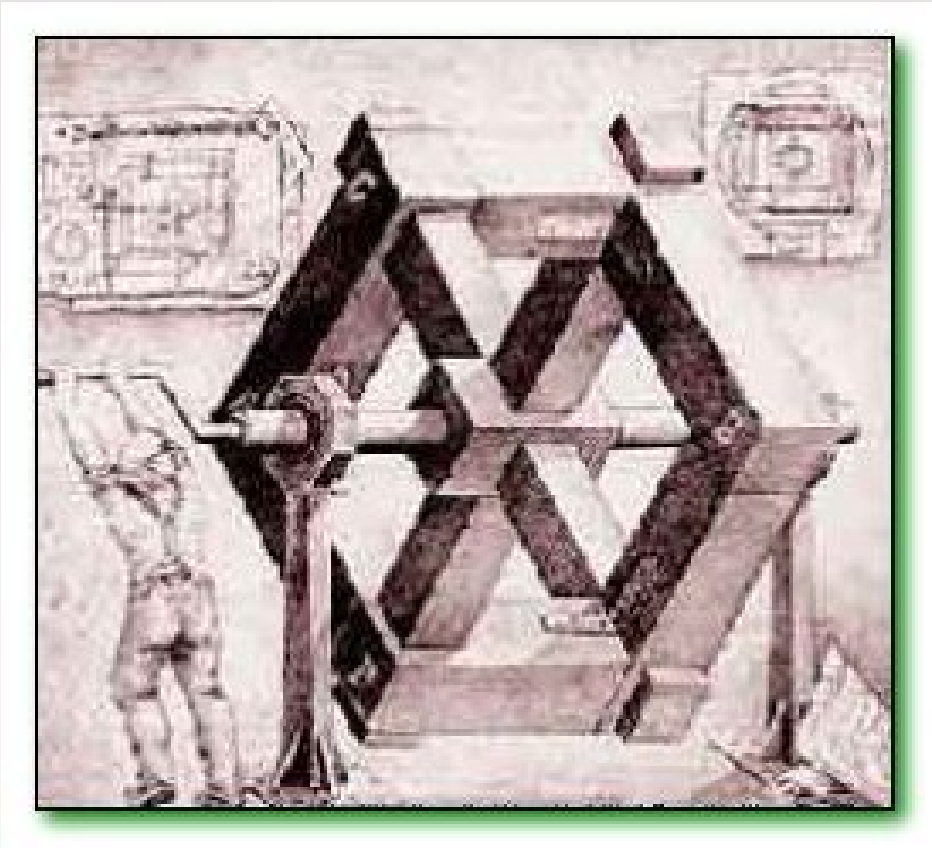
EPICS

- iThemba LABS
- What is EPICS?
- How does it work?
- Demonstration!
- Can we use it?
- Problems we face!



What is EPICS?

- **E**xperimental **P**hysics and **I**ndustrial **C**ontrol **S**ystem
- EPICS Base = Network Data System
- Records (more on this later)
- Hardware control (drivers)
- Operator Interfaces
- EPICS extensions (more on this later)

Global Collaboration

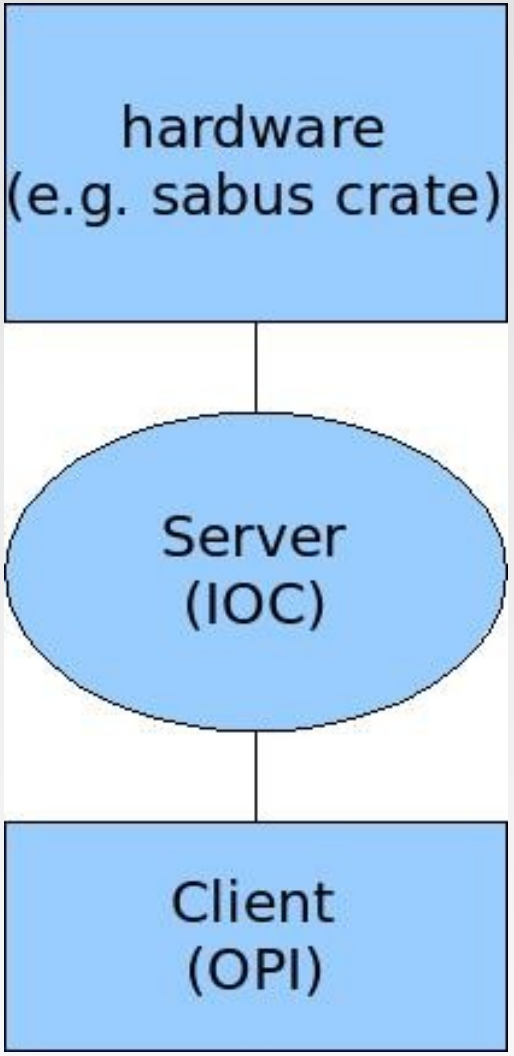
- Began in 1989 between LANL/GTA & ANL/APS
- Only became open source later
- Used in more than 8 major facilities world wide
- EPICS collaboration meeting held every so often
- Many people contributing (including us)

EPICS Base

- At the core EPICS is simply a program/tool to manage data in a network transparent environment.
- data is organized into records
- EPICS DataBase is not relational (not SQL)
- Data can be accessed from anywhere (Channel Access)
- Other usefull functionality

Global view

- This is the overview of the system - simplified
- The most important part of EPICS is in the Server and how the Server and client communicates.



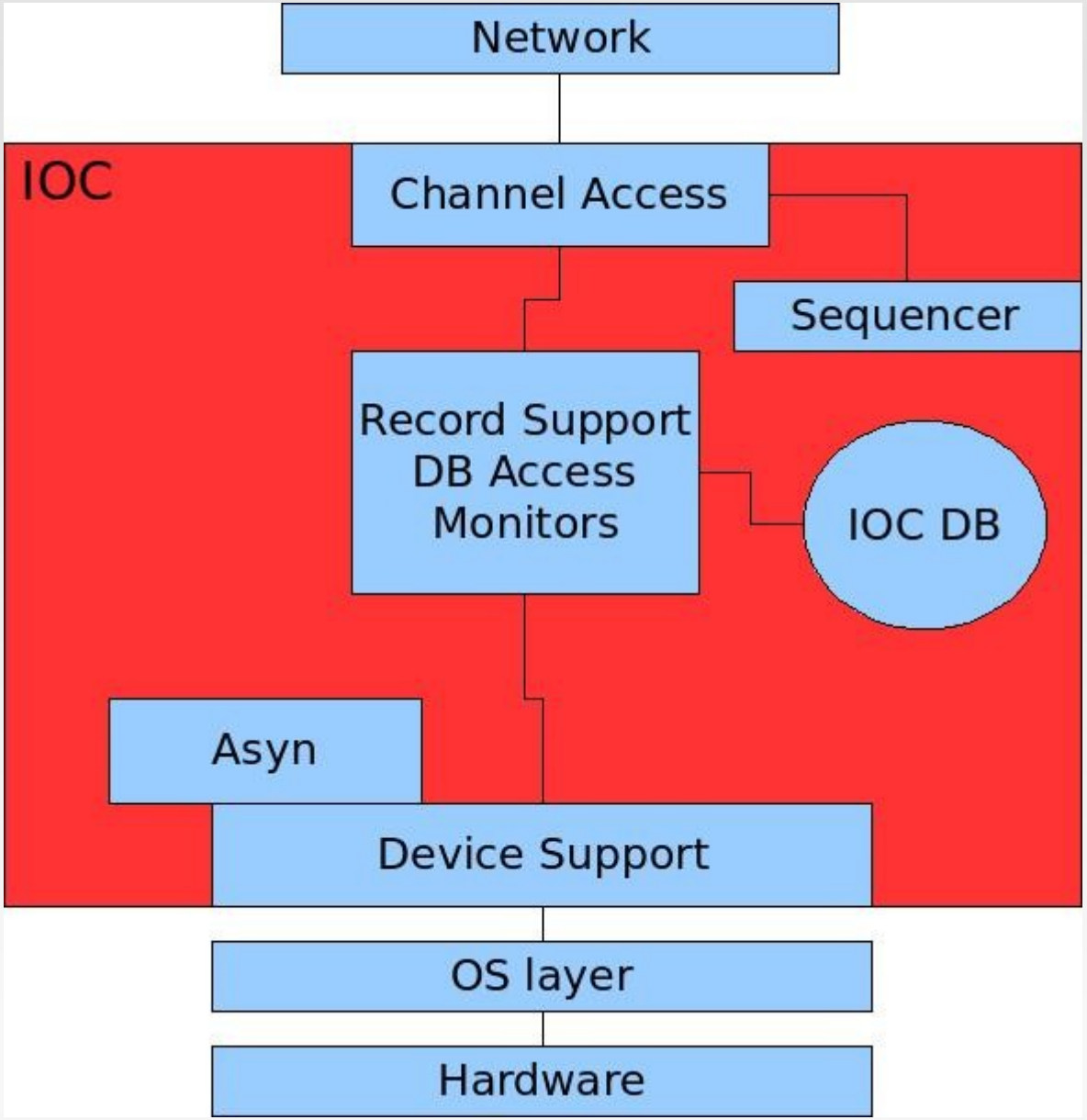
Client interfaces

- Different programs are available
- OPI = Operator Inteface
- General: MEDM
- Many extension programs work as clients.

The IOC – overview

- The IOC communicates with the hardware
- The IOC provides PV's (process variables) to the rest of the network (clients)
- It has an EPICS database in which all active records of this IOC are located
- Can run on Linux, RTEMS and Windows (cygwin is used under windows)
- Provides a local console interface
- Uses a startup script to load and initialize

The IOC - diagram



Device Support & Asyn

- The layer that is between Records and hardware.
- Provides an extra layer to seperate Record functionality from hardware functionality.
- Asyn is a library that provides functionality to create drivers with standard record interfaces
- Synchronous and Asynchronous support

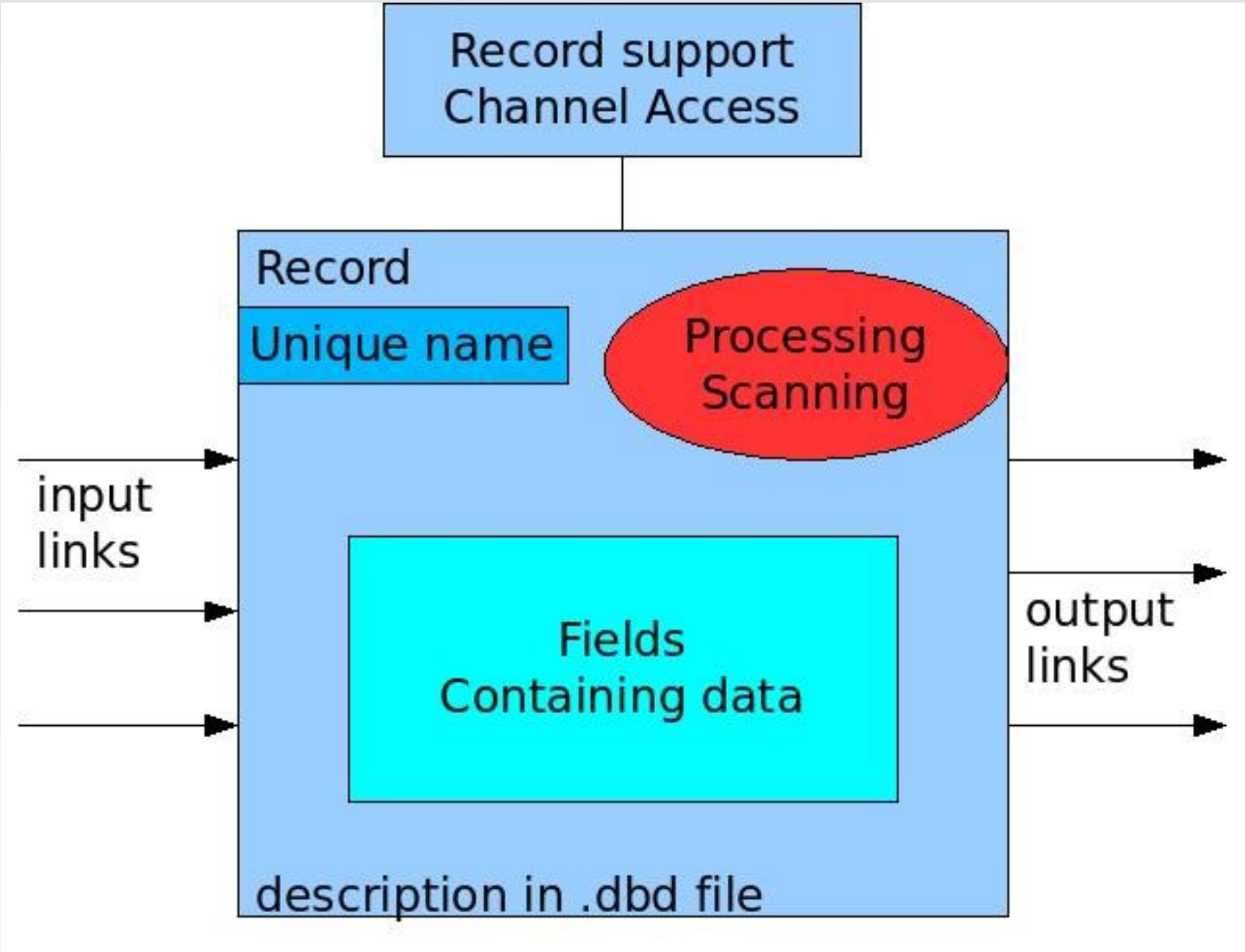
The IOC - Database

- Not a relational database!
- Contains the EPICS records
- Database configuration done in .db text file. (Can be done with some visualization programs)
- Database description in .dbd file (text)
- The database setup is static and the IOC must be restarted to change it.

Records

- A structure with Data fields
- Has a unique name (PV name)
- There are many standard usefull records
- Record fields can be accessed from anywhere
- Record can perform special functions ie. they are not just static data containers)
- Records can be linked to other records

Record - diagram



Record fields

- A field contains data
- Different types of data supported (int,string,float) – Arrays on all types
- There are standard fields: NAME, VAL, PROC, SCAN ect
- Fields can be monitored (CA – later)

Record processing

- Records can perform processing. Function depends on record types.
- When: Scan Rates / Passive / IO Intr
- Can perform calculations/conversions/etc
- Can trigger other records to be processed
- Some records does special processing if certain fields are modified

Record Alarms

- Most Records have an alarm status and severity
- Can be monitored and logged by special Alarm handler program.
- e.g. Analog Input Record
  Can be set to generate alarm if value goes too high or too low. Supports 2 alarm levels

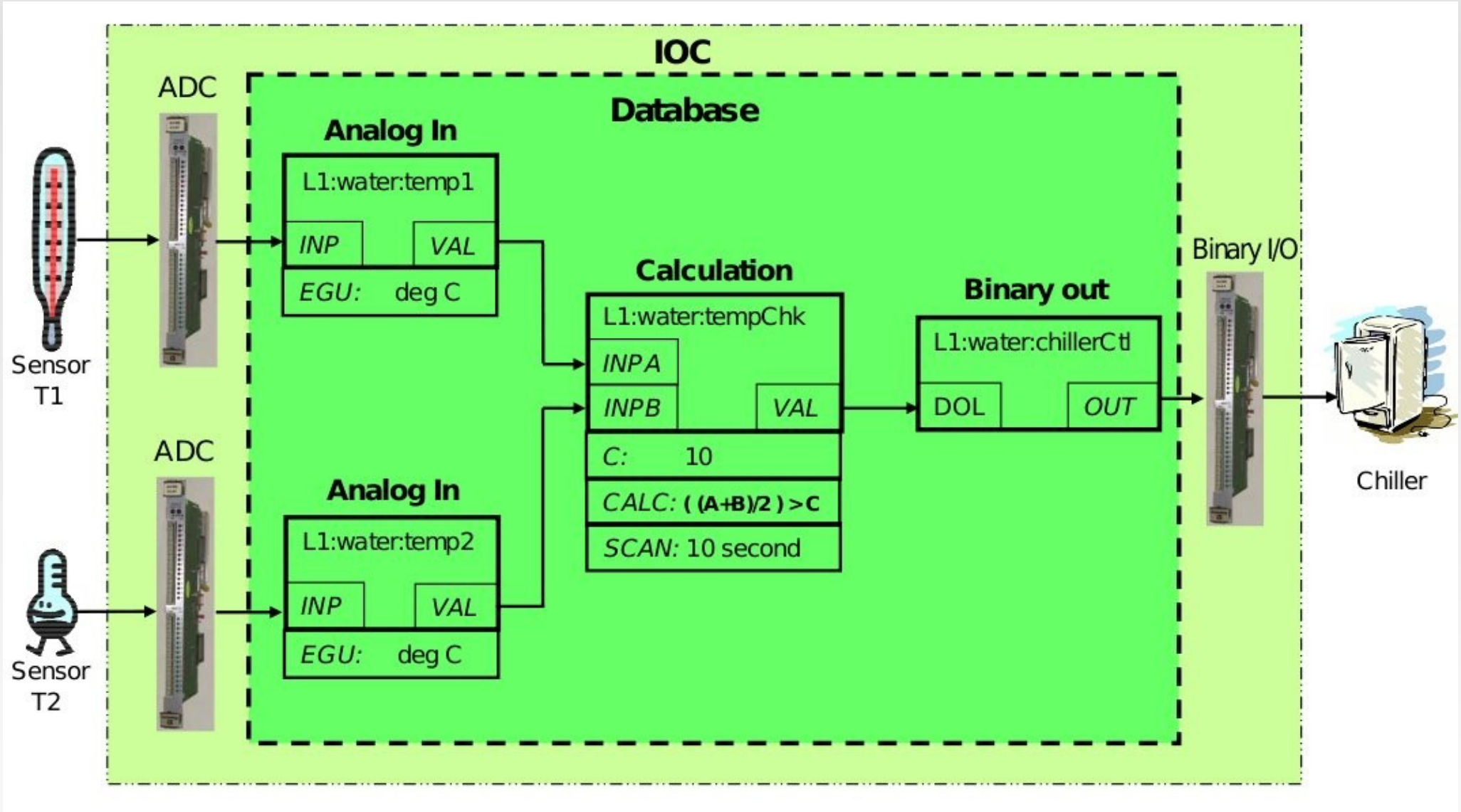
Some standard Records

- Analog in/out
- Binary in/out
- Calc
- Waveform
- Sequence
- PID control
- to name but a few. (Custom records can be created if needed)

Process Variables (PVs)

- A PV is a channel access ID to access a specific field of a specific record
- e.g. RF1:amplitude.VAL
- .VAL is the default field (if not specified)
- Command line utilities available to do basic Channel Access. (put/get/monitor)

Record link example



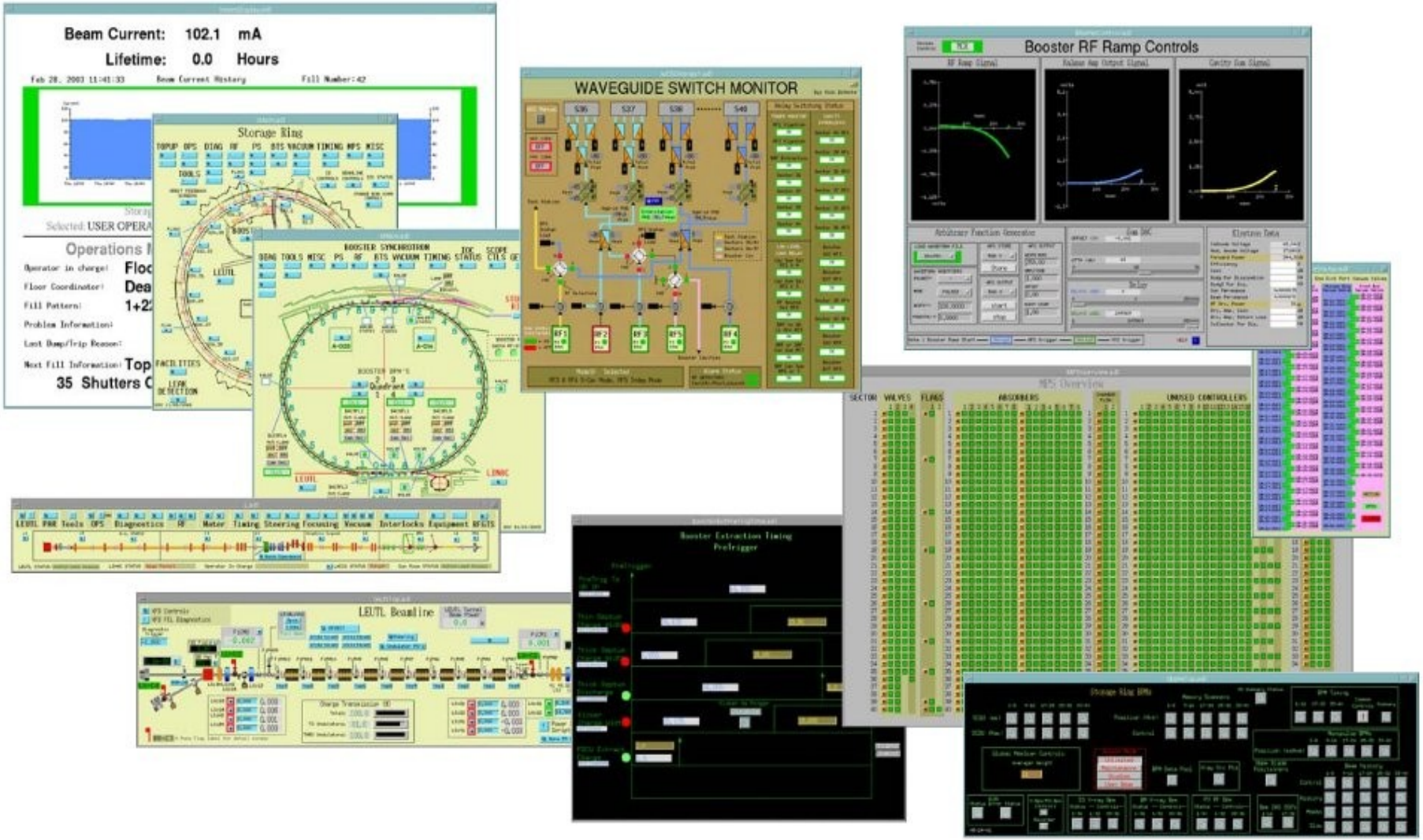
The Sequencer

- The sequencer is a **state machine** program
- Compiled to native C code – very fast
- Complex functionality on records
- Can run inside IOC or as a client program
- Fairly easy to write. (C type syntax called SNL)

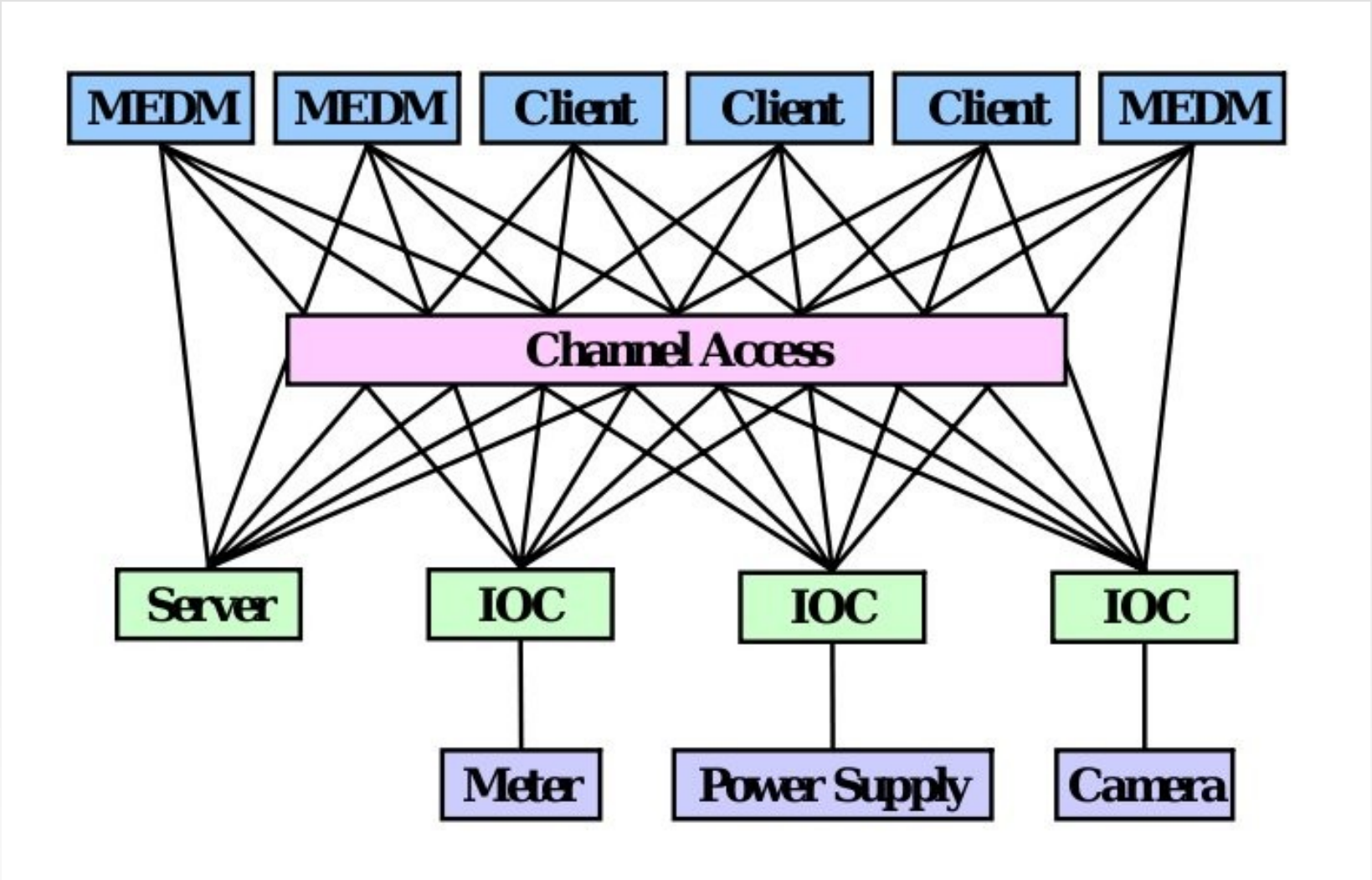
Operator Interfaces

- Any client program can access any record from any IOC on the local network.
- Interfaces can be created with MEDM. (Motif GUI)
- Other client programs exists for special functions:
  Alarm handlers
  Strip Tool
  ect

MEDM Examples



Channel Access



Channel Access - Function

- Finding PVs (Using broadcasting search messages)
- After a PV has been located a single TCP/IP connection is made between the client and server
- CA server – usually an IOC but anything that provides PVs to the network
- CA client – usually an OPI but anything that uses CA to access PVs

Channel Access - Function

- Reading Data from PVs (Over TCP/IP)
- Writing Data into PVs (Over TCP/IP)
- Monitoring PVs:
- Client request monitors (subscribing)
- Servers has list of monitors (client list)
- When value changes Server sends message to all clients
- Clients then reads new data
- Can monitor data/limits/alarms/time

Channel Access - Other

- Connections can be lost or PVs not found or not available
- Automatic Type conversion
- Scales to network throughput (data loss)
- Only searches local network – Needs EPICS gateways to go beyond
- Standard C library (Threading capable)

EPICS extensions

- Many extensions exist with specialized and general functionality
- Backup and Restore utility (BURT)
- Channel Access Save Restore (autosave/ChannelWatcher)
- Channel Archiver
- Alarm handler
- Array display tool
- CMLOG – Message Log system

EPICS extensions

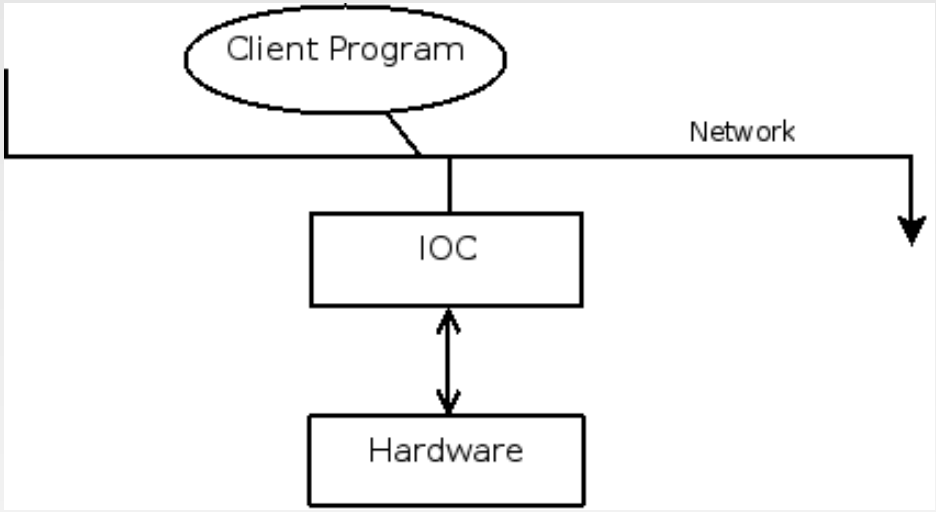
- auto save (Keep variables across Power-Down)
- Channel Watcher
- StripTool (Plot PVs over Time)
- Gateway (used to link PVs across sub-nets)
- probe (simply wathes/proves a PV)
- SDDS (self describing data sets)
- PHP / Python / Java / Matlab / LabView interfaces
- MEDM (Display manager)
- Histogram Tool
- More Available

Bringing it together

- The players:
- Hardware
- IOC's (Controlling computers)
- OPI's (Operator Interfaces)
- Other client programs. (eg Alarm Handler)

Global overview

- Can have multiple IOC's
- 1 IOC per machine
- Many client programs
- Scalable
- Hardware link can also be ethernet



SDDS

- Self Describing Data Sets
- Complex powerfull system on top of EPICS
- Data Analyzing/Collection
- Complex Process Control
- Higher level Control than general EPICS
- Complex, big, powerful and flexible
- Used by many other extensions

SDDS - more

- SDDS = Standardized way to store data
- Many tools available to ”process” data
- Data can come from many different sources. EPICS / simulation / matlab ect
- Data can be visualized in many ways. (Programs can be generic)

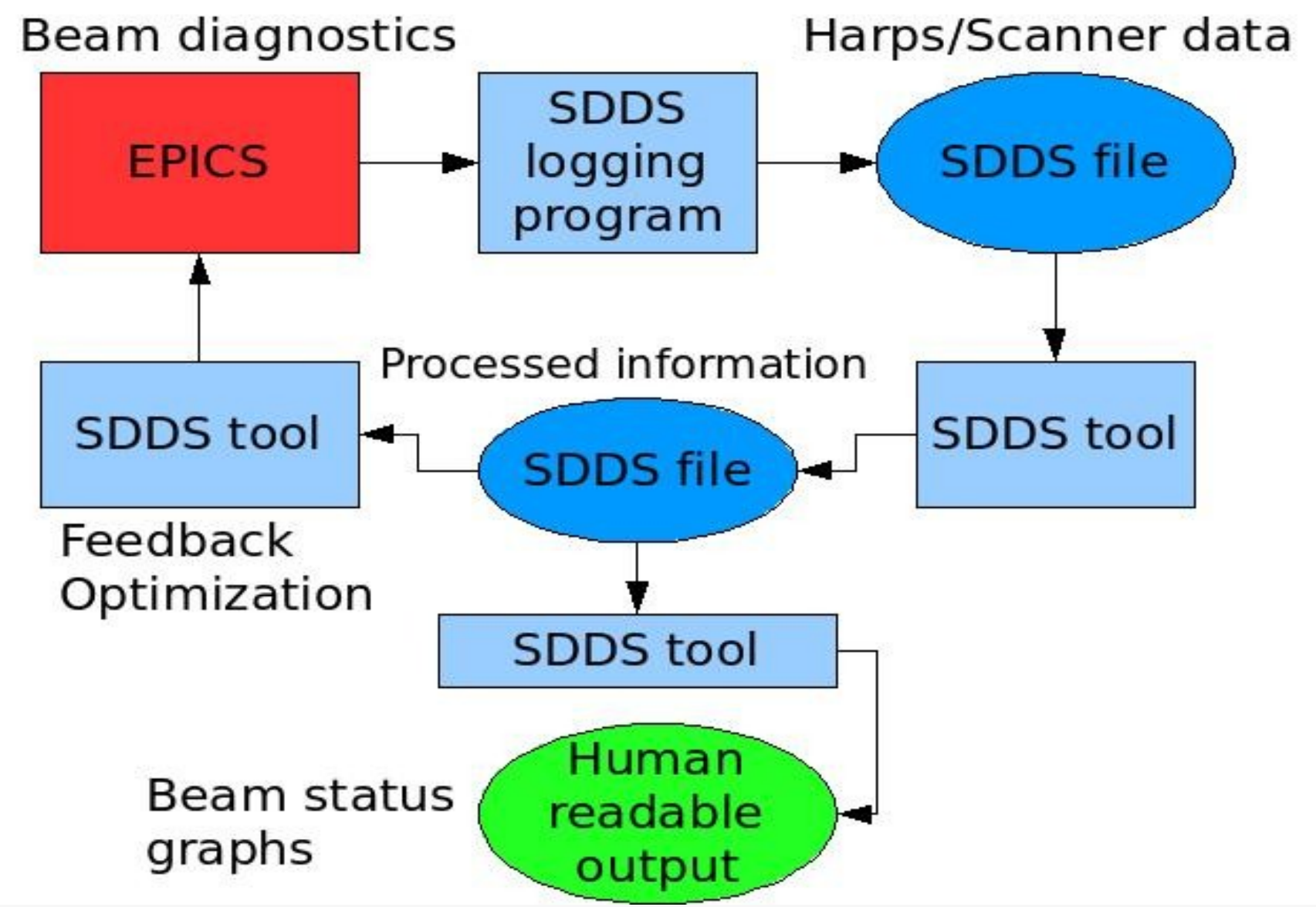
SDDS Concept

- We have Data – can store in text file/spreadsheet
- Try to organize – headers?
- SDDS access data by name
- Spreadsheet is owned by 1 program
- Any SDDS tool can work with SDDS data – extra/missing data will not break programs
- SDDS contains information about data types and so on
- Allows programs/systems to evolve without breaking code

SDDS and EPICS

- Data can be collected from EPICS
  - at intervals
  - event driven
  - alarm logging
  - save/restore of EPICS data
- Control of EPICS
  - feedback control
  - optimization

SDDS - Diagram

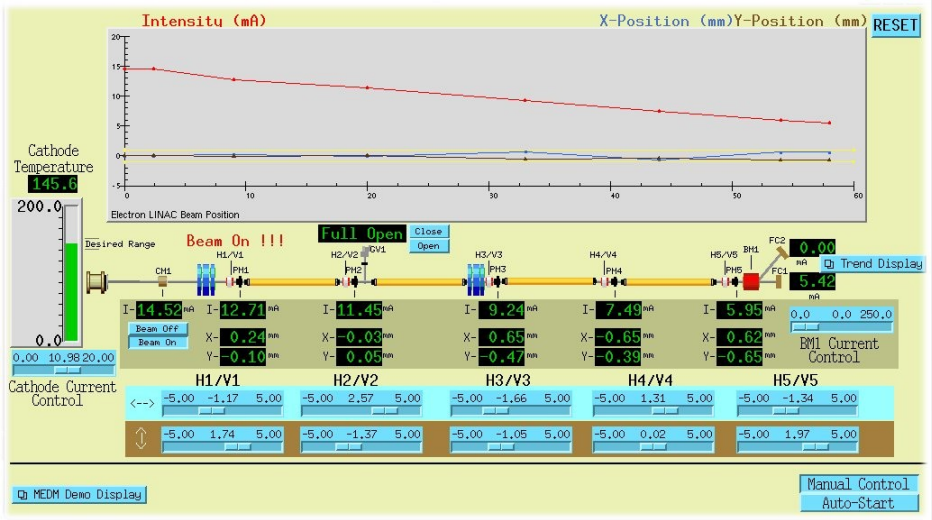


Questions?

- Any questions at this time?
- About half way to finish :)

EPICS in action

- Vlinac – simulation
- IOC console
- MEDM
- Alarm Handler
- StripTool
- Python Script
- Scanners maybe



CMLOG screenshot

File Options Preferences Help

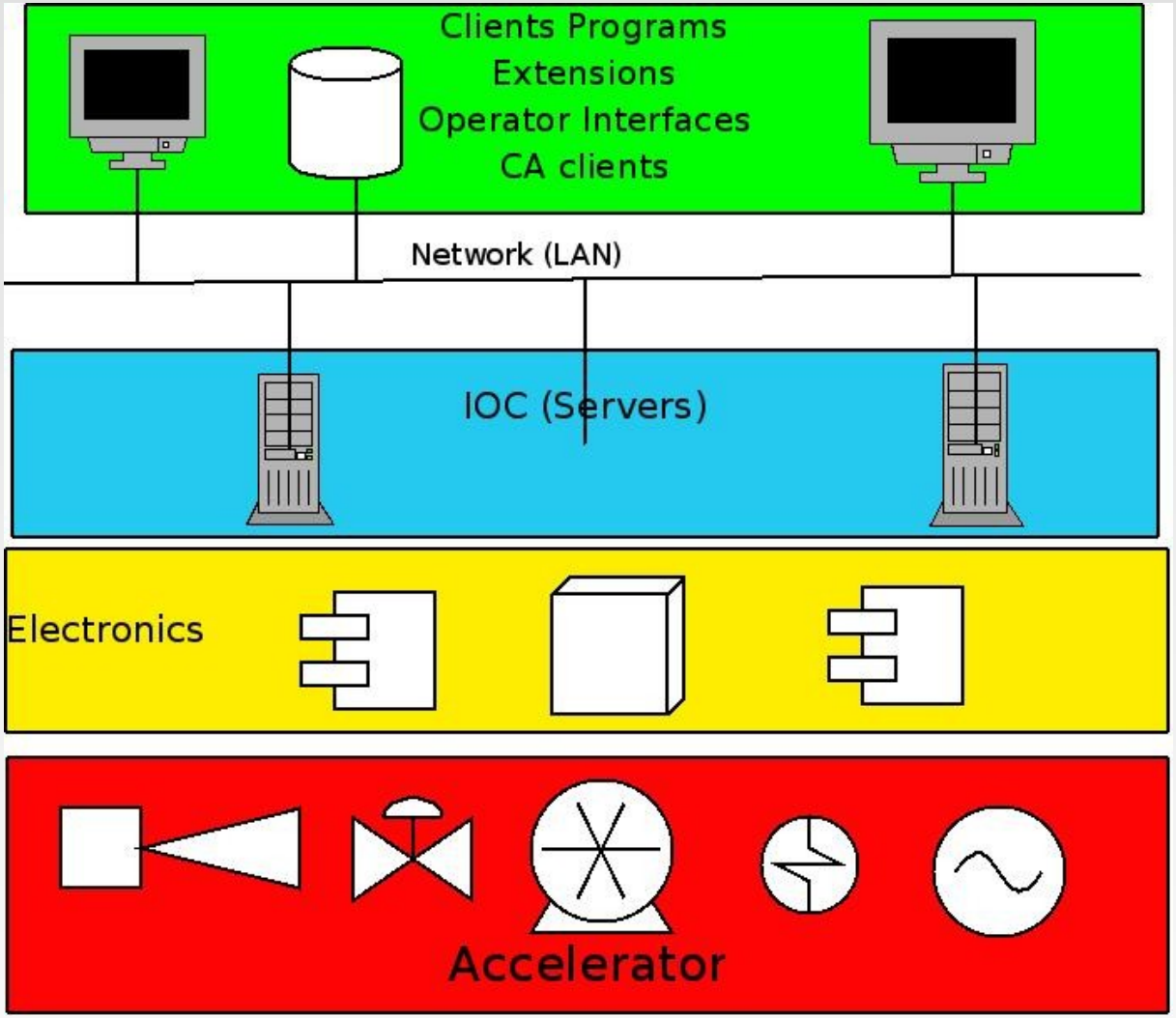
Facility	Host	User	Time	Status	Severity	Error	Object	Message
CODA	sysdevs1	chen	Wed Feb 23 11:25:46 2000	OK	SEV_INFO	20	N/A	New error message happend at 20
CODA	sysdevs1	chen	Wed Feb 23 11:25:47 2000	OK	SEV_WARN	21	N/A	New error message happend at 21
CODA	sysdevs1	chen	Wed Feb 23 11:25:48 2000	OK	SEV_ERROR	22	N/A	New error message happend at 22
CODA	sysdevs1	chen	Wed Feb 23 11:25:49 2000	OK	SEV_SEVERE	23	N/A	New error message happend at 23
CODA	sysdevs1	chen	Wed Feb 23 11:25:50 2000	OK	4	24	N/A	New error message happend at 24
CODA	sysdevs1	chen	Wed Feb 23 11:25:51 2000	OK	5	25	N/A	New error message happend at 25
CODA	sysdevs1	chen	Wed Feb 23 11:25:52 2000	OK	6	26	N/A	New error message happend at 26
CODA	sysdevs1	chen	Wed Feb 23 11:25:53 2000	OK	7	27	N/A	New error message happend at 27
CODA	sysdevs1	chen	Wed Feb 23 11:25:54 2000	OK	8	28	N/A	New error message happend at 28
CODA	sysdevs1	chen	Wed Feb 23 11:25:55 2000	OK	9	29	N/A	New error message happend at 29
CODA	sysdevs1	chen	Wed Feb 23 11:25:56 2000	OK	10	30	N/A	New error message happend at 30
CODA	sysdevs1	chen	Wed Feb 23 11:25:57 2000	OK	11	31	N/A	New error message happend at 31
CODA	sysdevs1	chen	Wed Feb 23 11:25:58 2000	OK	12	32	N/A	New error message happend at 32
CODA	sysdevs1	chen	Wed Feb 23 11:25:59 2000	OK	13	33	N/A	New error message happend at 33
CODA	sysdevs1	chen	Wed Feb 23 11:26:00 2000	OK	14	34	N/A	New error message happend at 34
CODA	sysdevs1	chen	Wed Feb 23 11:26:01 2000	OK	15	35	N/A	New error message happend at 35
CODA	sysdevs1	chen	Wed Feb 23 11:26:02 2000	OK	16	36	N/A	New error message happend at 36
CODA	sysdevs1	chen	Wed Feb 23 11:26:03 2000	OK	17	37	N/A	New error message happend at 37
CODA	sysdevs1	chen	Wed Feb 23 11:26:04 2000	OK	18	38	N/A	New error message happend at 38
CODA	sysdevs1	chen	Wed Feb 23 11:26:05 2000	OK	19	39	N/A	New error message happend at 39

Wed Feb 23 11:26:27 2000 From Wed Feb 23 11:25:34 2000 To

Learning EPICS

- As you can see there is a steep learning curve
- Luckily not everybody needs to learn everything!
- But on the other hand even end-users and operators will need to learn something
- Guided learning wiki page: http://medsvr.tlabs.ac.za/epics:learn
- Specific to operators: http://medsvr.tlabs.ac.za/epics:operatoreducation

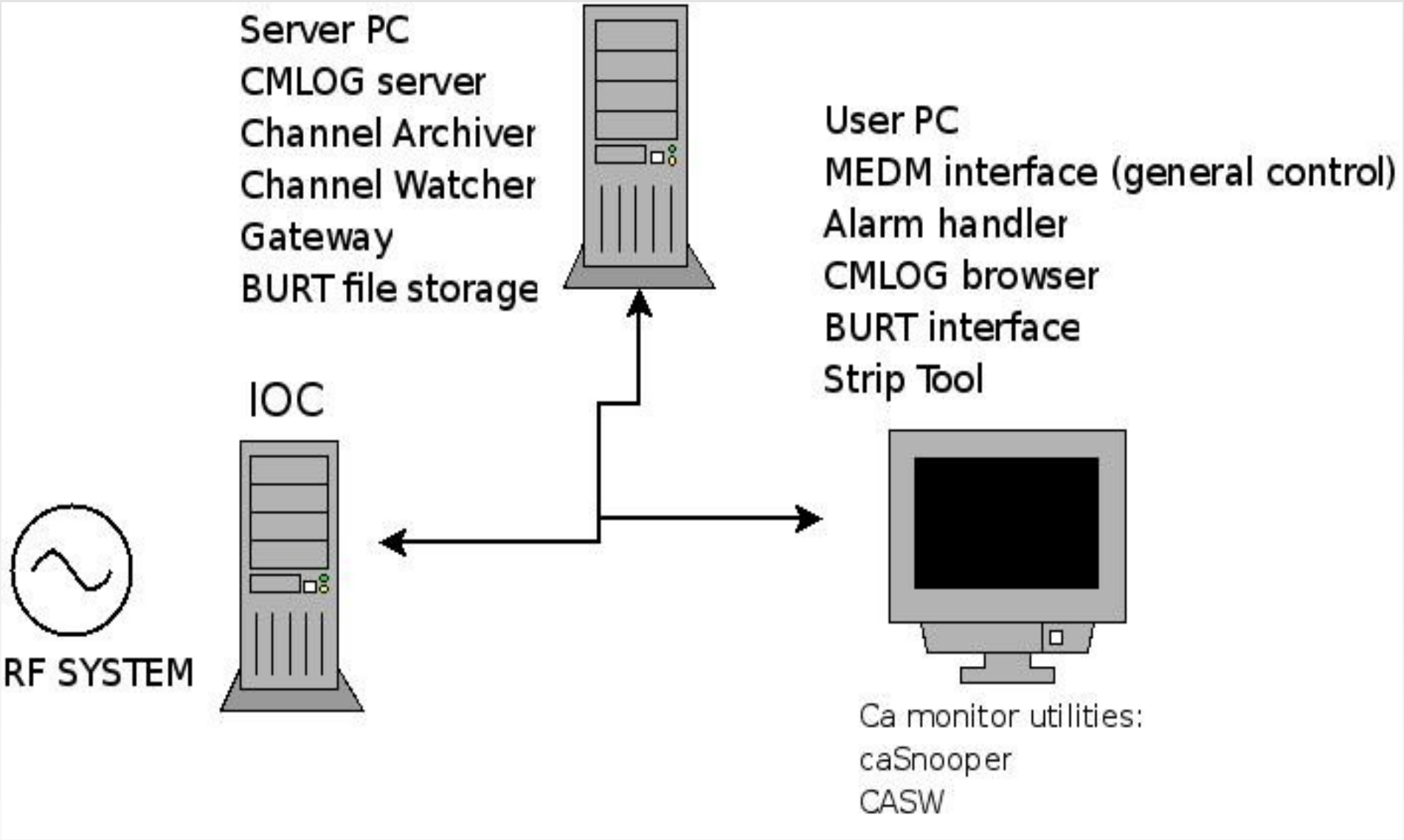
RECAP :)


Clients Programs
Extensions
Operator Interfaces
CA clients
Network (LAN)
IOC (Servers)
Electronics
Accelerator

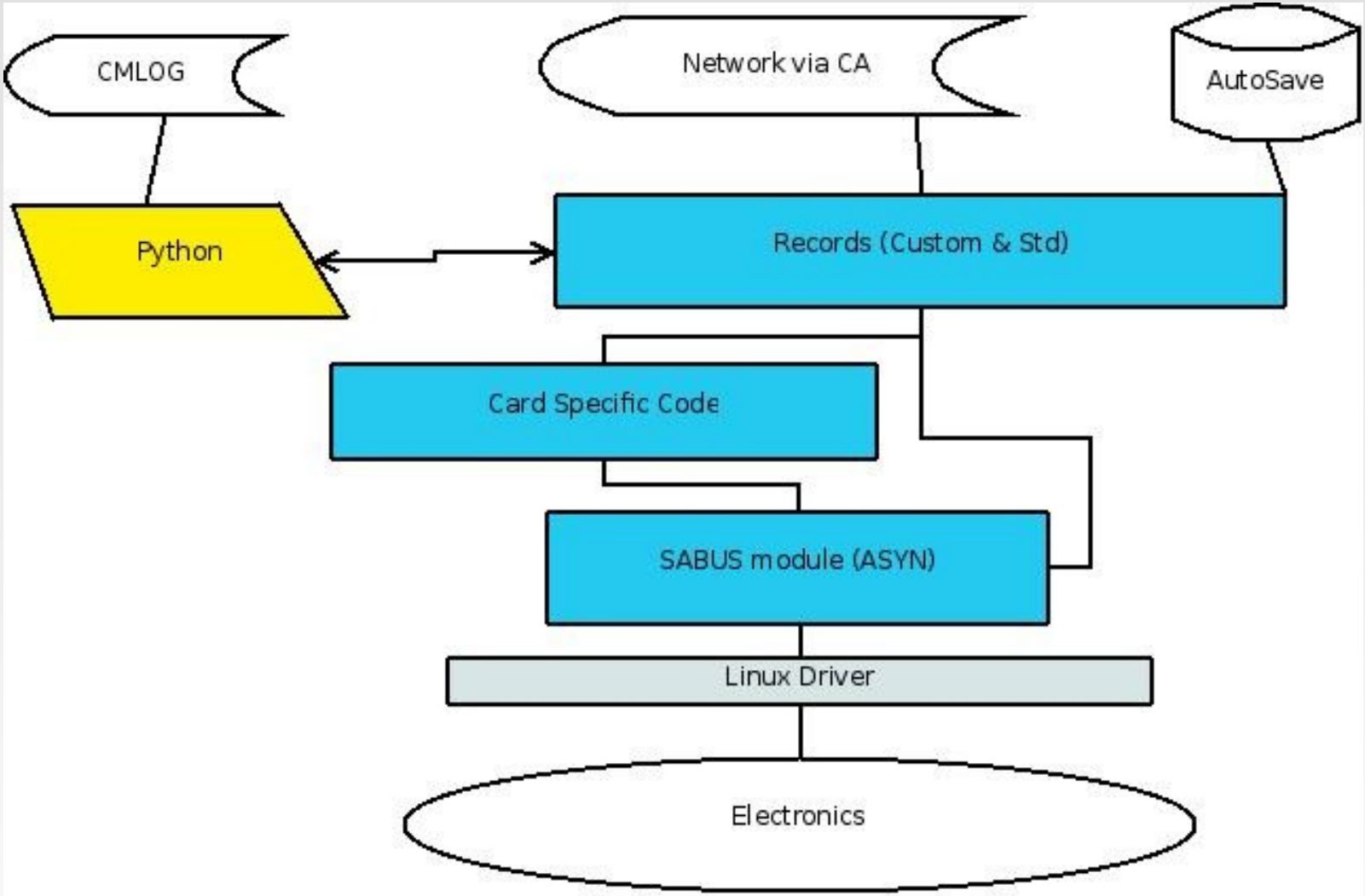
RECAP :}

- EPICS Base (core system / DB / network)
- Records (Fields / PVs / Processing)
- IOC (Server / DB / Hardware – CA)
- Device Support
- Channel Access (Data over network)
- OPI (MEDM / Alarm Handler)
- SDDS (Data Collection & Analysis)

RF system Overview



RF System - IOC



EPICS Community

- Global Community
- Many contributors
- Support YES! (mailing list)
- Open Source (this is good!)
- Lots of Expertise

What can we do? ...so far

- SABUS diff driver
- Support for SABUS: 24-bit IO, Stepper Motor & ADC-16(ECS43) (working on PSC)
- Can speak to rabbits (DDS control) (BETA)
- Bridge to the variable table (BETA)
- Busy developing RF system (SPC1FT) – ready for implementation
- Python inside IOC (used for RF system)
- National Instruments driver
- Comedi driver – now fully functional
- Scanners (custom record ect)
- Wiki: http://medsvr.tlabs.ac.za/epics
- This list is growing!!!

Can we use it?

- We certainly CAN!
- It provides a very Good BASE system for us to use.
- Support provided through mailing list
- Linux is a good platform for control systems
- Many things can be done without programming (db setup, interface creation, log systems)
- It is however not a plug-and-play solution

Problems - hardware

- Most of our hardware is custom made
- This requires custom device drivers and sometimes custom records to be created
- Not all our hardware was designed with EPICS in mind and therefore is sometimes difficult to control.

Problems - OPI

- The MEDM program uses a fairly outdated GUI
- Developing a Qt interface will take time
- On the bright side, MEDM can easily run on windows (Or that's what it claims)
- Even with MEDM creating interfaces takes time and effort

A QT client program?

- Not absolutely necessary
- BUT would be absolutely GREAT!
- Roadmap: (Not final!)
- Making a link between QT and CA
- Creating some custom widgets for PV display/control
- Linking QT with CMLOG
- Extending Designer and creating tools for easy custom interface creation with QT
- Maybe have some way to convert old MEDM screens?
- linking with SDDS

Problems – Programming

- It is true that a lot of things can be done without programming, and alot has already been done.
- But programming will need to be done.
- IOC's are to be written in C/C++. (No DotNet/c#/garbage collection)
- Client programs can be done in Python (SDDS also has many tools)

Problems - general

- EPICS does have a steep learning curve
- Everybody who works with the system will need to understand some basics, can't just put people in front of a screen
- As this will be a large project there must be good project management on a much larger scale. (Documentation etc)

Questions?

- Any Questions related to EPICS in general or EPICS at iThemba LABS?
- Further information at:
- http://medsvr.tlabs.ac.za/epics
- Documentation and everything else linked from there
- Need for a more indepth/specialized presentation for developers?

Thank you