Using SDDS for Accelerator Commissioning and Operation

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Introduction

- High-level applications at APS are based on
  - A common self-describing file protocol.
  - A toolkit of commandline programs that manipulate such files.
  - Tcl/Tk scripts to manage these programs and create GUIs.
- The protocol and programs are called "SDDS", for *Self-Describing Data Sets*

Outline of Presentation

- Concept and implementation
- What is self-describing data?
- SDDS file protocol and applications
- SDDS toolkit programs
- Advantages and problems
- Who uses SDDS?
- Applications
- Demos

Concept

- A generic data processing algorithm:
  Output = O_n ... O_2 O_1 *Input*
- Write programs that act as operators.
- Define a generic data-containing object for the operand.
- Applying sequences of programs creates arbitrarily complex transformations.
- Programs are re-used in many unrelated applications.

Examples of the Concept

- Simple lifetime measurement:
  acquireData | compute(Log) | fitPolynomial | display
- Robust lifetime measurement:
  acquireData | compute(Log) | fitPolynomial
  | removeOutliers | fitPolynomial | display
- Beam history analysis:
  acquireData | FFT | smooth | peakfind | collect(ByBPM)
  | display
- Find the noisiest power supply:
  acquireData | compute(Stats) | collect(BySupply) | sort
  | display

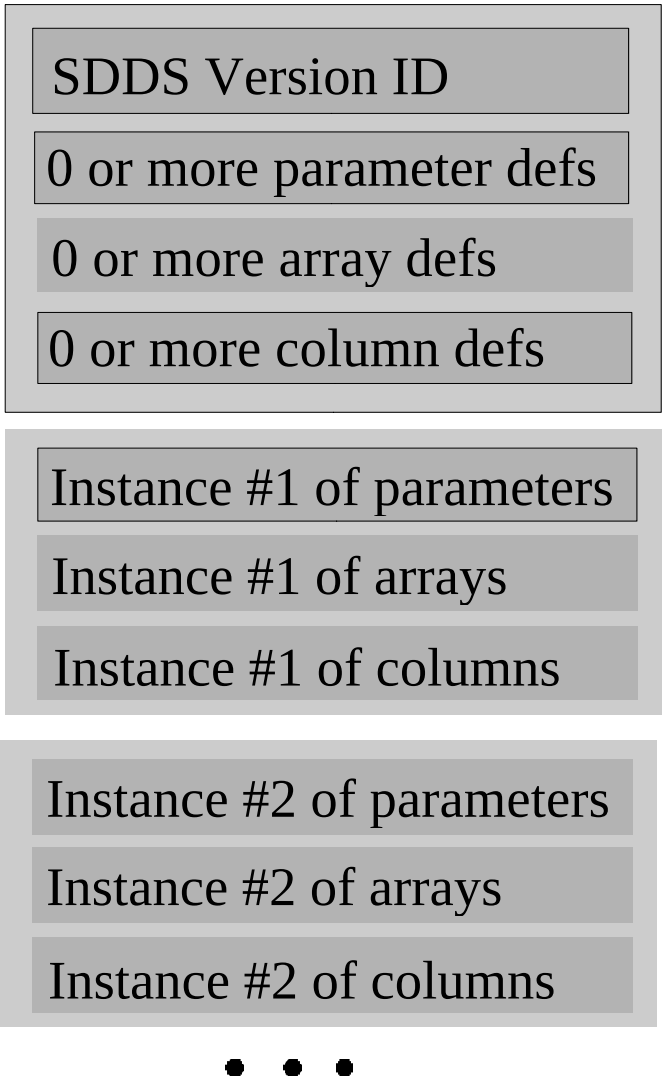
Implementation

- Consistently used a simple, common self-describing file protocol for data.
- Wrote generic, commandline programs using these files
  - Data collection
  - Data analysis
  - Graphics
  - Process control
- Used Tcl/Tk script language to
  - Record/create sequences
  - Create GUIs

What is Self-Describing Data?

- Identified and accessed by name only
- Units, data type, and other meta-data are included.
- Advantages:
  - Truly generic programs possible
  - Programs can verify and adapt to file contents
  - Augment file contents without breaking applications
  - Self-documenting
  - Integrates simulation, control system, and other data sources

SDDS File Protocol



Header: defines a data structure

Page 1: an instance of the structure

Page 2: an instance of the structure

Examples of Uses of SDDS Files

- Back-up and restore files (BURT)
- Archival data from machine monitoring
- Alarm history data
- Magnet conditioning instructions
- Waveforms from scopes and network analyzers
- Beam profile and images
- Feedback matrices
- Orbit correction configuration data
- Beam position monitor status database

SDDS Toolkit Programs

- SDDS is used by a group of about 70 generic programs
- Most of these "SDDS Toolkit" programs both read and write SDDS files, so
  - They can be used sequentially
  - Even simple tools become useful and productive
- About 20 EPICS-specific programs use SDDS
- Programs are commandline driven and hence scriptable

SDDS Toolkit Capabilities

- Device-independent graphics
- Equation evaluation
- Data filtering, sorting, collection, and cross-referencing
- Statistics, correlation analysis, and histograms
- Polynomial, exponential, and gaussian fitting
- Outlier analysis and removal
- Matrix operations
- FFT and digital filtering
- Derivatives and integrals
- Conversion to/from text and other formats

SDDS/EPICS Toolkit Capabilities

- Time-series data collection and statistics collection*
- Glitch/trigger initiated data collection*
- Synchronized data collection
- Alarm data collection*
- Experiment execution**
- Snapshot save, restore, and ramp**
- Feedforward, feedback**, and optimization**

*Used at APS for continuous archiving.
**Used at APS for routine operations.

Advantages of SDDS

- Tools for on-the-fly experiments, data analysis, etc.
- Permits very rapid testing, implementation of ideas
- Gives "muscle" to Tcl/Tk scripts
- Simplifies the development of new applications
- New programs have an amplified and often unexpected payoff
- Analysis capabilities comparable to MATLAB or IDL, but SDDS is free
- Open source

Problems/Complaints

- SDDS commandline tools are hard to use for newcomers and occassional users.
- SDDS files are not random-access files. A page is read into memory, following which the application requests copies of needed data.
- Does not provide cross-platform reading of binary files. (Solved in next release.)
- Slower execution than custom code.

Who Uses SDDS?

- APS depends on SDDS for accelerator operation, archiving, data analysis, and simulation.
- IPNS uses SDDS for archiving, analysis, and display.
- RHIC uses SDDS files throughout the control system but doesn't use SDDS tools at present.
- BESSY II uses SDDS files and tools for data archiving, automated processing, and some applications.
- DESY is adopting SDDS files for their data archives.
- SNS has some limited experimental use of SDDS.
- Accelerator simulators (ANL, DESY, LBL, SLAC, ...)

Selected Accelerator Physics Activities Performed with SDDS

- Magnetic measurement data analysis
- Magnet conditioning and configuration*

- Model-independent steering*
- Obit/trajectory response matrix measurement*
- Orbit correction*
- Insertion device beamline steering*

- Tune and chromaticity measurement*
- Beta-function and dispersion measurement and correction*

*GUI application

Selected Accelerator Physics Activities Performed with SDDS

- Dynamic aperture measurement*
- Energy aperture measurement*
- Physical aperture search

- BPM-to-quadrupole offset measurements with beam*
- BPM intensity dependence measurement and compensation*
- Automated BPM timing scans and timing setup.*

Selected Accelerator Physics Activities Performed with SDDS

- Transport line emittance measurement and beta-function matching*
- Bunch length measurement using rf zero-phasing*
- Automated processing of beam spot images from SASE FEL experiments*