Operational Tools at the Stanford Linear Accelerator Center

Greg White, for many, many, great programmers, scientists and engineers from the SLAC Controls Department, operations and physics groups.
SLAC Tools Technology Timeline
SLAC Tools Technology Timeline

Past

SCP

Present

Matlab

Future

Eclipse
Past 20 years! - The **SLAC Control Program**

“SCP” (pronounced “skip”)
Hierarchy of Applications Dynamically Linked Libraries

SHAREABLE HIERARCHY

Greg White, Stanford Linear Accelerator Center, 2007
Hierarchy of Applications Dynamically Linked Libraries
SCP Application “Integration”

Application state persists (mostly)
The SCP’s Characteristics

Advantages

- Integrated Applications, tools and science
- Rocket Fast
- Seamless User Interface
- One executable, giving macros
Beamline “z” plots
Save/Restore (aka “configs”)
Beam Position Monitors (BPM)
Reference BPM Orbit
Extant BPM Orbit
Beam Position Difference Orbits
Difference (Actual Orbit minus Reference Orbit)
Modelling
Orbit fitting
**“Correlation Plots”**

<table>
<thead>
<tr>
<th>TIME</th>
<th>RANGE</th>
<th>PRIMARY STEP VARIABLE (SLOW)</th>
<th>START AUTO ACQ.</th>
<th>SETTLE TIME 0.0000 0.0000</th>
<th>EXTRA SETTLE 0.0000 0.0000</th>
<th>BPM / TOROID AVERG 1</th>
<th>VDEH MEAS AVERG 1</th>
<th>FEEDBK 1-SHOT 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZERO</td>
<td>RANGE</td>
<td>SECONDARY STEP VARIABLE (FAST)</td>
<td>MANUAL ACQ.</td>
<td>ADD MANUAL SAMPLE</td>
<td>RETAKE MANUAL SAMPLE</td>
<td>DISPLAY SAMPLE</td>
<td>VAR. -- OFF</td>
<td>Display Next Page</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>-- OFF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Optional Range Entry:
- **PRIMARY**
  - HB601DCC Tt:SUMY
  - HB601DCC Tt:LIFETIME
  - HB601SAV E:NUMBUC K

- **SECONDARY**
  - PHYS ORBIT YPOS
  - TIME
  - Init All of CRR

Optional Range Entry:
- **SECONDRY**
  - PHYS ORBIT YPOS
  - TIME
  - Init All of CRR

**Steps** any controllable thing, reads any, up to 160, readable values

**Beam Synchronous** - knows what to do

**Total integration** - eg step ring frequency, do orbit fit, read fit params

**Includes** plotting, fitting, optimization (eg implements quad scan)

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Steering (Orbit Correction)
Orbit Correction

\[ \min \| Ax - b \|_2 \]

subject to \( x_j \leq x_{j\text{max}} \)

• Correction “methods”:
  - Robust Chi Sq
  - Paired correctors to bpms
  - Micado
  - SVD
  - others now seldom used

• Simultaneous Orbit and Dispersion Correction
• Transport or closed orbit
• Optional Boundary conditions (eg constant injector region)
• If underconstrained, finds soln with smallest corrs
• Iteratively removes BPMs with poor fit (liars)
• Handles degenerate system matrix (by SVD) but includes peak amplitude constraints (corrector Bmax)

Multi-knobs
Example MKB file

! her_energy.mkb
!
! JLN 06/12/99
! modified by tmh 6/13/99
! modified by mws 3/29/02 moved pr04 tune quads to pr03
!
! Change all HER bends and quads, knob in MeV
! coef equals 1/8973.3 * current BDES
! Q4 and Q5 are adjusted by extra factors of 1.3237 and 1.0766 to correct
! for the fact that we don't adjust Q1. Factors provided by Martin Donald.
!
! Various mods associated with power supply reconfiguration
! which allows for a 90 degree lattice.
!
SET/LABEL=HER_ENERGY
SET/REQ_ALL_DEVICES    ! assign fails at knobinit if not all devices accessible
SET/SENS=10             ! change energy by 10 MeV per turn
SET/PRIM=LGPS/SECN=BDES
!
! PR02
!
DEF/DEV=(*,PR02,5002,*)/COEF=2.2698e-4
DEF/DEV=(*,PR02,5003,*)/COEF=3.3607e-4
DEF/DEV=(*,PR02,5004,*)/COEF=-1.0076e-4
DEF/DEV=(*,PR02,5005,*)/COEF=2.8181e-3
DEF/DEV=(*,PR02,5006,*)/COEF=1.0076e-4
DEF/DEV=(*,PR02,5104,*)/COEF=-1.7536e-2 ! Q4 includes factor of 1.3237
DEF/DEV=(*,PR02,5105,*)/COEF=-1.7536e-2 ! Q4 includes factor of 1.3237
DEF/DEV=(*,PR02,5106,*)/COEF=1.1312e-2  ! Q5 includes factor of 1.0766

RETURN/SPACE=MORE, PREV/NEXT=SCROLL, INS/REM=PAN, SELECT=80/132, Q=QUIT
Bumps

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“Button Macros”
“Button Macros”
History/Archive Data

Chart Types: stripchart, Overlay, A vs B (interpolated), expressions in A, B and C
Linear and Log axes
Auto or manual scaling axes

Greg White, Stanford Linear Accelerator Center, 2007
The SCP’s Characteristics

Advantages

Integrated Applications, tools and science
Rocket Fast
Seamless User Interface
One executable, giving macros

Disadvantages

Very difficult to upgrade basis technology
Single threaded, one thing at a time
Impossible to collaborate
VMS based
SCP - Matlab - XAL - Eclipse - CA integration

Timeline
Transitionary Phase - Present

Past | Present | Future

SCP | Matlab | Eclipse

- Correlation Plots
- Buffered Acquisition
- Orbit Applications
- Multi-device knob
- On-line model
- Configuration management

- Beam Profile Image management
- Bunch Length Meas
- Feedback prototypes
- Emittance Measurement
- Correlation Plots
Beam Profile Image Management in Matlab

Thanks to Sergei Chevtsov

Greg White, Stanford Linear Accelerator Center, 2007
Bunch Length Measurement

Thanks to Mike Zelazny
Matlab based feedback!

Thanks to Diane Fairley
Transitionary Phase - Future (immediate)
Hybrid environment for applications (now in dev.)

From “LCLS Apps from 20000ft” (G. White)
http://confluence.slac.stanford.edu/x/IBk
SLAC Eclipse Accelerator Lab (SEAL) Modelling
SEAL including Control System Studio (CSS)

Thanks P. Chu, K. Kasemir, S. Chevtsov
SEAL Formatted Displays (ready to print, logbook)
Control Data Flow for Scientific Applications
Access to Archive/History Data
Middleware, connecting legacy to modern software

AIDA

Accelerator Integrated Data Access

AIDA helps programmers write high level applications which have to connect to different databases, data sources, or control systems, on possibly different platforms and whose APIs may be in different languages, to perform data interactions in the time-scales necessary for on-line accelerator applications. In the language of computer programming, it is a middleware framework and API for multi-platform, multi-language, distributed data access and message passing. It is implemented in Java, with Java and C++ APIs, on top of CORBA. It is now in use in the SLAC accelerator system.

 Authors: Greg White, George McIntyre, Bob Sass, Bob Hall, Ron MacKenzie

Users Guides

These pages are for users of Aida, such as physicists, operations and programmers wishing to use Aida to interact with data.

Basic User Guide to Aida

Individual Data Provider Users Guides

SLC Control Database
SLC Accelerator Model
EPICS Channel Archiver
SLC Magnet
SLC MasterOscillator
SLC Trigger

SLC History
EPICS Channel Access
SLC BPM Orbit Data
SLC Multiknob
SLC Klystron
SLC BGRP Set Variable

CVSWEB (Aida is in /package/aida).

Greg White, Stanford Linear Accelerator Center, 2007

George McIntyre, Bob Sass, Bob Hall, Ron MacKenzie, Greg White
Command Line Aida

CA
[tersk09]:u/cd/greg> aidaget XCOR:LM21:101//BDES
-6.954E-4

Model
[tersk09]:u/cd/greg> aidaget XCOR:IM20:121//twiss -DMODE=5
  0.00575
  6.350345
  1.2448077
  6.693392
  0.0
  0.0
  6.350699
  1.2381707
  6.542251
  0.0
  0.0

BPM
[tersk09]:u/cd/greg> aidaget P2BPMHER//BPMS -DBPMD=38 -DN=1024 -DCNFNUM=712
BPMS:PR10:8022   0.07417996  -0.07417996  3333.5989  0.0     17  0
BPMS:PR10:8032   1.0195395   -1.0195395  3356.7275  0.0     17  0
BPMS:PR10:8042   0.080591545  -0.080591545  3364.437  0.0     17  0
BPMS:PR10:9012  -0.9720128    0.9720128  3373.0083  0.0     17  0
BPMS:PR10:9022  0.09097895   -0.09097895  3380.6082  0.0     17  0
BPMS:PR10:9032  1.099201     -1.099201  3388.2083  0.0     17  0
  . . .
## AidaWeb: Web -> Excel, Scripts (by wget), Web Browser, Web Apps

```jsp?target=P2BPMHER%2F%2FBPMS+-+DBPMD%3D38&aidaGet=Get+Data```

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<th>0.0</th>
<th>3333.5989</th>
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<tr>
<td>BPMS:PR10:9082</td>
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<td>0.0</td>
<td>3426.2083</td>
<td>0.0</td>
<td>17</td>
<td>0</td>
</tr>
</tbody>
</table>
Aida (pure java API) in matlab History/Archiver access and plot

function [values, times ] = histDemo(name, starttime, endtime)

% Example >> histDemo('PB60:LUMCOR//HIST.pepii','05/06/2005 00:00:00',...
% '05/07/2005 00:00:00');

aidainit;

err=Err.getInstance();
da = DaObject();

disp 'Acquiring Data'
da.setParam('STARTTIME',starttime);
da.setParam('ENDTIME',endtime);
hist = da.getDaValue(name);

% Extract data from pure java to matlab
pts = hist.get(0).size();
dblArray = javaArray('java.lang.Double',pts);
values = double(hist.get(0).toArray(dblArray));
StringArray = javaArray('java.lang.String',pts);
times = char(hist.get(1).toArray(StringArray));

disp 'Plotting...'
plot(datenum(times),values,'-+');
datetick('x');
xlabel(sprintf('%s - %s',times(1,:),times(end,:))
title(name);

return;
Matlab java lessons

• `datenum()` converts time format data to plotable floats
• `datetick` tells current `plot()` to scribe axis with date/time

• textual date/time to float conversion is very costly (soln. use say unix time rather than text)

• Put java VM options in Matlab secret file `java.opt`. 
Aida CORBA Performance

Double: 1 or 2 ms, sometimes more

Nd Vector DaValue: < 10 ms, Median 3 ms, sometimes more. Eg History, BPM, model

Linear up to tested 4MBytes
Future XML Performance -> SOAP -> Web Services -> GRID Performance (Globus OGSA)

Efficient XML Interchange (EXI) Format 1.0

W3C Working Draft 16 July 2007

This version:
http://www.w3.org/TR/2007/WD-exi-20070716/

Latest version:
http://www.w3.org/TR/exi/

Previous version:
None (First Public Working Draft)

Editors:
John Schneider, AgileDelta, Inc.
Takuki Kamiya, Fujitsu Laboratories of America, Inc.

This document is also available in these non-normative formats: XML.

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Abstract

This document is the specification of the Efficient XML Interchange (EXI) format. EXI is a very compact representation for the eXtensible Markup Language (XML) Information Set that is intended to simultaneously optimize performance and the utilization of computational resources. The EXI format uses a hybrid approach drawn from the information and formal language theories, plus practical techniques verified by measurements, for entropy encoding XML information. Using a relatively simple algorithm, which is amenable to fast and compact implementation, and a small set of data types, it reliably produces efficient encodings of XML event streams. The event production system and format definition of EXI are presented.
Efficient XML Interchange Working Group of W3C

Performance of EXI candidates on XAL with lossless compression (no XML Schema)

Results per Test (% of tps)

Binary XML
EXI Processor
High perf XML processor
XML (JAXP)
EXI (Binary XML) on EPICS Archiver XML-RPC data

EXI candidates on EPICS Archiver without compression (no XML Schema)
Now > 7 X faster in network and processing time. More efficient float being added.
Sparklines
Edward Tufte

These little data lines, because of their active quality over time, are called sparklines: small, high-resolution graphics embedded in a context of words, numbers, images. Sparklines are data-intense, design-simple, word-sized graphics.

http://www.edwardtufte.com
http://sparkline.org/
What Did we Do Wrong - Bob Dalesio’s Slide

• Underestimated XAL integration (modelled elements, SMF layer, database integration)
• Underestimated db persistence
• Underestimated Eclipse questions
  – IDE RCP or our own Product
  – Building in a production environment
  – Distribution
• SWT <> Swing : Eclipse <> XAL
• Matlab pragmatism not accepted by everyone.
Questions - please talk to us!

- **Macros** (automatic script recording) over different hosts, OS? X11 only common factor!
- **Headless**, production, build of Eclipse?
- **3D visualization** for accelerator physics?
- **Impact/Parmela** -> **Elegant** -> **Genesis/Ginger**
Selected References

- These Proceedings
  - High-level Application Framework for LCLS, Paul Chu
  - Electron Bunch Length Measurement for LCLS at SLAC, Mike Zelazny
  - Scripting vs Programming: An Application Developer's Perspective, Sergei Chevtsov
- Visual Display of Quantitative Information. E. tufte.
  - [http://sparklines.org](http://sparklines.org)
to add

cmlog
crr plots