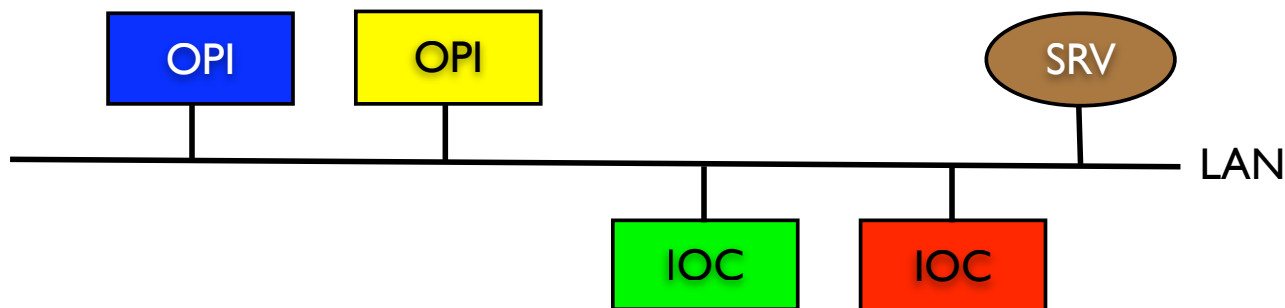


EPICS I

10 March 2008

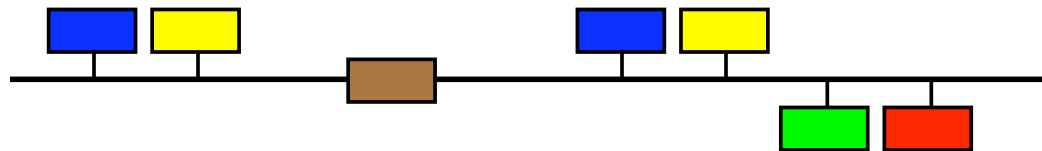
Basic Architecture

- **IOC (Input Output Controller)**
 - This is the *server*; at least one required
 - Real-time system that defines the Application
 - Traditionally a VME or cPCI crate (hard); can also be any PC/OS (soft)
- **OPI (Operator Interface)**
 - Workstation/PC with traditional OS (but could be diskless)
 - Runs EPICS *clients*
- **SRV (Server)**
 - Where Applications are built and loaded from
 - Can be file server for OPI clients
 - Can be archival repository



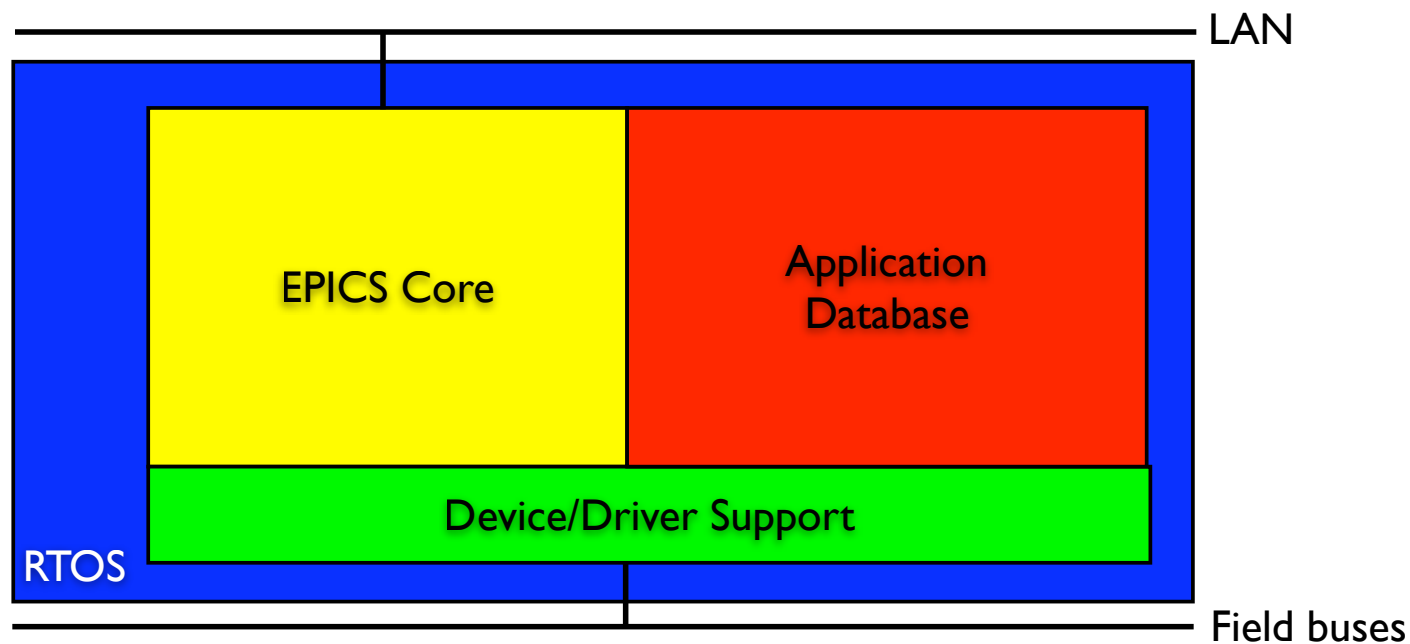
Basic Architecture

- Architecture is 'Flat'
 - Data moves peer-to-peer (no copy/no relay)
 - No central services; uses a 'discovery' protocol
 - No single-point-of-failure
- All entities are independent
 - Clients and servers can be started and stopped in any order
 - Minor versions can be mixed (3.x with 3.y)
- Network
 - Basic system runs on LAN
 - Gateways, switches, and routers can join LANs over WANs

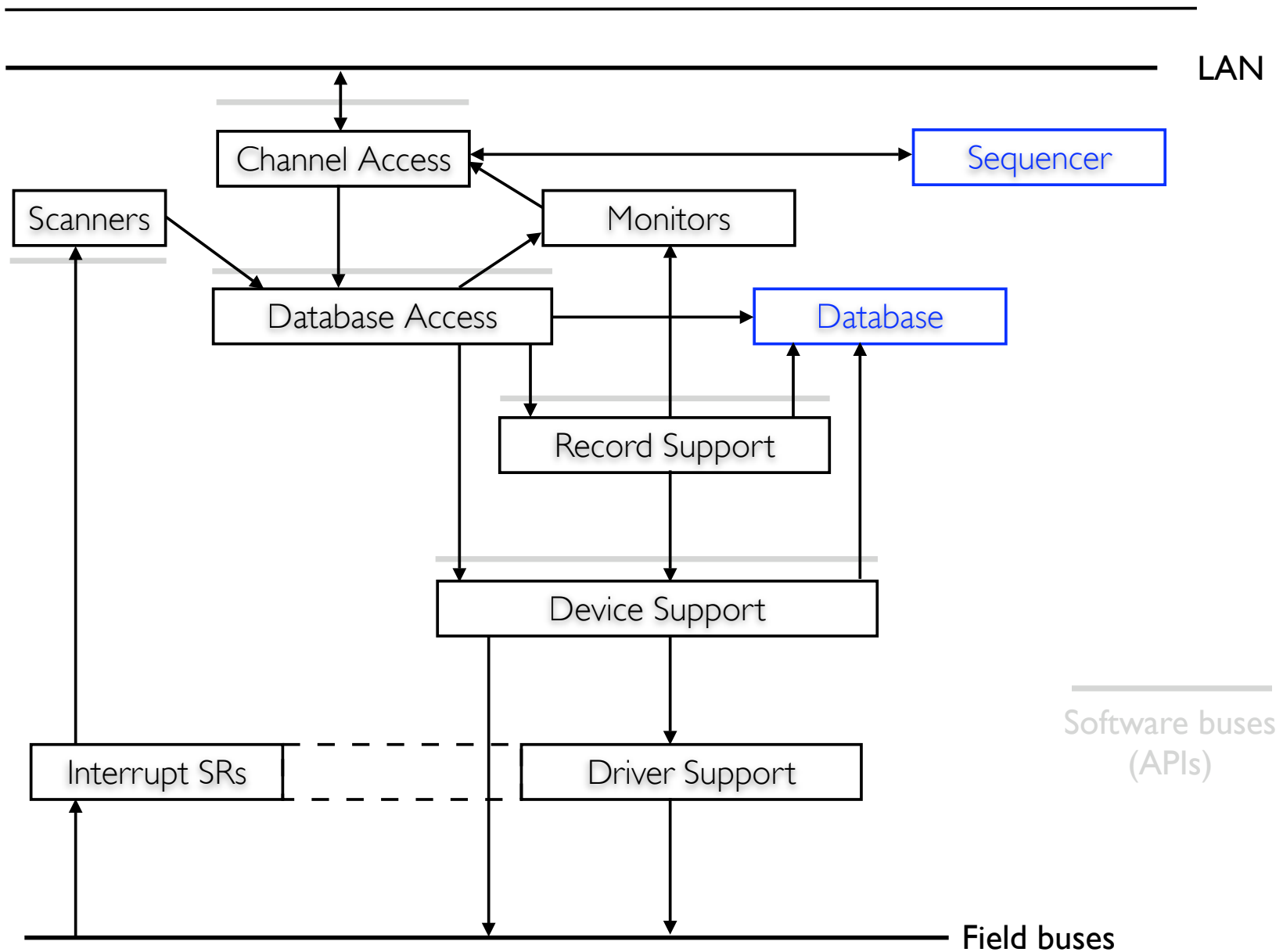


IOC: Basic Components

- EPICS Core ('iocCore'; 'base')
 - Shared (re-entrant) code for records
 - Channel Access server and client
- Application Database
 - Instances of record types, possibly linked
- Device/Driver Support
 - Device- and bus-specific code



IOC: Components



IOC: Components

- The **Database** and the **Sequencer** are the Application
 - Sequencer is a true *client*
- Channel Access (CA) is the *only* external entry point
- Record-/Device-/Driver-Support/Scanners provided to Application Developer

The Database is the Heart of EPICS

Channel Access is the Backbone of EPICS

The IOC Developer's Guide is the primary reference

IOC: Components

- Database (DB)
 - Memory-resident collection of 'function-blocks' (*aka* 'records')
 - Composed/Aggregated ('linked') to form combinatorial explosion of new functionality
 - Linkage mechanism 'transparent'
 - Deterministic; runs synchronously or asynchronously; periodically or even-driven
 - Has fine-grained Access Control
 - Provides Simulation and Tracing
 - Has textual and graphical representation (using VDCT)
 - This is main effort for Application Developer
 - Supports a rich variety of instantiation and macro substitution facilities

The fundamental job of the Application Developer is to instantiate and link records into the right processing 'chains'

IOC: Components

- Record Support

- Provides functionality for record types
 - Processing is what records 'do'
 - I/O records use Device Support for hardware access
- I/O records perform scaling, smoothing, masking, shifting, linearization, etc
- Performs limit checking and raises alarms
- Triggers monitors (callbacks)
- 'Pulls' or 'pushes' (or monitors) data via *Links*
 - Can link to records on other IOCs via Channel Access (ie, an IOC is also a *client*)

IOC: Components

- Record Types

- I/O types

- Analog IN/OUT (ADC, DAC)
 - Binary IN/OUT (TTL, relay, ...)
 - Long IN/OUT (Counter, Timer, Scalar)
 - Motor
 - String IN/OUT (TCP/IP, RS-232, GPIB, ...)
 - Waveform (Digitizer, camera, ...)

- Secondary processing types

- Calculation
 - Escape-to-C subroutine
 - Proportional-Integral-Derivative (feedback)
 - Transform

IOC: Components

- Record Types
 - Data Storage types
 - Compression
 - Histogram
 - SubArray
 - State
 - Control
 - Data Fanout
 - Control Fanout
 - Event
 - Select
 - Sequence
 - Scan
 - Wait

The Record Reference Manual and other documents provide details

IOC: Components

•Record Fields

A record's attributes are held in its *fields*. A field name is a 3- or 4-character abbreviation. Each field of a record (also called a *Process Variable*, or PV) is a *Channel*.

All records 'inherit' a core set of fields:

- NAME—the only way CA clients can find it
- DESC—a free-form description
- VAL —the quantity ('value') of interest
- FLNK—forward processing to another record

Other records have more specific fields:

- DTYP—device type for I/O records
- INP —input parameters for I/O records
- OUT —output parameters for I/O records

IOC: Components

- Device Support
 - Isolates Record Support from hardware details
 - New devices use can old records
 - Optionally uses Driver Support
 - ‘Soft’ types (available for most records) provide place-holders for simulation, client persistence, ‘global’ items, etc
- Driver Support
 - Used typically for non-trivial low-level bus I/O, wire protocols, etc
 - *Not EPICS-specific (but usually bus-specific and often OS-specific)*

*A large repertoire of Device and Driver routines
are shared by the EPICS community*

IOC: Components

- Scanners

- These are the active threads that call the working records' code
- Every record has a one of these scanning types specified:
 - Periodic
 - A (modifiable) selection of rates, typically 10 Hz to 1 minute
 - Event
 - One of 255 'soft' events, via other records or Channel Access
 - Via hardware interrupt (I/O complete)
 - Supports asynchronous I/O with appropriate Driver Support
 - Passive
 - Invoked by 'push', 'pull', or 'forward' link from another record
 - Invoked by Channel Access 'put'

Selecting the best scanning option for each record is the 'art' of configuring an EPICS database; and often many equivalent solutions exist

IOC: Components

- Channel Access (CA)
 - It is the only portal between external entities and the database
 - Even a co-resident Sequencer is a 'pure' CA client
 - It is fundamentally a publish/subscribe paradigm
 - Based on TCP/IP
 - TCP for data transport
 - UDP for connection management
 - Basic Operations
 - Search and Connect to a Channel*
 - Write to that Channel ('put')
 - Read from that Channel ('get')
 - Monitor (await callback from) that Channel
 - Disconnect from that Channel

**A Channel is defined as:*

`"<record_name>.<field_name>"`

IOC: Components

- Channel Access...
 - Read and Monitor return:
 - Value requested
 - Time-stamp
 - Status (read/write/access/undefined/...)
 - Severity (normal/minor/major/undefined)
 - Hard and Soft IOCs contain both client and server
 - OPI tools use only client

IOC: other

- Autosave
 - Implements 'warm reboot'
 - Saves changed values ('set-points') back to server
 - Restores them after reboot
 - Developer supplies a list of PVs
- Console access
 - 'Debug' serial port on all IOCs wired to Terminal Server
 - Can watch start-up script
 - Can run CA, Sequencer, DB diagnostics
- VME Remote crate control
 - Control/Monitor power, voltages, temperatures
 - 'Hard' and 'Soft' reset when even Console access fails
- IOC self-monitoring
 - heart-beat, time-of-day, resource loading

Sequencer

Implements a true Finite-State Machine (FSM), with some Harel extensions. Source code is written in the State Notation Language (SNL) which is compiled into C by the EPICS build system. (Channel Access and Connection Management is part of SNL.) A Sequencer program is a collection of communicating 'state sets', each of which has states and transitions.

Whereas the Database is optimum for combinatorial solutions, the Sequencer is best for time-dependent solutions.

State transitions are triggered by any combination of: elapsed time; channel change; channel value; and software event.

SNL code is re-entrant and supports multiple instantiation with macro substitution.

Inspection of running sequences is provided. It runs directly on an IOC and also on any OPI or SRV host.

```
State A{
    when( X ) {
        do Y;
    } State B;
    ...
}
...
```

Client Tools

- All of these allow drag-and-drop of PV names between them
- `caget` and `caput` from command line
 - Quick sanity check on all of the following...
- Probe
 - Single PV GUI-style diagnostic; handy monitor/adjust functions
- Extensible Display Manager (EDM)
 - Implements 'soft' control panels for typical devices
 - Drag-and-drop from palette of appropriate widgets
 - Only PV names required
 - Excellent macro substitution facility
 - Pre-built screens for all known devices
- StripTool
 - Multi-channel emulation of paper strip-chart recorder
- Alarm Handler (ALH)
 - Provides a hierarchy to drill down to 'first-fault'
 - Can invoke EDM screens, dial pagers, call processes, give help
 - Excellent macro substitution facility

Client Tools

- Channel Access is available as library or plug-in for
 - Matlab
 - C/C++
 - Python
 - Mathematica
 - Java
 - Perl
 - LabView
 - Unix/Linux shells