Decision Support System for the Advanced Photon Source

D. A. Dohan
Advanced Photon Source
Control System Phases

- Create/assemble the tools
- Build the C/S and make it work (get beam!)
Control System Phases

- Create/assemble the tools
- Build the C/S and make it work (get beam!)
  - Mature control system (maintenance phase)
- Migrate
Symptoms of a Mature Control System

- routine machine operation
  - tight boundary conditions for software changes
- #LOC is stable or diminishing
  - better, not more code
  - detailed understanding of device and subsystem behavior
  - explore client application interaction
- obsolete hardware – replacement issues, spares strategy
- staff turnover
- architectural design choices (good and bad) are here to stay
Symptoms of a Mature Control System

- routine machine operation
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HOWEVER:

- new functionality and capabilities continually being requested
APS operation
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145 networked IOCs
EPICS Control Software

High Level Clients:
MEDM, AH, SDDS Logger, etc

channel access

embedded P/S controllers,
PLCs, timing system DSPs, …

APS Control System Software
record(ai, "L3:DG10:cDelayAI") { 
  field(DESC, "Chan C Delay")
  field(SCAN, "Passive")
  field(PINI, "NO")
  field(TSEL, "0")
  field(DTYP, "DG535 Delay Generator (GPIB)")
  field(SDIS, "L3:DG10:scanDisableCC.VAL NPP NMS")
  field(DISS, "INVALID")
  field(PRI0, "LOW")
  field(FLNK, "L3:DG10:cDelaySI.VAL")
  field(INP, "#L1 A15 @45")
  field(PREC, "16")
  field(LINR, "NO CONVERSION")
  field(EGUF, "1000")
  field(EGU, "sec")
  field(HOPR, "1000")
  field(LOPR, "0")
  field(HHSV, "NO_ALARM")
  field(LLSV, "NO_ALARM")
  field(HSV, "NO_ALARM")
  field(LSV, "NO_ALARM")
  field(SIOL, "L3:DG10:cDelaySetAO.VAL NPP NMS")
  field(SIML, "L3:DG10:SimModeBO.VAL NPP NMS")
  field(SIMS, "NO_ALARM")
}
• APS installed EPICS database:
  ~ 270,000 records
  ~ 7,000,000 user defined fields

• Maintenance/documentation issues
  – staff turnover
  – documentation retrieval
  – control code as ultimate documentation

• Decision Support System
  “A decision support system (DSS) is a computer program application that analyzes business data and presents it so that users can make business decisions more easily. It is an "informational application" (in distinction to an "operational application" that collects the data in the course of normal business operation).”

• DSS – APS control code inspection using RDB (SQL)
  – part of a larger project to capture APS devices and connections in an RDB
Relational Model

- **Modeling choices**
  - Model simplicity vs query efficiency

- **PV-centric**
  - do not need to know which system, IOC, or db_file contains the record.
Simplified ERD /Server Model
EPICS database creation

dct, vi, gdct, yacc/sed

user area

cvs repository

system area

IOC

bootParams
Oracle database loading

dct, vi, gdct, yacc/sed

cvs repository

user area

extract db info

bootParams

system area
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### matching records

Total Rows = 392

#### Results Page

<table>
<thead>
<tr>
<th>SYS</th>
<th>IOC</th>
<th>REC_NAME</th>
<th>TYPE</th>
<th>i/o</th>
</tr>
</thead>
<tbody>
<tr>
<td>linac</td>
<td>loc4</td>
<td>L2:MEOB8I</td>
<td>bi</td>
<td>a/b</td>
</tr>
<tr>
<td>linac</td>
<td>loc4</td>
<td>L2:QM1:CurrentAI</td>
<td>ai</td>
<td>a/b</td>
</tr>
<tr>
<td>linac</td>
<td>loc4</td>
<td>L2:QM1:CurrentAQ</td>
<td>ao</td>
<td></td>
</tr>
<tr>
<td>linac</td>
<td>loc4</td>
<td>L2:QM1:DacAQ</td>
<td>ao</td>
<td>a/b</td>
</tr>
<tr>
<td>linac</td>
<td>loc4</td>
<td>L2:QM1:MagOverTempBI</td>
<td>bi</td>
<td>a/b</td>
</tr>
<tr>
<td>linac</td>
<td>loc4</td>
<td>L2:QM1:OffBO</td>
<td>bo</td>
<td></td>
</tr>
<tr>
<td>linac</td>
<td>loc4</td>
<td>L2:QM1:OnBO</td>
<td>bo</td>
<td></td>
</tr>
<tr>
<td>linac</td>
<td>loc4</td>
<td>L2:QM1:OutVoltageAI</td>
<td>ai</td>
<td>a/b</td>
</tr>
<tr>
<td>linac</td>
<td>loc4</td>
<td>L2:QM1:PsEnableBO</td>
<td>bo</td>
<td>a/b</td>
</tr>
<tr>
<td>linac</td>
<td>loc4</td>
<td>L2:QM1:PsStatusBI</td>
<td>bi</td>
<td>a/b</td>
</tr>
<tr>
<td>linac</td>
<td>loc4</td>
<td>L2:QM1:ResetBO</td>
<td>bo</td>
<td></td>
</tr>
<tr>
<td>linac</td>
<td>loc4</td>
<td>L2:QM1:localRemoteBI</td>
<td>bi</td>
<td>a/b</td>
</tr>
<tr>
<td>linac</td>
<td>loc4</td>
<td>L2:QM2:CurrentAI</td>
<td>ai</td>
<td>a/b</td>
</tr>
<tr>
<td>linac</td>
<td>loc4</td>
<td>L2:QM2:CurrentAQ</td>
<td>ao</td>
<td></td>
</tr>
<tr>
<td>linac</td>
<td>loc4</td>
<td>L2:QM2:DacAQ</td>
<td>ao</td>
<td>a/b</td>
</tr>
<tr>
<td>linac</td>
<td>loc4</td>
<td>L2:QM2:MagOverTempBI</td>
<td>bi</td>
<td>a/b</td>
</tr>
<tr>
<td>linac</td>
<td>loc4</td>
<td>L2:QM2:OffBO</td>
<td>bo</td>
<td></td>
</tr>
<tr>
<td>linac</td>
<td>loc4</td>
<td>L2:QM2:OnBO</td>
<td>bo</td>
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<td>loc4</td>
<td>L2:QM2:OutVoltageAI</td>
<td>ai</td>
<td>a/b</td>
</tr>
<tr>
<td>linac</td>
<td>loc4</td>
<td>L2:QM2:PsEnableBO</td>
<td>bo</td>
<td>a/b</td>
</tr>
</tbody>
</table>

Records 1 to 20

1 2 3 4 5 6 7 8 9 10

 <<< << < > >> >>>
record detail

Selection Criteria

<table>
<thead>
<tr>
<th>System</th>
<th>IOC</th>
<th>Location</th>
<th>Filename</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>if</td>
<td>locmon</td>
<td>A01.4 RELAY RACK 02</td>
<td>/home/helios7/NPD/iocapps/R3.13.2/ioc/sc11/f1App/db1/lab.db</td>
<td>dip</td>
</tr>
</tbody>
</table>

PV Name | Last Reboot Time | Last Reload Time
-------|-----------------|-------------------

Links | ADL

Field Data | Field Data | Field Data
-----------|------------|------------
DESC       | FNLK       | LLOL       |
ASG        | IMP        | HIGH      |
SCAN 1.second | PREC    | LOW       |
PINF        | LINR       | HHSV      |
PHAS 0      | EGUF       | MAJOR     |
FVNT 0      | EGUL       | LLSV      |
TSEL        | EQU volts  | MAJOR     |
DTPY AB-1771FE | MOPR 9.49 | LSV       |
DISV 1      | LORR       | HYS1      |
SD1S        | ADFP       | ADEL      |
AGDT YES    | ASLO       | MDEL      |
DSS         | SMCC       | SIOL      |
FRD0        | HIIII      | SIML      |

Top | Links | ADL

Links

<table>
<thead>
<tr>
<th>Used by (record/field)</th>
<th>Rec.Type</th>
<th>With Field Value</th>
<th>In IOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1:Cl:TunerPosition CC INPA</td>
<td>calc</td>
<td>S1:Cl:TunerPosition.VAL NPP NMS</td>
<td>loc1fclav</td>
</tr>
<tr>
<td>S1:Cl:TunerSetPIHorAO DOL</td>
<td>ao</td>
<td>S1:Cl:TunerPosition.HIGH NPP NMS</td>
<td>loc1fclav</td>
</tr>
<tr>
<td>S1:Cl:TunerSetPLorAO DOL</td>
<td>ao</td>
<td>S1:Cl:TunerPosition.LOW NPP NMS</td>
<td>loc1fclav</td>
</tr>
<tr>
<td>S1:Cl:TunPosHIH AO OUT</td>
<td>ao</td>
<td>S1:Cl:TunerPosition.MHI PP NMS</td>
<td></td>
</tr>
<tr>
<td>S1:Cl:TunPosLOLO AO OUT</td>
<td>ao</td>
<td>S1:Cl:TunerPosition.LOLO PP NMS</td>
<td></td>
</tr>
<tr>
<td>S1:Cl:TunPosL_LOLO AO OUT</td>
<td>ao</td>
<td>S1:Cl:TunerPosition.HIGH PP NMS</td>
<td></td>
</tr>
</tbody>
</table>

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## MEDM clients

<table>
<thead>
<tr>
<th>ISS</th>
<th>NO_ALARM</th>
<th></th>
<th></th>
<th>SMEO</th>
<th>0.0000009e+00</th>
<th></th>
<th>SIML</th>
<th></th>
<th></th>
<th>SIMS</th>
<th>NO_ALARM</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRIO</td>
<td>LOW</td>
<td></td>
<td></td>
<td>HIHI</td>
<td>8.0</td>
<td></td>
<td>SINS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Links**

<table>
<thead>
<tr>
<th>Used by (record/field)</th>
<th>Rec.Type</th>
<th>With Field Value</th>
<th>In IOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1:OMH:ResistanceCC INPA</td>
<td>calc</td>
<td>L1:OMH:CurrentAI.VAL.NPP MS</td>
<td></td>
</tr>
<tr>
<td>L1:OMH:ToleranceCC INPB</td>
<td>calc</td>
<td>L1:OMH:CurrentAI.VAL.NPP NMS</td>
<td></td>
</tr>
<tr>
<td>L1:OMH:readyCC INPC</td>
<td>calc</td>
<td>L1:OMH:CurrentAI.VAL.NPP MS</td>
<td></td>
</tr>
</tbody>
</table>

**ADL**

<table>
<thead>
<tr>
<th>Field</th>
<th>Cnt</th>
<th>ADL Path</th>
</tr>
</thead>
<tbody>
<tr>
<td>EL_OMH_ctl_1.adl</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>EL_OMH_ctl_1.adl, 'dev=L1:QM4'</td>
<td>1</td>
<td>,linac/xLinPsEng.adl</td>
</tr>
<tr>
<td>EL_OMH_ctl_1.adl, 'dev=L1:QM4'</td>
<td>1</td>
<td>,linac/xLinPsEng.adl, 'dev=L1:QM4,local=$local' ,xxlinPsStandardize.adl</td>
</tr>
<tr>
<td>EL_OMH_ctl_1.adl, 'dev=L1:QM4'</td>
<td>1</td>
<td>,linac/xLinPsEng.adl, 'dev=L1:QM4,local=$local' ,xxlinPsDegauss.adl</td>
</tr>
<tr>
<td>L1IMagnets.adl</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L1IMagnets.adl, 'dev=L1:QM4'</td>
<td>1</td>
<td>,xxLinPsStandardizeAB.adl</td>
</tr>
<tr>
<td>L1IMagnets.adl, 'dev=L1:QM4'</td>
<td>1</td>
<td>,xxLinPsDegaussAb.adl</td>
</tr>
<tr>
<td>L1IMagnets.adl, 'dev=L1:QM4'</td>
<td>1</td>
<td>,xxLinPsEng.adl</td>
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<td>L1IMagnets.adl, 'dev=L1:QM4'</td>
<td>1</td>
<td>,xxLinPsEng.adl, 'dev=L1:QM4,local=$local' ,xxlinPsStandardize.adl</td>
</tr>
<tr>
<td>L1IMagnets.adl, 'dev=L1:QM4'</td>
<td>1</td>
<td>,xxLinPsEng.adl, 'dev=L1:QM4,local=$local' ,xxlinPsDegauss.adl</td>
</tr>
</tbody>
</table>

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Orphan Records

Query to locate all pvs that

- Have no other PVs linked to them
- Do not link to other PVs
- Do not connect to external hardware
- Have no client application connections (MEDM, SDDS logger, etc)

Records matching these criteria are potentially ‘orphan’ records, possibly left over from a prior or test subsystem, and probably provide no useful function. **Candidates for removal.**
Discussion

PV Relational Database
Query language provides useful decision support features
- explore logic, pv clients, orphan records
- new rdb modeling and query requests
IOC/PV-centric basis for hardware documentation

Extensions (under development)
Allan Bradley wiring list documentation
Hardware ‘connection’ database

Future:
Oracle based documentation
Source code tells you what was done, but not why
-> IOC, db file, and record based documentation (from db file)
Equipment/device failure histories – referenced through the PV database
Add/remove(rename PVs (under development)

- When an IOC reboots, the database loader scripts archive the records have been added or removed.
- User action required to indicate renamed records.
- Display accumulated additions/deletions (for a given IOC) between any to points in time.
## Record Count by Type

```
select rec_type, count(rec_type) rec_type_count 
from epics_records
group by rec_type
order by rec_type_count desc
```

<table>
<thead>
<tr>
<th>REC_TYPE</th>
<th>REC_TYPE_COUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>bi</td>
<td>68446</td>
</tr>
<tr>
<td>ai</td>
<td>49535</td>
</tr>
<tr>
<td>bo</td>
<td>35225</td>
</tr>
<tr>
<td>calc</td>
<td>27944</td>
</tr>
<tr>
<td>ao</td>
<td>22939</td>
</tr>
<tr>
<td>sub</td>
<td>11030</td>
</tr>
<tr>
<td>fanout</td>
<td>7469</td>
</tr>
<tr>
<td>seq</td>
<td>5998</td>
</tr>
<tr>
<td>mbbo</td>
<td>4825</td>
</tr>
<tr>
<td>mbbi</td>
<td>4207</td>
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<tr>
<td>waveform</td>
<td>3571</td>
</tr>
<tr>
<td>longout</td>
<td>2401</td>
</tr>
<tr>
<td>stringin</td>
<td>2052</td>
</tr>
</tbody>
</table>

...
Cross IOC PVs

```sql
select a.REC_NAME, e.ioc_name ioc1, f.ioc_name ioc2, a.USED_BY_REC
from EPICS_RECORD_HITS_DERIVED a, EPICS_RECORDS b,
     EPICS_RECORDS d, epics_ioc_table e, epics_ioc_table f
where a.REC_NAME = b.rec_name
    and a.USED_BY_REC = d.rec_name
    and b.IOC_ID <> d.ioc_id
    and b.ioc_id = e.io_ioc_id
    and d.ioc_id = f.io_ioc_id
order by e.ioc_name;
```

<table>
<thead>
<tr>
<th>REC_NAME</th>
<th>IOC1</th>
<th>IOC2</th>
<th>USED_BY_REC</th>
</tr>
</thead>
<tbody>
<tr>
<td>S14BFL:CamSelBi</td>
<td>iocs13vp</td>
<td>iocs7vp</td>
<td>S07BFL:SelSeq</td>
</tr>
<tr>
<td>S14BFL:CamSelBi</td>
<td>iocs13vp</td>
<td>iocs33vp</td>
<td>S31BFL:SelSeq</td>
</tr>
<tr>
<td>S:SRcurrentAI</td>
<td>iocsrscope</td>
<td>iocrf2cav</td>
<td>S2:C3:LowPowerCC</td>
</tr>
<tr>
<td>iocsrtune:ASScanSUB</td>
<td>iocsrtune</td>
<td>iocs39vp</td>
<td>S:ASMainScan3SEQ</td>
</tr>
</tbody>
</table>

2107 rows selected.

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Entity Relation Model/Server Model

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