Das2-Pyserver 2.2 Users Guide

Revision 2019-08-24

Purpose	Who	Date
Initial Draft	C. Piker	2015-03-18
Updates to allow for hourly and yearly cache blocks	C. Piker	2017-05-19
Updates to align with current versions for das2 library and tools	C. Piker	2017-07-28
Bumped version number, install instruction updates	C. Piker	2018-03-05
Included Server-Reader interface as this has been removed from ICD	C. Piker	2019-08-20
Moved internal developer specifications to their own file	C. Piker	2019-08-23

Revisions

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Acronym	**Meaning**
CGI	Common Gateway Interface, A definition of how programs invoked via a Web-Server should interact with that Web-server. See RFC-3875 at http://www.ietf.org/rfc/rfc3875 .
DSDF	Data Set Descriptor File, A file defining a Das 2.2 data source for use via das2-pyserver.
HTTP	HyperText Transfer Protocol, The basic transport protocol for most of the world's data.
IDL	Interactive Data Language, a proprietary software language from Harris Geospatial Solutions, Inc.
NFS	Network File System - A longstanding Linux/Unix file sharing protocol
SDDAS	Southwest Data Display and Analysis System

Table I: Acronyms used within this document

Issue	**Affects**
GAVO DaCHS listing appendix not written	Appendix A:
Das2 Federated Catalog listing appendix not written	Appendix B:

Table II: Known document Issues

Document	**Purpose**	**Location**
Das2.2 ICD	Defines the das version 2.2 server-client interface	http://das2.org
Heliophysics API	Defines the Heliophysics Application Programming interface client-server interface	https://github.com/hapi-server/data-specification
GAVO DaCHS Software Distribution	Documentation on the Virtual Observatory data center helper suite software	http://soft.g-vo.org/dachs

Table III: Related Documents

A note on UTF-8

Das2 was developed by English speaking programmers, and thus has not been tested under non English locales. Despite this history, it is the desire of the das2 developers that the software should work with labels and descriptions in any language and thus UTF-8 is taken as the default encoding for all text handling. Please report any problems you encounter with text containing unicode characters at code points above 127. Bugs of this nature will be dealt with promptly.

1: Overview

Das2 servers typically provide data relevant to space plasma and magnetospheric physics research. To retrieve data, an HTTP GET request is posted to a das2 server by a client program and a self-describing stream of data values covering the requested time range, at the requested time resolution, is provided in the response body.

This software, das2-pyserver, provides a caching middleware layer between server-side das2 readers, which stream data at full resolution to their standard output channel, and remote client programs such as Autoplot or SDDAS. The server handles common operations such as network transport, data reduction, authentication and caching, but it relies on specialized reader programs for full resolution data streams.

When using das2-pyserver, the two part das2 client-server system become a three part client-server-reader system. Each part is described below in order of increasing "distance" from the original data files:

1. One or more **readers**. These programs read data from some source and provide it in a standardize format. Readers are accompanied via Data Source Definition Files (DSDFs) which tells das2-pyserver how to run the reader.
2. **Das2-pyserver**. This software. It is run via Apache and provides responses for HTTP GET queries. Depending on the information requested and the server configuration, the response may be generated from internal information, or by running a reader.
3. One or more **clients**. These programs are the end destination for the data stream, and are typically plotting programs such as Autoplot or SDDAS, but maybe custom analysis scripts written in Python or IDL.

When handling das2.2 ***discovery*** and ***dsdf*** queries only the DSDF files are read. Readers are not run, this information flow is depicted in figure 1.1.

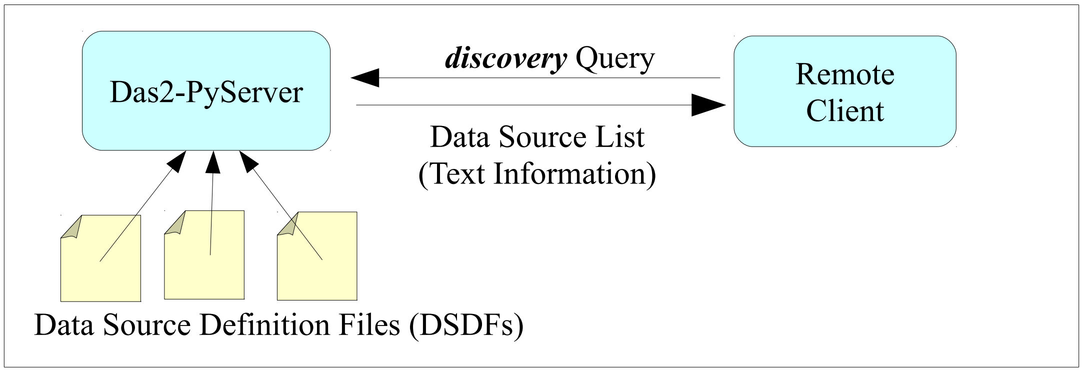

Das2-PyServer
discovery Query
Remote Client
Data Source List (Text Information)
Data Source Definition Files (DSDFs)

Figure 1.1: Server handling a das2 discovery query, information source in yellow

When handling a query for uncached data values, the server runs an external reader program. Depending on the details of the request, reader output may be streamed through a data reduction program. This information flow is depicted in figure 1.2.

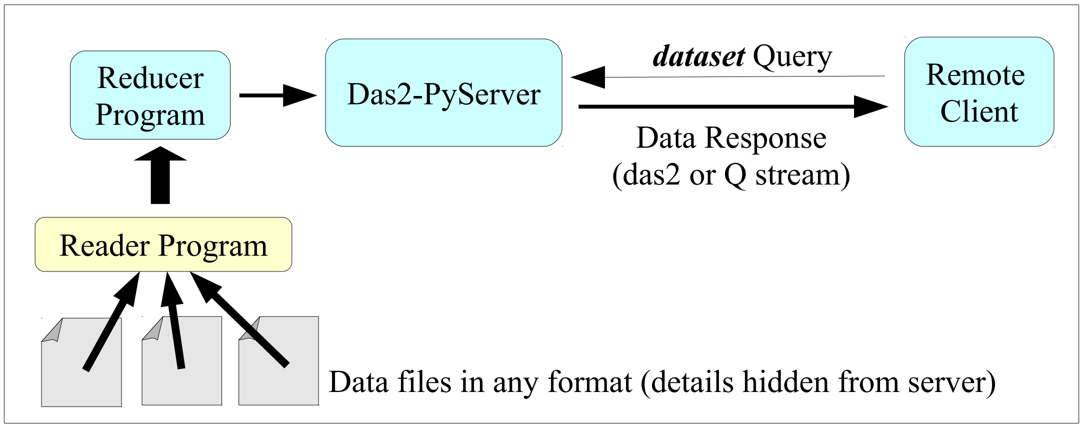

Reducer Program
Das2-PyServer
dataset Query
Remote Client
Data Response (das2 or Q stream)
Reader Program
Data files in any format (details hidden from server)

Figure 1.2: Server handling a das2 data query, information source in yellow

If data are requested for a time range that has been cached, the server may not run the reader at all. This is useful when long time ranges are requested or when a reader program is particularly inefficient. Whenever the server receives a request for data it checks the data source's DSDF file to see if caching is allowed. If so, das2-pyserver enters a cache request into a Redis job queue and then continues on to supply data is the standard fashion as described above. Subsequent requests for the same time range and similar resolution will read from the cache block files as depicted in figure 1.3. Depending on the details of the data request this can *significantly* reduce the time needed to satisfy the request.

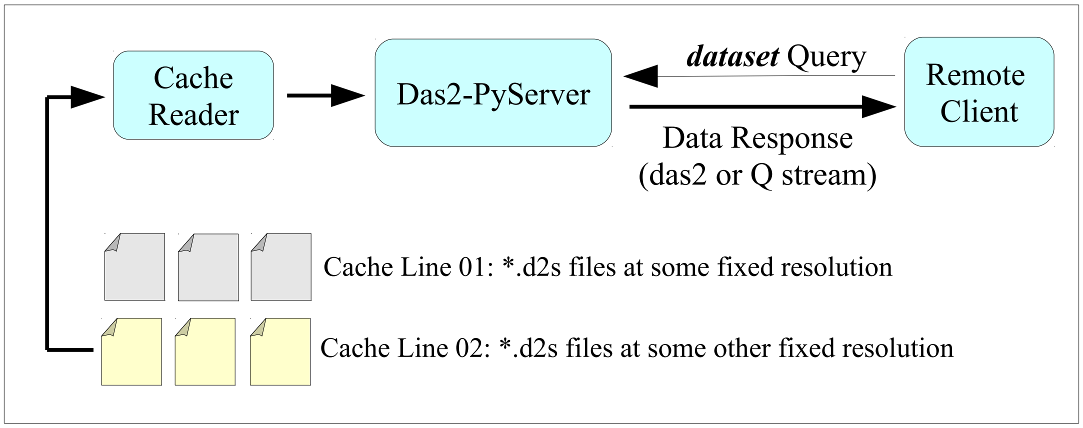

Cache Reader
Das2-PyServer
dataset Query
Remote Client
Data Response (das2 or Q stream)
Cache Line 01: *.d2s files at some fixed resolution
Cache Line 02: *.d2s files at some other fixed resolution

Figure 1.3: Handling a das2 data query using the pre-reduced cache, information source in yellow

The first das2 server program was a single-page CGI perl script written in 2002 in support of the University of Iowa's RPWS investigation on board the Cassini spacecraft as part of the das2 data display project. The python version was initially created in support of the EMFISIS instrument on board the twin Van Allen Probes and deployed at the University of New Hampshire. The caching subsystem was written to support the Waves instrument on the Juno mission to Jupiter. As of September 2019, primary data from at least 16 space based instruments and ground observatories as well as location and attitude information are available from various installations of the das2-pyserver software. Das2 client programs and libraries include, but are not limited to, Autoplot[1], SDDAS[2], das2py[3], and das2pro[4].

1 http://autoplot.org, maintained by J.B. Faden, Cottage Systems
2 http://www.sddas.org, maintained by J. Mukherjee, Southwest Research Institute
3 https://das2.org/das2py, maintained by C.W. Piker, The University of Iowa
4 https://github.com/das-developers/das2pro, maintained by C.W. Piker, The University of Iowa

2: Installation

Compilation and installation of das2-pyserver software currently requires a Linux environment. That can change if there is ever a demand for using the software on Windows or MacOS.

2.1: Prerequisites

Insure that the following programs are installed on your system before beginning the installation procedure.

1. Python >= 2.6, or Python >= 3.4
2. Apache2, any remotely recent version
3. Redis, known to work with version 3.2 or higher
4. redis-py, known to work with version 2.10 or higher
5. libdas2.3, latest version recommended

Since libdas2 provides small binaries needed by das2-pyserver, and since there are no pre-built libdas2.3 packages, installation instructions for both libdas2 and das2-pyserver are included below. In these instructions the '$' character is used at the beginning of a line to indicate commands that you'll need to run in a Bourne compatible shell (bash, ksh, etc.).

Example prerequisite package installation commands are provided below for CentOS 7 ...

```
$ sudo yum install gcc subversion git
$ sudo yum install expat-devel fftw-devel openssl-devel
$ sudo yum install python3 python3-numpy python3-devel  # or python2 equ.
$ sudo yum install redis
$ sudo pip3 install redis                               # if using python3
# --or--
$ sudo yum install python2-redis                        # if using python2
```

... and Debian 9

```
$ sudo apt-get install gcc subversion git
$ sudo apt-get install libexpat-dev libfftw3-dev libssl-dev
$ sudo apt-get install python3-dev python3-distutils python3-numpy  # or py2 eq
$ sudo apt-get install redis-server
$ sudo apt-get install python3-redis                    # or python2 equivalent
```

2.2: Get the Source Code

For now, some of the sources are in a University of Iowa SVN server and some are on github.com. All sources will be moved to github.com as time permits.

```
$ svn co https://saturn.physics.uiowa.edu/svn/das2/core/stable/libdas2_3
$ git clone https://github.com/das-developers/das2-pyserver.git
```

2.3: Build and Install

Decide where your das2-pyserver code and configuration information will reside. In the example below the directory `/usr/local/das2srv` is selected, but you can choose any location you like. These environment variables will be used through out the setup, so leaving your terminal window open though the testing stage will save time.

```
$ export PREFIX=/usr/local/das2srv   # Adjust to taste
$ export PYVER=3.6                   # or 2.7, or 3.7 etc.
$ export N_ARCH=/                    # omit per-OS sub-directories
$ export SERVER_ID=solar_orbiter_2   # for ex. ID should not contain white space
```

Test your PYVER setting by making sure the following command brings up a python interpreter:

```
$ python$PYVER
```

The following sequence will build, test, and install libdas2.3 and das2py if you have all prerequisite libraries installed:

```
$ cd libdas2_3
$ make
$ make test
$ make pylib
$ make pylib_test
$ make install
$ make pylib_install
```

Now build and install the python module and example configuration files. Set `--install-lib` and `--prefix` as indicated, unless you want to hand edit `das2server.conf` after installation. There is no need to run build before this step.

```
$ cd ../das2-pyserver
$ python${PYVER} setup.py install --prefix=${PREFIX} \
  --install-lib=${PREFIX}/lib/python${PYVER}
```

Copy over the example configuration file:

```
$ cd $PREFIX/etc
$ cp das2server.conf.example das2server.conf
```

2.4: Configure Apache

Apache configurations vary widely by Linux distribution and personal taste. The following procedure is provided as an example and has been tested on CentOS 7.

First determine which directory on your server maps to an Apache HTTPS CGI directory. To do this inspect /etc/httpd/conf/httpd.conf (or similar). The default is `/var/www/cgi-bin`. To provide better URLs for your site add the line:

```
ScriptAlias /das/ "/var/www/cgi-das/"
```

directly under the line:

```
ScriptAlias /cgi-bin/ "/var/www/cgi-bin/"
```

inside the `<IfModule alias_module>` section of `httpd.conf`.

Then provide configuration information for your `/var/www/cgi-das` directory inside the `/etc/httpd/conf.d/ssl.conf` file. We're editing the `ssl.conf` instead of `httpd.conf` because das2 clients may transmit passwords.

```
<Directory "/var/www/cgi-das">
  Options ExecCGI FollowSymLinks

  # Make sure Authorization HTTP header is available to Das CGI scripts
  RewriteRule ^ - [E=HTTP_AUTHORIZATION:%{HTTP:Authorization}]
  RewriteEngine on

  AllowOverride None
  Allow from all
  Order allow,deny
</Directory>
```

By default, authorization headers are not made available to CGI scripts. The re-write rule above allows the Authorization header to be passed down to the das2_srvcgi_main script. This is needed to allow your server to support password protected data sources.

Now symlink the top level CGI scripts into your new CGI directory. Choose the name of the symlink carefully as it will be part of the public URL for your site:

```
$ cd /var/www/cgi-das
$ sudo ln -s $PREFIX/bin/das2_srvcgi_main server
$ sudo ln -s $PREFIX/bin/das2_srvcgi_logrdr log
```

Set the permissions of the log directory so that Apache can write logging information:

```
$ chmod 0777 $PREFIX/log   # Or change the directory ownership
```

Finally, trigger a re-read of the Apache's configuration data:

```
$ sudo systemctl restart httpd.service
$ sudo systemctl status httpd.service
```

2.5: Test the Server

Test the server by pointing your web browser at the following two locations:

```
https://localhost/das/server
https://localhost/das/log
```

If this works, try browsing your new server with Autoplot (http://autoplot.org) or SDDAS (http://www.sddas.org).

If you are using Autoplot, copy the URI below into the Autoplot address bar

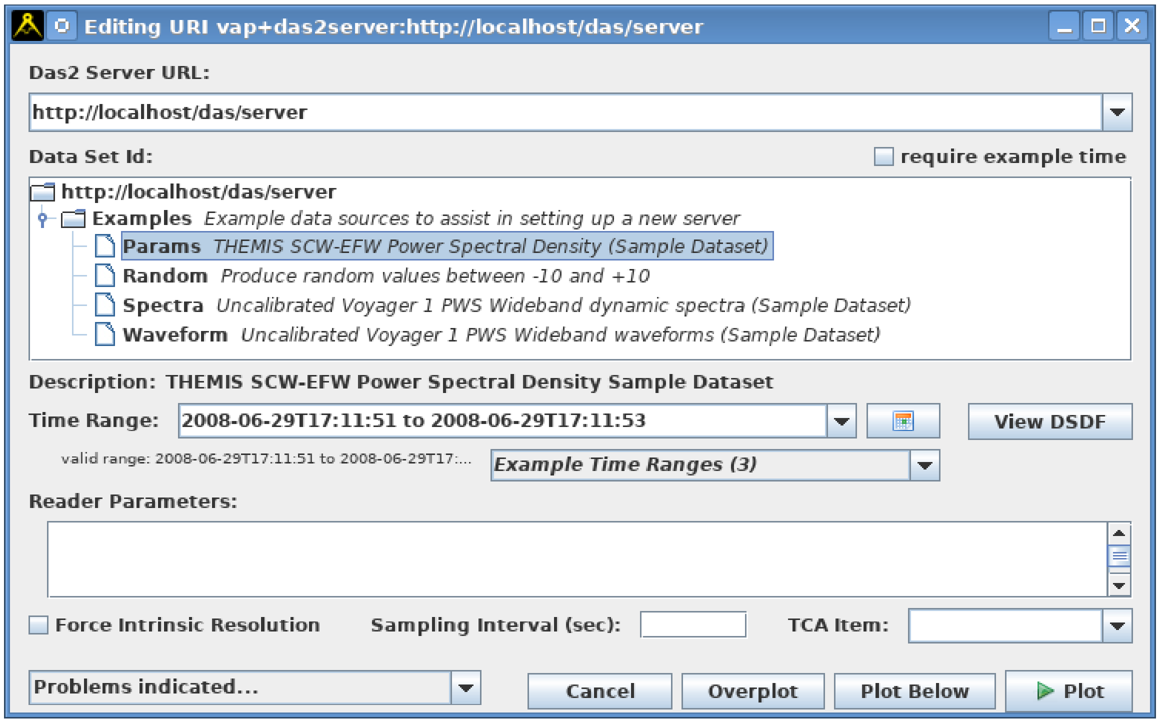
```
vap+das2server:https://localhost/das/server
```

and then click the green "Go" button. A dialog box similar to the one in figure 2.1 should appear.

If you are using SDDAS select start gPlot. In the main window click "Sources", then in the sources dialog select Add | Das2. Change the URL in the Das2 Source dialog to:

```
https://localhost/das/source
```

and click the "..." button. You should see a server browse dialog similar to figure 2.2.



Editing URI vap+das2server:http://localhost/das/server

Das2 Server URL: http://localhost/das/server

Data Set Id: ☐ require example time

- http://localhost/das/server
  - **Examples** *Example data sources to assist in setting up a new server*
    - **Params** *THEMIS SCW-EFW Power Spectral Density (Sample Dataset)*
    - **Random** *Produce random values between -10 and +10*
    - **Spectra** *Uncalibrated Voyager 1 PWS Wideband dynamic spectra (Sample Dataset)*
    - **Waveform** *Uncalibrated Voyager 1 PWS Wideband waveforms (Sample Dataset)*

Description: THEMIS SCW-EFW Power Spectral Density Sample Dataset

Time Range: 2008-06-29T17:11:51 to 2008-06-29T17:11:53

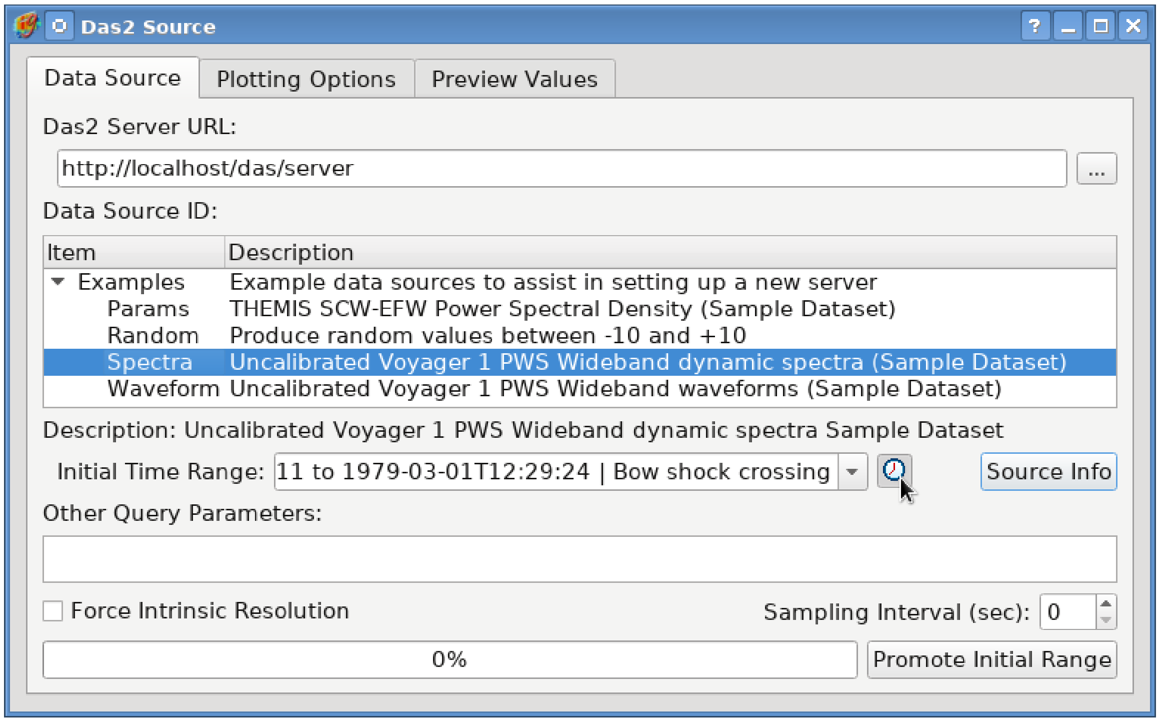
valid range: 2008-06-29T17:11:51 to 2008-06-29T17:... *Example Time Ranges (3)*

Reader Parameters:

☐ Force Intrinsic Resolution Sampling Interval (sec): TCA Item:

Problems indicated...

Figure 2.1: Browsing a new das2-pyserver installation in Autoplot



Das2 Source

Das2 Server URL: http://localhost/das/server

Data Source ID:

Item	Description
Examples	Example data sources to assist in setting up a new server
Params	THEMIS SCW-EFW Power Spectral Density (Sample Dataset)
Random	Produce random values between -10 and +10
Spectra	Uncalibrated Voyager 1 PWS Wideband dynamic spectra (Sample Dataset)
Waveform	Uncalibrated Voyager 1 PWS Wideband waveforms (Sample Dataset)

Description: Uncalibrated Voyager 1 PWS Wideband dynamic spectra Sample Dataset

Initial Time Range: 11 to 1979-03-01T12:29:24 | Bow shock crossing

Other Query Parameters:

☐ Force Intrinsic Resolution Sampling Interval (sec): 0

0%

Figure 2.2: Browsing a new das2-pyserver installation in SDDAS

The server comes preconfigured with a set of example data sources. Try to load and display a few of these. The `Examples/Random` source should always work no matter the given time range. For the others, example times are provided and should be selected in the manner appropriate to your das2 client program.

2.6: Basic Customization

When das2-pyserver is initially installed it has no site name, no logo, has no knowledge of any peer servers, no user names or groups and all cache files are written under the installation directory, thus some post-install customization is in order. All top-level programs supplied with the server have a compiled in default location for the configuration file:

```
$PREFIX/etc/das2server.conf
```

Here `$PREFIX` is whatever location you selected for the `PREFIX` variable in section 2.3 above. This file controls most of the operations of the server. The default configuration file is heavily commented so changing the value should be relatively easy.

2.6.1 Server Identification

Set the following values in das2server.conf to identify your site, and server.

- Set the site identification by changing the value of **`SITE_NAME`**
- Set the contact information by changing **`CONTACT_EMAIL`** and **`CONTACT_URL`**.

Then replace the file:

```
$PREFIX/static/logo.png
```

with a small image that can be used identify your server in a list of das2 servers.

2.6.2 Logging Setup

By default the das2_srvcgi_main program writes log information into the directory:

```
$PREFIX/log
```

Since this program is run by Apache the log directory must be writable by whichever account is used to run Apache on your computer. To avoid having an Apache writable directory under `$PREFIX` set the value **`LOG_PATH`** in das2server.conf to another location.

By default only the local computer is allowed to view logging information at the address:

```
https://localhost/das/log
```

This is fine if your das2-pyserver instance is running on your workstation, but not useful if you've installed the software to a remote server. The list of addresses allowed to view log information is configured by the **`VIEW_LOG_ALLOW`** value. Change this if needed to allow connections from your local workstation.

2.6.3 Library and Run Paths

Before running any sub-programs, all top-level das2-pyserver programs add any paths listed in **`BIN_PATH`** to the *front* of the sub-program's `PATH` environment variable. If you have readers than are in a directory other than `$PREFIX/bin` and don't want to put complete path information into your DSDFs then add extra directories to the value of **`BIN_PATH`**.

Also before running an sub-programs, das2-pyserver top-level programs add any paths listed in **`LIB_PATH`** to the front of the sub-program's `LD_LIBRARY_PATH` environment variable. If your readers depend on libraries that are not automatically locatable by your operating system's program loader you can add extra paths here.

Note that internally das2-pyserver top-level programs also use **`BIN_PATH`** and **`LIB_PATH`** so unless you know what you're doing it's best to append to these variables instead of over-writing them.

2.6.4 Peer Servers

Das2-pyserver uses the file:

```
$PREFIX/etc/das2peers.ini
```

to provide the information needed to satisfy the das2 Peers Query. An example file is include with the basic installation. Copy and customize this file to your liking.

```
$ cd $PREFIX/etc
$ cp das2peers.ini.example das2peers.ini
```

Note this is read as a UTF-8 file so go ahead and add non 7-bit ASCII characters if you like.

3: Data Sources

Das2-pyserver does not read data files directly. Instead it runs programs called readers, which are given query parameters on their command line, gather data from an input source, and emit data streams on their standard output channel. Readers are independent programs, thus they can be written in any language executable by the host operating system.

3.1: Reader Command Line Interface

Das2-pysever readers are always stand alone programs which must support one of the following command line patterns:

A) ***`program`*** **`MIN_TIME MAX_TIME [ EXTRA_PARAMETERS... ]`**

B) ***`program`*** **`SAMPLING_INTERVAL MIN_TIME MAX_TIME [ EXTRA_PARAMETERS... ]`**

Where:

- *`program`* - any string executable by `/bin/sh`, including pipe (i.e "`|`") characters.
- `SAMPLING_INTERVAL` - For readers marked as requiring time interval values (see **`requiresInterval`** below), this is the expected time interval between data points. The value is an ASCII floating point positive real number greater than 0.0 in units of seconds.
- `MIN_TIME` - The inclusive lower bound UTC time of the query interval. The value should be an ISO-8601 time point string.
- `MAX_TIME` - The exclusive upper bound UTC time of the query interval. The value should be an ISO-8601 time point string.
- `EXTRA_PARAMETERS` - Optional extra parameters sent by the das2 client program. There are no restrictions on these parameters, however pyserver will check them for shell and SQL escapes. The extra parameters passed to a program may be specified as multiple arguments or they may arrive as a single quoted argument with space separated sub-components.

Version 2.2 of das2-pyserver only supports data queries over time, and the command line interface between the server and the reader reflects this limitation. For now, queries over other physical parameters such as latitude and longitude are not supported. A more general command line interface is planned for version 2.3 of the software.

3.2: Data Source Definition Files (DSDF)

In order to identify the programs that will supply data streams, das2-pyserver depends on small text files called Data Source Definition Files (DSDF). DSDFs serve two purposes on a das2-pyserver:

1. They supply the information used to satisfy ***discovery*** and ***dsdf*** queries from the das2.2 ICD without running any additional sub programs.
2. Internal keywords such as `reader` and `reducer` are used to tell das2-pyserver how to produce, reduce, and cache data, and thus satisfy ***dataset*** queries.

The root directory containing the data source definition tree is determined by the **`DSDF_ROOT`** keyword in the `das2server.conf` file.

Data source definition files must end in the suffix:

.dsdf

or das2-pyserver will ignore them.

3.2.1 DSDF format

Though the server is written in python, DSDFs use IDL syntax, thus strings are marked by single quotes ('), a semicolon ';' represents the start of a comment, and comments run to the end of the line. Each non-comment line in the must follow the

```
keyword = value
```

pattern. Das2-pyserver ignores any keywords not required for it internal operations. Thus any keyword may be used, so long as it contains only the characters a-z, A-Z, 0-9 and the underscore, _. A reference of keywords understood by the server and a description of their values is provided in section 6.2.

3.3: Example DSDFs

Since most people learn by example, this section provides a variety of DSDFs each focused on a particular aspect of defining a data source.

3.3.1 Minimal Example

The following is a minimal DSDF, only required keywords are present. The reader is assumed to follow command line **pattern A** from section 3.1 above and that it uses the default reducer as specified in `das2server.conf`.

```
description     = 'A data source description'
reader          = '/path/to/some/program'
das2Stream      = 1
techContact     = 'Able Tech <able-tech@somewhere.edu>'
exampleRange_00 = '2017-09-15 to 2017-09-16'
```

Listing 3.1: Minimal DSDF

3.3.2 Non-default data reducer

The following file Voyager PWS file tells das2-pyserver how to run the data reader, which reducer should be used to handle long time ranges, and provides a few example times to get to interesting data quicker. The required keywords are in bold font.

```
description = 'Electric Field averages and peaks from the Voyager 1 PWS SA'
techContact = 'Jane Doe <jane-doe@uiowa.edu>'
sciContact = 'Dr. Scientist <doc-sci@uiowa.edu>'

reader = '/usr/local/das2srv/bin/vgpw_sa_rdr 1'
das2Stream = 1
reducer = 'das2_bin_peakavgsec' ; Overrides D2S_REDUCER from das2server.conf

validRange = '1977-09-05 to now'
exampleRange_00 = '2014-08-31 to 2014-09-01|Latest Data'
exampleRange_01 = '1979-03-01 to 1979-04-14|Jupiter Encounter'
exampleRange_02 = '1980-11-10 to 1980-11-14|Saturn Encounter'
```

Listing 3.2: DSDF using a non-standard reducer

Unlike the `das2_bin_avgsec` reducer which only outputs average values, the `das2_bin_peakavgsec` reducer outputs two data variables for each data variable in the input. One is a variable of averages, the other contains bin peaks. The result of using this reducer can be seen in figure 3.1 which was generated by displaying long duration Voyager 1 PWS spectrum analyzer data in Autoplot. The gray peaks are the maximum values generated for each bin, and the black fill represents the average value.

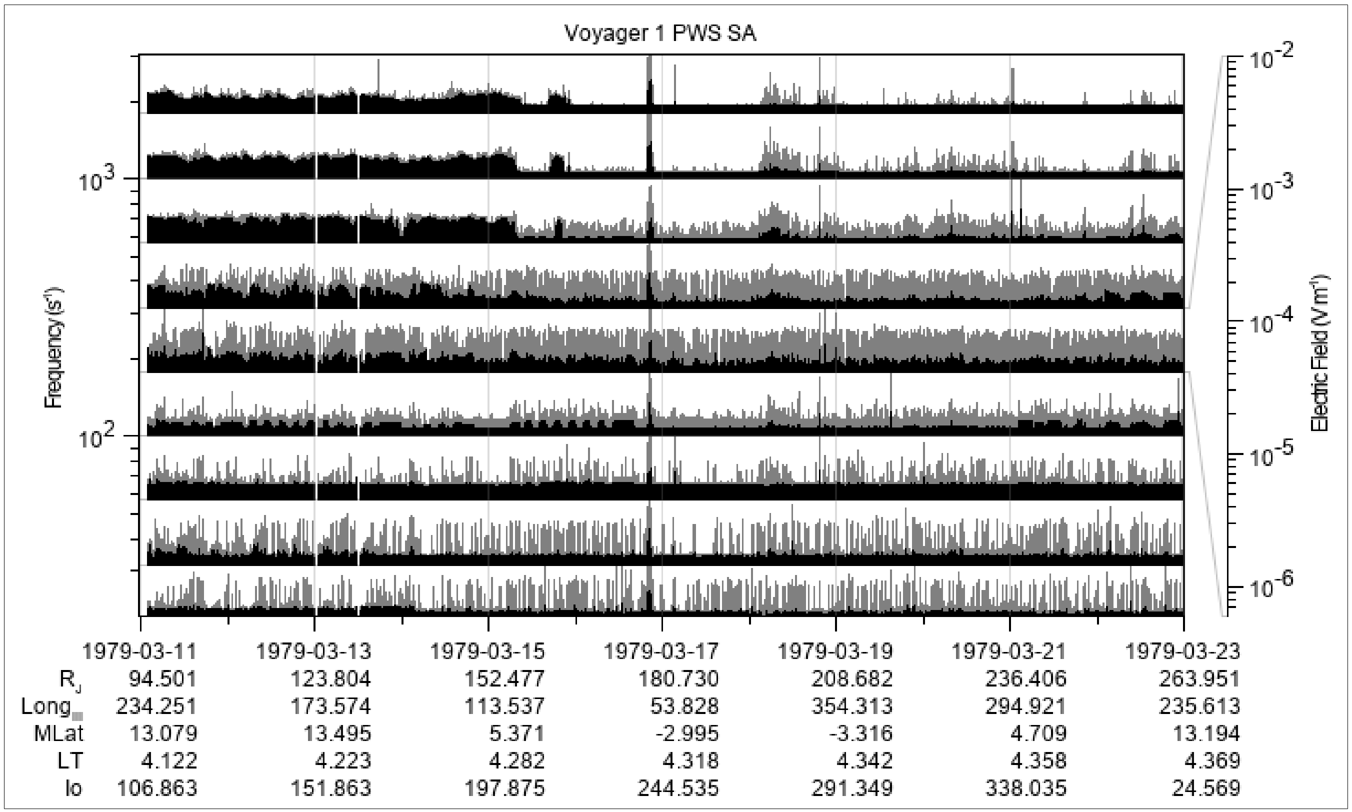


Figure 3.1: Using the das2_bin_peakavgsec reducer for data, and an interval reader for tick labels

3.3.3 Interval Data Source

The following Juno Ephemeris DSDF is for an interval based data source. Interval sources are typically the output of mathematical models. In this case, the data are produced by SPICE calculations. Since this is an interval source, the reader must follow command line pattern B from Section 3.1. Interval sources directly provide data at the required resolution, the special flag `not_reducible` is set in Listing 3.3 to insure that the server does not pass the output of the reader through a reducer .

```
description        = 'Juno Solar orbit parameters'
techContact        = 'John Doe <john-doe@uiowa.edu>'

reader             = '/usr/local/das2srv/bin/juno_l5_position HGI'
das2Stream         = 1
requiresInterval   = 1
reducer            = 'not_reducible'

; Use post earth fly-by data for a test range, with a 3-hr "tick" interval
exampleRange_00    = '2013-11-01 to 2013-11-02'
exampleInterval_00 = 10800
```

Listing 3.3: DSDF specifying an interval based reader

Also, notice the characters "HGI" in for the `reader` value. Das2-pyserver adds command line arguments after whatever string is provide for the `reader` value. Thus, fixed command line arguments

may be provided to the reader so long as these occur **before** the arguments supplied by das2-pyserver when invoking the reader. An interval based source, much like this one, was used to provide X-axis annotations for the Figure 3.1 above.

3.3.4 Protected Data Sources

By default all time ranges from all data sources are authorized for all users, and no authentication is requested of the user. The DSDF keywords `readAccess` and `securityRealm` are used to trigger authentication requests. The `readAccess` value is a pipe, "|", separated list of access conditions. The **first** condition to succeed grants access and no further conditions are checked. The value of the `securityRealm` keyword will be displayed to end users as part of the authentication prompt.

Access can be granted base on typical criteria such as the user name, or group membership. In the flowing DSDF snippet only the users "able" and "anna" are able to download any data.

```
description   = 'Van Allen Probe A, EMFISIS WBR Cross-correlations Test'
readAccess    = 'USER:able|USER:anna'
securityRealm = 'EMFISIS Operations Team'
```

Listing 3.4: DSDF snippet for user based authentication, auth items in bold.

In addition since all data queries supply a min time and a max time, authentication can be triggered based on the age of the data. In the following DSDF snippet any Juno Waves data that are at least one year and 1 month old are accessible without a password. Since the AGE based test fails for newer data, the second condition is consulted. This one requires that the authenticated user is a member of the "waves_team" group in the `$PREFIX/etc/group` file.

```
description   = 'Juno Waves Electric Survey'
readAccess    = 'AGE:1y1m|GROUP:waves_team'
securityRealm = 'U. Iowa Space Physics'
```

Listing 3.5: DSDF snippet for data age and group membership authentication, auth items in bold.

User names and groups are defined in the files:

```
$PREFIX/etc/passwd
$PREFIX/etc/group
```

by default, however these locations can be changed by the **`USER_PASSWD`** and **`USER_GROUP`** keywords of the das2server.conf file. Section 6.2 provides more information on the values of **`readAccess`**, and section 7.3.2 provides information on the password file maintenance tool: `das2_srv_passwd`.

3.3.5 Cache Directives

Das2-pyservers was created to feed data to graphical clients. In many situations the data stored on disk are more detailed that an application can display. Take for example a magnetometer than produces one measurement every quarter of a second. Typically a scientist will want to view all data for a particular day, or maybe all data for a multi-day orbit. For our hypothetical instrument, a day's measurements are 345,600 data points. Since an average computer screen is only around 2000 pixels wide sending a whole day's worth of measurements at intrinsic resolution is a waste of network bandwidth and client memory. To address this issue das2-pyserver may be directed to pre-read and reduce the output of a reader and save the resulting stream in a disk cache. This results in a *dramatic* improvement in display performance when navigating large datasets.

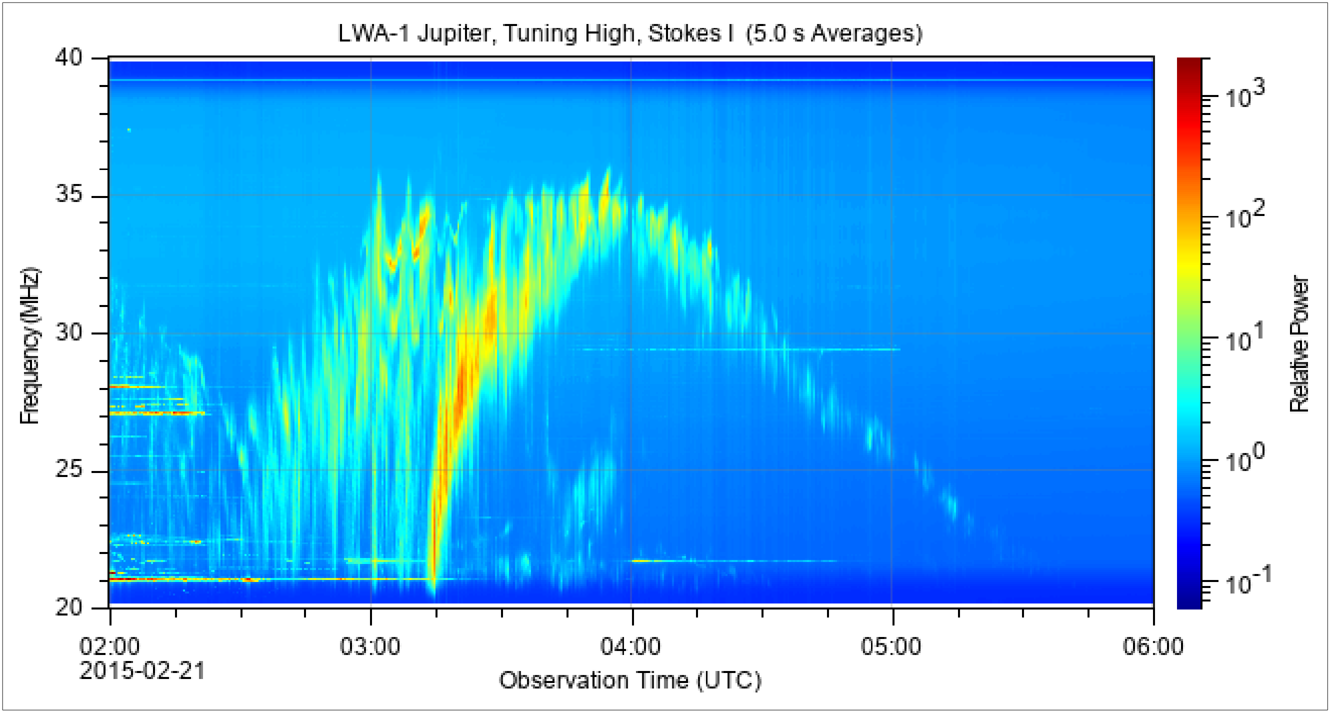


Figure 3.2: Summary plot of a 962 gigabyte dataset from LWA-1 loads in less than two seconds

The following data source provides ground based radio astronomy measurements from the first Long Wave Array station (LWA-1) of Jupiter. Since ground stations typically emit far more data than spacecraft over a similar time scales these data are cached at varying resolutions so that graphical data set navigation is practical.

```
description      = 'LWA-1 Jupiter, Stokes I Parameter at High and Low Tunings'
techContact      = 'Jane Doe <jane-doe@gsfc.nasa.gov>'
sciContact       = 'Masafumi Imai <not-his@real.address.edu>'
reader           = '/usr/local/bin/lwa1_l2drx_rdr'
das2Stream       = 1

; This reader can take an extra parameter
param_00         = 'high | Output the 20-40 MHz range instead of 10-30 MHz'

exampleRange_00  = '2015-02-21 to 2015-02-22 | Low Tuning (1.1 TB)'

; The second example range uses an extra parameter along with the time range
exampleRange_01  = '2015-02-21 to 2015-02-22 | High Tuning (1.1 TB)'
exampleParams_01 = 'high'

cacheLevel_00    = '10 ms | persecond'   ; caching low-tuning (default) values
cacheLevel_01    = '50 ms | perminute'
cacheLevel_02    = '250 ms | perminute'
cacheLevel_03    = '1 s | hourly'
cacheLevel_04    = '5 s | daily'

cacheLevel_10    = '10 ms | persecond | high'  ; caching high-tuning values
cacheLevel_11    = '50 ms | perminute | high'
cacheLevel_12    = '250 ms | perminute | high'
cacheLevel_13    = '1 s | hourly | high'
cacheLevel_14    = '5 s | daily | high'
```

Listing 3.6: An example of deep multi-resolution cache configuration with an `EXTRA_PARAMETER`

To add to the complications, this reader for this data set is able to produce data for the low tuning of the LWA (10 to 30 MHz) and the high tuning (20 to 40 MHz). By default the reader outputs the low tuning, but if supplied with an optional `EXTRA_PARAMETER` on the command line (see Section 3.1) that reads "high" it will output the high tuning.

To enable caching, the **`WORK_QUEUE_CONN`** value in the `das2server.conf` file must point to a running instance of the Redis key-server software. In addition, at least one das2_srv_arbiter program instance must be running and listening to the same Redis server. See section

Assuming that worker programs are running, cache directives similar to the ones in listing 3.6 alone are enough to trigger creation of cache blocks on demand, however for the first read of a given range and resolution of a data set is very slow. To pre-cache the data use the `das2_srv_todo` program describe in Section 7: Server Program Reference.

3.4: Reader output

In order to create a valid, responsive, and reusable data reader, a few ground rules are necessary.

3.4.1 Output Channels

The most important rules for das2-pyserver readers are:

1. **ONLY formatted streams are emitted on the standard output channel**
2. **ALL error and information messages are sent to the standard error channel**

The methods for writing to a selected output channel varies from one programming environment to another. For Python 3 programs use:

```
sys.stdout.buffer.write()    # das2 or Q streams
sys.stderr.buffer.write()    # anything else
```

To make your reader more responsive, **flush** the **standard output** channel **after each** header or data **packet**. Again the methods for doing this vary, using Python 3 as an example:

```
sys.stdout.buffer.flush()   # After each complete header or data packet
```

Many common libraries violate these rules buy sending their error messages to the standard output channel. The NAIF SPICE toolkit is notorious for this. It is possible to setup CSPICE so that errors are handled by your reader instead of spewing to the standard output channel. See the CSPICE functions, `errpart_c`, `erract_c`, `errdev_c`, `failed_c`, `getmsh_c` in the NAIF documentation for details.

3.4.2 Output format recommendation

Readers are expected to output a compliant das2 or Q stream as defined in the Das2.2 Interface Control Document. Binary das2 output is recommended since das2-pyserver can convert this to text format on request (see section 5.3) or convert das2 streams to HAPI format (section 5.2) if desired by the client program. In addition, automatic conversion of das2 streams to VOTables is planned for a future release of the software.

Unfortunately, there are many data sets that the das2.2 stream format cannot represent. For example any data sets that contain text data and any arrays higher than rank 2 are not accounted for. Until an upgraded das2 stream format is supported by libdas2, das2pro and Autoplot; readers should output Q streams in these cases since Q streams are understood by Autoplot, which is the most commonly used das2-pyserver client.

4: Asynchronous Processing

By default, das2-pyserver programs run synchronously with das2 client requests. A client opens an HTTP connection to Apache, Apache then starts an instance of `das2_srvcgi_main` which then runs the necessary reading and reduction programs. For small data requests this state of affairs provides acceptable performance. However as data requests encompass larger and larger time intervals, reading through all the necessary data files can drag down response times. Even though the output stream remains roughly constant in size due to larger averaging intervals, the responsiveness of the server suffers. In order to address the problem, some data processing has to occur when clients are not in contact with the server. To provide for asynchronous processing, a task queue is maintained by a Redis[5] key server, and tasks are preformed by one or more waiting instances of `das2_srv_arbiter`.

4.1: Redis Setup

The only work queue manager currently supported by das2-pyserver is Redis, though the code is modular and others could be added if desired. Check that das2-pyserver is configured to point to the Redis server and database you wish to use for the das2-pyserver work queue. In `das2server.conf` update the following keyword as desired.

```
WORK_QUEUE_CONN = localhost:6379:0
```

Connection parameters are separated by colons. The value above assumes that Redis runs on the same computer as your das2 server (`localhost`), that it uses the default Redis port (`6379`) and that values should be stored in database number `0`. The database configuration should be as follows:

1. **Independent** das2-pyserver's **must** use **separate** databases
2. **Clustered**[6] das2-pyserver's **must** use the **same** database

If needed, install the Redis key-server on the computer that will host your work-queue database. To see if it's already installed, try the following command:

```
$ redis-cli
```

If this program is not present run a command similar to the ones listed below to install it:

```
$ sudo yum install redis                                # RedHat, CentOS, etc.
$ sudo apt install redis                                # Debian, Ubuntu, etc.
```

If the output of running redis-cli is:

Could not connect to Redis at 127.0.0.1:6379: Connection refused

then your redis server is not running, enable it issuing commands similar to these:

```
$ sudo systemctl start redis.service            # see if it starts
$ sudo systemctl status redis.service           # check on the status
$ sudo systemctl enable redis.service           # makes the change persistent
```

and then re-run the redis-cli program again.

Next test to see if das2-pyserver can create keys inside inside the specified database. This will test

5 See http://redis.io for more information on Redis, and advanced key-value cache and store server.
6 Consult the das2-developers if you want to do this. It's not hard but requires NFS.

Redis, your firewall settings (if applicable), and your `das2server.conf` settings.

```
$ $PREFIX/bin/das2_srv_todo -t
```

Here `$PREFIX` is the top-level directory for your server, as specified in Section 2.3. You should see the output:

das2_todo list contains no tasks.

Assuming this works, it's time to setup your database listener programs.

4.2: Testing Task Handling

On startup, the program `das2_srv_arbiter` connects to the Redis database indicated by the `WORK_QUEUE_CONN` keyword in `das2server.conf` and checks the list named "das2_todo". If this list contains any entries, the program reads the last entry in the list and attempts to do the task indicated. If no work is indicated then the program sleeps waiting for a change in the list. Multiple worker programs can run simultaneously because Redis guarantees that only one will succeed at removing a task from the "todo" list. Thus multiple worker programs are always assigned different tasks instead of working on the same task and over-writing each others output.

Once installed as a service, `das2_srv_arbiter` instances are started automatically on boot-up. However, they can be run directly as well. In this section we are going to run `das2_srv_arbiter` interactively to test the task handling system. The task we're going to run is a data cache operation using one of the example data sources supplied with das2-pyserver.

Open a new terminal and start an instance of the task handler:

```
$ $PREFIX/bin/das2_srv_arbiter
```

`here $PREFIX` is the top-level directory for your server, as specified in Section 2.3. You should see output ending with the line:

Connection to job broker established

Now add a cache directive to the Examples/Spectra data source included with das2-pyserver. Open the file: `$PREFIX/datasets/Examples/Spectra.dsdf` and check to see if it contains the following line. If it's not present, add it.

```
cacheLevel_00 = '10 s | daily'
```

This directive tells das2-pyserver that it can generate cache blocks with 10 second time bins for this data source.

Then read the data source using `wget` (or Autoplot if you desire). A `wget` command similar to the following will do the job. Careful, though it's line-wrapped in this document, the command below **is a single line**.

```
wget --content-disposition 'https://localhost/das/server?
server=dataset&dataset=Examples/Spectra&start_time=1979-03-01&end_time=1979-03-
02&resolution=30'
```

Since these data are now cacheable, but no cache blocks are suitable for fulfilling this request, das2_srvcgi_main to enter a cache task into the Redis database so that the next read will be fast. Since a worker program is running and listening for new tasks you should see a message that start with the following text in the terminal running `das2_srv_arbiter`.

Starting Task - '2019-08-24T02:09:27.690|localhost/das/server||127.0.0.1||apache|TASK_CACHE|...

After couple seconds the task should complete, to see the cache block look in:

```
$PREFIX/cache/data/Examples/Spectra/_noparam/bin-10s/1979/03
```

Subsequent reads for day 1979-03-01 of this data set at ten second resolution or lower will no longer trigger the reader. Instead data will be read from the cache. The worker program will stay alive listening for new tasks indefinitely, to close down the worker program, hit

```
CTRL+C
```

in the terminal you were using to run `das2_srv_arbiter`.

4.3: Automatic Startup

You can run worker programs within a terminal to hand all the das2-pyserver processing needs, but it is more convenient for the worker programs to start automatically when your server boots.

TODO:

5: Extra Services

In addition to the standard services defined in the Das2.2 Interface Control Document, das2-pyserver provides extra functionality. These extra services may or may not be supported by any given das2 client program, but they do not interfere with support for the standard das2.2 *id*, *logo*, *discovery*, *dsdf*, *dataset* and *peers* responses.

5.1: Server-side Plot Creation

Das2-pyserver may be used to trigger creation of finished plots instead of data value streams.

5.1.1 External Interface

This extra feature is triggered by the **`server=image`** query parameter the following HTTP GET header example:

Image Request

```
GET /das/server?server=image&dataset=Example/Spectra&start_time=2010-001&end_time=2010-002
HTTP/1.0
Host: localhost
Accept: *
```

A successful response will include a PNG image as the sole item in the message body.

Image Response

```
HTTP/1.1 200 OK
Date: Tue, 23 Jul 2013 21:10:53 GMT
Server: Apache/2.0.63
Connection: close
Content-Type: image/png
```

(PNG Binary Image bytes follow...)

Server side image processing is handled **synchronously**. As of August 2019, no tasks are defined for image generation or retention.

5.1.2 Internal Interface

To enable server-side plot generation set the **`PNG_MAKER`** keyword in the das2server.conf file to point to your image creation script. For example:

```
    PNG_MAKER = autoplot_url2png.py
```

Any program may be used to generate the images but only Autoplot has been tested. The script listed above is included in the das2-pyserver `bin` directory by default. An image creation program must have the following command line interface.

```
PROGRAM in_fmt=FMT time.min=TIME_MIN time.max=TIME_MAX
```

Like other das2-pyserver programs, the image creation program is expected to behave as a classic UNIX filter with the following inputs and outputs:

- **Standard Input:** A das2 or Q stream. The format corresponds to value of in_fmt

- **Standard Output:** A PNG Image
- **Standard Error:** Any UTF-8 text
- **Return Value:** 0 if image creation was successful, a non-zero value otherwise

Note that an input stream that contains **no data** values is **legal** and should not trigger a non-zero return. In such a case the plotter should draw an empty plot scaling the X axis by the time range given in `time.max` and `time.min`, and the Y axis form 0 to 1 or by the range given in any stream packet headers. Temporary files are okay, but these must be cleaned by the image creation program as the server has no way of knowing where these reside.

5.2: Heliophysics API Subsystem

Some das2 readers output data that can be represented by the stream format defined by the Heliophysics Application Programming Interface[7] (HAPI) specification. A das2-pyserver can emulate a HAPI server at the sub path 'hapi', For example:

```
https://localhost/das/server/hapi
```

5.2.1 Enabling HAPI support

To enable this functionality, edit the `das2server.conf` file so that it contains the following:

```
ENABLE_HAPI_SUBSYS = true
```

This will change the landing page generated by das2_srvcgi_main so that it includes a statement that HAPI support is enabled and a link to the HAPI landing page.

For each source that you wish to provide automatic output conversion, edit the DSDF as follows:

```
hapi = 1
```

This will cause das2-pyserver to add the source to it's HAPI catalog response. Many das2 readers modify their output in the presence of the `EXTRA_PARAMETERS` described in the command line interface in Section 3.1. Since the HAPI protocol does forbids supporting extra parameters some das2 sources must be represented as more that one HAPI date endpoint. To split your source, add **`subSource_SS`** keywords to the DSDF similar to the following example:

```
hapi = 1
subSource_00 = 'E | Survey Mode Electric Spectral Densities | 0.0'
subSource_01 = 'B | Survey Mode Magnetic Spectral Densities | 0.0 | B '
```

In the example above, the variable resolution das2 `Cassini/RPWS/Survey_KeyParam` source has been specified as two, fixed resolution end points which will have the HAPI IDs:

1. `Cassini/RPWS/Survey_KeyParam,E`
2. `Cassini/RPWS/Survey_KeyParam,B`

The resolution will be fixed at the intrinsic value (indicated by 0.0) for both sub-sources. The first HAPI source one will take no `EXTRA_PARAMETERS`. The second will run the supplied reader with the extra parameter string "B".

By default if no **`subSource_SS`** keywords are present in the DSDF, reader output will not be reduced and not extra parameters will be supplied. Interval based readers follow command line **pattern B** and thus

7 https://github.com/hapi-server/data-specification

required a sub-source definition in order to set their `SAMPLING_INTERVAL` parameter. If no sub-source is defined, then no HAPI end point will be advertised for the DSDF, despite any other settings for the source.

5.2.2 Source Restrictions

As of version 2.0, the HAPI GET interface assumes public data sources and forbids extra query parameters. Variable time resolution streams and selectable intervals are not supported. Furthermore HAPI streams may only define a single packet type (unlike das2 and Q streams). The following common das2 data sources will not fit within the HAPI specification even with sub-source definitions and are thus excluded from the automatically generated HAPI catalog response:

- Variable Y-axis data sources such as the Cassini/RPWS/Survey source.
- Any data source that redirects operations to another server
- Any data source that requires authentication

5.2.3 HAPI Info Cache

HAPI requires that data set headers be deliverable without the data themselves and vice-verse. Since das2 and Q streams always include headers, this information is not included in DSDFs directly and thus must be determined by running a reader. Since reader's can be slow, HAPI *info* responses are cached if asynchronous processing has been enabled (see Section 4). Info response data is stored in the sub-directory `hapi` inside the directory defined by **`CACHE_ROOT`** in das2server.conf.

5.3: Simple Extensions

TODO

6: Server File Reference

6.1: Main Configuration

All provided programs whose name begins with '`das2_srv`' use the **`das2server.conf`** file to direct some or all of their actions. The location of this file for a particular das2-pyserver instance is compiled into the top-level programs during installation. The location of the file is:

```
$PREFIX/etc/das2server.conf
```

Here `$PREFIX` is an environment variable that was specified during installation (see Section 2.3) and has no default value.

The only hard-coded path on the server is the configuration file `das2server.conf` itself. All other locations, including the DSDF root directory, the logging directory, the cache location and even the program and library paths are specified in the configuration file. The server is so flexible that the configuration file can even be used to swap in custom code for parts of the main CGI routine! Flexibility like this can break things. If you are having problems on your server's first run consult the logs. If that isn't helpful, try using a web-browser to issue a debug query to the server which will look similar to:

```
http://localhost/das/server?server=debug
```

This will cause das2-pyserver to dump it's configuration information to your browser.

The server also depends various utility programs supplied by libdas2 to handle tasks such as converting data streams to ASCII text, up-converting old das1 reader output to das2.2 format, reducing data streams, and reading data caches. Utility programs **do not** consult das2server.conf, but instead must receive all necessary configuration information on their respective command lines.

6.1.1 Format

File comments start with the hash symbol '#' and may begin at any point on a line. Comment characters within double-quotes are ignored.

Each non-comment line of the main configuration file follows the pattern:

```
KEYWORD = VALUE
```

The file is strictly line-delimited, there are no line-continuation characters. Keywords are any portion of the line up to the first "=" character. Values are anything after the first "="character. Values need not be quoted, but maybe if desired, and have to be if they contain hash symbols.

While parsing the file, das2-pyserver programs strip all white space, from the keyword and value, and then strip begin and end double-quote characters in the value.

6.1.2 Keyword Reference

Any keyword may be present in the file, the server programs ignore keywords they do not understand. A list of the keyword used by at least one server program and it's purpose and example values are provided in table 6.1 below.

Keyword	**Notes**
`BIN_PATH`	Extra directories to prepend to the system PATH. Separate multiple extra directories with colons no matter the host operating system's path separator. If the libdas2 utility programs are not on the path the server will not function. Example: `"/usr/local/das2srv/bin:/usr/local/juno/bin"`
`CACHE_ROOT`	The path on your local file system where das2_srv_arbiter instances can store data. This includes storage of pre-reduced data and HAPI headers. This directory needs to be readable by the Apache user and writable by the `das2_srv_arbiter` user. Example: `/mass_storage/1/das2srv/cache`

`CONTACT_EMAIL`	Provides a contact email for overall problems with the server. Individual data sources use the **`techContact`** keyword to provide customized contact information. Since this address will appear on the front page of your server, you can use replacement characters to obscure the address a bit, for example:
	`&#45;  '-'`
	`@#46;  '.'`
	`&#64;  '@'`
	`&#117; 'u'`
	Example: `"someone.helpful@somewhere.edu"`

`CONTACT_URL`	Provides a contact URL, for example a departmental web page, to state who is responsible for the server. This is used by das2_srvcgi_main when generating the main page. Example: `"http://okf.ufa.cas.cz/en/"`
`DAS23_PROTOTYPE`	Enable support for the evolving das2.3 protocol by setting this value to "true". This will alter the landing page of the server and enable many features that are probably broken and unsupported by most das2 client programs. Example: `"false"`
`D2S_REDUCER`	The program to use for data reduction if the **`reducer`** keyword was not present in the source DSDF and the reader produces das2.2 streams. Example: `"das2_bin_avgsec"`
`D2S_CACHE_RDR`	The program to use for reading cache blocks if the **`cacheReader`** keyword was not specified in the source DSDF file and the reader produces das2.2 streams. Example: `"das2_cache_rdr"`
`D2S_TO_UTF8`	The program used to convert das2.2 format binary streams to text (UTF-8) streams. Example: `"das2_ascii"`
`DAS1_TO_DAS2`	Program to up-convert das1 streams to das2 streams, only used by the U. Iowa group.
`DSDF_ROOT`	The path on your local file system to the top of the Data Set Definition file tree. See sections 3 and 6.2 for information on the contents of DSDF files. Example: `"/usr/local/das2srv/datasets"`
`ENABLE_HAPI_SUBSYS`	Set this to "true" to enable support for the heliophysics API. This will alter the landing page created by `das2_srvcgi_main`, and will enable support for the **`hapi`** and **`subSource_SS`** keywords in DSDFs. Since many das2 streams can not be converted to HAPI format and since the HAPI server protocol does not allow for server-side data reduction or interval based readers, enabling this feature is discouraged. Example: `"false"`

Keyword	Notes
`IGNORE_REDIRECT`	Set this value to "true" to ignore the `server` and `rename` keywords in DSDF files. Example: `"false"`
`LIB_PATH`	Extra directories to prepend to the system LD_LIBRARY_PATH. Separate multiple extra directories with colons no matter the host operating system's path separator. Example: `"/usr/local/das2srv/lib"`
`LOG_PATH`	The location for log files written by `das2_srvcgi_main` (and thus by the Apache user) and for log files written by `das2_srv_arbiter`. Example: `"/var/log/das2srv"`
`MAIN_SERVER_URL`	This is used by `das2_srvcgi_logrdr` to create links to the main server web-page. If this value doesn't contain '`//`' then it is assumed to be relative to the parent URL of the das2_srvcgi_logrdr script. If '`//`' is present it is assumed to be an absolute link. Example: `"server"`
`MODULE_PATH`	Extra directories to prepend to the python's sys.path. Separate multiple paths them via colons, no matter the operating system's path separator character. If the das2, _das2 and das2server modules are not on the python path, the server will not function. Example: `"/usr/local/das2srv/lib:/usr/local/das2srv/python3.6"`
`PEERS_FILE`	The path to a file listing das2 peer servers. The format an content of the peers file is described in section 6.3. Example: `"/usr/local/das2srv/etc/das2peers.ini"`
`PNG_MAKER`	The path to a script that can output PNG images and that follows the command line pattern specified in section 5.1. If this keyword is given then server-side plot creation extension will be enabled. Example: `"/usr/local/das2srv/bin/autoplot_url2png.py"`
`QDS_REDUCER`	The program to use for data reduction if the **`reducer`** keyword was not present in the source DSDF and the reader produces Q streams. Though no Q stream reducer is supplied with das2-pyserver, Autoplot may be used as a Q stream reducer so long is it is wrapped in bash script that emulates the command line expected for das2_bin_avgsec. Example: `"QReduce.sh"`
`QDS_CACHE_RDR`	The program to use for reading cache blocks if the **`cacheReader`** keyword was not specified in the source DSDF file and the reader produces Q streams. No known Q stream cache reader exists as of August 2019.
`QDS_TO_UTF8`	The program used to convert Q format binary streams to text (UTF-8) streams. No known Q stream text convert exists as of August 2019.
`RESOURCE_ROOT`	The path on your local file system to the top of the static file resource tree. Static resources include the default CSS style sheet, as well as any server images and logos. Example: `"/usr/local/das2srv/static"`
`SAMPLE_DSDF`	This affects the introduction page generated by das2_srvcgi_main if no HTTP get arguments are supplied. It's use to specify and example data source that can be used to demonstrate the das2.2 query protocol. The value should be a relative path from the root of the directory supplied in **`DSDF_ROOT`** without the `.dsdf` extension for the file name. Example: `"Juno/WAV/Survey"`

Keyword	Notes
`SAMPLE_START`	The minimum time to use in the sample queries on the front page. Should be an ISO-8601 time string. Example: "2019-01-01T01:00"
`SAMPLE_END`	The maximum time to use in the sample queries on the front page. Should be an ISO-8601 time string. Example: "2019-01-01T13:00"
`SERVER_ID`	A short lowercase string used to distinguish this das2 server from others you may operate. Should be all lowercase without white space. Example: `"jupiter"`
`SITE_NAME`	The value to return for das2.2 *Identification* queries. Will also appear on the front page generated by `das2_srvcgi_main`. Unlike the **`SERVER_ID`**, this value does not need to be unique. Example: `"University of Iowa, Department of Physics and Astronomy"`
`SITE_PATH_URI`	The default das2 federated catalog path prefix to apply to sources on this server. Like the **`SITE_NAME`** this value need not be unique. In order to hook into the federated das2 catalog system, the string should start with `"tag:das2.org,2012:site:/"` or `"tag:das2.org,2012:test:/"` To view existing site prefix values visit https://das2.org/browse. Example: `"tag:das2.org,2012:site:/swri"`
`SKIP_LOWERCASE`	If set to true `das2_srvcgi_main` will skip directories that contain only lower-case names when generating das2 Discovery responses. Example: `"false"`
`TEST_FROM`	This is used to indicate that passwords should **never** be requested from connections at a given set of addresses. It used to facalitate internal automated testing services. Only individual IP addresses are supported. Host names and network ranges will not parse. Has not been tested with IPv6 at this time. Separate each IP address with a space. Example: `"127.0.0.1 192.168.1.10 10.0.0.63"`
`USER_PASSWD`	The path on your local file system to the user account password file. This is the file maintained by `das2_srv_passwd`. Example: `"/usr/local/das2srv/etc/passwd"`
`USER_GROUP`	The path on your local file system to the user account group file. There is no program for maintaining this file, it is hand edited. Example: `"/usr/local/das2srv/etc/group"`
`VIEW_LOG_ALLOW`	Used to restrict the range of addresses that can use the das2_srvcgi_logrdr script. Due to a bug, this is not currently used. Restricting the address range that can connect to the log service must be handled in the Apache configuration.
`VIEW_LOG_URL`	This is used by das2_srvcgi_main to create links to the log reader web page. If this value dosen't contain '//' then it is assumed to be relative to the parent URL of the `das2_srvcgi_main` script. If `'//'` is present it is assumed to be an absolute link. Example: `"log"`

Keyword	Notes
`WORK_QUEUE_BROKER`	`das2_srvcgi_main` and `das2_srv_todo` can record jobs to be preformed later, such as building data caches. Since many CGI instances may be running at a single time a distributed work queue broker is used to handle the task queue. By default redis is the only broker supported, so there is currently only one valid value for this keyword: Example: `"redis"`
`WORK_QUEUE_CONN`	This is the information needed to connect to the work queue broker given by the `WORK_QUEUE_BROKER` keyword. Connection parameters are broker software specific. Redis Example: `"localhost:6379:0"`

Table 6.1: Keyword reference for `das2server.conf`

6.2: Data Source Definition Files

All data source definition files must end in the suffix:

`.dsdf`

and must be under the directory indicated by **`DSDF_ROOT`** in the `das2server.conf` file. It is recommended that sub-directories are used to categorize sources by the observing platform and the instrument. But any hierarchy of directories that makes since for your installation is fine. Each directory may have a file name:

`_dirinfo_.dsdf`

that provides a description of the contents of the directory. Though any keywords are permitted inside `_dirinfo_.dsdf` only the `description` keyword is used by das2-pyserver. Table 6.2 below provides a list of keywords used by the server, or by other known das2 programs.

Keyword	Required	Value Description
`description`	**yes**	A human readable description of the data source.
`summary`	no	A longer form string describing data processing and other details of the source. The value for this keyword typically extends over many lines and thus makes use of the IDL string concatenation and line continuation syntax, i.e.: `'First line of value, ' + $` `'second line of value.'`
techContact	**yes**	An email address indicating who to contact if there is a problem with a reader. An example value: 'Some Person <some-person@uiowa.edu>'
sciContact	no	An email address providing contact information for questions about scientific usefulness or interpretation of the data source.
`reader`	**yes**	An arbitrary string that provides the beginning portion of the command line needed to invoke the reader. Additional arguments are supplied by the server as defined in Section 3.1. Readers produce data at the intrinsic resolution of the data files.
requiresInterval	**maybe**	Set to '1' to indicate that the server should supply the interval between measurements on the reader command line. This triggers use of command line **pattern B** as defined in Section 3.1. The first output time should be `MIN_TIME` and each successive time should be larger by the value of `SAMPLING_INTERVAL`.

Keyword	Required	Value Description
`das2Stream`	**maybe**	If set to '`1`' then the reader produces a das2.2 stream as defined in the Das2.2 Interface Control Document. If the output is a das2.2 stream this value is required, if it is a Q stream, this keyword should not be present.
`qstream`	**maybe**	If set to '1' the reader produces a Q Stream as defined in the Das2.2 Interface Control Document. If the output is a Q stream this keyword is required, if it is a das2.2 stream this keyword should not be present.

`exampleRange_EN`	**yes**	An example time that is known to provide visible data. Here **`EN`** represents the two-digit example number. This is use by client programs to 'just get something on the screen'. There can be up to 100 example ranges, **at least one is required** for automated testing. The format of this string field is as follows:
		`'START_TIME to END_TIME | NAME'`
		using Voyager as an example:
		exampleRange_01 = '1979-03-01 to 1979-04-14|Jupiter Encounter'
		exampleRange_02 = '1980-11-10 to 1980-11-14|Saturn Encounter'
		The `'|Name'` portion of the string is optional, but encouraged.

exampleInterval_EN	**maybe**	Here **`EN`** represents the two-digit example number. This keyword is required for each `exampleRange` when the reader follows command line **pattern B** and thus requires an interval parameter.
exampleParams_EN	no	Here **`EN`** represents the two-digit example number. Specifies extra parameters to provide to a reader when called for a numbered `exampleRange.` This keyword is adds the given reader parameter string to the reader when the associated `exampleRange_XX` is used. Where the characters XX are replaced by the example number.

cacheLevel_LN	no	Here **`LN`** represents the two-digit cache level number.
		If a work queue has been enabled for the server and das2_srv_arbiter instances are running, then the servers can store pre-reduced datasets.
		To direct the server to generate a set of pre-reduced datasets use this keyword. The value format is:
		`RESOLUTION | BLOCK_SIZE [| EXTRA_PARAMETERS]`
		● `RESOLUTION` is a das2 datum string indicating a time duration (typically given in seconds), or the keyword '`intrinsic`' to indicate caching the highest resolution available from the data source.
		● `BLOCK_SIZE` determines the coverage period of each cache block. The following keywords may be used: **`presecond`**, **`perminute`**, **`hourly`**, **`daily`**, **`monthly`**.
		● `EXTRA_PARAMETERS` A string of optional extra parameters to send to the reader when producing the cache.
		Example **`cacheLevel_XX`** values:
		`cacheLevel_00 = 'intrinsic | hourly'`
		`cacheLevel_01 = '1 s | daily'`
		`cacheLevel_02 = '60 s | daily | -r no-spikes'`
		Cached streams are generated via the reduction program specified in the **`reducer`** keyword thus if reducer = 'not_reducable' only **`intrinsic`** resolution may be used when specifying cache levels. If any extra parameters are specified, these are provided to the reader as given.

Keyword	Required	Value Description
cacheReader	no	If this item is blank the default cacheReader for the output type (`das2Stream` or `qstream`) will be invoked to read the data cache
readAccess	no	This value controls when authorization is needed and who is authorized. The format of this field is: `'`*`AUTH_METHOD`*`:`*`TEST`*` [| `*`AUTH_METHOD`*`:`*`TEST`*` ]'` here *`AUTH_METHOD`* is a token stating the authorization method and *`TEST`* is the value to test against. `AUTH_METHOD` may be one of `AGE`, `GROUP` or `USER`. If **any** one authorization method succeeds then access is granted. Thus authorization methods are combined using a logical OR test. An example for voyager follows: **`readAccess = `**`'AGE:1y6m|GROUP:voyager|USER:don'` In this example data older that 18 months is automatically authorized, so is anyone in the group `voyager`, as well as the user `don`.
securityRealm	no	This string should be provided by a Das2 client to end-user that is providing the authentication token and provides a context-clue as to what password is expected. For example: **`securityRealm`** = 'Juno Magnetospheric Working Group' indicates that users in the MWG should have access to these associated data stream.
`reducer`	no	One of the key benefits of serving data via a program instead of directly transmitting files is that data reduction can take place on the server which can drastically reduce the network bandwidth required to produce a plot. There are three categories to the values for this keyword. ● If this keyword is not specified default data reduction programs defined by either `D2S_REDUCER` or `QDS_REDUCER` in `das2server.conf` will be used to process the reader's output stream. ● If set to the value "`not_reducible`" no server-side data reduction will be preformed. ● If set to the name of a program on the server then that program will be used to reduce data in the streaming dimension before delivery.
`rename`	no	If a data source is renamed this keyword may be used in the **old** copy of the data source to point clients to the new location. If `das2_srvcgi_main` detects this keyword it will issue an HTTP redirect to the new location. This may be used in conjunction with the **`server`** keyword. DSDF files containing the keyword **`rename`** are not included in the output of das2 *Discovery* queries.
`server`	no	One das2-pyserver can advertise the existence of data sets hosted via another das2 server. The other server need not be a das2-pyserver instance. If this keyword is present and it's value doesn't match the URL of the server which was contacted, then `das2_srvcgi_main` issues an HTTP redirect to the client. This keyword may be used in conjunction with the **`rename`** keyword to change the dataset HTTP get parameter issues in the redirect.
testInterval	maybe	This keyword is required if **`testRange`** is given and the reader requires an interval parameter.

Keyword	Required	Value Description
testRange	no	A test time that is expected to provide unchanging visible data. It is use by automated end-to-end testing software to make sure that the output of a reader doesn't change over time.
validRange	no	A time range over which the data source may produce output. The syntax is: `validRange = BEGIN to END` Instead of a timestamp, the END may be denoted by the case-insensitive word 'now' for on-going missions. The following example is for Voyager 1 PWS Waveform data: `validRange = '1977-09-05T00:00 to NOW'` Though not required, usage of this keyword is highly recommended.
AnyKeyword	no	Any other key = value pair may be included in the file but only the ones above have specific uses.

Table 6.2: DSDF Keywords

6.2.1 Unknown Keywords

Unknown keywords are ignored by das2-pyserver, so you may add extra values, such as EPN-TAP[8] parameters, das2 catalog parameters and HAPI sub-source definitions to the files if desired. However, these extra keywords are delivered to clients when generating Das2.2 *dsdf* responses. Thus specialize clients can take advantage of any extra keywords you provide. Extension Section 5.2, Appendix A: and Appendix B: define the extra keywords upon which they depend.

6.3: Server Peers: das2peers.ini

6.4: Authentication: passwd, group

8 The EPN-TAP protocol for Planetary and Science Virtual Observatory, DOI: 10.1016/j.ascom.2014.07.008

7: Server Program Reference

7.1: Web Service Programs

7.1.1 das2_svrcgi_main

Purpose:	Main Das2 PyServer CGI program
Usage:	**das2_srvcgi_main** (All options are set via CGI/1.1 Environment Variables)
Scope:	Server Specific Program
Config:	das2server.conf, data set DSDF files

das2_svrcgi_main is meant to be invoked by a web-server that supports the CGI/1.1 interface standard. Most of the program's activity is directed by two inputs:

1. The CGI environment variables associated with a client request
2. The contents of the das2server.conf file

At present the POST method is not handled by the program, so standard input is not read. Furthermore das2_svrcgi_main does not write to standard error. All error messages out output as HTTP responses on standard output, as is expected of a CGI program. Configuration file details are provided in Section 5, environment variables used by this program are listed below.

Environment Variable	Summary
`HTTP_AUTHORIZATION` (optional)	Used to authenticate client programs if a data source has the keyword `readAccess` in it's DSDF file. (See Das2.2 ICD, Table 5)
`HTTP_USER_AGENT`	Used to determine if error messages should be output as Das2 Stream comments or as plain text.
`PATH_INFO`	Used to determine which resource file a client program is trying to access. (Das 2.3 protocol will use this for data source location as well)
`QUERY_STRING`	Used to determine which action the client is requesting
`REMOTE_ADDR`	Used to save log messages by remote IP address and for allowing some IP addresses to skip authentication all together
`REQUEST_METHOD`	Current version merely checks to make sure POST is not in use.
`SCRIPT_NAME`	Used to determine the URL to the Das2 PyServer itself
`SERVER_NAME`	Used to determine the URL to the Das2 PyServer itself
`SERVER_PORT`	Used to determine the URL to the Das2 PyServer itself
`SERVER_SIGNATURE`	Used to advertise the underlying web-server software on auto-generated web pages.

7.1.2 das2_srvcgi_logrdr

Purpose:	Log Reader CGI program
Usage:	**das2_srvcgi_logrdr** (All options are set via CGI/1.1 Environment Variables)
Scope:	Server specific program
Config:	das2server.conf

7.2: Asynchronous Processing Programs

7.2.1 das2_srv_arbiter

Purpose:	Server background processing manager
Usage:	**das2_srv_arbiter** [-h] [--no-daemon]
Scope:	Server specific program
Config:	das2server.conf

Handles Jobs received from the task queue broker. The format

7.2.2 das2_srv_todo

Purpose:	Adds tasks to a Das2 server's task lisk
Usage:	**das2_srv_todo** [-h] [--no-daemon]
Scope:	Server specific program
Config:	das2server.conf

Handles Jobs received from the task queue broker. The format

7.3: Utility Programs

7.3.1 das2_ascii

Purpose:	Converts a input binary das2 stream to an output text das2 stream
Usage:	**das2_ascii** [-h] [--no-daemon]
Scope:	Server specific program

7.3.2 das2_srv_passwd

Purpose:	Manage user accounts for Das2 Servers

Usage:	**das2_srv_passwd** [-h] `[-c] [-b] username [password]`
Scope:	Server Specific Program
Config:	das2server.conf

das2_srv_passwd updates the file indicated by the USER_PASSWD entry in a server's das2server.conf file. At present all password strings are stored using the CRYPT method. Das2 systems are assumed to operate in a somewhat friendly environment. Scientific data are usually not interesting to hackers, and user accounts on Das2 systems mostly exist to prevent premature publishing of data. For these reasons the crypt algorithim is considered sufficient to provide what little security is needed.

7.3.3 das2_bin_avg

Purpose:	Reduces the size of Das2 streams by averaging over values in the first <x> plane in a stream.
Usage:	das2_bin_avg [-b BEGIN] BIN_SIZE
Scope:	General Program
Config:	(none)

7.3.4 das2_bin_avgsec

Purpose:	Reduces the size of Das2 streams by averaging over time
Usage:	das2_bin_avgsec [-b BEGIN] BIN_SECONDS
Scope:	General Program
Config:	(none)

das2_bin_avgsec is a classic Unix filter, reading Das 2 Streams on standard input and producing a time-reduced Das 2 stream on standard output. The program averages <y> and <yscan> data values over time, but does not preform rebinning across packet types. Only values with the same packet ID and the same plane name are averaged. Within `<yscan>` planes, only Z-values with the same Y coordinate are combined.

It is assumed that <x> plane values are time points. For this reducer, only the following <x> unit values are allowed:

us2000 - Microseconds since midnight, January 1st 2000

t2000 - Seconds since midnight, January 1st 2000

mj1958 - Days since midnight January 1st 1958

t1970 - Seconds since midnight, January 1st 1970

All time values, regardless of scale, epoch, or representation in the input stream are handled as 8-byte IEEE floating point numbers internally. ASCII times are converted internally to us2000 values.

The BIN_SECONDS parameter provides the number of seconds over which to average <y> and <yscan> plane values. Up to total of 99 <y> and <yscan> planes may exist in each packet type, and up to 99 packet types may exist in the input stream. This is a plane limit, not a limit on the total number of data vectors. <yscan> planes may contain an arbitrary number of vectors. The output stream has the same number of packet types and planes as the input stream, but presumably with many fewer time points.

Option	Summary
-b BEGIN	Instead of starting the 0th bin at the first time value received, specify a starting bin. This useful when creating pre-generated caches of binned data as it keeps the bin boundaries predictable.

7.3.5 das2_bin_peakavgsec

7.3.6 das2_cache_rdr

Purpose:	Pre-reduced dataset reader
Usage:	**das2_srv_cacherdr** [-h] `DATASET_NAME NORM_PARAMS RESOLUTION BEGIN END`
Scope:	Server specific program
Config:	das2server.conf, data set DSDF files

das2_cache_rdr selects pre-generated das2 stream files from a hierarchical data cache of pre-binned data. Full path to cache files is:

```
CACHE_ROOT/dataset_name/norm_params/resolution_dir/block_dirs
```

Parameter	Summary
DATASET_NAME	The name of the dataset, i.e. the relative path to the DSDF file from the root of the DSDF tree.
NORM_PARAMS	A normalized string representing the parameters set to the reader. The assumption is that when readers are called with different parameter sets the output data set changes. Each different parameter set is a different set of cache files. The string '`_noparam`' can be used to indicate that no parameters were given to the reader when the cache files were generated. See section , part for a description of reader parameter string normalization.
RESOLUTION	An integer providing the resolution requested. The largest bin size that does not exceed this value will be selected as the dataset. The string '`intrinsic`' can be used to select the best resolution available. Also a BINSZ of 0 may be given to select native resolution as well.
BEGIN	The starting value of the lookup parameter.
END	The ending value of the lookup parameter.

Appendix A: Listing Das2 Sources in DaCHS Servers

TODO: Short Description of the VESPA effort, link to site

Pointer to setup instructions for DaCHS

Pointer to scripts used to populate DaCHS entries

Notes on needing a very low resolution cache since whole range is advertised

DSDF Keyword	Value Description
dataproduct_type	
feature_name	
measurement_type	
target_class	
target_name	
target_region	

Appendix B: Listing Das2 Sources in Das2 Catalogs

TODO: Short description of federated catalog project, in terms of generic GET services

Pointer to using das2py to view catalog entries

Pointer to das2_cat_import for reading server listings

Need for hand editing the upper interface layer

DSDF Keyword	Value Description

data_DN	An informational keyword used to name dependent data variables in the reader's output stream. Here **`DN`** represents the two-digit data item number.
	Setting this keyword allows a das2 client to ask the user at load time which variables they wish to plot. It has no baring on the actual reader output, clients are responsible for filtering out undesired data variables.
	The format is:
	
	`data_DN = 'ID [| DESCRIPTION | UNITS]'`
	
	In the following example the das2 reader that produces magnetic X, Y, Z and Magnitude values each as a separate <y> vector.
	
	`data_00 = 'mag | Magnetic Field Magnitude | nT'`
	`data_01 = 'x_gsm | X component in the GSM frame | nT'`
	`data_02 = 'y_gsm | Y component in the GSM frame | nT'`
	`data_03 = 'z_gsm | Z component in the GSM frame | nT'`
	
	For das2.2 streams, `ID` values above must match the **`name`** attribute value given in the `<y>`, `<yscan>` and `<z>` elements in the packet headers. For QStreams, `ID` values above match the **`id`** attribute in `<qdataset>` elements in the packet headers. See the Das2.2 ICD for more information an das2 stream and Q stream packet headers.
	
	Though this keyword is not required, it is strongly recommended for streams that produce more than one top-level data variable by default.

item_DN	A synonym for data_DN
coord_CN	Here **`CN`** represents the two-digit coordinate number. Used by the das2 federated catalog importer to determine any coordinates on which the data values depend. By default it is assumed that all data are dependent on time. Values are similar to **`data_DN`** above. An example of adding frequency as coordinate value follows: `coord_00 = 'frequency|Channel Center Frequencies|Hz'` Time can also be listed as well, though this is presumed.