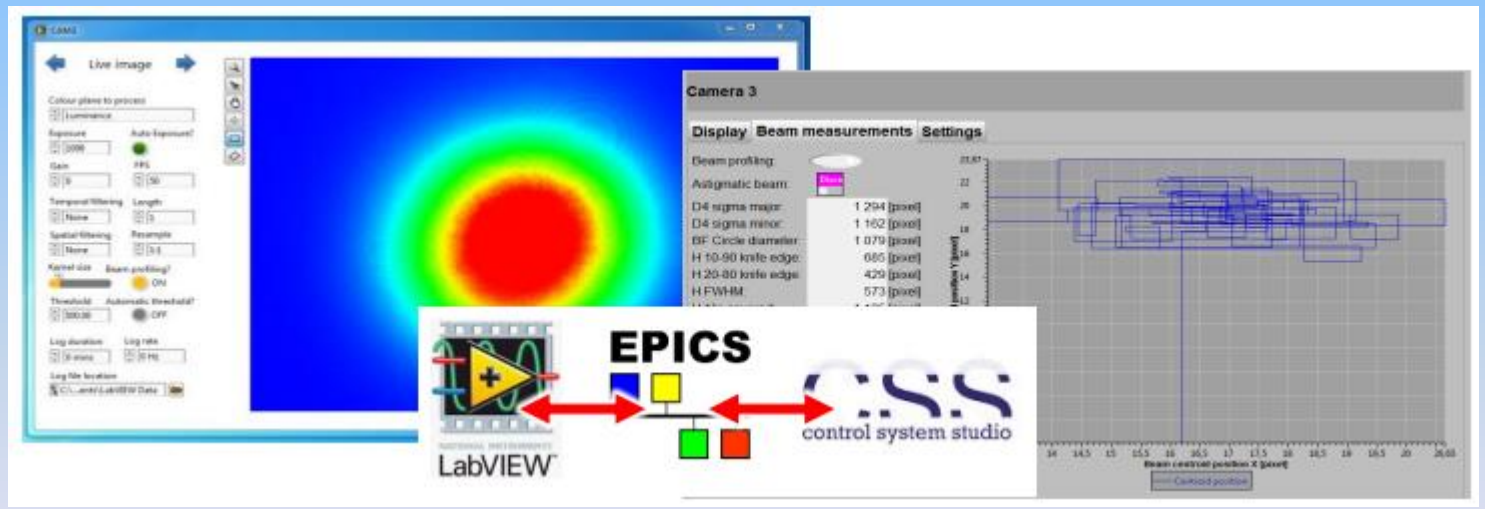
8. DSC Module via Shared Variables (NI)
9. LV-native CA (LabIOC – Observatory Sciences)

* surveyed 2014 – not an exhaustive list. Credit goes to: various presentations at EPICS collaborations and NIWeek by Alexander Zhukov, ORNL; GSI wiki summary; Tech Talk [http://www.aps.anl.gov/epics/tech-talk/]

Testing by ELI Beamlines

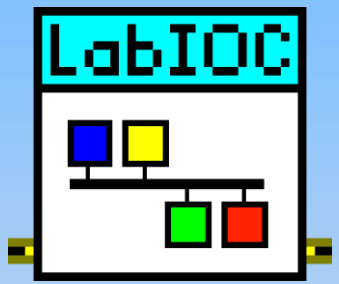
Courtesy of Eli-Beamlines

Early testing of NI EPICS module carried out by ELI Beamlines.
Basically works, but...
Project has been put on ice (NI's unofficial warning in 2013)
Network SVs must be used (slow, unstable, poor scalability)
Not a full implementation (PVs on server-side have only few fields)
Missing fields confuse clients (e.g. Control System Studio)
Type-casting bugs (string and integer)



Demonstration of LabVIEW camera server on RMC-8354 using NI EPICS module to link to a Control System Studio secondary display (developed 2012-2013)

Observatory Sciences & LabIOC



- Observatory Sciences was contracted by ELI Beamlines (Prague) in 2014 to produce a library to bridge the gap between LabVIEW and EPICS.
- The first version of LabIOC was made available in 2015.
- LabIOC was described in a paper at the ICALEPCS conference in Melbourne, Australia, October 2015:

  Extreme Light Infrastructure, Beamlines - Control System Architecture for the L1 Laser, Jack Naylon et al

  http://icalepcs.synchrotron.org.au/talks/tud3o02_talk.pdf

LabIOC Goals

Goals for LabIOC:

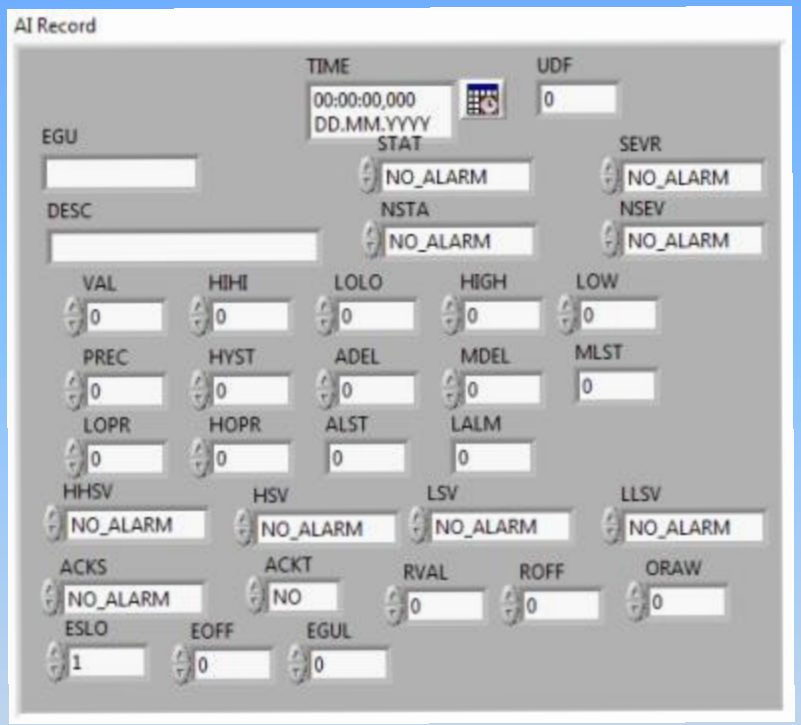
- Offer an easy way for non-EPICS experienced LabVIEW developers to interface to EPICS applications/facilities
- Offer good performance and reliability
- Ensure the library will continue to work as future versions of LabVIEW are released
- Portable: ensure library will work identically on all NI LabVIEW.
- Keep the library interface simple
- Provide more than just the Channel Access communications protocol for PVs

LabIOC

- Implemented as a LabVIEW library consisting of over 700 VIs
- Works on all LabVIEW supported platforms, including Windows, Linux and LabVIEW Real-Time
- Implemented EPICS Channel Access communications protocol using only native LabVIEW nodes (TCP, UDP, Queues, Notifiers)
- Implemented most common EPICS record structures
- Works seamlessly with current EPICS tools (caget, caput, camonitor, EDM, CSS, etc)
- Designed with input from users at ELI Beamlines & National Energetics to ensure product works as expected
- Concentrated on performance of library
- Designed for LabVIEW engineers, no EPICS experience required (no EPICS installation or EPICS libraries required)

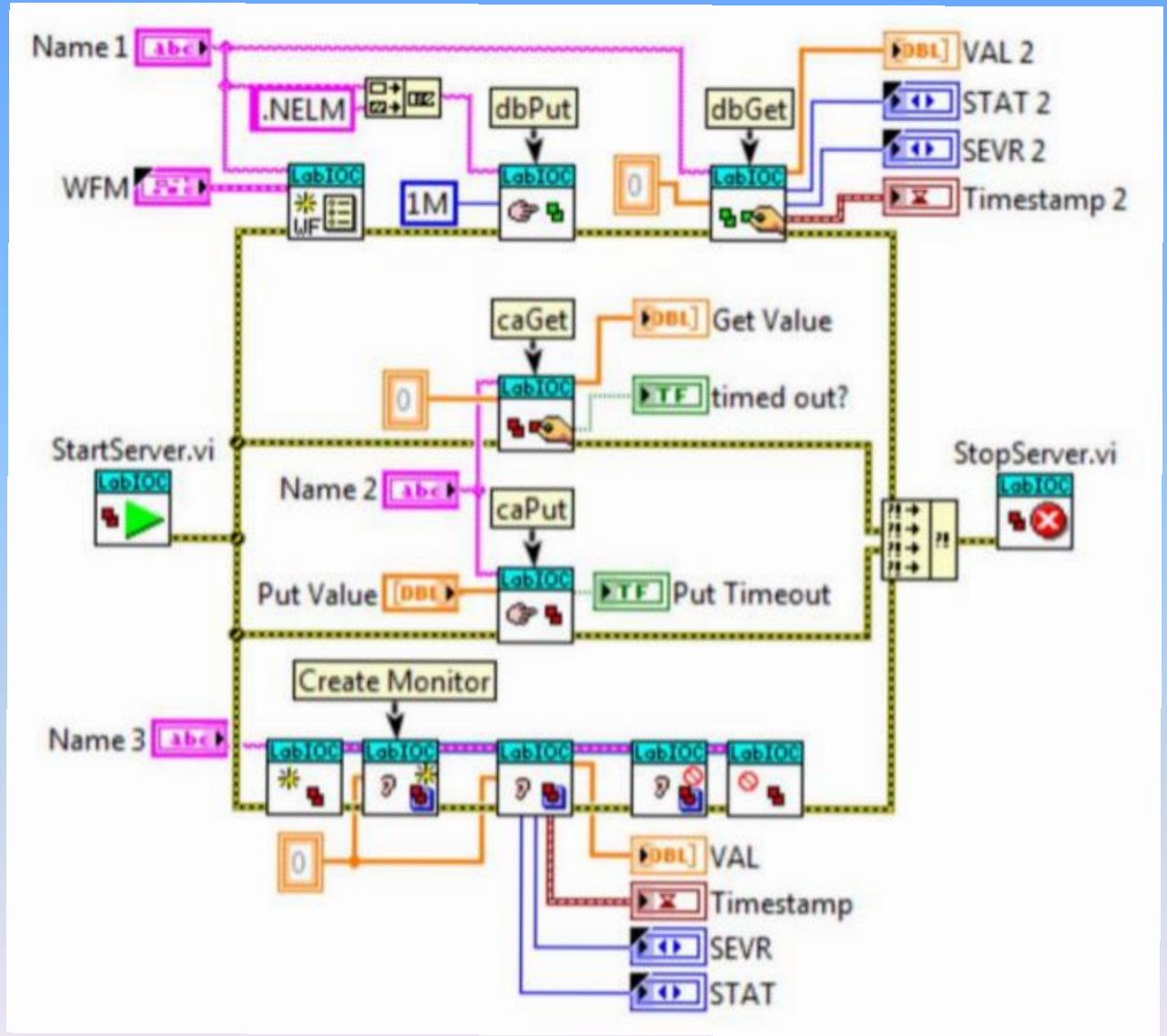
LabIOC

- LabIOC has full support for basic EPICS record types:
  - ai/ao
  - bi/bo
  - longin/longout
  - mbbi/mbbo
  - stringin/stringout
  - waveform
- Polymorphic VIs used for standard LabVIEW types:
  - I8
  - I16
  - I32
  - SGL
  - DBL
  - STR
  - Boolean
  - Arrays of all types above – typecasting as appropriate



Example LabVIEW Control for EPICS AI record

Example LabIOC VI Set



Courtesy of Eli-Beamlines

LabIOC Server Capabilities

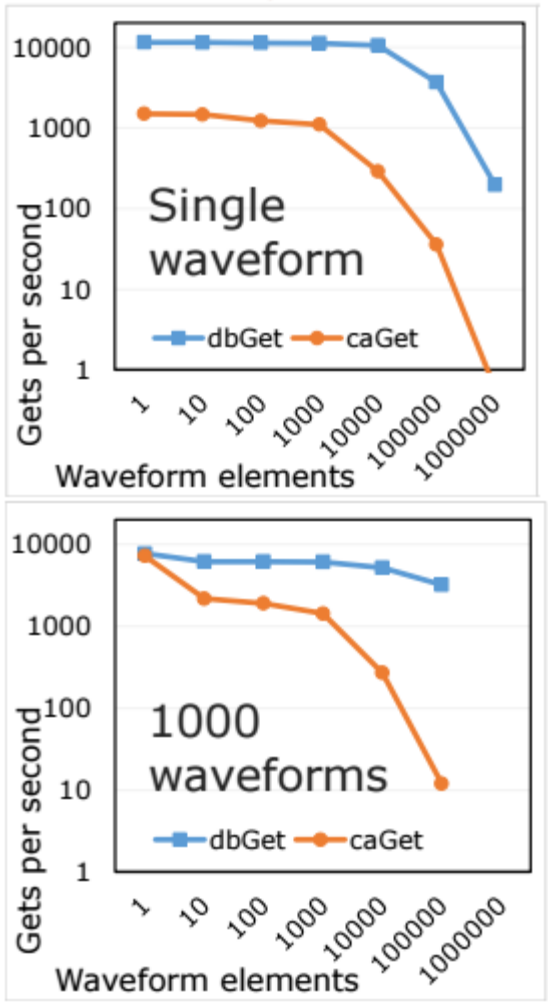
- Start and stop server with VIs
- EPICS records supported with
  - Limits
  - Engineering units
  - Display limits
  - Enumerated names
  - Display precision
  - Alarm status
  - Alarm severity
- Write to record fields (dbPut) with polymorphic VIs
- Read from record fields (dbGet) using polymorphic VIs
- Channel access communication complexities are removed from the program

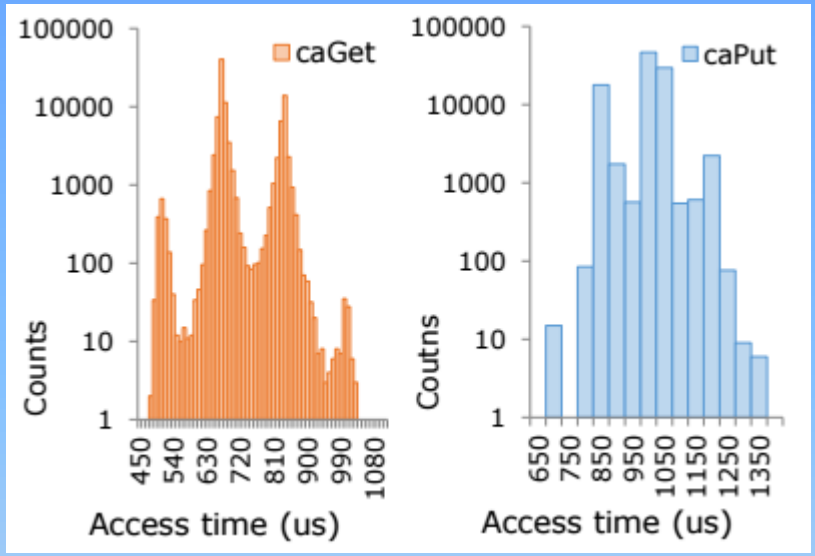
LabIOC Client Capabilities

- Very simple interface
  - Create channel
  - Read channel
  - Write channel
  - Monitor channel
  - Delete channel
- Channel Access handled by the library
- Created channels share TCP connections where appropriate
- Works with all EPICS servers (LabVIEW or native EPICS)
- LabVIEW standard types are supported (polymorphic VIs)

LabIOC ELI Testing Results

Courtesy of Eli-Beamlines



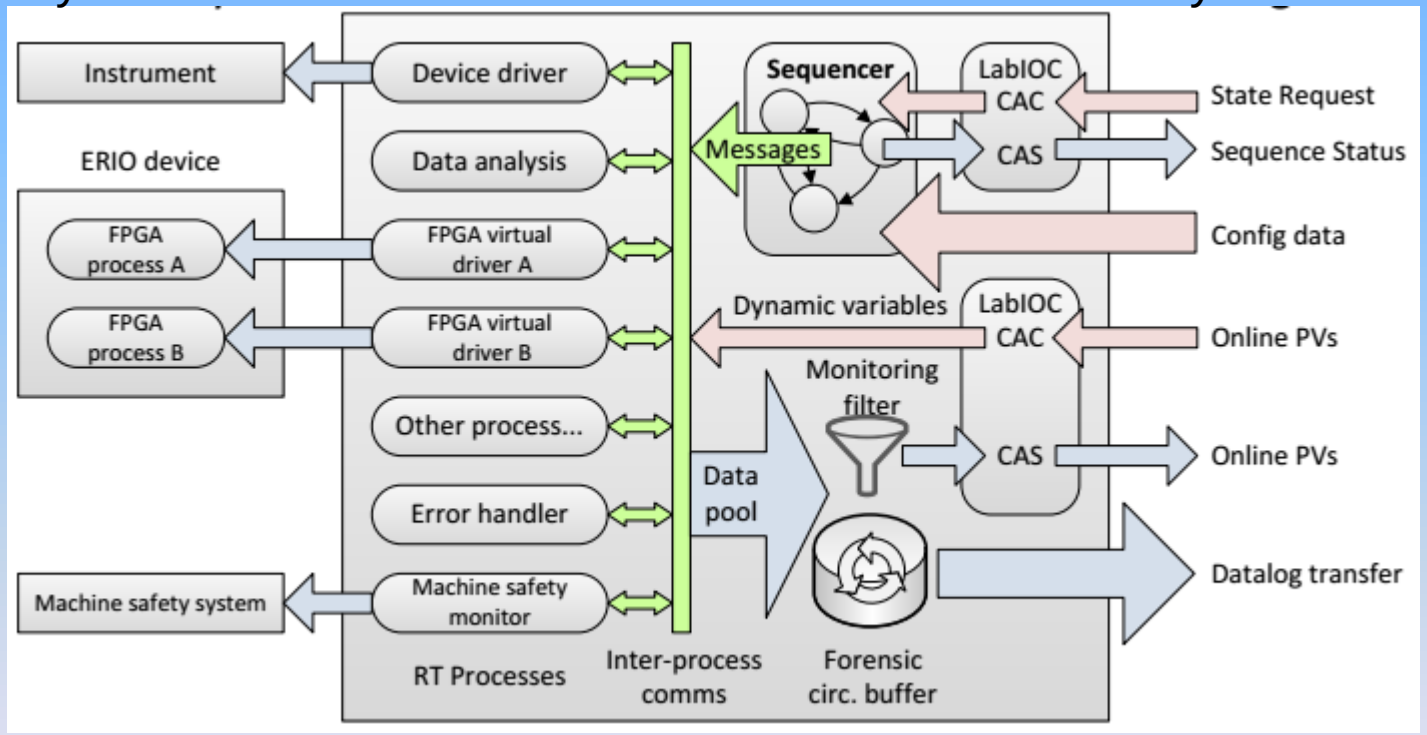


Testing carried out by ELI and National Energetics

Performance is good. Work will continue on streamlining library

LabIOC In Use
ELI Framework

Courtesy of Eli-Beamlines



Acknowledgements

- APS (EPICS Introduction Presentation)
- ELI Beamlines (Dr Jack Naylon)