Introduction To EPICS

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EPICS Introduction

What is *EPICS**?

- Experimental Physics and Industrial Control System
- An architecture for building scalable control systems
- A collection of code and documentation comprising a software toolkit
- A collaboration of major DOE labs, industry, and others

See also ...

- http://www.atdiv.lanl.gov/doc/epics/epicshm.html
- http://csg.lbl.gov/CSG.html
- http://altavista.digital.com (search for ‘epics & control’)

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* Reference: *Overview of the Experimental Physics and Industrial Control system: EPICS* by Steve Lewis, LBL

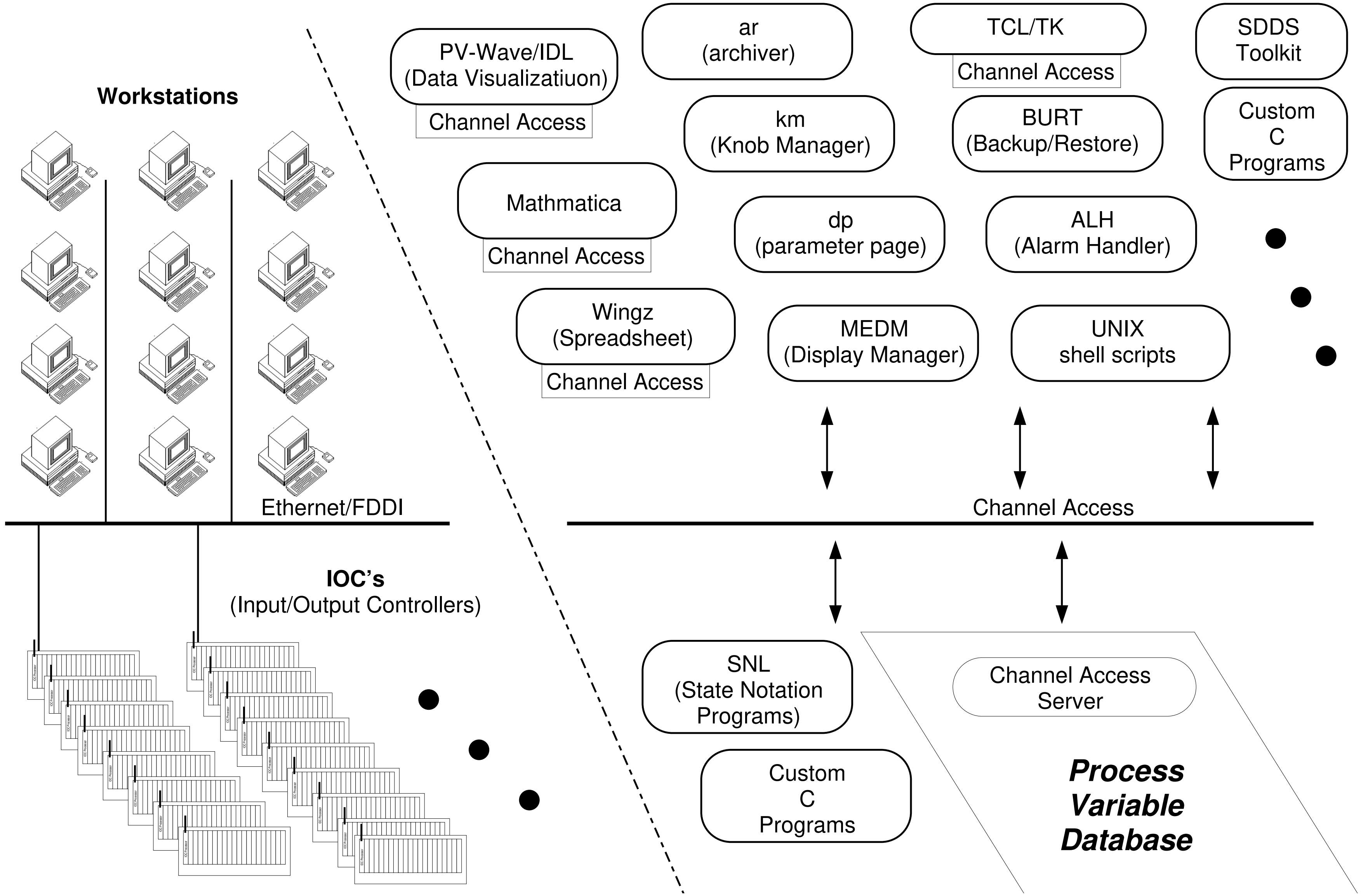
EPICS - An Architecture

- The "Standard Model" for Control System Architectures in the '90s'

Workstations ↔ Network ↔ Controllers ↔ I/O ↔ Equipment

- "Standards based"
    - Unix/X-windows
    - Ethernet/FDDI and TCP/IP
    - VME
- Client/Server Model
- Distributed Real-time Process Variable Database (No central database)
- Scalable from [1 workstation/1 ioc] to [15 workstations/8 X-terms/110 IOCs] (at least)

Architecture and Tools



EPICS - Supported Hardware

- Workstations*
    - Sun (SunOs, Solaris)
    - HP (HPUX)
    - Silicon Graphics (Unix)
    - DEC (VMS and OSF1)
    - PC (Windows NT, 3.1, ‘95, Linux)
- Input/Output Controllers
    - VME/VXI based CPU’s (680X0 CPU’s...) running vxWorks
    - Discussions about the PowerPC, Pentium, MIPS

* Sun and HPUX have the most complete support, others are partial support of certain tools

EPICS - Supported Hardware

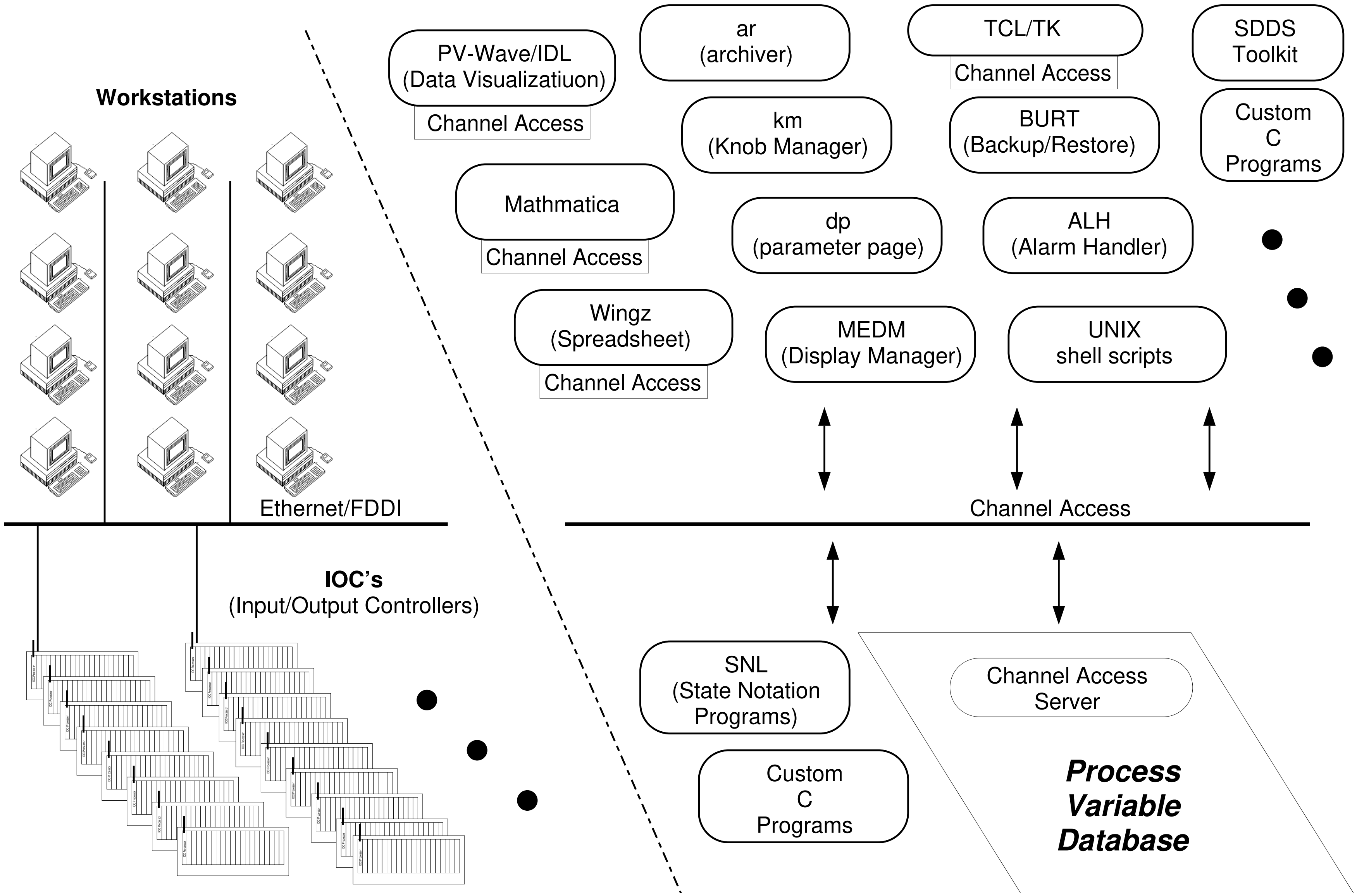
- IO Types (here at ANL)
    - VME I/O
    - VXI I/O (MXI bus connection/mapping)
    - GPIB Instruments
    - Bitbus
    - RS232/RS422 Instruments
    - Allen Bradley Data Highway (1771 series I/O)
    - CAMAC
- Fieldbus Survey : http://herao1.desy.de/cc/www/info/fieldbus-summary-95.html

EPICS - Software Tools (Channel Access)

The Software Bus

- Clients (requestors) and Servers (providers)
- Based on the Process Variable (PV) Name (28 character string)
- Operations include Search, Get, Put, Add Event (add monitor)
- “Monitors” send data to the client only when it has changed
- Attributes include Alarm Status, Units, Precision, Time, Enumeration Strings, Graphic Limits, Control Limits, Alarm Limits
- Full Channel Access Library and an EZCA Library

Architecture and Tools



EPICS - Software Tools (IOC)

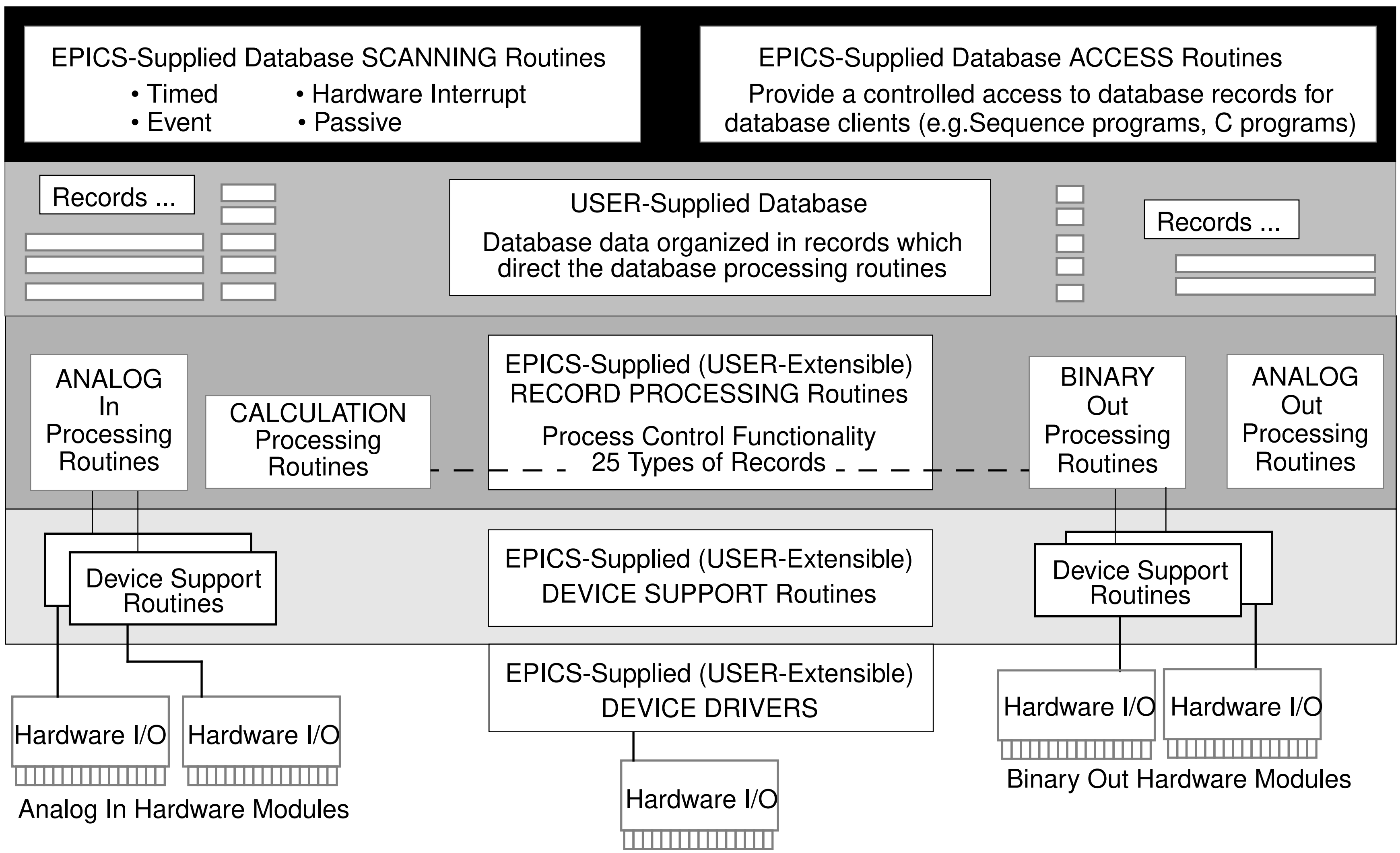
IOC: Input/Output Controller

- Record Type: A previously defined ‘building block’ with a unique structure of fields and a unique processing routine to accomplish a specific function. ‘Record support’ refers to the processing routine and the definition of the structure (e.g. an analog input record is used to monitor an analog signal, convert it to engineering units, check the value against alarm limits, and notify interested channel access clients of any significant change)
- Record: A particular instance of a ‘Record Type’ with appropriate values entered into appropriate fields
- Database: A collection of ‘records’
- Scanned (processed): Executing the record processing routine (unique to a record type) for a particular record

EPICS - Software Tools (IOC) (cont)

- The IOC's fundamental responsibility is to input data from the 'process' (and/or the operator), manipulate it in a predefined manner, and <optionally> output data to control the 'process'
- Inputs, data manipulation, and outputs are defined by the 'Application Developer' by configuring 'records' that become part of the IOC's database
- The IOC's primary task is to 'scan' the database, deciding when to and knowing how to execute predefined records
- Records can be linked together to create control algorithms and sequences
- Input and output records have a field in which to specify the 'device type'.

IOC Internals



Database Record Types by Category

INPUTS

Analog Input
Binary Input
Muli-bit Binary Input
Digitized Analog Input
State
String Input
Long Input
Pulse Counter

ALGORITHMS

Calculation
PID
Signal Select
Data Compression
Subroutine
Fanout
Histogram

OUTPUTS

Analog Output
Binary Output
Multi-bit Binary Output
Stepper Motor
Timing Signal
Permissive
String Output
Long Output
Pulse Train
Pulse Delay

Analog Input Record

```
struct aiRecord{
    /* start of ai specific fields */
    double              val;        /* Current EGU Value */
    struct link         inp;        /* Input Specification */
    short               prec;       /* Display Precision */
    unsigned short      linr;       /* Linearization */
    float               eguf;       /* Engineer Units Full */
    float               egul;       /* Engineer Units Low */
    char                egu[16];    /* Engineering Units */
    float               hopr;       /* High Operating Range */
    float               lopr;       /* Low Operating Range */
    float               aoff;       /* Adjustment Offset */
    float               aslo;       /* Adjustment Slope */
    float               smoo;       /* Smoothing */
    float               hihi;       /* Hihi Alarm Limit */
    float               lolo;       /* Lolo Alarm Limit */
    float               high;       /* High Alarm Limit */
    float               low;        /* Low Alarm Limit */
    unsigned short      hhsv;       /* Hihi Severity */
    unsigned short      llsv;       /* Lolo Severity */
    unsigned short      hsv;        /* High Severity */
```

```
        unsigned short          lsv;        /* Low Severity */
        double                  hyst;       /* Alarm Deadband */
        double                  adel;       /* Archive Deadband */
        double                  mdel;       /* Monitor Deadband */
        double                  lalm;       /* Last Value Alarmed */
        double                  alst;       /* Last Value Archived */
        double                  mlst;       /* Last Val Monitored */
        double                  eslo;       /* Rawto EGU Slope */
        long                    roff;       /* Raw Offset */
        caddr_t                 pbrk;       /* Ptrto brkTable */
        short                   init;       /* Initialized? */
        short                   lbrk;       /* LastBreak Point */
        long                    rval;       /* Current Raw Value */
        long                    oraw;       /* Previous Raw Value */
};
```

EPICS - Software Tools (Application Developer)

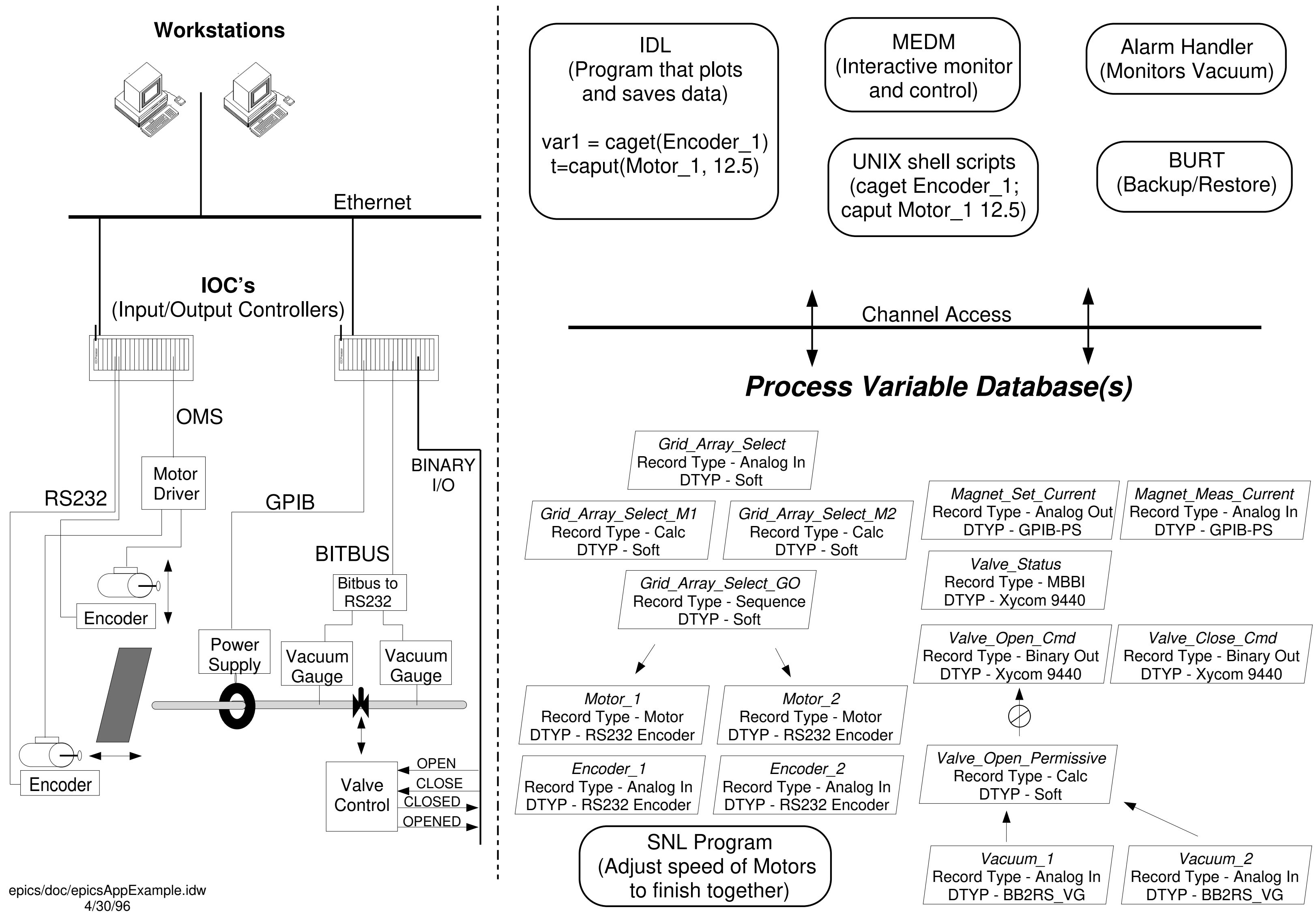
- Database Configuration (DCT, GDCT, CAPFAST)
- State Notation (State Machine) Language
- Graphical Display Editors (MEDM, EDD)
- Channel Access Library and EZCA

EPICS - Software Tools (Extensions)

Usually Channel Access Clients that need data from the IOCs or have data for the IOCs

- Graphical Display Tools
- Alarm Manager
- Archiving tools
- Backup/Restore
- Macros/Scripts
- Commercial Applications with interface routines
- ...

An EPICS Application



EPICS - A Collaboration

- Initial collaboration between Los Alamos National Lab (Ground Test Accelerator) and Argonne National Lab (Advanced Photon Source)
- Other major DOE sites
    - Lawrence Berkeley
    - Stanford Linear Accelerator Collider Lab
    - CEBAF
    - Brookhaven National Lab
- Other DOE sites/Non-DOE sites/International sites
    - See attached list

Collaborators (as of 5/1/96)

Colliders	Detectors	Commercial
The Advanced Photon Source (ANL)	Halls A, B, and C Slow Controls (CEBAF)	The High Power Laser Experiment (Boeing)
The Advanced Light Source (LBNL)	Advanced Light Source Beamlines (partial) (LBNL)	Wafer Fabrication Plant (AMD)
The Tesla Test Facility (DESY)	Gammasphere (LBNL)	Liquefied Nature Gas Plant (Baltimore G&E)
The Continuous Electron Beam Accelerator Facility	Advanced Photon Source Beamlines (ANL)	Tunnel Fire Ventilation Test Program (DOT/Bechtel-Parsons-Brinkerhoff)
The Bates Linear Accelerator (MIT)	The PHENIX detector system for RHIC Slow Controls (BNL/LANL)	Flexible Manufacturing Facility (Allied Signal)
RF for Next Linear Collider (SLAC)	The STAR detector system for RHIC Slow Controls (Creighton/U. Wash/Kent State/UCLA/LBNL)	Wastewater Treatment (Western Lake Superior Sanitary District)
DAHRT (LANL)	The Biotechnology Beamline (SSRL)	Potable Water Distribution (St. Louis County)
The Advanced Free Electron Laser (LANL)	The BaBar detector for B-factory Slow Controls (SLAC/LBNL)	Compressor Control (Baltimore G&E)
The HERA cryogenic plant (DESY)	Structural Biology Research Group (Riken)	GM Fuel Cell Program (LANL)

The Intense Pulsed Neutron Source (ANL)

Free Electron Laser (Budker INP

The Tesla Test Facility Injector (SACLAY)

Racetrack Microtron (U/Ala)

The Free Electron Laser Program (Duke)

The Heavy Ion Fusion Test Stand (LBNL)

RF and feedback for B-factory (SLAC)

The Average Power Laser Experiment (LANL)

LAMPF/LANSCE (LANL)

Advanced Light Source (partial) (LBNL)

National Laboratory for High Energy Physics (KEK)

Berlin Electron Synchrotron Light Source (BESSY II)

Microtron (University of Athens)

RF (PSI)

NASA Langley (wind tunnels)

Telescopes

The Gemini 8-M Telescope (AURA)

Kitt Peak Observatory (NOAO)

The United Kingdom Infrared Telescope upgrade (JAC)

The William Herschel Telescope/ WFFOS instrument (INGT)

The Keck II Telescope (CARA)

LIGO (CalTech)

Plant Simulation (Knolls)

Flight Simulation (JPL)

Fuel Depots (US Navy)

Product Storage/Movement Facility (Citgo)

Ground Tracking Station (NASA Canberra)

Well Head/Extraction (Saphania Oil Field)

EPICS - A Collaboration (cont.)

- Quarterly “collaboration” meetings at different sites (see example agenda)
    - Application Discussions
    - System Development/Evolution Discussions
    - Training/Tutorials
- EPICS List Servers (send e-mail to “listserv@aps.anl.gov” for more info)
    - tech-talk (internals)
    - epics_applications
    - beamline_controls
    - archives at http://www.aps.anl.gov/asd/controls/epics/maillists.html

Suppose I wanted to ...

- ... monitor and interact with my equipment
  - Define records/devices for each point to monitor and control
  - Create a Display Manager screen that connects to the PV's
  - Use any other EPICS compatible tool to access the PV's
- ... create a closed loop algorithm to maintain the temperature of my soup at 155 degrees.
  - Define a record to monitor the temperature and to control the temperature.
  - Define a PID record in the IOC or write a program on your workstation to implement your desired algorithm or add channel access capabilities to a third party 'closed loop control' package.

Suppose I wanted to ...

- ... inhibit control of certain process variables from certain users
    - configure the channel access security feature of EPICS
- ... record the settings of 1500 Process Variables so I can return to this setup tomorrow.
    - use BURT
- ... acquire and store 100 MBytes of data in 10 seconds or less
    - design a data acquisition system
- ... add my own support for records or devices
    - follow the rules and you get alot ‘for free’
- ... get more information about obtaining EPICS.
    - Bob Dalesio - LANL - dalesio@luke.atdiv.lanl.gov