UT-BATTELLE

EPICS Overview

2006

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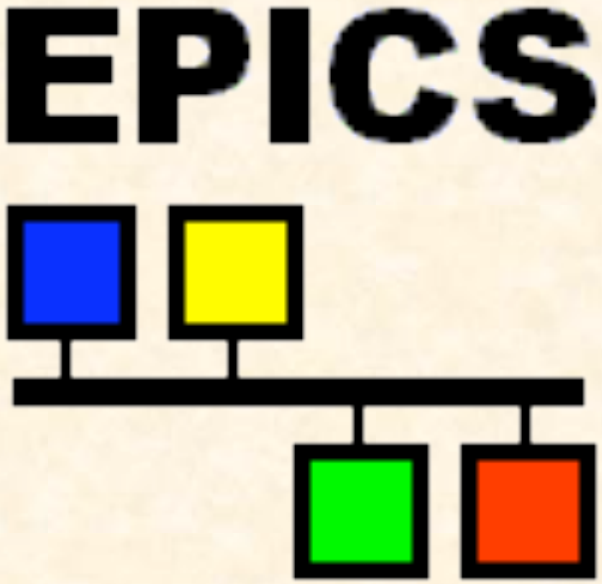
SNS SPALLATION NEUTRON SOURCE

OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY

What is EPICS?



History of EPICS

- ~1989: Collaboration
  - LANL Ground Test Accelerator
  - ANL Advanced Photon Source
- Until 2004:
  - License agreement required
  - LANL registered >150
- Now:
  - http://www.aps.anl.gov/epics

"Experimental Physics and Industrial Control System"

- Not EPICs nor EPIC's

- "Exp. Phys Ind. Ctrl. Sys ….. Toolkit"
  - Not one program.
  - Doesn't do anything out of the box.
  - Can be used in different ways.

EPICS is a Toolkit, a Framework

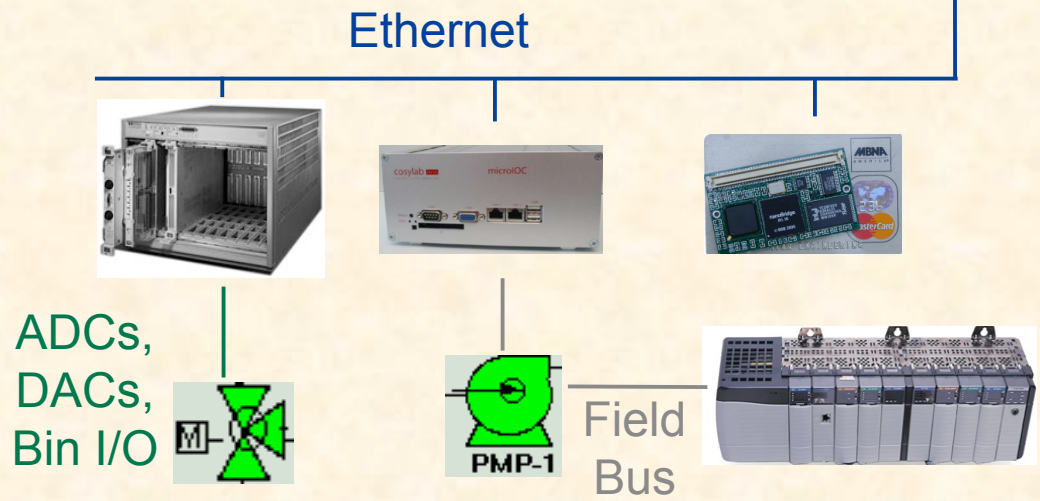
- … for distributed control systems.
- Contents:
  - See http://www.aps.anl.gov/epics.
- Open source; free software
  - .. as in beer
  - and speech.

Distributed Control System?

Distributed Control System

- **Workstations, operator interfaces.**

- **Data processing middle layer, archive, …**
- **Front-end Computers**
- **I/O, PLCs, …**
- **Plant**



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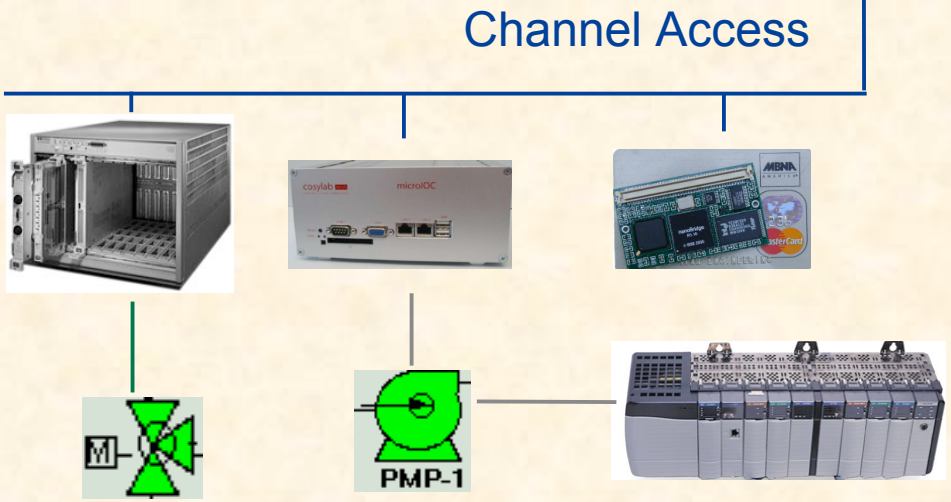
EPICS: Distributed Control System

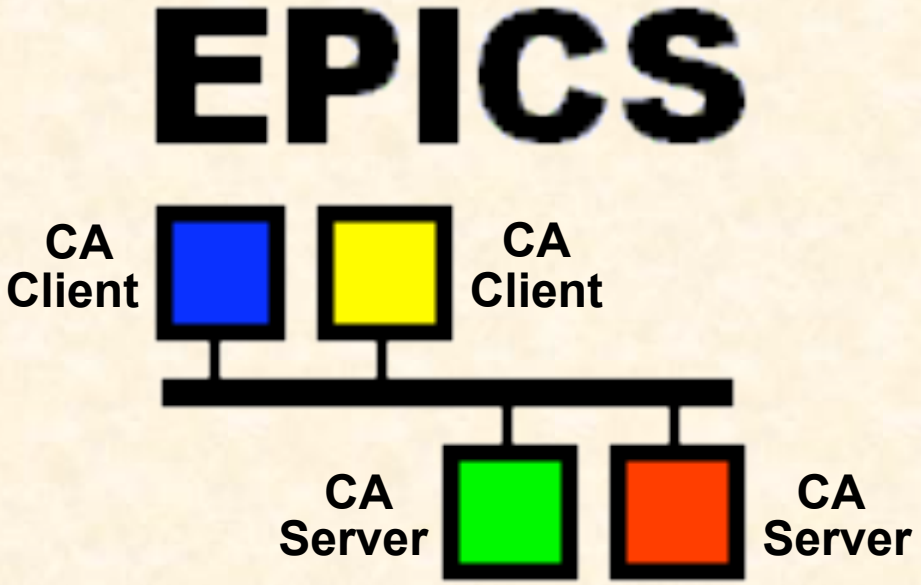
- **EPICS Extensions:**
  - **EDM, StripTool, ALH,…**
  - **Archiver, …**

- **EPICS Base: Input/Output Controller (IOC)**



The Logo

- "Client/Server"
- Channel Access



EPICS Base: IOC Toolkit

- Database
- Sequencer
- ChannelAccess

IOC Database

- Configuration instead of Coding
- 'iocCore' software loads and executes 'Records'

- Example Assignment:
  - Read some temperature sensor
  - Open/close a valve when value is above resp. below some threshold

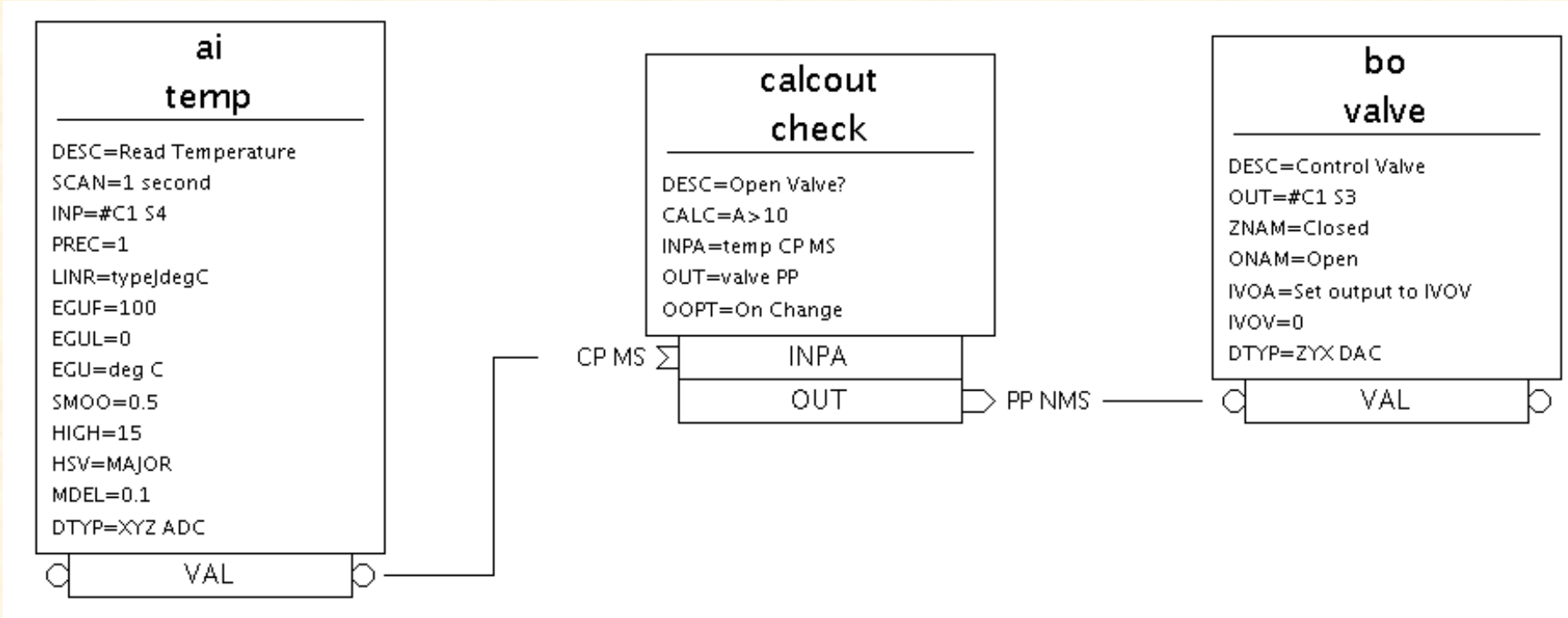
The Example in simplified Code

```
Sensor temp = open_device(…);

Valve valve = open_device(…);

Loop:

      if (temp.value() > 10)
           valve.open();
      else
           valve.close();

      delay(1.0);
```

What we omitted

- Error checking
- Code comments
- Apply some smoothing to the temperature reading to filter noise.
- Send current temperature and valve state to network clients (operator display).
- Attach a time stamp to the data, so that network clients can see for example when the valve was last opened.
- Send warnings if the temperature is close to the threshold, or an alarm when way above.
- Allow runtime changes of the threshold from the remote operator interface.
- Allow runtime changes to the scan rate.
- Maybe allow runtime changes to the device address?

This IOC 'Database' does all that



- **At first glance, this might look much worse than the code, but…**
  - **that was simplified code.**
  - **there's no way the full code for the above would fit on one screen.**
  - **after learning more about the database (~2 days), this becomes much more readable than somebody else's custom code for the same functionality.**

Some Detail on an EPICS 'Record'

```
record(ai, temp)
{
  field(DESC, "Read Temperature")
  field(SCAN, "1 second")
  field(DTYP, "XYZ ADC")
  field(INP,  "#C1 S4")
  field(PREC, "1")
  field(LINR, "typeJdegC")
  field(EGUF, "100")
  field(EGUL, "0")
  field(EGU,  "deg C")
  field(SMOO, "0.5")
  field(HIGH, "15")
  field(HSV,  "MAJOR")
  field(MDEL, "0.1")
}
```

- Configuration instead of Programming
- "SCAN=1 second" instead of starting periodic thread, delaying until next multiple of 1 second, locking required resources, …
- "SMOO=0.5" configures the smoothing algorithm.
- Almost any field in any record is accessible via network at runtime
  - Change scan rate, smoothing, …

IOC Database

- A single record often handles the scanning, signal conditioning, alarming of a temperature, pressure, or similar analog reading.
- Combined with binary and computational records, it can express most of the data flow logic for a front-end computer
  - Avoiding the pitfalls of real-time, multithreaded and networked programming.
- One can have thousands of records in one IOC.
  - Well suited for systems with high signal counts, like vacuum or water systems with relatively simple logic but many, many sensors and valves.
- kHz-rate processing with record chains is doable
  - Of course limited by CPU. Not 1000nds of kHz rate-records…

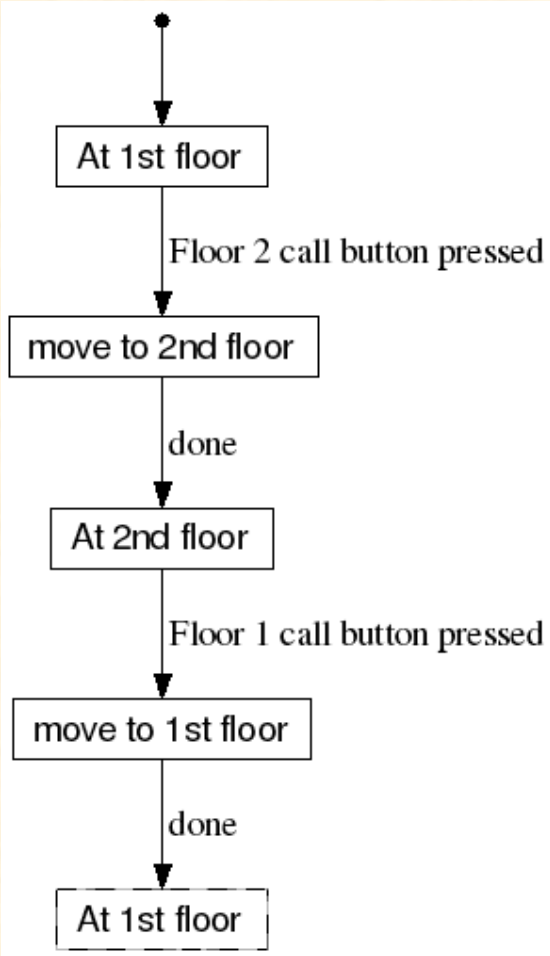
Device Support

- Software layer that interfaces records to hardware
  - EPICS web site lists many existing ones.
  - Well defined Interfaces allow adaptation of new or custom hardware.

EPICS Sequencer

- Adds state-machine behavior to the IOC

```
program Elevator_Simulation

ss Elevator
{
    state floor1
    {
        when (floor2_call)
        {
        } state goto2
    }

    state goto2
    {
     …
```



EPICS Channel Access

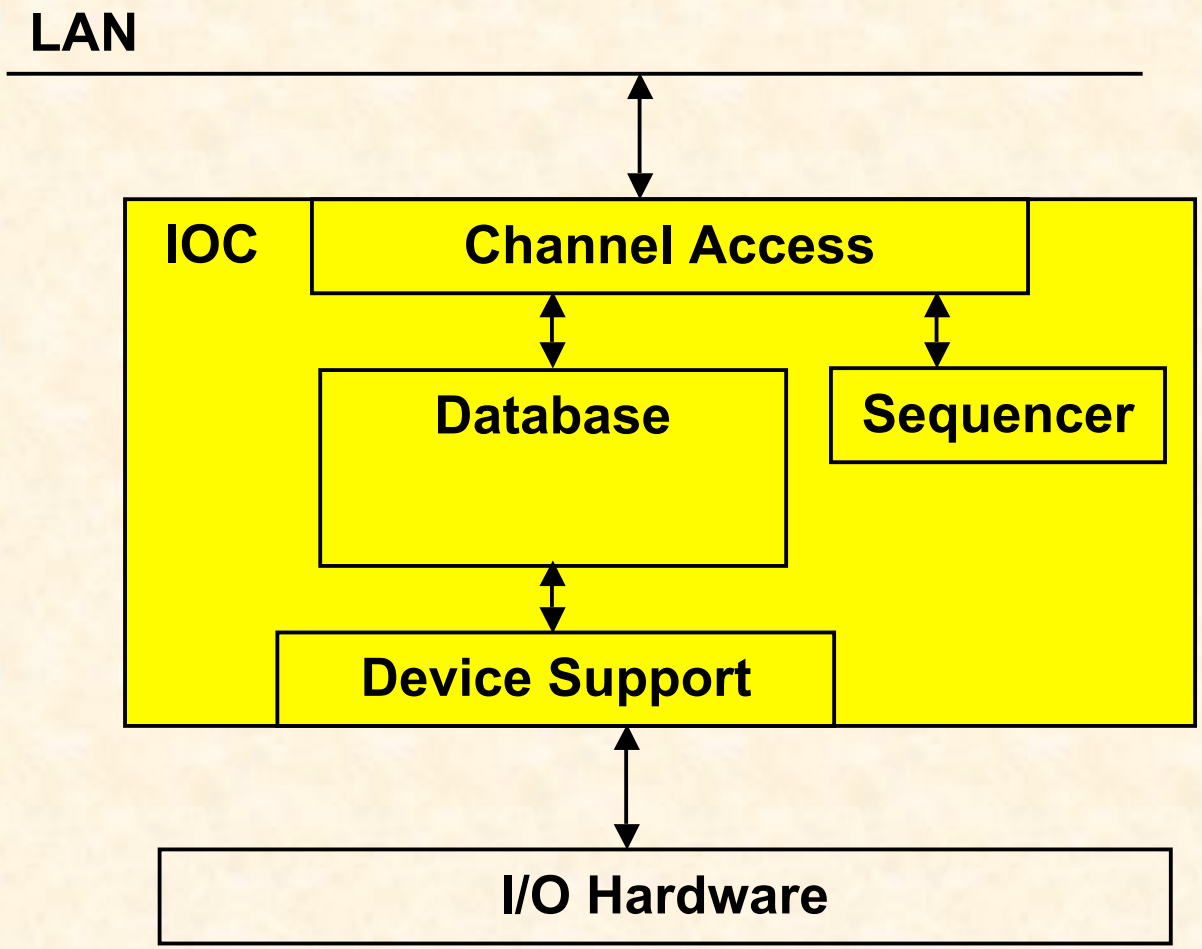
- The network protocol used by IOCs and applications to communicate on the network.
- Ideally, 'plug and play'
  - Once you know the ProcessVariable (PV) name.
  - Don't worry about network addresses, or data type differences between the server and client.

EPICS Base: IOC Toolkit

- Database, Sequencer, ChannelAccess.
- Plus: portability libraries
  - Linux, OS X, Win32, vxWorks, RTEMS, others.
- Basis for most of the "extensions"
  - Technically, sequence is bundled as 'extension'.

- Probably the main difference between EPICS and other systems, where the support for front-end computers is often only helper libraries.

IOC Summary


LAN
IOC
Channel Access
Database
Sequencer
Device Support
I/O Hardware

EPICS: The community

- Members:
  - SNS, ANL/APS, SLAC, LANL, JLAB/CEBAF, LBNL, Fermilab D0, Keck & Gemini Telescopes … in the USA
  - Canadian Light Source
  - DESY, BESSY in Germany
  - PSI/SLS in Switzerland, SACLAY in France
  - Diamond light source in England
  - KEK-K in Japan, IHEP in China
- Yearly collaboration meetings
  - One each in US and elsewhere
  - 100+ people attended in 2004, 05, 06.
- 'Tech-Talk' email reflector usually provides responses within a few hours.
- APS Training sessions produced very nice presentations
  - About a dozen people contributed
  - You'll recognize a lot of it in this week's talks.

Some Other Realities

- There is no full-time EPICS development group.
  - 'Base' code managed quite well at APS.
  - For the rest, most community members have a few smart people who implement what's needed locally, and provide that for free.
    If that works for you: Great.
    If not, you can ask for help, but you're basically on your own.
- Use of EPICS has grown tremendously
  - Very good for finding and fixing bugs.
  - Aided in portability.
  - … but limits flexibility for fundamental changes, so EPICS database and network protocol basically unchanged since 1990.

EPICS Vocabulary

- EPICS Base
  - IOC, 'hard' and 'soft'
  - Database (records)
  - Driver/Device support
  - Sequencer (states)
  - Channel Access (process variables, aka channels)
- Extensions
  - EDM, StripTool, …

What's next?

- In client/server system, you can't use one without the other.
  - Chicken vs. egg problem.
- Plan
  - Rush through a softIOC setup to have a 'server'.
  - Look at basic CA clients.
  - Thoroughly introduce EDM.
  - Then go back to IOC database.
  - Continued ping-pong between IOC and client side of EPICS.

Acknowledgements

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  - Daryl Murphy, Ernest, Greg Lawson, Shaun Cooper