Software Development Kit for Multicore Acceleration
Version 3.0

Data Communication and Synchronization for Hybrid-x86 Programmer's Guide and API Reference Version 1.0 DRAFT

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Note
Before using this information and the product it supports, read the information in "Notices" on page 107.

Edition notice

This edition applies to version 1.0, release 1.0 of the *Data Communication and Synchronization on Hybrid Programmer's Guide and API Reference* and to all subsequent releases and modifications until otherwise indicated in new editions.

Contents

About this publication

This programmer's guide provides detailed information regarding the use of the Data Communication and Synchronization library APIs. It contains an overview of the Data Communication and Synchronization library, detailed reference information about the APIs, and usage information for programming with the APIs.

For information about the accessibility features of this product, see Appendix G, "Accessibility features," on page 105.

Who should use this book

This book is intended for use by accelerated library developers and compute kernel developers.

Related information

See "Related documentation" on page 111.

How to send your comments

Your feedback is important in helping to provide the most accurate and highest quality information. If you have any comments about this publication, send your comments using Resource Link™ at http://www.ibm.com/servers/resourcelink. Click **Feedback** on the navigation pane. Be sure to include the name of the book, the form number of the book, and the specific location of the text you are commenting on (for example, a page number or table number).

Chapter 1. Overview

The Data Communication and Synchronization (DaCS) library provides a set of services which ease the development of applications and application frameworks in a heterogeneous multi-tiered system (for example a 64 bit x86 system (x86_64) and one or more Cell BE systems). The DaCS services are implemented as a set of APIs providing an architecturally neutral layer for application developers on a variety of multi-core systems. One of the key abstractions that further differentiates DaCS from other programming frameworks is a hierarchical topology of processing elements, each referred to as a *DaCS Element* (DE). Within the hierarchy each DE can serve one or both of the following roles:

A general purpose processing element, acting as a supervisor, control or master processor. This type of element usually runs a full operating system and manages jobs running on other DEs. This is referred to as a *Host Element* (HE).

A general or special purpose processing element running tasks assigned by an HE. This is referred to as an *Accelerator Element* (AE).

DaCS on Hybrid

DaCS on Hybrid (DaCSH) is an implementation of the DaCS API specification which supports the connection of an HE on an x86_64 system to one or more AEs on Cell Broadband Engines (CBEs). In SDK 3.0, DaCSH only supports the use of sockets to connect the HE with the AEs. Direct access to the Synergistic Processor Elements (SPEs) on the CBE is not provided. Instead DaCSH provides access to the PowerPC® Processor Element (PPE), allowing a PPE program to be started and stopped and allowing data transfer between the x86_64 system and the PPE. The SPEs can only be used by the program running on the PPE.

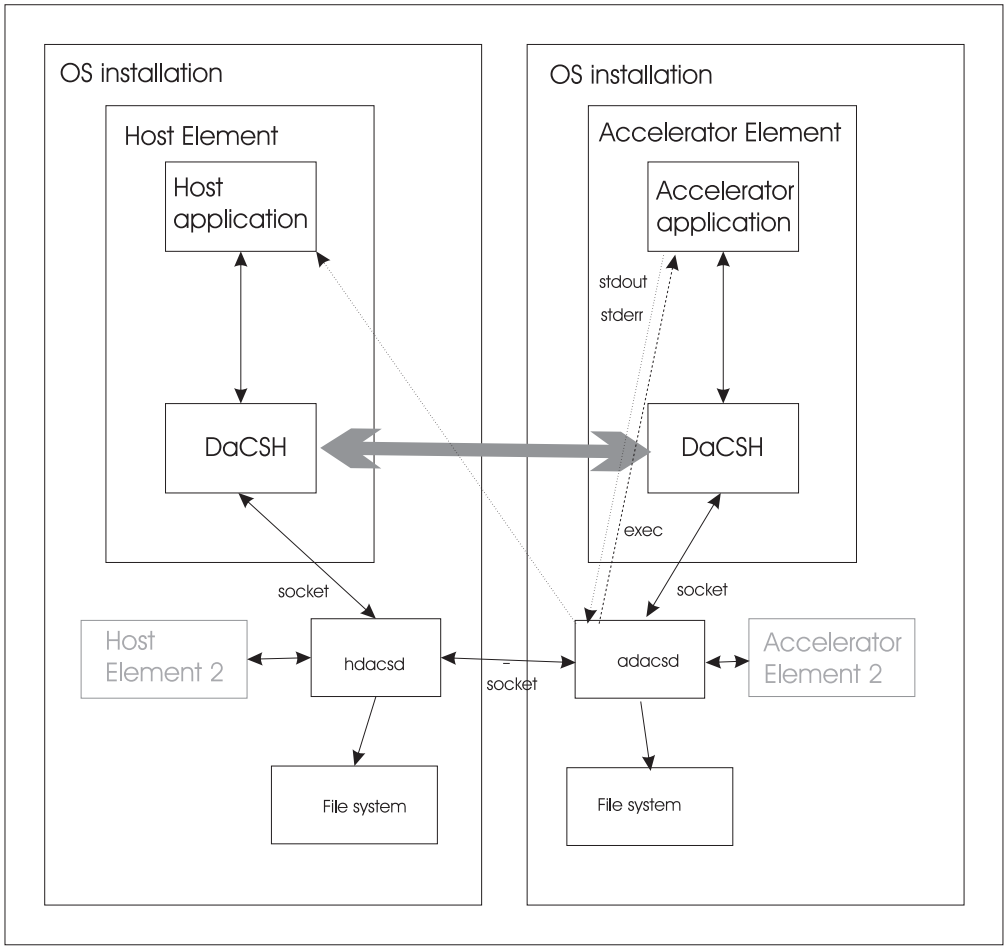
The program running on the PPE to work with the SPEs can also be a DaCS program. In this case the program will use DaCS on Cell (DaCSC - see *DaCS Programmer's Guide and API Reference for Cell BE*); the PPE will act as an AE for DaCSH (communicating with the x86_64 system) and as an HE for DaCSC (communicating with the SPEs). The DaCS API on the PPE is supported by a combined library which, when the PPE is being used with both DaCSH and DaCSC, will automatically use the parameters passed to the API to determine if the PPE is an AE talking to its HE (DaCSH) or an HE talking to its AEs (DaCSC).

In order to manage the interactions between the HE and the AEs DaCSH starts a service on each of them. On the host system the service is the Host DaCS daemon (`hdacsd`) and on the accelerator the service is the Accelerator DaCS daemon (`adacsd`). These services are shared between all DaCSH processes for an operating system image. For example, if the x86_64 system has multiple cores that each run a host application using DaCSH, only a single instance of the `hdacsd` service is needed to manage the interactions of each of the host applications with their AEs via DaCSH. Similarly, on the accelerator, if the CBE is on a Cell Blade (which has two CBEs), a single instance of the `adacsd` service is needed to managed both of the CBEs acting as AEs, even if they are used by different HEs.

When a host application starts using DaCSH this connects to the `hdacsd` service. This service manages the system topology from a DaCS perspective (managing reservations) and starts the accelerator application on the AE. Only process management requests will use the `hdacsd` and `adacsd` services. All other interactions between the host and accelerator application will flow via a direct

socket connection.

The following diagram provides a summary of the DaCS daemons and their relationships:



where:

- the host application (which uses DaCS) is assumed to be started outside of the scope of DaCS;
- the broad arrow represents the flow of data (since only process management requests are handled by the hdacsd and adacsd services);
- the lines marked 'socket' are control socket connections (DaCSd will be a service that is called via ports reserved for DaCS usage. The connections that will be created are between the hdacsd and the adacsd, and between the adacsd and the host application, for stderr and stdout redirection.);
- more than one element (host and accelerator) is shown, as from the perspective of the DaCS services it is shared at an OS installation level (multiple host applications could be using the hdacsd, and multiple accelerator applications could be using the adacsd);
- The `stderr` and `stdout` streams of an AE application on the accelerator system are redirected to the HE application.
- For DaCSH the configuration information used for topology management will be retrieved from the file system on the Host Element.
- The hdacsd and adacsd can be configured using configurations files from the file system.

- –
- The DaCSH daemons are user space programs, and are not privileged kernel modules.

User Ids

The accelerator application will be started using the user id of the host application. These user ids must already be setup on the accelerator.

Coexistence with DaCS for Cell

DaCS for Hybrid can coexist and work with DaCS on Cell. To use them both you must install both. For instructions on installing DaCS on Cell see the *SDK 3.0 Installation Guide*.

When both are installed the application using DaCS on the PPU can be both an AE for the x86_64 HE and an HE for the SPU AEs. The DaCS library automatically directs the requests appropriately based on the passed parameters. For example a `dacs_send()` is passed the DE Id and Pid of the destination to send the message to. This is used by the DaCS library to determine if it should be sent to the x86_64 HE using DaCS for Hybrid or to a SPU AE using DaCS for Cell.

All three (x86_64, PPU and SPU) can work together with remote memory and mutexes. When these are created on the PPU they are created in a way that allow them to be used with both the x86_64 HE and the SPU AE. In this way processes on all three can be synchronized using a mutex or can share remote memory. Note, however, that this must be initiated on the PPU (which is shared between the two). It is not possible for the x86_64 HE to create the mutex and share it with the PPU AE and then for the PPU (as an HE) to share it with its SPU AEs. This does not work as a mutex can only be shared by the DE that created it - the x86_64 DE cannot see the SPU DE.

Services

The DaCS services can be divided into the following categories:

Resource reservation
The resource reservation services allow an HE to reserve AEs below itself in the hierarchy. The APIs abstract the specifics of the reservation system (O/S, middleware, etc.) to allocate resources for an HE. Once reserved, the AEs can be used by the HE to execute tasks for accelerated applications.

Process management
The process management services provide the means for an HE to execute and manage accelerated applications on AEs, including, but not limited to, remote process launch, remote process termination, and remote error notification.

The host system DaCSd (`hdacsd`) provides services to the HE applications. The accelerator DaCSD (`adacsd`) provides services to the `hdacsd` and HE application, including the launching of the AE applications on the accelerator for the HE applications.

Group management
The group management services provide the means to designate dynamic

groups of processes for participation in collective operations. In SDK 3.0 this is limited to process execution synchronization (*barrier*).

Remote memory
The remote memory services provide the means to create, share, transfer data to, and transfer data from a remote memory segment. The data transfers are performed using a one-sided put/get remote direct memory access (rDMA) model. These services also provide the ability to scatter/gather lists of data, and provide optional enforcement of ordering for the data transfers.

Message passing
The message passing services provide the means for passing messages asynchronously, using a two-sided send/receive model. Messages are passed point-to-point from one process to another.

Mailboxes
The mailbox services provide a simple interface for synchronous transfer of small (32-bit) messages from one process to another.

Process Synchronization
The process synchronization services provide the means to coordinate or synchronize process execution. In SDK 3.0 this is limited to the *barrier* synchronization primitive.

Data Synchronization
The data synchronization services provide the means to synchronize and serialize data access. These include management of *wait identifiers* for synchronizing data transfers, as well as *mutex* primitives for data serialization.

Error Handling
The error handling services enable the user to register error handlers and gather error information.

Chapter 2. Installing and configuring DaCS

The DaCS library should be installed as a component of the Cell BE Software Development Kit. In order for it to work correctly:

- library path information may need to be set up (by using `LD_LIBRARY_PATH` or `ldconfig`) or you may specifically skip this and use RPATH information when linking DaCS applications, and
- daemons are not started immediately after installation and will need to be configured on the host and started on the host and accelerators.

Installation

Several packages are available that provide the means to develop, deploy and debug DaCS applications on your x86_64 and Cell BE system. The following table shows the package names with a short description:

Table 1.

Package	Description
dacs-hybrid-3.0.$.$.ppc64.rpm	DaCS for Hybrid Runtime - Contains the optimized PPU shared library.
dacs-hybrid-devel-3.0.#-#.ppc64.rpm	DaCS for Hybrid Development - Contains the header files, optimized static PPU libraries, and debug libraries (PPU static and shared).
dacs-hybrid-debuginfo-3.0#-#.ppc64.rpm	DaCS for Hybrid Debug Symbols - Contains the debugging symbols for the DaCS runtime library.
dacs-hybrid-trace-3.0.#-#.ppc64.rpm	DaCS for Hybrid Trace Enabled Runtime - Contains the trace enabled PPU shared library.
dacs-hybrid-trace-debuginfo-3.0.#-#.ppc64.rpm	DaCS for Hybrid Trace debug symbols - Contains the debugging symbols for the DaCS trace-enabled runtime library.
dacs-hybrid-trace-devel-3.0.#-#.ppc64.rpm	DaCS for Hybrid Trace Enabled Development - Contains the header files and trace-enabled PPU static library.
dacs-hybrid-3.0.$.$.x86_64.rpm	DaCS for Hybrid Runtime - Contains the optimized x86_64 shared library.
dacs-hybrid-devel-3.0.#-#.x86_64.rpm	DaCS for Hybrid Development - Contains the header files, optimized static x86_64 libraries, and debug libraries (x86_64 static and shared).
dacs-hybrid-debuginfo-3.0#-#.x86_64.rpm	DaCS for Hybrid Debug Symbols - Contains the debugging symbols for the DaCS runtime library.
dacs-hybrid-trace-3.0.#-#.x86_64.rpm	DaCS for Hybrid Trace Enabled Runtime - Contains the trace enabled x86_64 shared library.

Table 1. (continued)

Package	Description
dacs-hybrid-trace-debuginfo-3.0.#-#.x86_64.rpm	DaCS for Hybrid Trace debug symbols - Contains the debugging symbols for the DaCS trace-enabled runtime library.
dacs-hybrid-trace-devel-3.0.#-#.x86_64.rpm	DaCS for Hybrid Trace Enabled Development - Contains the header files and trace-enabled x86_64 static library.
dacs-hybrid-cross-devel-3.0.#-#.noarch.rpm	DaCS for Hybrid Cross Development - Contains the header files and libraries needed for cross-architecture development.

See the *SDK 3.0 Installation Guide* for detailed installation and configuration information.

Chapter 3. Programming with DaCS

How to compile and build applications which use DaCS

Process Management Model

When working with the host and accelerators there has to be a way to uniquely identify the participants that are communicating. From an architectural perspective, each accelerator could have multiple processes simultaneously running, so it is not enough simply to identify the accelerator. Instead the unit of execution on the accelerator (the DaCS Process) must be identified using its DaCS Element Id (DE id) and its Process Id (Pid). The DE Id is retrieved when the accelerator is reserved (using `dacs_reserve_children()`) and the Pid when the process is started (using `dacs_de_start()`). Since the parent is not reserved and a process is not started on it two constants are provided to identify the parent `DACS_DE_PARENT` and `DACS_PID_PARENT`. Similarly, to identifying the calling process itself, the constants `DACS_DE_SELF` and `DACS_PID_SELF` are provided.

Resource Sharing Model

The APIs supporting the locking primitives, remote memory access, and groups follow a consistent pattern of creation, sharing, usage and destruction:

- Creation: An object is created which will be shared with other DEs, for example with `dacs_remote_mem_create()`.
- Sharing: The object created is then shared by linked share and accept calls. The creator shares the item (for instance with `dacs_remote_mem_share()`), and the DE it is shared with accepts it (in this example with `dacs_remote_mem_accept()`). These calls must be paired. When one is invoked it waits for the other to occur. This is done for each DE the share is actioned with.
- Usage: This may require closure (such as in the case of groups) or it the object may immediately be available for use. For instance remote memory can immediately be used for put and get.
- Destruction: The DEs that have accepted an item can release the item when they are done with it (for example by calling `dacs_remote_mem_release()`). The release does not block, but notifies the creator that it is not longer being used and cleans up any local storage. The creator does a destroy (in this case `dacs_remote_mem_destroy()`) which will wait for all of the DEs it has shared with to release the item, and then destroy the shared item.
-

DaCS API functions

The DaCS library API services are provided as functions in the C language. The protocols and constants required are made available to the compiler by including the DaCS header file dacs.h as:

#include <dacs.h>

In general the return value from these functions is an error code (see Appendix F, “Error codes,” on page 103). Data is returned within parameters passed to the functions.

Note: Implementations may provide options, restrictions and error codes that are not specified here.

Note: When more than one error condition is present it is not guaranteed which one will be reported.

To make these services accessible to the runtime code each process must create a DaCS environment. This is done by calling the special initialization service `dacs_runtime_init()`. When this service returns the environment is set up so that all other DaCS function calls can be invoked.

When the DaCS environment is no longer required the process must call `dacs_runtime_exit()` to free all resources used by the environment.

Building a DaCS application

Three versions of the DaCS libraries are provided with the DaCS packages: optimized, debug and traced. The optimized libraries have minimal error checking and are intended for production use. The debug libraries have much more error checking than the optimized libraries and are intended to be used during application development. The traced libraries are the optimized libraries with performance and debug trace hooks in them. These are intended to be used to debug functional and performance problems that might be encountered. The traced libraries use the interfaces provided by the Performance Debug Tool (PDT) and require that this tool be installed. See Appendix D, "Performance and debug trace," on page 97 for more information on configuring and using traced libraries, and Appendix C, "DaCS debugging," on page 91 for debug libraries.

Both static and shared libraries are provided for the x86_64 and PPU. The desired library is selected by linking to the chosen library in the appropriate path. The static library is named libdacs.a, and the shared library is libdacs.so. The locations of these are:

Table 2.

Description	PPU Library Path	x86_64 Library Path
Optimized	/prototype/usr/lib64	/prototype/usr/spu/lib64
Debug	/prototype/usr/lib64/dacs/debug	/prototype/usr/spu/lib64/dacs/debug
Traced	/prototype/usr/lib64/dacs/trace	/prototype/usr/spu/lib64/dacs/trace

Affinity requirements for host applications

A hybrid DaCS application on the host (x86_64) must have processor affinity to start. This can be done:

- on the command line,
- in `mpirun`, or
- through the `sched_setaffinity` function.

Here is a command line example to set affinity of the shell to the first processor:

```
taskset -p 0x00000001  $$
```

The bit mask, starting with 0 from right to left, is an index to the processor affinity setting. Bit 0 is on or off for CPU 0, bit 1 for CPU 1, and bit number *x* is CPU number *x*. `$$` means the current process gets the affinity setting.

```
taskset -p $$
```

will return the mask setting as an integer. Using the `-c` option makes the `taskset` more usable. For example,

```
taskset -pc 7  $$
```

will set the processor CPU affinity to CPU 7 for the current process. The `-pc` parameter sets by process and CPU number.

```
taskset -pc  $$
```

will return the current CPU setting for affinity for the current process. See the man page for `taskset` for more details.

To launch a DaCS application use a `taskset` call, for example:

```
taskset 0x00000001  HelloDaCSApp Mike
```

or equivalently

```
taskset -c 0 HelloDaCSApp Mike
```

where the application program is `HelloDaCSApp` and is passed an argument of `"Mike"`.

According to the man page for `taskset` a user must have `CAP_SYS_NICE` permission to change CPU affinity.

On the accelerator system the `adacsd` launch of an AE application on a specific CBE includes setting the affinity to the CBE and its associated memory node. If the launch is on the Cell Blade as a resource no affinity is set.

Chapter 4. Initializing the DaCS daemons

Starting and stopping the DaCS services

The daemons can be stopped and started using the shell `service` command in the `sbin` directory. For example, to stop the host daemon type:

```
/sbin/service hdacsd stop
```

and to restart the host daemon type:

```
/sbin/service hdacsd start
```

The accelerator daemon (adacsd) may be restarted in like manner. See the man page for `service` for more details on the service command.

DaCS daemon Configuration

The host daemon service is named `hdacsd` and the accelerator daemon service is named `adacsd`. Both daemons are configured using their respective /etc/dacsd.conf files.

Default versions of these files are automatically installed with each of the daemons. These default files contain comments on the parameters and values currently supported.

Note:

It is recommended that the configuration files are backed up before making any changes.

When one of these files is changed the changes will not take affect until the respective daemon is restarted as described above.

The default configuration for the daemons will work in most situations. The configuration file contains the following options:

`dacsd_receive_timeout`
: The default receive timeout in seconds. 0 (zero) means no timeout. For example, to set a timeout of 5 seconds use:

  ```
  dacsd_receive_timeout=5
  ```

`dacsd_kill_timeout`
: The default `dacs_de_kill` timeout; the number of seconds between sending `SIGTERM` and `SIGKILL`. 0 (zero) means that `dacsd_he_terminate` will send `SIGKILL` immediately, without sending `SIGTERM`. For example, to set a timeout of 5 seconds use:

  ```
  dacsd_kill_timeout=5
  ```

blade_monitor_interval
: The period in seconds between polling Cell Blades to track their availability. Setting this to 0 disables the Cell Blade monitor. For example, to set a period of 60 seconds use:

  ```
  blade_monitor_interval=60
  ```

dacs_topology_config

The topology configuration file, for example:

```
dacs_topology_config=/etc/dacs_topology.config
```

ae_cwd_prefix

The AE Current Working Directory prefix. Each AE process started by `dacs_de_start` is given a temporary current working directory named <ae_cwd_prefix>/adacsd-tmp/<HE # Process Info>/<AE Process Info>. DaCS applications refer to this by `$AE_CWD` in the `dacs_de_start` program parameters and environment variables. When `adacsd` starts it will clear the directory <ae_cwd_prefix>/adacsd-tmp. When an AE process ends, `adacsd` will remove the directory <ae_cwd_prefix>/adacsd-tmp/<HE Process Info>/<AE Process Info>. When an HE process ends, adacsd will remove the directory <ae_cwd_prefix>/adacsd-tmp/<HE Process Info>. An example of this parameter is:

```
ae_cwd_prefix=/adacsd
```

ae_cwd_keep

The default for this is

```
ae_cwd_keep=false
```

which means the AE Current Working Directory and its contents are deleted when the AE process terminates. To prevent this use:

```
ae_cwd_keep=true
```

he_tar_command

`dacs_de_start` transfers files via tar. The tar commands are configurable to help with debugging, but should not normally be changed. Configuring these commands incorrectly will cause `dacsd_he_xfer` to fail. The default is:

```
he_tar_command="/bin/tar cf -"
```

An example of a debug setting is:

```
he_tar_command="/usr/bin/strace -o/tmp/he_tar_strace /bin/tar cvvf -"
```

ae_tar_command

See the `he_tar_command`. The default for this is:

```
ae_tar_command="/bin/tar xf -"
```

and an example is:

```
ae_tar_command="/usr/bin/strace -o/tmp/ae_tar_strace /bin/tar xvvf -"
```

adacsd_use_numa

This is a temporary workaround for problems with `libnuma` versions before 0.9.10. The default is:

```
adacsd_use_numa=true
```

To disable `numa` support use:

```
adacsd_use_numa=false
```

Default startup options

These are:

```
ADACSD_ARGS="--log /var/log/adacsd.log --pidfile /var/run/adacsd.pid"
HDACSD_ARGS="--log /var/log/hdacsd.log --pidfile /var/run/hdacsd.pid"
```

Chapter 5. Initializing and closing down the DaCS library

The **dacs_runtime_init** and **dacs_runtime_exit** services initialize and close down access to the DaCS library.

Call `dacs_runtime_init()` before you use any other DaCS services, and do not use any DaCS services after you have called `dacs_runtime_exit()`.

Calling `dacs_runtime_exit()` on an AE causes the communications between the AE and HE to be stopped. Calling `dacs_runtime_init()` after `dacs_runtime_exit()` will fail because once communications are stopped they can only be initiated by the HE calling `dacs_de_start()` to start a new process.

dacs_runtime_init

NAME

dacs_runtime_init - Initialize all runtime services for DaCS.

SYNOPSIS

DACS_ERR_T dacs_runtime_init (void *, void *)

Call parameters
All parameters must be set to `NULL` for SDK 3.0. Passing in a value other than `NULL` will result in the error `DACS_ERR_INVALID_ADDR`.

DESCRIPTION

The `dacs_runtime_init` service initializes all runtime services for DaCS.

Note: This service must be called for every process before any other DaCS services can be used. All other DaCS services will return `DACS_ERR_NOT_INITIALIZED` if called before this service.
A host process may call this service more than once, provided there is a call to `dacs_runtime_exit()` in between. An accelerator process may only call this service once, even if there is an intervening call to `dacs_runtime_exit()`.

RETURN VALUE

The `dacs_runtime_init` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return.
- `DACS_ERR_INVALID_ADDR`: invalid pointer.
- `DACS_ERR_NO_RESOURCE`: unable to allocate required resources.
- `DACS_ERR_INITIALIZED`: DaCS is already initialized.
- `DACS_ERR_DACSD_FAILURE`: unable to communicate with DaCSd.
- `DACS_ERR_VERSION_MISMATCH`: version mismatch between library and DaCSd.

USAGE

For debug or performance operations on a remote workstation client pass `DACS_START_PARENT` to **dacs_de_start()**.

`dacs_runtime_init()` respects the following environment variables for setting up an event listener for a remote workstation client:

- `DACS_LISTENER_HOST`: the IP address of the workstation client.
- `DACS_LISTENER_PORT`: the IP port listening on the workstation client.
- `DACS_LISTENER_EVENT`: the named event to send to the client workstation:
  - `DACS_LISTENER_EVENT=CELL_APP_LISTENER`: see **dacs_de_start** for more details;
  - otherwise, all events are sent to the remote workstation client.

SEE ALSO

dacs_runtime_exit(3)

dacs_runtime_exit

NAME

dacs_runtime_exit - Close down all runtime services for DaCS.

SYNOPSIS

DACS_ERR_T dacs_runtime_exit (void)

Parameters
None

DESCRIPTION

The `dacs_runtime_exit` service closes down and destroys all runtime services, processes, transfers, and memory used by DACS. After calling this service, no other DaCS services can be used until another `dacs_runtime_init()` is performed. Calling `dacs_runtime_init()` after a `dacs_runtime_exit()` is only support for a host process.

RETURN VALUE

The `dacs_runtime_exit` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return.
- `DACS_ERR_DACSD_FAILURE`: unable to communicate with DaCSd.

SEE ALSO

dacs_runtime_init(3)

Chapter 6. Reservation services

In the DaCS environment, hosts and accelerators have a hierarchical parent-child relationship. This hierarchy forms a logical topology of parents, children, and peers. In SDK 3.0 only child-related APIs are defined and supported.

dacs_get_num_ avail_children

NAME

dacs_get_num_ avail_children - Return the number of children of the specified type available to be reserved.

SYNOPSIS

DACS_ERR_T dacs_get_num_ avail_children (DACS_DE_TYPE_T *type*, **uint32_t** **num_children* **)**

Call parameter

`type` — The type of children to report. This can be any of:

- **DACS_DE_SYSTEMX**,
- **DACS_DE_CELL_BLADE**,
- **DACS_DE_CBE**, or
- **DACS_DE_SPE**.

Return parameter

`*num_children` — The number of available children. This may be zero if either no children of the requested type exist, or children exist but cannot be reserved.

DESCRIPTION

The `dacs_get_num_avail_children` service returns the number of children of the caller of the specified type that are available for reservation.

Note: This service returns the number of children that were available at the time of the call. The actual number can change any time after the call. The number of children is only returned upon success.

RETURN VALUE

The `dacs_get_num_avail_children` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return.
- `DACS_ERR_INVALID_ADDR`: invalid pointer.
- `DACS_ERR_INVALID_ATTR`: invalid flag or enumerated constant.
- `DACS_ERR_DACSD_FAILURE`: unable to communicate with DaCSd.

SEE ALSO

dacs_reserve_children(3), dacs_release_delist(3)

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dacs_reserve_children

NAME

dacs_reserve_children - Reserve children of a specified type.

SYNOPSIS

DACS_ERR_T dacs_reserve_children (DACS_DE_TYPE_T *type*, **uint32_t** **num_children* , **de_id_t** **de_list* **)**

Call parameters

`type`	The type of children to report. This can be any of: • **DACS_DE_SYSTEMX**, • **DACS_DE_CELL_BLADE**, • **DACS_DE_CBE**, or • **DACS_DE_SPE**.
`*num_children`	A pointer to the number of children requested.

Return parameters

`*num_children`	A pointer to the number of children actually reserved. This may be less than or equal to the number requested.
`*de_list`	A pointer to a location where the list of reserved children is returned. The space for this list must be allocated by the caller and must have enough room for `num_children` entries.

DESCRIPTION

The `dacs_reserve_children` service attempts to reserve the requested number of children of the specified type. The actual number reserved may be less than or equal to the number requested. The actual number and list of reserved children is returned to the caller.

RETURN VALUE

The `dacs_reserve_children` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return.
- `DACS_ERR_INVALID_ATTR`: invalid flag or enumerated constant.
- `DACS_ERR_INVALID_ADDR`: invalid pointer.
- `DACS_ERR_INVALID_SIZE`: number of children requested must be greater than zero.
- `DACS_ERR_DACSD_FAILURE`: unable to communicate with DaCSd.

SEE ALSO

dacs_get_num_avail_children(3), dacs_release_delist(3)

dacs_release_de_list

NAME

dacs_release_de_list - Release the reservations for a list of DEs.

SYNOPSIS

DACS_ERR_T dacs_release_de_list (uint32_t *num_des* **, de_id_t** **de_list* **)**

Call parameters

`num_des`	The number of DEs in the list.
`*de_list`	A pointer to the list of DEs to release.

DESCRIPTION

The `dacs_release_de_list` service releases the reservation for the specified list of DEs. On successful return all DEs in the list are released (made available). On failure none of the DEs in the list are released.

RETURN VALUE

The `dacs_release_de_list` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return.
- `DACS_ERR_INVALID_ADDR`: invalid pointer.
- `DACS_ERR_INVALID_DE`: the specified DE is either invalid or not reserved.
- `DACS_ERR_RESOURCE_BUSY`: the resource is in use.
- `DACS_ERR_INVALID_SIZE`: invalid list size.
- `DACS_ERR_DACSD_FAILURE`: unable to communicate with DaCSd.

SEE ALSO

dacs_get_num_avail_children(3), dacs_reserve_children(3)

Chapter 7. Process management

This chapter describes the functions for starting, stopping and monitoring processes on DEs.

Current Working Directory

A key element in process management is the current working directory on the accelerator file system. DaCS internally determines this for the `dacs_de_start()` call. For environment variables such as `PATH` or `LD_LIBRARY_PATH`, the underlying implementation will substitute the current working directory for `$AE_CWD`.

For example, if the current working directory on the accelerator is /DACS-TMP/HOME/USER then `PATH=$AE_CWD:/USR/BIN` points to /DACS-TMP/HOME/USER:/USR/BIN on the accelerator file system, and `LD_LIBRARY_PATH=$AE_CWD:/DACS_LIB` points to /DACS-TMP/HOME/USER:/DACS_LIB.

All files transferred by `dacs_de_start()` are placed in the current working directory. This will be unique across all AE applications on an accelerator.

When the launched accelerator process terminates, DaCS clears the working directory by default. A configuration option in `/etc/dacsd.conf` is available to allow retention of the current working directory.

Note: The programmer using LD_LIBRARY_PATH may need to incorporate the DaCS libraries, and any required ".so" files, into the environment variable for running accelerator DaCS applications. See the accompanying documentation and readme files for these considerations.

Note: See Appendix C, "DaCS debugging," on page 91 for how to keep core dumps for launched accelerator applications.

Environment variables in Hybrid DaCS

Hybrid DaCS (tier 1) has specific environment variables in the process issuing the `dacs_de_start()` call. This allows an external program such as a debugging or profiling tool to be started which in turn starts the accelerator process. These variables are described in "ENVIRONMENT" on page 23.

dacs_de_start

NAME

dacs_de_start - Start a process on a DE.

SYNOPSIS

DACS_ERR_T dacs_de_start (de_id_t *de*, **void** **prog*, **char const** ***argv*, **char const** ***envv*, **DACS_PROC_CREATION_FLAG_T** *creation_flags*, **dacs_process_id_t** **pid* **)**

Call parameters

`de`	The target DE where the program will execute.
`*prog`	A pointer to the program text to execute. What this points to is platform-dependent, and also dependent on the `creation_flags` parameter.
`**argv`	A pointer to an array of pointers to argument strings (the argument list), terminated by a `NULL` pointer.
`**envv`	A pointer to an array of pointers to environment variable strings (the environment list), terminated by a `NULL` pointer.
`creation_flags`	An implementation-specific flag that specifies how the executable program is found. This can be any of: • `DACS_PROC_LOCAL_FILE`: a fully qualified pathname, • `DACS_PROC_LOCAL_FILE_LIST`: a list of fully qualified pathnames, • `DACS_PROC_REMOTE_FILE`: a fully qualified path on a remote system, or • `DACS_PROC_EMBEDDED`: the handle of an embedded executable image.

Return parameter

`*pid`	A pointer to a location where the process id is stored on successful return.

DESCRIPTION

The `dacs_de_start` service starts a process on the specified DE. The service can be called several times to start one or more processes on the same DE. The number of processes that can be started on a particular DE is platform and implementation dependent.

Note: In the execution environment, the environment variables in `DACS_START_ENV_LIST` will be a list appended to the environment variables in the list under parameter `char const **envv`.

Note: The use of duplicate environment variables across the lists in the `dacs_de_start()` service and `DAC_START_ENV_LIST` is possible. However the value that will be used is implementation dependent, because `getenv()` is used and what it returns is implementation dependent.

Note: Some implementations may prohibit one type of DE from starting processes on another DE. If this situation exists, the **dacs_de_start()** service returns `DACS_ERR_PROHIBITED`.

RETURN VALUE

The dacs_de_start service returns an error indicator defined as:

- DACS_SUCCESS: normal return.
- DACS_ERR_INVALID_ADDR: a pointer is invalid.
- DACS_ERR_INVALID_ATTR: a flag or enumerated constant is invalid.
- DACS_ERR_NO_RESOURCE: unable to allocate required resources.
- DACS_ERR_PROHIBITED: the operation is prohibited by the implementation.
- DACS_ERR_INVALID_DE: the specified DE is either invalid or not reserved.
- DACS_ERR_INVALID_TARGET: the operation is not allowed for the target DE.
- DACS_ERR_PROC_LIMIT: the maximum number of processes supported has been reached.
- DACS_ERR_INVALID_PROG: the specified program could not be executed.
- DACS_ERR_INVALID_ARGV: *argv* is too large or invalid.
- DACS_ERR_INVALID_ENV: *envv* is too large or invalid.
- DACS_ERR_DACSD_FAILURE: unable to communicate with DaCSd.
- DACS_ERR_SYSTEM: A system error was encountered. This often indicates the executable file was not found on the remote system.

ENVIRONMENT

Hybrid DaCS has specific environment variables in the process issuing the dacs_de_start() call. This allows an external program such as a debugging or profiling tool to be started which in turn starts the accelerator process.

These variables are:

DACS_START_PARENT
specifies the command used to start an auxiliary program which starts the accelerator process. Within the command, %e , %a and %p are replaced respectively by the accelerator executable name, the accelerator arguments, and the parent's listening port value.

For example, given:

```
DACS_START_PARENT="/usr/bin/gdb --args %e %a"
```

then:

```
dacs_de_start (de, "myaccel", "myargs", 0, ppid)
```

would launch the command:

```
/usr/bin/gdb --args myaccel myargs
```

DACS_START_FILES
specifies the name of a file which contains a list of files to transfer to the PPE prior to launching the accelerator process. File names are fully-qualified POSIX-compliant pathname files.

DACS_START_ENV_LIST
specifies an additional list of environment variables for the initial program spawn on the accelerator. List items are separated by semicolons. An example of the format is:

```
ENV1=VAL1;ENV2=VAL2;QSHELL_*;ENV3
```

where:

- ENV1 and ENV2 are the environment variables and *VAL1* and *VAL2* are their respective settings,
- *QSHELL_** means pull all environment variables prefixed with *QSHELL_* from the present environment, and
- ENV3 means pull the environment variable from the present environment and pass on.

Delete functions, such as <name>= and <prefix>*= to drop environment variables by name or prefix, are not supported in SDK 3.0.

DACS_PARENT_PORT
specifies the value of %p to pass in the dacs_de_start() call. This value is post-incremented in the environment so that it is one more on the next dacs_de_start() call.

Note: The port allocated by DACS_PARENT_PORT is solely the responsibility of the environment setter and is not guaranteed to be available on the accelerator OS.

SEE ALSO

dacs_num_processes_supported(3), dacs_num_processes_running(3), dacs_de_wait(3), dacs_de_test(3)

dacs_num_processes_supported

NAME

dacs_num_processes_supported - Return the number of processes that can be started on a DE.

SYNOPSIS

DACS_ERR_T dacs_num_processes_supported (de_id_t *de*, **uint32_t** **num_processes* **)**

Call parameter

de	The DE to query.

Return parameter

*num_processes	A pointer to a location where the maximum number of processes that can be started on this DE is stored.

Note: In SDK 3.0 the value returned in num_processes can only be 1 or 0.

DESCRIPTION

The dacs_num_processes_supported service returns the number of simultaneous processes that can be started on the specified DE. The target DE must have been reserved by the caller.

RETURN VALUE

The dacs_num_processes_supported service returns an error indicator defined as:

- DACS_SUCCESS: normal return.
- DACS_ERR_INVALID_DE: the specified DE is either invalid or not reserved.
- DACS_ERR_INVALID_ADDR: the pointer is invalid.
- DACS_ERR_INVALID_TARGET: the operation is not allowed for the target de.

SEE ALSO

dacs_de_start(3), dacs_num_processes_running(3), dacs_de_wait(3), dacs_de_test(3)

dacs_num_processes_running

NAME

dacs_num_processes_running - Return the number of processes currently running on a DE.

SYNOPSIS

DACS_ERR_T dacs_num_processes_running (de_id_t *de*, **uint32_t** **num_processes* **)**

Call parameter

`de`	The DE to query.

Return parameter

`*num_processes`	A pointer to a location where the number of processes currently running on the target DE is stored.

DESCRIPTION

The `dacs_num_processes_running` service returns the number of processes currently running on the specified DE. This includes all processes that have been started (with `dacs_de_start()`) and have not yet had their exit status reaped (with `dacs_de_test()` or `dacs_de_wait()`). The target DE must have been reserved by the caller.

RETURN VALUE

The `dacs_num_processes_running` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return.
- `DACS_ERR_INVALID_DE`: the specified DE is either invalid or not reserved.
- `DACS_ERR_INVALID_ADDR`: the pointer is invalid.
- `DACS_ERR_INVALID_TARGET`: the operation is not allowed for the target de.

SEE ALSO

dacs_de_start(3), dacs_num_processes_supported(3), dacs_de_wait(3), dacs_de_test(3)

dacs_de_wait

NAME

dacs_de_wait - Block the caller waiting for a process running on a DE to finish.

SYNOPSIS

DACS_ERR_T dacs_de_wait (de_id_t *de*, **dacs_process_id_t** *pid*, **int32_t** **exit_status* **)**

Call parameters

`de`	The target DE.
`pid`	The target process.

Return parameter

`*exit_status`	A pointer to a location where the exit code is stored (if `DACS_STS_PROC_FINISHED` or `DACS_STS_PROC_FAILED`) or the signal number (if `DACS_STS_PROC_ABORTED`).

DESCRIPTION

The `dacs_de_wait` service returns the status of the target process, if it was successful, or an error code.. If the process is running at the time of the call, the call blocks until it finishes execution. If the process has finished execution at the time of the call, the call does not block.

When this service or `dacs_de_test()` detects a finished, failed, or aborted status, the status is reaped. Once the status of a process has been reaped, subsequent calls to query its status will fail with `DACS_ERR_INVALID_PID`.

RETURN VALUE

The `dacs_de_wait` service returns an error indicator defined as:

- `DACS_STS_PROC_FINISHED`: the process finished execution without error.
- `DACS_STS_PROC_FAILED`: the process exited with a failure.
- `DACS_STS_PROC_ABORTED`: the process terminated abnormally. The platform-specific exception code is returned in *exit_status*. For Linux/UNIX this is the signal number which caused the termination.
- `DACS_ERR_INVALID_DE`: the specified DE is either invalid or not reserved.
- `DACS_ERR_INVALID_PID`: the specified PID does not refer to a valid process.
- `DACS_ERR_INVALID_TARGET`: the operation is not allowed for the target process.
- `DACS_ERR_INVALID_ADDR`: the pointer is invalid.
- `DACS_ERR_DACSD_FAILURE`: unable to communicate with DaCSd.

SEE ALSO

dacs_de_start(3), dacs_num_processes_supported(3), dacs_num_processes_running(3), dacs_de_test(3)

dacs_de_test

NAME

dacs_de_test - Test the status of a process.

SYNOPSIS

DACS_ERR_T dacs_de_test (de_id_t *de*, **dacs_process_id_t** *pid*, **int32_t** **exit_status* **)**

Call parameters

`de`	The target DE.
`pid`	The target process.

Return parameter

`*exit_status`	A pointer to a location where the exit code is stored (if `DACS_STS_PROC_FINISHED` or `DACS_STS_PROC_FAILED`) or the signal number (if `DACS_STS_PROC_ABORTED`).

Note: If the return value is `DACS_STS_PROC_RUNNING` then the `exit_status` is not modified.

DESCRIPTION

The `dacs_de_test` service returns the status of the target process, if it was successful, or an error code.

When this service or `dacs_de_wait()` detects a finished, failed, or aborted status, the status is reaped. Once the status of a process has been reaped, subsequent calls to query its status will fail with `DACS_ERR_INVALID_PID`.

RETURN VALUE

The `dacs_de_test` service returns an error indicator defined as:

- `DACS_STS_PROC_RUNNING`: the process is still running.
- `DACS_STS_PROC_FINISHED`: the process finished execution without error.
- `DACS_STS_PROC_FAILED`: the process exited with a failure.
- `DACS_STS_PROC_ABORTED`: the process terminated abnormally. The platform-specific exception code is returned in *exit_status*. For Linux/UNIX this is the signal number which caused the termination.
- `DACS_ERR_INVALID_DE`: the specified DE is either invalid or not reserved.
- `DACS_ERR_INVALID_PID`: the specified PID does not refer to a valid process.
- `DACS_ERR_INVALID_TARGET`: the operation is not allowed for the target process.
- `DACS_ERR_INVALID_ADDR`: the pointer is invalid.
- `DACS_ERR_DACSD_FAILURE`: unable to communicate with DaCSd.

SEE ALSO

dacs_de_start(3), dacs_num_processes_supported(3), dacs_num_processes_running(3), dacs_de_wait(3)

Chapter 8. Group functions

Group functions allow you to organize processes into groups so that they can be treated as a single entity.

Definitions

Group

A group is a collection of related processes that share a common set of resources. A process is an identifiable unit of execution.

A group is referred to by a handle. The handle may be a pointer, offset, index or any other unique identifier of the group.

Group Member

A group member is a process, uniquely identifiable by its DE and PID combination.

The members of a group work together to perform a common task, through the use of shared resources. Being a member of a group requires participation in group activities.

Group design

Membership

In DaCS membership is by invitation only. A process cannot declare itself a member of a group; it must be added by the group creator. This works on the basis that the creator of a group resource knows which processes will be participating in the use of the resource. The member being added to a group must also cooperate by accepting membership, and must make a request to leave a group.

Group Leader/Owner

Groups can only be created on an HE. The HE, by creating a group, implicitly becomes the group owner. This does not imply membership or participation in the group. The group owner is responsible for adding and removing members from the group. It is also responsible for allocating resources to be shared with the group. When the group is no longer needed, and all members have left, the owner then has the responsibility of destroying the group.

When DaCS for Hybrid is working with DaCS for Cell, creation of a group on a PPU is done in the PPU's role as an HE. This means that only it and the SPU AEs can be members of the gorup. Trying to share the group with the x86_64 HE (which is done as a PPU AE) will fail.

Barriers

Certain resources require a group in order to work properly. One such resource is a barrier. Without a known and fixed set of participants barriers cannot work properly. For this reason the concept of groups is necessary.

Barriers provide synchronization of a fixed number of participants. Groups are required in order for the barrier functionality to properly track barrier quora. Barriers are an implied resource associated with being in a group; they are not allocated, initialized, shared or destroyed.

Group usage scenario

Group operations can be classified into three stages: initialization, operation and termination. An example showing the services used in these stages follows.

Initialization

The following steps, in this order, would be used by the group owner and members to create and join a group.

Owner	Members
Create the group: `dacs_group_init( &group, flags );` This creates an opaque group handle. The handle will then used by all members during group operations.	
Add members (identified by DE and PID) to the group, one by one: `dacs_group_add_member( de, pid, group );`	
	Accept their addition, individually: `dacs_group_accept( de, pid, group );`
(Optional) Add itself to the group: `dacs_group_add_member( DACS_DE_SELF, DACS_PID_SELF, group );` (This does not require an accept response.)	
Close the initialization of the group: `dacs_group_close( group );`	

Operation

Group operations are controlled by *barriers*. These are used to synchronize the processing by different members of the group. If it is necessary to ensure that no member enters a new stage of processing before other members are ready then each member must make a call:Each member will then be blocked until all members have made this call. When the last member is accounted for all members will be released.

Owner	Members
	Wait on barrier, individually: `dacs_barrier_wait( group );`

Termination

The following steps, in this order, would be used by the group owner and members to remove a group.

Owner	Members
Destroy the group: `dacs_group_destroy( group );`	
	Leave the group, individually: `dacs_group_leave( group );`

Group owner functions

dacs_group_init

NAME

dacs_group_init - Initialize a DaCS group.

SYNOPSIS

DACS_ERR_T dacs_group_init (dacs_group_t **group***, uint32_t** *flags* **)**

Call parameter

`flags`	Flags for group initialization.

Return parameter

`*group`	A pointer to a group handle which is filled in upon successful return.

Note: In SDK 3.0 no flags will be supported and the flags value passed in must be zero.

DESCRIPTION

The `dacs_group_init` service initializes a DaCS group and returns a handle to the group. The calling process is the owner of the group. The owner process is not a member of the group by default, but may add itself as a member.

RETURN VALUE

The `dacs_group_init` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return.
- `DACS_ERR_INVALID_ADDR`: the pointer is invalid.
- `DACS_ERR_INVALID_ATTR`: the flag or enumerated constant is invalid.
- `DACS_ERR_NO_RESOURCE`: could not allocate required resources.

SEE ALSO

dacs_group_add_member(3), dacs_group_close(3), dacs_group_destroy(3), dacs_group_accept(3), dacs_group_leave(3), dacs_barrier_wait(3)

dacs_group_add_member

NAME

dacs_group_add_member - Add a member to a DaCS group.

SYNOPSIS

DACS_ERR_T dacs_group_add_member (de_id_t *de*, **dacs_process_id_t** *pid*, **dacs_group_t** *group* **)**

Call parameters

de	The DE ID of the member to add. The group owner may specify a value of DACS_DE_SELF to add itself.
pid	The process ID of the member to add. The group owner may specify a value of DACS_PID_SELF to add itself.
group	The handle of the group to which the new member is to be added.

DESCRIPTION

The dacs_group_add_member service adds the specified de/pid as a member of the specified group. This service can only be called by the process which owns the group. If the owner process is adding itself the service returns immediately. If the member to be added is not the owner of the group this service blocks, waiting for an associated dacs_group_accept() call from the new member.

RETURN VALUE

The dacs_group_add_member service returns an error indicator defined as:

- DACS_SUCCESS: normal return.
- DACS_ERR_INVALID_DE: the specified DE is either invalid or not reserved.
- DACS_ERR_INVALID_PID: the specified PID does not refer to an active process.
- DACS_ERR_INVALID_HANDLE: the group handle does not refer to a valid group.
- DACS_ERR_INVALID_TARGET: this operation is not allowed for the target process.
- DACS_ERR_GROUP_CLOSED: the group is closed.
- DACS_ERR_GROUP_DUPLICATE: the specified process is already a member of the specified group.
- DACS_ERR_NO_RESOURCE: unable to allocate required resources.

SEE ALSO

dacs_group_init(3), dacs_group_close(3), dacs_group_destroy(3), dacs_group_accept(3), dacs_group_leave(3), dacs_barrier_wait(3)

dacs_group_close

NAME

dacs_group_close - Close a DaCS group.

SYNOPSIS

DACS_ERR_T dacs_group_close (dacs_group_t *group* **)**

Call parameter

`group`	The handle of the group to close.

DESCRIPTION

The `dacs_group_close` service closes the initialization of the specified group. Once closed, new members cannot be added to the group. The specified group must have been initialized with `dacs_group_init()`. This service may only be called by the owner of the group. Group collective operations will block until the group is closed.

RETURN VALUE

The `dacs_group_close` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return.
- `DACS_ERR_INVALID_HANDLE`: the group handle does not refer to a valid group.
- `DACS_ERR_NOT_OWNER`: the caller is not the owner of the group.
- `DACS_ERR_GROUP_CLOSED`: the group is already closed.

SEE ALSO

dacs_group_init(3), dacs_group_add_member(3), dacs_group_destroy(3), dacs_group_accept(3), dacs_group_leave(3), dacs_barrier_wait(3)

dacs_group_destroy

NAME

dacs_group_destroy - Remove a DaCS group.

SYNOPSIS

DACS_ERR_T dacs_group_destroy (dacs_group_t **group* **)**

Call parameter

`*group`	A pointer to the handle of the group to remove.

DESCRIPTION

The `dacs_group_destroy` service removes the specified group and invalidates the handle. This service may only be called by the owner of the group, and blocks until all other members have left the group. If the calling process is the owner of the group and also a member of the group it is implicitly removed from the group when it is destroyed

RETURN VALUE

The `dacs_group_destroy` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return.
- `DACS_ERR_INVALID_ADDR`: the pointer is invalid.
- `DACS_ERR_INVALID_HANDLE`: the group handle does not refer to a valid group.
- `DACS_ERR_NOT_OWNER`: the caller is not the owner of the group.
- `DACS_ERR_GROUP_OPEN`: the group has not been closed.

SEE ALSO

dacs_group_init(3), dacs_group_add_member(3), dacs_group_close(3), dacs_group_accept(3), dacs_group_leave(3), dacs_barrier_wait(3)

Group member functions

Group member functions allow processes to join or leave groups created by other processes.

dacs_group_accept

NAME

dacs_group_accept - Accept membership to a DaCS group.

SYNOPSIS

DACS_ERR_T dacs_group_accept (de_id_t *de*, **dacs_process_id_t** *pid*, **dacs_group_t** **group* **)**

Call parameters

de	The DE ID of the group owner.
pid	The process ID of the group owner.

Return parameter

*group	A pointer to the handle of the group to be filled in.

DESCRIPTION

The dacs_group_accept service accepts membership to a group and returns the group handle. For each dacs_group_accept() call there must be an associated dacs_group_add_member() call by the owner of the group. This service blocks until the caller has been added to the group by the group owner.

RETURN VALUE

The dacs_group_accept service returns an error indicator defined as:

- DACS_SUCCESS: normal return.
- DACS_ERR_INVALID_DE: the specified DE is either invalid or not reserved.
- DACS_ERR_INVALID_PID: the specified pid does not refer to an active process.
- DACS_ERR_INVALID_ADDR: the pointer is invalid.
- DACS_ERR_INVALID_TARGET: the operation not allowed for the target process.

SEE ALSO

dacs_group_init(3), dacs_group_add_member(3), dacs_group_close(3), dacs_group_destroy(3), dacs_group_leave(3), dacs_barrier_wait(3)

dacs_group_leave

NAME

dacs_group_leave - Request from a member to leave a DaCS group.

SYNOPSIS

DACS_ERR_T dacs_group_leave (dacs_group_t **group* **)**

Call parameter

`*group`	A pointer to the handle of the group to leave.

DESCRIPTION

The `dacs_group_leave` service removes the calling process from the specified group. All members other than the owner must leave the group before it can be destroyed. The specified group handle is invalidated upon successful return. This service does not block unless the group is not yet closed.

RETURN VALUE

The `dacs_group_leave` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return.
- `DACS_ERR_INVALID_ADDR`: the pointer is invalid.
- `DACS_ERR_INVALID_HANDLE`: the group handle does not refer to a valid DaCS group.
- `DACS_ERR_OWNER`: the owner of the group may not leave it.

SEE ALSO

dacs_group_init(3), dacs_group_add_member(3), dacs_group_close(3), dacs_group_destroy(3), dacs_group_accept(3), dacs_barrier_wait(3)

Process synchronization

The process synchronization services provide a means to coordinate or synchronize process execution.

dacs_barrier_wait

NAME

dacs_barrier_wait - Synchronize members of a group.

SYNOPSIS

DACS_ERR_T dacs_barrier_wait (dacs_group_t *group* **)**

Call parameter

`group`	The handle of the group with which to synchronize.

DESCRIPTION

The `dacs_barrier_wait` service blocks the caller on a group barrier until all members in the group have reached the barrier. The caller must be a member of the specified group.

RETURN VALUE

The `dacs_barrier_wait` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return.
- `DACS_ERR_INVALID_HANDLE`: the group handle does not refer to a valid DaCS group.

SEE ALSO

dacs_group_init(3), dacs_group_add_member(3), dacs_group_close(3), dacs_group_destroy(3), dacs_group_accept(3), dacs_group_leave(3)

Chapter 9. Data communication

The data communication services transfer data from one process to another. To accommodate transfers across systems with different data representation formats (endian-ness), the services provide an option for byte swapping. The types of byte swapping supported are:

DACS_BYTE_SWAP_DISABLE
no byte-swapping .

DACS_BYTE_SWAP_HALF_WORD
byte-swapping for halfwords (2 bytes).

DACS_BYTE_SWAP_WORD
byte-swapping for words (4 bytes).

DACS_BYTE_SWAP_DOUBLE_WORD
byte-swapping for double words (8 bytes).

Different platforms and implementations may also have different alignment restrictions for the data being transferred. The data communication services will return the `DACS_ERR_NOT_ALIGNED` error code when those alignment restrictions are not met.

The data communication services require that the caller specify either the source or destination DE and PID, as appropriate. As a convenience to the programmer, the special values `DACS_DE_PARENT` and `DACS_PID_PARENT` are defined, which can be used to refer to the parent DE and PID respectively. The special values `DACS_DE_SELF` and `DACS_PID_SELF` are also provided for those interfaces where the caller is the target of the operation.

Note: In SDK 3.0 direct communication is only allowed between a parent and its children. Attempts to communicate to a process which is not the parent or child of the initiator will result in an error of `DACS_ERR_INVALID_TARGET`.

Three different data communication models are supported: remote direct memory access (rDMA), message passing, and mailboxes.

Remote Direct Memory Access (rDMA)

Managing Remote Memory.

The remote memory management services provide the means for sharing memory regions with remote processes. A memory region is made available to remote consumers using a *share/accept* model whereby the owner of the memory creates and shares a remote memory handle which is then accepted and used by remote processes.

Note: With the exception of `dacs_remote_mem_query()`, the DaCS memory transfer services can only be used by the remote processes, and only after they have accepted a share. The owner of the shared memory cannot use these services.

Note: When DaCS for Hybrid is being used with DaCS for Cell, remote memory that is created on the PPU (using `dacs_remote_mem_create()`) can be shared with both the x86_64 (HE) and with the SPUs (AEs). If this is done then either can use

the put or get services to get from the memory shared by the PPU.

dacs_remote_mem_create

NAME

dacs_remote_mem_create - Designate a region in the memory space of the current process for access by remote processes.

SYNOPSIS

DACS_ERR_T dacs_remote_mem_create (void **addr*, **uint64_t** *size*, **DACS_MEMORY_ACCESS_MODE_T** *access_mode*, **dacs_remote_mem_t** **mem* **)**

Call parameters

`*addr`	A pointer to the base address of the memory region to be shared.
`size`	The size of the memory region in bytes.
`access_mode`	The access mode to be given to the memory region. This may be: • DACS_READ_ONLY, • DACS_WRITE_ONLY, or • DACS_READ_WRITE.

Return parameter

`*mem`	A pointer to a remote memory handle to be filled in.

DESCRIPTION

The `dacs_remote_mem_create` service creates and returns a handle associated with the given memory region. The returned handle can be used with the `dacs_remote_mem_share()` and `dacs_remote_mem_accept()` services to share and gain access to remote shared memory.

RETURN VALUE

The service `dacs_remote_mem_create` returns an error indicator defined as:

- `DACS_SUCCESS`: normal return.
- `DACS_ERR_INVALID_ADDR`: the pointer is invalid.
- `DACS_ERR_INVALID_ATTR`: the flag or enumerated constant is invalid.
- `DACS_ERR_NO_RESOURCE`: unable to allocate required resources.
- `DACS_ERR_INVALID_SIZE`: a size of zero was requested.

SEE ALSO

dacs_remote_mem_share(3), dacs_remote_mem_accept(3), dacs_remote_mem_release(3), dacs_remote_mem_destroy(3), dacs_remote_mem_query(3)

dacs_remote_mem_share

NAME

dacs_remote_mem_share - Pass a memory handle from the current process to a remote process.

SYNOPSIS

DACS_ERR_T dacs_remote_mem_share (de_id_t *dst_de*, **dacs_process_id_t** *dst_pid*, **dacs_remote_mem_t** *mem* **)**

Call parameters

`dst_de`	The target DE for the share.
`dst_pid`	The target process for the share.
`mem`	The handle of the remote memory to be shared.

DESCRIPTION

The `dacs_remote_mem_share` service shares the specified remote memory handle from the current process to the remote process specified by `dst_de` and `dst_pid`. This service then blocks, waiting for a matching call to the `dacs_remote_mem_accept` service on the remote side.

RETURN VALUE

The `dacs_remote_mem_share` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return.
- `DACS_ERR_INVALID_DE`: the specified DE is either invalid or not reserved.
- `DACS_ERR_INVALID_PID`: the specified PID does not refer to an active process.
- `DACS_ERR_INVALID_TARGET`: this operation is not allowed for the target process.
- `DACS_ERR_INVALID_HANDLE`: the remote memory handle is invalid.
- `DACS_ERR_NOT_OWNER`: this operation is only valid for the owner of the resource.

SEE ALSO

dacs_remote_mem_create(3), dacs_remote_mem_accept(3), dacs_remote_mem_release(3), dacs_remote_mem_destroy(3), dacs_remote_mem_query(3)

dacs_remote_mem_accept

NAME

dacs_remote_mem_accept - Accept a memory handle from a remote process.

SYNOPSIS

DACS_ERR_T dacs_remote_mem_accept (de_id_t *src_de*, **dacs_process_id_t** *src_pid*, **dacs_remote_mem_t** **mem* **)**

Call parameters

`src_de`	The source DE which is sharing the remote memory handle.
`src_pid`	The source process which is sharing the remote memory handle.

Return parameter

`*mem`	A pointer to the accepted memory handle.

DESCRIPTION

The `dacs_remote_mem_accept` service blocks the caller until it receives a remote memory handle from an associated `dacs_remote_mem_share()` call. The remote memory handle is filled in upon successful return.

RETURN VALUE

The `dacs_remote_mem_accept` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return.
- `DACS_ERR_INVALID_DE`: the specified DE is either invalid or not reserved.
- `DACS_ERR_INVALID_PID`: the specified PID does not refer to an active process.
- `DACS_ERR_INVALID_TARGET`: this operation is not allowed for the target process.
- `DACS_ERR_INVALID_ADDR`: the pointer is invalid.
- `DACS_ERR_NO_RESOURCE`: unable to allocate the required resources.

SEE ALSO

dacs_remote_mem_create(3), dacs_remote_mem_share(3), dacs_remote_mem_release(3), dacs_remote_mem_destroy(3), dacs_remote_mem_query(3)

dacs_remote_mem_release

NAME

dacs_remote_mem_release - Release a previously accepted remote memory handle.

SYNOPSIS

DACS_ERR_T dacs_remote_mem_release (dacs_remote_mem_t **mem* **)**

Call parameter

`*mem`	A pointer to the remote memory handle.

DESCRIPTION

The `dacs_remote_mem_release` service releases a previously accepted remote memory object and invalidates the handle. When all accepters have released the object it may be destroyed by its owner. This service does not block.

RETURN VALUE

The `dacs_remote_mem_release` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return.
- `DACS_ERR_INVALID_ADDR`: the pointer is invalid.
- `DACS_ERR_INVALID_HANDLE`: the specified handle does not refer to a valid remote memory object.
- `DACS_ERR_OWNER`: this operation is not valid for the owner of the resource.

SEE ALSO

dacs_remote_mem_create(3), dacs_remote_mem_share(3), dacs_remote_mem_accept(3), dacs_remote_mem_destroy(3), dacs_remote_mem_query(3)

dacs_remote_mem_destroy

NAME

dacs_remote_mem_destroy - Invalidate sharing of a specified memory region.

SYNOPSIS

DACS_ERR_T dacs_remote_mem_destroy (dacs_remote_mem_t **mem* **)**

Call parameter

`*mem`	A pointer to a remote memory handle.

DESCRIPTION

The `dacs_remote_mem_destroy` service invalidates the sharing of a specific memory region which has been created by `dacs_remote_mem_create()`. Only the creator of the memory region may destroy it. This service blocks until all users of the memory region have released it.

RETURN VALUE

The `dacs_remote_mem_destroy` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return.
- `DACS_ERR_INVALID_ADDR`: the pointer is invalid.
- `DACS_ERR_INVALID_HANDLE`: the remote memory handle is invalid.
- `DACS_ERR_NOT_OWNER`: this operation is only valid for the owner of the resource.

SEE ALSO

dacs_remote_mem_create(3), dacs_remote_mem_share(3), dacs_remote_mem_accept(3), dacs_remote_mem_release(3), dacs_remote_mem_query(3)

dacs_remote_mem_query

NAME

dacs_remote_mem_query - Query the attributes of a remote memory region.

SYNOPSIS

DACS_ERR_T dacs_remote_mem_query (dacs_remote_mem_t *mem*, **DACS_REMOTE_MEM_ATTR_T** *attr*, **uint64_t** **value* **)**

Call parameters

`mem`	The handle of the remote memory area to query.
`attr`	The attribute to be queried. This may be one of: DACS_REMOTE_MEM_SIZE, DACS_REMOTE_MEM_ADDR, or DACS_REMOTE_MEM_ACCESS_MODE.

Return parameter

`*value`	A pointer to the location where the attribute value is to be returned. If the requested attribute is DACS_REMOTE_MEM_ACCESS_MODE, the output value will be one of: DACS_READ_ONLY, DACS_WRITE_ONLY, or DACS_READ_WRITE.

DESCRIPTION

The `dacs_remote_mem_query` service queries the attributes of the specified remote memory region. The memory region being queried must have been created or accepted by the caller.

RETURN VALUE

The `dacs_remote_mem_query` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return.
- `DACS_ERR_INVALID_ADDR`: the pointer is invalid.
- `DACS_ERR_INVALID_ATTR`: the flag or enumerated constant is invalid.
- `DACS_ERR_INVALID_HANDLE`: the specified handle is invalid.

SEE ALSO

dacs_remote_mem_create(3), dacs_remote_mem_share(3), dacs_remote_mem_accept(3), dacs_remote_mem_release(3), dacs_remote_mem_destroy(3)

rDMA block transfers

The DMA services provide a means to perform direct memory accesses to and from remote memory.

dacs_put

NAME

dacs_put - Initiate a data transfer from local memory to remote memory.

SYNOPSIS

DACS_ERR_T dacs_put (dacs_remote_mem_t *dst_remote_mem*, **uint64_t** *dst_remote_mem_offset*, **void** **src_addr*, **uint64_t** *size*, **dacs_wid_t** *wid*, **DACS_ORDER_ATTR_T** *order_attr*, **DACS_BYTE_SWAP_T** *swap* **)**

Call parameters

`dst_remote_mem`	The remote memory handle of the destination buffer.
`dst_remote_mem_offset`	The offset into the remote buffer where the put is to be performed.
`*src_addr`	A pointer to the source memory buffer.
`size`	The size of the transfer.
`wid`	The communications wait identifier.
`order_attr`	An ordering attribute. Possible values are: • `DACS_ORDER_ATTR_FENCE`: execution of this operation is delayed until all previously issued DMA operations to the same DE using the same `wid` have completed. • `DACS_ORDER_ATTR_BARRIER`: execution of this command and all subsequent DMA operations are delayed until all previously issued DMA operations to the same DE using the same `wid` have completed. • `DACS_ORDER_ATTR_NONE`: no ordering is enforced.
`swap`	The little-endian or big-endian byte-swapping flag.Possible values are: • `DACS_BYTE_SWAP_DISABLE`, • `DACS_BYTE_SWAP_HALF_WORD`, • `DACS_BYTE_SWAP_WORD` or • `DACS_BYTE_SWAP_DOUBLE_WORD`. See Chapter 9, “Data communication,” on page 39 for details.

DESCRIPTION

The `dacs_put` service initiates data transfer from the caller memory, specified by `src_addr`, to the target memory, specified by `dst_remote_mem` and `remote_mem_offset`. This operation is non-blocking (the call initiates the transfer, but the transfer may continue after the call returns). To ensure that the transfer has completed on the DE, so that the local buffer can be reused or changed, you should issue a call to `dacs_wait()` or `dacs_test()` with the same wait identifier.

The target remote memory region must have been previously accepted by the caller with a call to `dacs_remote_mem_accept()`.

Note: The user of the `dacs_put()` and `dacs_get()` methods is the process that accepted the memory handle. The owner of the remote memory cannot use these functions.

RETURN VALUE

The dacs_put service returns an error indicator defined as:

- DACS_SUCCESS: normal return.
- DACS_ERR_BUF_OVERFLOW: the buffer has overflowed - the specified offset or size exceed the bounds of the target buffer.
- DACS_ERR_NOT_ALIGNED: the buffer is not aligned correctly for the size of the transfer.
- DACS_ERR_INVALID_ADDR: the pointer is invalid.
- DACS_ERR_INVALID_ATTR: the flag or enumerated constant is invalid.
- DACS_ERR_INVALID_SIZE: the size was zero or not supported by the platform.
- DACS_ERR_INVALID_WID: the wait identifier is invalid.
- DACS_ERR_INVALID_HANDLE: the remote memory handle is invalid.
- DACS_ERR_NO_PERM: the resource attributes do not allow this operation.

SEE ALSO

dacs_get(3), dacs_put_list(3), dacs_get_list(3), dacs_test(3), dacs_wait(3)

dacs_get

NAME

dacs_get - Get data from remote memory to local memory.

SYNOPSIS

DACS_ERR_T dacs_get (void **dst_addr*, **dacs_remote_mem_t** *src_remote_mem*, **uint64_t** *src_remote_mem_offset*, **uint64_t** *size*, **dacs_wid_t** *wid*, **DACS_ORDER_ATTR_T** *order_attr*, **DACS_BYTE_SWAP_T** *swap* **)**

Call parameters

`*dst_addr`	A pointer to the base address of the destination memory buffer.
`src_remote_mem`	The remote memory handle of the source buffer.
`src_remote_mem_offset`	The offset into the offset in remote buffer where the get is to start.
`size`	The size of the transfer.
`wid`	A communications wait identifier.
`order_attr`	An ordering attribute. Possible values are: • `DACS_ORDER_ATTR_FENCE`: execution of this operation is delayed until all previously issued DMA operations to the same DE using the same `wid` have completed. • `DACS_ORDER_ATTR_BARRIER`: execution of this command and all subsequent DMA operations are delayed until all previously issued DMA operations to the same DE using the same `wid` have completed. • `DACS_ORDER_ATTR_NONE`: no ordering is enforced.
`swap`	The little-endian or big-endian byte-swapping flag.Possible values are: • `DACS_BYTE_SWAP_DISABLE`, • `DACS_BYTE_SWAP_HALF_WORD`, • `DACS_BYTE_SWAP_WORD` or • `DACS_BYTE_SWAP_DOUBLE_WORD`. See Chapter 9, "Data communication," on page 39 for details.

DESCRIPTION

The `dacs_get` service returns data from the target memory, specified by `src_remote_mem` and `src_remote_mem_offset`, to the caller memory, specified by `dst_addr`. This operation is non-blocking (the call initiates the transfer, but the transfer may continue after the call returns). To ensure that the transfer has completed you should issue a call to `dacs_wait()` or `dacs_test()` with the same wait identifier.

The target remote memory region must have been previously accepted by the caller using a call to `dacs_remote_mem_accept()`.

Note: The user of the `dacs_put()` and `dacs_get()` methods is the process that accepted the memory handle. The owner of the remote memory cannot use these functions.

RETURN VALUE

The dacs_get service returns an error indicator defined as:

- DACS_SUCCESS: normal return.
- DACS_ERR_BUF_OVERFLOW: the buffer has overflowed - the specified offset and size exceed the bounds of the target buffer.
- DACS_ERR_NOT_ALIGNED: the buffer is not aligned properly for its size.
- DACS_ERR_INVALID_ADDR: the pointer is invalid.
- DACS_ERR_INVALID_ATTR: the flag or enumerated constant is invalid.
- DACS_ERR_INVALID_SIZE: the size is zero or not supported by the platform.
- DACS_ERR_INVALID_WID: the wait identifier is invalid.
- DACS_ERR_INVALID_HANDLE: the remote memory handle is invalid.
- DACS_ERR_NO_PERM: the resource attributes do not allow this operation.

SEE ALSO

dacs_put(3), dacs_put_list(3), dacs_get_list(3), dacs_test(3), dacs_wait(3),

rDMA list transfers

The DMA list services enable scatter/gather operations between non-contiguous regions of memory and one contiguous region of memory.

The list services operate on DMA list elements. A list element is defined as a tuple {*offset*, *size*}, where *offset* is a 64-bit offset into the remote memory block, and *size* is the size of the block.

dacs_put_list

NAME

dacs_put_list - Push data from local memory blocks to a remote memory area.

SYNOPSIS

DACS_ERR_T dacs_put_list (dacs_remote_mem_t *dst_remote_mem*, **dacs_dma_list_t** **dst_dma_list*, **uint32_t** *dst_list_size*, **void** **src_addr*, **dacs_dma_list_t** **src_dma_list*, **uint32_t** *src_list_size*, **dacs_wid_t** *wid*, **DACS_ORDER_ATTR_T** *order_attr*, **DACS_BYTE_SWAP_T** *swap* **)**

Call parameters

`dst_remote_mem`	The remote memory handle for the destination buffer.
`*dst_dma_list`	A pointer to a list of entries describing the transfer locations in the destination buffer.
`dst_list_size`	The number of elements in the destination DMA list.
`src_addr`	The base address of the source memory buffer.
`*src_dma_list`	A pointer to a list of entries describing the transfer locations in the source buffer.
`src_list_size`	The number of elements in the source DMA list.
`wid`	The communications wait identifier associated with this transfer.
`order_attr`	Ordering attribute. Possible values are: • `DACS_ORDER_ATTR_FENCE`: execution of this operation is delayed until all previously issued DMA operations to the same DE using the same `wid` have completed. • `DACS_ORDER_ATTR_BARRIER`: execution of this operation and all subsequent DMA operations are delayed until all previously issued DMA operations to the same DE using the same `wid` have completed. • `DACS_ORDER_ATTR_NONE`: no ordering is enforced.
`swap`	The little-endian or big-endian byte-swapping flag.Possible values are: • `DACS_BYTE_SWAP_DISABLE`, • `DACS_BYTE_SWAP_HALF_WORD`, • `DACS_BYTE_SWAP_WORD` or • `DACS_BYTE_SWAP_DOUBLE_WORD`. See Chapter 9, "Data communication," on page 39 for details.

DESCRIPTION

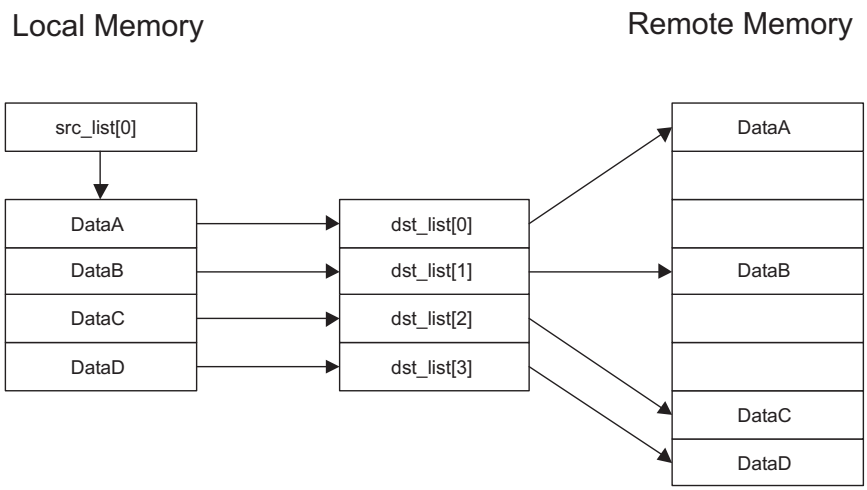
The `dacs_put_list` service pushes data from the memory blocks specified in the `src_dma_list` to the remote memory area referenced by the `dst_remote_mem` handle using the specified `dst_dma_list`.The interface supports the specification of two DMA lists, one of which must contain a single element. This applies to both *Scatter* (`src_list_size=1`) and *Gather to Remote* (`dst_list_size=1`) operations.

The source address for each DMA operation is an effective address formed by the sum of `src_addr` and the offset specified in each DMA list element. The assumption is that all of the source data is in a contiguous buffer starting at `src_addr`. For cases where the source data may not be in a contiguous buffer with a known base address, a source address of zero may be specified. In this case the actual address of the data can be used as the offset in the DMA list element.

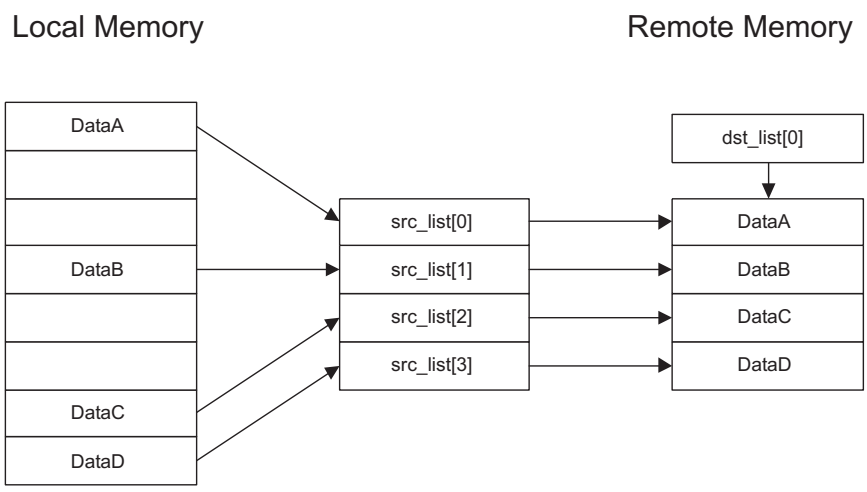
This is an asynchronous service in that the data transfers are only initiated (but not completed) when it returns. To ensure completion of the transfer on this DE you must make a call to `dacs_wait()` or `dacs_test()` with the same wait identifier. This ensures that the local buffers and transfer list parameter can be changed or reused.

The target remote memory region must have been previously accepted by the caller with a call to `dacs_remote_mem_accept()`.

dacs_put_list - Scatter (src_list_size = 1 dst_list_size = 4)



Dacs_put_list - Gather to Remote (src_list_size = 4 dst_list_size = 1)



Put list to a remote memory region with src_list_size = 1

RETURN VALUE

The dacs_put_list service returns an error indicator defined as:

- DACS_SUCCESS: normal return.
- DACS_ERR_BUF_OVERFLOW: the buffer has overflowed - the specified offset or size of one or more list elements exceed the bounds of the target buffer.
- DACS_ERR_NOT_ALIGNED: the buffer is not aligned correctly for the size of the transfer.
- DACS_ERR_INVALID_ADDR: the pointer is invalid.
- DACS_ERR_INVALID_ATTR: the flag or enumerated constant is invalid.
- DACS_ERR_INVALID_SIZE: the size is zero or not supported by the platform.
- DACS_ERR_INVALID_WID: the wait identifier is invalid.
- DACS_ERR_INVALID_HANDLE: the remote memory handle is invalid.
- DACS_ERR_NO_RESOURCE: unable to allocate required resources.
- DACS_ERR_NO_PERM: the resource attributes do not allow this operation.

SEE ALSO

dacs_put(3), dacs_get(3), dacs_get_list(3), dacs_test(3), dacs_wait(3),

dacs_get_list

NAME

dacs_get_list - Get data from a remote memory area and place it in local buffers.

SYNOPSIS

DACS_ERR_T dacs_get_list (void **dst_addr*, **dacs_dma_list_t** **dst_dma_list*, **uint32_t** *dst_list_size*, **dacs_remote_mem_t** *src_remote_mem*, **dacs_dma_list_t** **src_dma_list*, **uint32_t** *src_list_size*, **dacs_wid_t** *wid*, **DACS_ORDER_ATTR_T** *order_attr*, **DACS_BYTE_SWAP_T** *swap* **)**

Call parameters

`*dst_addr`	A pointer to the base address of the destination memory buffer.
`*dst_dma_list`	A pointer to a list of entries describing transfer locations in the destination buffer.
`dst_list_size`	The number of elements in the destination DMA list.
`src_remote_mem`	A handle for the remote source memory buffer.
`*src_dma_list`	A pointer to a list of entries describing transfer locations in the source buffer.
`src_list_size`	The number of elements in the source DMA list.
`wid`	The communication wait identifier associated with this transfer.
`order_attr`	Ordering attribute. Possible values are: • `DACS_ORDER_ATTR_FENCE`: execution of this operation is delayed until all previously issued DMA operations to the same DE using the same `wid` have completed. • `DACS_ORDER_ATTR_BARRIER`: execution of this operation and all subsequent DMA operations are delayed until all previously issued DMA operations to the same DE using the same `wid` have been completed. • `DACS_ORDER_ATTR_NONE`: no ordering is enforced.
`swap`	The little-endian or big-endian byte-swapping flag.Possible values are: • `DACS_BYTE_SWAP_DISABLE`, • `DACS_BYTE_SWAP_HALF_WORD`, • `DACS_BYTE_SWAP_WORD` or • `DACS_BYTE_SWAP_DOUBLE_WORD`. See Chapter 9, "Data communication," on page 39 for details.

DESCRIPTION

The `dacs_get_list` service gets data from the remote memory area referenced by the `dst_remote_mem` struct, using the specified `dma_list`, and places it in the buffers specified by `dst_dma_list`.The interface supports the specification of two DMA lists, one of which must contain a single element. This applies to both *Gather* (`dst_list_size=1`) and *Scatter to local* (`src_list_size=1`) operations.

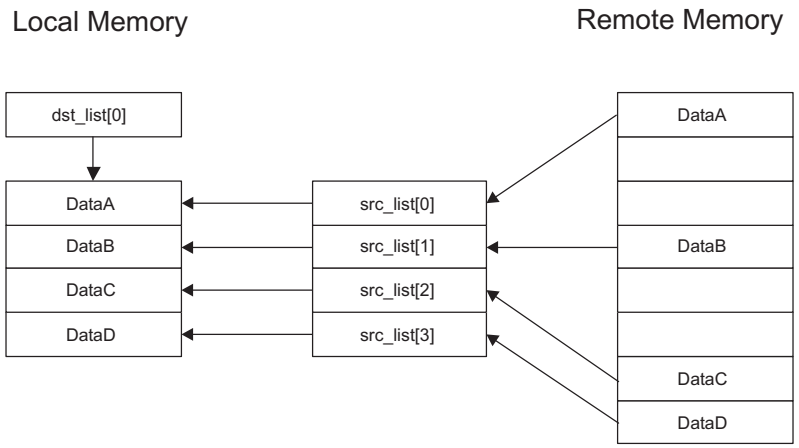
The destination address for each DMA operation is an effective address formed by the sum of `dst_addr` and the offset specified in each DMA list element. The assumption is that the destination buffers for the data are all within a contiguous buffer starting at `dst_addr`. For cases where the destination buffers may not be in a contiguous buffer with a known base address, a destination address of zero may be specified. In this case the actual address of the destination buffer can be used as

the offset in the DMA list element.

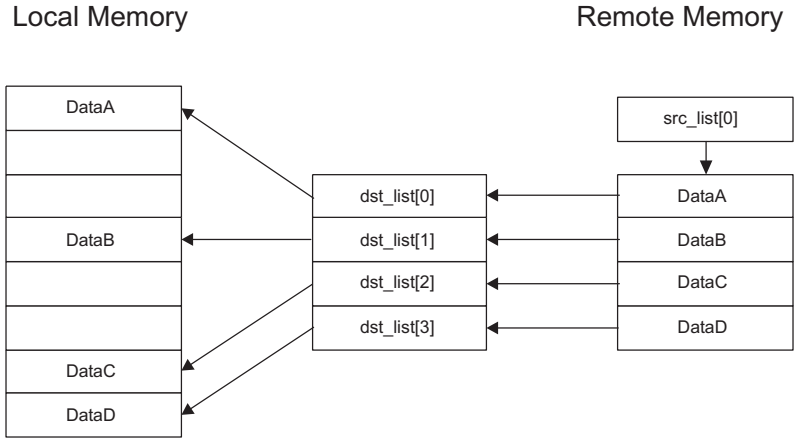
This is an asynchronous service in that the data transfers are only initiated (but not completed) when it returns. To ensure completion of the transfer you should make a call to `dacs_wait()` or `dacs_test()` passing the wait identifier.

The target remote memory region must have been previously accepted by the caller with a call to `dacs_remote_mem_accept()`.

dacs_get_list - Gather (src_list_size = 4 dst_list_size = 1)



dacs_get_list - Scatter to local (src_list_size = 1 dst_list_size = 4)



Get list from a remote memory region with source list size = 1

RETURN VALUE

The dacs_get_list service returns an error indicator defined as:

- DACS_SUCCESS: normal return.
- DACS_ERR_BUF_OVERFLOW: the buffer has overflowed - the specified offset or size of one or more list elements exceed the bounds of the target buffer.
- DACS_ERR_NOT_ALIGNED: the buffer is not aligned correctly for the size of the transfer.
- DACS_ERR_INVALID_ADDR: the pointer is invalid.
- DACS_ERR_INVALID_ATTR: the flag or enumerated constant is invalid.
- DACS_ERR_INVALID_SIZE: the size is zero or not supported by the platform.
- DACS_ERR_INVALID_WID: the wait identifier is invalid.
- DACS_ERR_INVALID_HANDLE: the remote memory handle is invalid.
- DACS_ERR_NO_RESOURCE: unable to allocate required resources.
- DACS_ERR_NO_PERM: the resource attributes do not allow this operation.

SEE ALSO

dacs_put(3), dacs_get(3), dacs_put_list(3), dacs_test(3), dacs_wait(3),

Message passing

The messaging passing services provide two way communications using the familiar send/recv model. These services are asynchronous, but can be synchronized using the dacs_test() and dacs_wait() services as needed.

dacs_send

NAME

dacs_send - send a message to another process

SYNOPSIS

DACS_ERR_T dacs_send (void **src_data*, **uint32_t** *size*, **de_id_t** *dst_de*, **dacs_process_id_t** *dst_pid*, **uint32_t** *stream*, **dacs_wid_t** *wid*, **DACS_BYTE_SWAP_T** *swap* **)**

Call parameters

**src_data*	A pointer to the beginning of the source (send) message buffer.
size	The size of the message buffer.
dst_de	The message destination DE.
dst_pid	The message destination process.
stream	The identifier of the stream on which the message is to be sent.
wid	A wait identifier.
swap	The little-endian or big-endian byte-swapping flag.Possible values are: • DACS_BYTE_SWAP_DISABLE, • DACS_BYTE_SWAP_HALF_WORD, • DACS_BYTE_SWAP_WORD or • DACS_BYTE_SWAP_DOUBLE_WORD. See Chapter 9, "Data communication," on page 39 for details.

DESCRIPTION

The dacs_send service asynchronously sends a message to another process. Upon successful return a send operation is either pending or in progress. Use dacs_test() or dacs_wait() to test for completion on this DE, so that the local buffer can be reused or changed..

Note: The size of the buffer at the destination process must be greater than or equal to amount of data sent; otherwise the send operation fails silently. This error will later be reported by dacs_test() or dacs_wait() as DACS_ERR_BUF_OVERFLOW.

RETURN VALUE

The dacs_send service returns an error indicator defined as:

- DACS_SUCCESS: normal return.
- DACS_ERR_INVALID_ADDR: the pointer is invalid.
- DACS_ERR_INVALID_ATTR: the flag or enumerated constant is invalid.
- DACS_ERR_NO_RESOURCE: unable to allocate required resources.
- DACS_ERR_INVALID_DE: the specified DE is either invalid or not reserved.
- DACS_ERR_INVALID_PID: the specified PID does not refer to an active process.
- DACS_ERR_INVALID_TARGET: this operation is not allowed for the target process.
- DACS_ERR_NOT_ALIGNED: the requested data transfer does not have proper alignment for its size.
- DACS_ERR_INVALID_SIZE: the size is zero or not supported by the platform.
- DACS_ERR_INVALID_WID: the wait identifier is invalid.
- DACS_ERR_INVALID_STREAM: the stream identifier is invalid.

SEE ALSO

dacs_recv(3), dacs_wait(3), dacs_test(3)

dacs_recv

NAME

dacs_recv - receive a message from another process

SYNOPSIS

DACS_ERR_T dacs_recv (void **dst_data*, **uint32_t** *size*, **de_id_t** *src_de*, **dacs_process_id_t** *src_pid*, **uint32_t** *stream*, **dacs_wid_t** *wid*, **DACS_BYTE_SWAP_T** *swap* **)**

Call parameters

**dst_data*	A pointer to the beginning of the destination (receive) data buffer.
size	The size of the message buffer.
src_de	The message source DE.
src_pid	The message source process.
stream	The stream on which to receive the message, or **DACS_STREAM_ALL**.
wid	A wait identifier.
swap	The little-endian or big-endian byte-swapping flag.Possible values are: • DACS_BYTE_SWAP_DISABLE, • DACS_BYTE_SWAP_HALF_WORD, • DACS_BYTE_SWAP_WORD or • DACS_BYTE_SWAP_DOUBLE_WORD. See Chapter 9, "Data communication," on page 39 for details.

Return parameter

**dst_data*	The pointer to the received data buffer.

DESCRIPTION

The dacs_recv service asynchronously receives a message from another process. Upon successful return a receive operation is either pending or in progress. You should use dacs_test() or dacs_wait() to test for completion.

The number of bytes sent by the source process must be less than or equal to the local buffer size, otherwise the receive operation fails.

Stream identifiers are used to select messages for reception. A message will be received if the stream identifier of the message matches the stream identifier specified to dacs_recv(), or if DACS_STREAM_ALL is specified. Stream identifier values must be between 0 and DACS_STREAM_UB inclusive.

The swap flag must be the same at both ends of the transfer. If not the completion test (dacs_test() or dacs_wait()) will fail with DACS_ERR_BYTESWAP_MISMATCH, and no data is transferred.

RETURN VALUE

The dacs_recv service returns an error indicator defined as:

- DACS_SUCCESS: normal return.
- DACS_ERR_INVALID_ADDR: the pointer is invalid.
- DACS_ERR_INVALID_ATTR: the flag or enumerated constant is invalid.
- DACS_ERR_NO_RESOURCE: unable to allocate required resources.
- DACS_ERR_INVALID_DE: the specified DE is either invalid or not reserved.
- DACS_ERR_INVALID_PID: the specified PID does not refer to an active process.
- DACS_ERR_INVALID_TARGET: this operation is not allowed for the target process.
- DACS_ERR_NOT_ALIGNED: the buffer is not aligned properly for the size of the transfer.
- DACS_ERR_INVALID_SIZE: the size is zero or not supported by the platform.
- DACS_ERR_INVALID_WID: the wait identifier is invalid.
- DACS_ERR_INVALID_STREAM: the stream identifier is invalid.

SEE ALSO

dacs_send(3), dacs_wait(3), dacs_test(3)

Mailboxes

The mailbox services provide a simple method of passing a single 32-bit unsigned word between processes. These services use a blocking read/write model. The mailbox is a FIFO queue with an implementation-specific depth.

Mailboxes are between a host (parent) and an accelerator process (DE id and Pid). Each mailbox has two sets of slots. One set is written to by the host and read by the accelerator process, and the other is written to by the accelerator process and read by the host. A host with a single accelerator running a single process will have one mailbox with 32 slots in each set. A host with two accelerators, each running a single process, will have two mailboxes each with 32 slots in each set. Thus the host will have 32 slots in one mailbox for mail coming from one accelerator process and 32 slots in another mailbox for mail coming from the other accelerator process.

Note: Byte-swapping is done automatically if required. A DE cannot write to its own mailbox and can only read from its own mailbox. Any attempt to do otherwise returns an error.

For hybrid the mailbox depth is on a per child process basis, and the values are 32 (host) and 32 (accelerator); each accelerator process has 32/32.

dacs_mailbox_write

NAME

dacs_mailbox_write - Send a single variable to another process.

SYNOPSIS

DACS_ERR_T dacs_mailbox_write (uint32_t **msg*, **de_id_t** *dst_de*, **dacs_process_id_t** *dst_pid*)

Call parameters

**msg*	A pointer to the message to write.
dst_de	The message destination DE.
dst_pid	The destination process id.

DESCRIPTION

The `dacs_mailbox_write` service writes a single 32-bit unsigned integer to the specified target mailbox. There are an number of mailbox slots for each process; this number is defined by the implementation. If the destination has an empty mailbox slot this service returns immediately. Otherwise this service blocks until a slot becomes available.

RETURN VALUE

The `dacs_mailbox_write` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return.
- `DACS_ERR_INVALID_ADDR`: the pointer is invalid.
- `DACS_ERR_INVALID_DE`: the specified DE is either invalid or not reserved.
- `DACS_ERR_INVALID_PID`: the specified PID does not refer to an active process.
- `DACS_ERR_INVALID_TARGET`: this operation is not allowed for the target process.

SEE ALSO

dacs_mailbox_read(3), dacs_mailbox_test(3)

dacs_mailbox_read

NAME

dacs_mailbox_read - Receive a single variable from another process.

SYNOPSIS

DACS_ERR_T dacs_mailbox_read (uint32_t **msg*, **de_id_t** *src_de*, **dacs_process_id_t** *src_pid*)

Call parameters

src_de	The message source DE.
src_pid	The message source process.

Return parameter

**msg*	A pointer to the message received.

DESCRIPTION

The `dacs_mailbox_read` service reads a single 32-bit unsigned integer from the specified source mailbox. There are a number of mailbox slots for each process; this number is defined by the implementation. If the source does not have any pending mailbox messages this service call blocks until one arrives.

RETURN VALUE

The `dacs_mailbox_read` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return.
- `DACS_ERR_INVALID_ADDR`: the pointer is invalid.
- `DACS_ERR_INVALID_DE`: the specified DE is either invalid or not reserved.
- `DACS_ERR_INVALID_PID`: the specified PID does not refer to an active process.
- `DACS_ERR_INVALID_TARGET`: operation not allowed for the target process.

SEE ALSO

dacs_mailbox_write(3), dacs_mailbox_test(3)

dacs_mailbox_test

NAME

dacs_mailbox_test - Test if a mailbox access will succeed.

SYNOPSIS

DACS_ERR_T dacs_mailbox_test (DACS_TEST_MAILBOX_T *rw_flag*, **de_id_t** *de*, **dacs_process_id_t** *pid*, **int32_t** **mbox_status*)

Call parameters

rw_flag Flag to indicate which mailbox to test:

- **DACS_TEST_MAILBOX_READ**: test the read mailbox to see if a call to **dacs_mailbox_read()** will block, or
- **DACS_TEST_MAILBOX_WRITE**: test the write mailbox to see if a call to **dacs_mailbox_write()** will block.

de The DE owning the mailbox to test.

pid The process owning the mailbox to test

Return parameter

**mbox_status* A pointer to the location where the mailbox status is returned. The contents are:

set to zero if the mailbox will block, or

set to non-zero if the mailbox will not block.

DESCRIPTION

The `dacs_mailbox_test` service allows the programmer to test if the mailbox will block before calling `dacs_mailbox_read()` or `dacs_mailbox_write()`.

RETURN VALUE

The `dacs_mailbox_test` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return.
- `DACS_ERR_INVALID_ADDR`: the pointer is invalid.
- `DACS_ERR_INVALID_ATTR`: the flag or enumerated constant is invalid.
- `DACS_ERR_INVALID_DE`: the specified DE is either invalid or not reserved.
- `DACS_ERR_INVALID_PID`: the specified PID does not refer to an active process.
- `DACS_ERR_INVALID_TARGET`: this operation is not allowed for the target process.

SEE ALSO

dacs_mailbox_read(3), dacs_mailbox_write(3)

Chapter 10. Wait identifier management services

These services are intended to manage wait identifiers (WIDs), which are used to synchronize data communication. A WID is required for the data communication services, and is used to test for completion of asynchronous data transfers.

dacs_wid_reserve

NAME

dacs_wid_reserve - Reserve a wait identifier.

SYNOPSIS

DACS_ERR_T dacs_wid_reserve (dacs_wid_t **wid* **)**

Return parameter

**wid*	A pointer to the reserved wait identifier.

DESCRIPTION

The `dacs_wid_reserve` service reserves a wait identifier.

RETURN VALUE

The `dacs_wid_release` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return.
- `DACS_ERR_INVALID_ADDR`: the pointer is invalid.
- `DACS_ERR_NO_WIDS`: no wait identifiers are available.

SEE ALSO

dacs_wid_release(3)

dacs_wid_release

NAME

dacs_wid_release - Release a reserved wait identifier.

SYNOPSIS

DACS_ERR_T dacs_wid_release (dacs_wid_t **wid* **)**

Call parameter

**wid*	A pointer to the wait identifier to be released.

DESCRIPTION

The `dacs_wid_release` service releases the reserved wait identifier. If a data transfer using the wait identifier is still active, an error is returned and the wait identifier is not released.

RETURN VALUE

The `dacs_wid_release` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return; the wait identifier was invalidated.
- `DACS_ERR_INVALID_ADDR`: the pointer is invalid.
- `DACS_ERR_WID_ACTIVE`: a data transfer involving the wait identifier is still active.
- `DACS_ERR_INVALID_WID`: the specified wait identifier is not reserved.

SEE ALSO

dacs_wid_reserve(3)

Chapter 11. Transfer completion

A wait identifier is reserved and assigned to a data communication operation when it is started. These routines test the wait identifier to see if the communication operation has completed.

dacs_test

NAME

dacs_test - Test if communication operations have finished on this DE so the parameters can be changed or reused.

SYNOPSIS

DACS_ERR_T dacs_test (dacs_wid _t *wid* **)**

Call parameter

`wid`	A communication wait identifier

DESCRIPTION

The `dacs_test` service checks the data transfers for the given communication wait identifier and returns their status.

RETURN VALUE

The `dacs_test` service returns an error indicator defined as:

- `DACS_WID_READY`: all data transfers have completed.
- `DACS_WID_BUSY`: one or more data transfers have not completed.
- `DACS_WID_NOT_ACTIVE`: there are no outstanding transfers to test.
- `DACS_ERR_INVALID_WID`: the specified wait identifier is invalid.
- `DACS_ERR_BYTESWAP_MISMATCH`: the Little-endian / Big-endian architectures at the ends of the transfer are incompatible.
- `DACS_ERR_BUF_OVERFLOW`: the data to be transferred is too large for the receive buffer.

SEE ALSO

dacs_wait(3), dacs_put(3), dacs_get(3), dacs_put_list(3), dacs_get_list(3)

dacs_wait

NAME

dacs_wait - Wait for a communications operation to finish.Wait for communication operations to finish on this DE so the parameters can be changed or reused.

SYNOPSIS

DACS_ERR_T dacs_wait (dacs_wid_t *wid* **)**

Call parameter

`wid`	A communication wait identifier

DESCRIPTION

The `dacs_wait` service blocks the caller, waiting for outstanding data transfers for the given wait identifier to complete. It returns when all outstanding transfers are finished. If one or more of the transfers fails, the first failure encountered is reported.

RETURN VALUE

The `dacs_wait` service returns an error indicator defined as:

- `DACS_WID_READY`: all data transfers have completed.
- `DACS_WID_NOT_ACTIVE`: there are no outstanding transfers to test.
- `DACS_ERR_INVALID_WID`: the specified wait identifier is invalid.
- `DACS_ERR_BYTESWAP_MISMATCH`: the Little-endian / Big-endian architectures at the ends of the transfer are incompatible.
- `DACS_ERR_BUF_OVERFLOW`: the data to be transferred is too large for the receive buffer.

SEE ALSO

dacs_test(3), dacs_put(3), dacs_get(3), dacs_put_list(3), dacs_get_list(3)

Chapter 12. Locking Primitives

Shared data accesses can be serialized with DaCS by using a **mut**ual **ex**clusion primitive (mutex) to protect critical sections. A mutex can be hosted on any DE memory space and can be local or remote relative to the process calling these services.

The significant features of a mutex are:

- the mutex is not recursive,
- it is held by a particular DE/PID and that DE/PID is the only one that can unlock it, and
- the lock is not thread based within the DE/PID. Any thread in the locking DE/PID can unlock the mutex.

Sharing Mutexes

When a mutex is created on a PPU, which is an AE for DaCS for Hybrid, and the PPU is also a host for DaCS on Cell, the mutex can be shared by the PPU with both the x86_64 (DaCS for Hybrid HE) and the SPU (DaCS for Cell HE). The mutex can then be used to synchronize processes across all three levels.

The services which process a mutex fall into two categories:

mutex management services, for managing the mutex shared resource, which include `dacs_mutex_init()`, `dacs_mutex_share()`, `dacs_mutex_accept()`, `dacs_mutex_release()` and `dacs_mutex_destroy()`, and

mutex locking services, for locking and unlocking a mutex, which include `dacs_mutex_lock()`, `dacs_mutex_unlock()` and `dacs_mutex_try_lock()`.

dacs_mutex_init

NAME

dacs_mutex_init - Initialize a mutual exclusion variable.

SYNOPSIS

DACS_ERR_T dacs_mutex_init (dacs_mutex_t **mutex* **)**

Return parameter

`*mutex`	A pointer to a newly initialized mutex handle.

DESCRIPTION

The `dacs_mutex_init` service initializes a mutual exclusion variable and returns a handle to it.

RETURN VALUE

The `dacs_mutex_init` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return.
- `DACS_ERR_INVALID_ADDR`: the pointer is invalid.
- `DACS_ERR_NO_RESOURCE`: unable to allocate required resources.

SEE ALSO

dacs_mutex_share(3), dacs_mutex_accept(3), dacs_mutex_lock(3), dacs_mutex_try_lock(3), dacs_mutex_unlock(3), dacs_mutex_release(3), dacs_mutex_destroy(3)

dacs_mutex_share

NAME

dacs_mutex_share - Share a mutual exclusion variable with a remote process.

SYNOPSIS

DACS_ERR_T dacs_mutex_share (de_id_t *dst_de*, **dacs_process_id_t** *dst_pid*, **dacs_mutex_t** *mutex* **)**

Call parameters

`dst_de`	The target DE for the share.
`dst_pid`	The target process for the share.
`mutex`	The handle of the mutex that is to be shared.

DESCRIPTION

The `dacs_mutex_share` service shares the specified mutual exclusion variable between the current process and the remote process specified by `dst_de` and `dst_pid`. This service blocks the caller, waiting for the remote process to call `dacs_mutex_accept()` to accept the mutex.

RETURN VALUE

The `dacs_mutex_share` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return; sharing succeeded.
- `DACS_ERR_INVALID_DE`: the specified DE is either invalid or not reserved.
- `DACS_ERR_PID`: the specified PID does not refer to an active process.
- `DACS_ERR_TARGET`: this operation is not allowed for the target process.
- `DACS_ERR_HANDLE`: the specified mutex handle is not valid.

SEE ALSO

dacs_mutex_init(3), dacs_mutex_accept(3), dacs_mutex_lock(3), dacs_mutex_try_lock(3), dacs_mutex_unlock(3), dacs_mutex_release(3), dacs_mutex_destroy(3)

dacs_mutex_accept

NAME

dacs_mutex_accept - Receive a share on a mutual exclusion variable from a remote process.

SYNOPSIS

DACS_ERR_T dacs_mutex_accept (de_id_t *src_de*, **dacs_process_id_t** *src_pid*, **dacs_mutex_t** **mutex* **)**

Call parameters

`src_de`	The source DE which is sharing the mutex handle.
`src_pid`	The source PID which is sharing the mutex handle.

Return parameter

`*mutex`	A pointer to the handle of the accepted mutex.

DESCRIPTION

The `dacs_mutex_accept` service receives a mutual exclusion variable from a remote process. The service blocks until the remote process shares the mutex with a call to `dacs_mutex_share()`.

RETURN VALUE

The `dacs_mutex_accept` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return.
- `DACS_ERR_INVALID_ADDR`: the pointer is invalid.
- `DACS_ERR_INVALID_DE`: the specified DE is either invalid or not reserved.
- `DACS_ERR_INVALID_PID`: the specified PID does not refer to an active process.
- `DACS_ERR_INVALID_TARGET`: this operation is not allowed for the target process.

SEE ALSO

dacs_mutex_init(3), dacs_mutex_share(3), dacs_mutex_lock(3), dacs_mutex_try_lock(3), dacs_mutex_unlock(3), dacs_mutex_release(3), dacs_mutex_destroy(3)

dacs_mutex_lock

NAME

dacs_mutex_lock - Acquire a lock on a mutual exclusion variable.

SYNOPSIS

DACS_ERR_T dacs_mutex_lock (dacs_mutex_t *mutex* **)**

Call parameter

`mutex`	The handle of the mutex to lock.

DESCRIPTION

The `dacs_mutex_lock` service acquires the specified mutex. The caller must either be the owner of the mutex, or have previously accepted the mutex with a call to `dacs_mutex_accept()`. This service blocks the caller until the mutex is acquired.

RETURN VALUE

The `dacs_mutex_lock` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return; lock succeeded.
- `DACS_ERR_INVALID_HANDLE`: the specified mutex handle is not valid.

SEE ALSO

dacs_mutex_init(3), dacs_mutex_share(3), dacs_mutex_accept(3), dacs_mutex_try_lock(3), dacs_mutex_unlock(3), dacs_mutex_release(3), dacs_mutex_destroy(3)

dacs_mutex_try_lock

NAME

dacs_mutex_try_lock - Attempt to acquire a lock on a mutual exclusion variable.

SYNOPSIS

DACS_ERR_T dacs_mutex_try_lock (dacs_mutex_t *mutex* **)**

Call parameter

`mutex`	The handle of the mutex to lock.

DESCRIPTION

The `dacs_mutex_try_lock` service attempts to acquire a lock on a mutex. The caller must either be the owner of the mutex, or have previously accepted the mutex with a call to `dacs_mutex_accept()`. If the mutex is available for locking, this service gets the lock and returns. If a lock on the mutex is not available, this method returns with a `DACS_ERR_MUTEX_BUSY` status.

RETURN VALUE

The `dacs_mutex_try_lock` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return; lock was acquired.
- `DACS_ERR_MUTEX_BUSY`: the mutex is not available.
- `DACS_ERR_INVALID_HANDLE`: the specified mutex handle is not valid.

SEE ALSO

dacs_mutex_init(3), dacs_mutex_share(3), dacs_mutex_accept(3), dacs_mutex_lock(3), dacs_mutex_unlock(3), dacs_mutex_release(3), dacs_mutex_destroy(3)

dacs_mutex_unlock

NAME

dacs_mutex_unlock - Unlock a mutual exclusion variable.

SYNOPSIS

DACS_ERR_T dacs_mutex_unlock (dacs_mutex_t *mutex* **)**

Call parameter

`mutex`	The handle of the mutex to unlock.

DESCRIPTION

The `dacs_mutex_unlock` service unlocks a mutex. The caller must either be the owner of the mutex, or have previously accepted the mutex with a call to `dacs_mutex_accept()`.

RETURN VALUE

The `dacs_mutex_unlock` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return; unlock succeeded.
- `DACS_ERR_INVALID_HANDLE`: the specified mutex handle is not valid.

SEE ALSO

dacs_mutex_init(3), dacs_mutex_share(3), dacs_mutex_accept(3), dacs_mutex_lock(3), dacs_mutex_try_lock(3), dacs_mutex_release(3), dacs_mutex_destroy(3)

dacs_mutex_release

NAME

dacs_mutex_release - Release a mutual exclusion variable.

SYNOPSIS

DACS_ERR_T dacs_mutex_release (dacs_mutex_t **mutex* **)**

Call parameter

`*mutex`	A pointer to the handle of the mutex to release.

DESCRIPTION

The `dacs_mutex_release` service releases a previously accepted mutex object and invalidates the handle. When all accepters have released the mutex, it may be destroyed by its owner. This service does not block.

The release will succeed whether or not the mutex is held by the caller.

RETURN VALUE

The `dacs_mutex_release` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return.
- `DACS_ERR_INVALID_ADDR`: the pointer is invalid.
- `DACS_ERR_INVALID_HANDLE`: the specified mutex handle is invalid.
- `DACS_ERR_OWNER`: this operation is not allowed for the owner of the resource.

SEE ALSO

dacs_mutex_init(3), dacs_mutex_share(3), dacs_mutex_accept(3), dacs_mutex_lock(3), dacs_mutex_try_lock(3), dacs_mutex_unlock(3), dacs_mutex_destroy(3)

dacs_mutex_destroy

NAME

dacs_mutex_destroy - Destroy a mutual exclusion variable.

SYNOPSIS

DACS_ERR_T dacs_mutex_destroy (dacs_mutex_t **mutex* **)**

Call parameter

`mutex`	A pointer to the handle of the mutex to destroy.

DESCRIPTION

The `dacs_mutex_destroy` service destroys the specified mutex and invalidates the handle. This service blocks until all users of the mutex have released it. The mutex may only be destroyed by the process that initialized it (the owner).

The destroy will succeed whether or not the mutex is held by its owner.

RETURN VALUE

The `dacs_mutex_destroy` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return.
- `DACS_ERR_INVALID_ADDR`: the pointer is invalid.
- `DACS_ERR_INVALID_HANDLE`: the specified mutex handle is invalid.
- `DACS_ERR_NOT_OWNER`: this operation is only valid for the owner of the resource.

SEE ALSO

dacs_mutex_init(3), dacs_mutex_share(3), dacs_mutex_accept(3), dacs_mutex_lock(3), dacs_mutex_try_lock(3), dacs_mutex_unlock(3), dacs_mutex_release(3)

Chapter 13. Error handling

DaCS provides support for registration of user-created error handlers which are called under certain error conditions. The error handlers can be called for synchronous or asynchronous errors.

In SDK 3.0 any synchronous error reported to the error handlers will cause the process to abort. This will happen when DaCS has detected a fatal error from which it cannot recover. Asynchronous errors include child failures (host process) and termination requests from a parent (accelerator process). Abnormal child termination will cause the parent to abort after calling all registered error handlers.

A normal child exit with a non-zero status will be reported asynchronously to the error handlers, but will not cause the process to abort. This allows the parent process to determine if the non-zero exit represents an error condition.

When it is called a user error handler is passed an error object describing the error, which can be inspected using services provided. The error object contains the DE and PID of the failing process. These can be used to call `dacs_de_test()` to reap its status and so allow another process to be started on that DE.

The DaCS library uses the `SIGTERM` signal for handling asynchronous errors and termination requests. A dedicated error handling thread is created in `dacs_runtime_init()` for this purpose. Applications using the DaCS library should not create any application threads before calling `dacs_runtime_init()`, and no application thread should unmask this signal.

User error handler example

User error handler registration

For this example we're going to create an user error handler called `my_errhandler`. Once this has been defined we can register the user error handler using the `dacs_errhandler_reg` API:

```
dacs_rc= dacs_errhandler_reg((dacs_error_handler_t)&my_errhandler,0);
```

Note: If the address of `my_errhandler` is not passed or the cast to `dacs_error_handler_t` is omitted the compiler will produce warnings.

User error handler code:

```
/*****************************************************************
Example of a user error handler
This includes invocations of additional functions of
the passed "dacs_error_t" error parameter
*****************************************************************/
int my_errhandler(dacs_error_t error){
        /*need local variables for passback of values */
        DACS_ERR_T dacs_rc=0;
        DACS_ERR_T dacs_error_rc;//hold code for error
        de_id_t de=0;
        dacs_process_id_t pid=0;
        uint32_t code = 0;
        const char * error_string;

        /* Get the DACS_ERR_T in the error to learn what happened */
```

```
   printf("\n\n--in my_dacs_errhandler\n");
        dacs_error_rc=dacs_rc=dacs_error_num(error);
        printf("  dacs_error_num indicates DACS_ERR_T=%d %s\n",
               dacs_rc,dacs_strerror(dacs_rc));

        /* Get the exit code in the error to learn what happened */
        dacs_rc=dacs_error_code(error,&code);
        if(dacs_rc){//if error invoking dacs_error_code
          printf("  dacs_error_code call had error DACS_ERR_T=%d %s\n",
                 dacs_rc,dacs_strerror(dacs_rc));
        }
        else {
          if (DACS_STS_PROC_ABORTED==dacs_error_rc){
             printf("  dacs_error_code signal signal=%d  ",code);
          }
          else if (DACS_STS_PROC_FAILED==dacs_error_rc){
             printf("  dacs_error_code exit code=%d\n",code);
          }
          else {//else reason is different than aborted or failed
             printf("  dacs_error_code exit/signal code=%d\n",code);
          }
        }

        /* Get the error string in the error to learn what happened */
        dacs_rc=dacs_error_str(error,&error_string);
        if(dacs_rc){//if error invoking dacs_error_str
          printf("  dacs_error_str call had error DACS_ERR_T=%d %s\n",
                 dacs_rc,dacs_strerror(dacs_rc));
        }
        else {
          printf("  dacs_error_str=%s\n",error_string);
        }

        /* what DE had this error ? */
        dacs_rc=dacs_error_de(error,&de);
        if(dacs_rc){//if error invoking dacs_error_de
          printf("  dacs_error_de call had error DACS_ERR_T=%d %s\n",
                 dacs_rc,dacs_strerror(dacs_rc));
        }
        else {
          printf("  dacs_error_de=%08x\n",de);
        }

        /* what was the dacs_process_id_t? */
        dacs_rc=dacs_error_pid(error,&pid);
        if(dacs_rc){//if error invoking dacs_error_pid
          printf("  dacs_error_pid call had error"
                 "DACS_ERR_T=%d %s\n",dacs_rc,dacs_strerror(dacs_rc));
        }
        else {
          printf("  dacs_error_pid=%ld\n",pid);
        }
        printf("exiting user error handler\n\n");
        return 0;//in SDK 3.0, return value is ignored
}
```

User error handler output

Example output if the accelerator program exits with a return code of 9:

```
--in my_dacs_errhandler
  dacs_error_num indicates DACS_ERR_T=4 DACS_STS_PROC_FAILED
  dacs_error_code exit code=9
  dacs_error_str=DACS_STS_PROC_FAILED
  dacs_error_de=01020200
  dacs_error_pid=5503
exiting user error handler
```

Example output if the accelerator program aborts:

```
--in my_dacs_errhandler
  dacs_error_num indicates DACS_ERR_T=5 DACS_STS_PROC_ABORTED
  dacs_error_code signal signal=6    dacs_error_str=DACS_STS_PROC_ABORTED
  dacs_error_de=01020200
  dacs_error_pid=5894
exiting user error handler
```

dacs_errhandler_reg

NAME

dacs_errhandler_reg - Register an error handler to be called when an asynchronous or fatal error occurs.

SYNOPSIS

DACS_ERR_T dacs_errhandler_reg (dacs_error_handler_t *handler*, **uint32_t** *flags* **)**

Call parameters

`handler`	A pointer to an error handling function. This function will be passed the error object containing the error information, and returns a boolean indicating whether termination is requested or not. For fatal internal errors the process will be terminated without consideration for the handler's return value.
`flags`	Flags for error handling options. **Note:** In SDK 3.0 no flags are supported: the flags value passed in must be 0 (zero).

The prototype of the handler is:

int (*dacs_error_handler_t)(dacs_error_t *error* **)**

The user-registered handler must accept a handle to an error object, and return 1 (one) or 0 (zero) to indicate whether the error is deemed fatal or not.

DESCRIPTION

The `dacs_errhandler_reg` service registers an error handler. This handler will then be called whenever an asynchronous DaCS process fails, or a synchronous DaCS process encounters a fatal error.

Note: In SDK 3.0 the return value from the user handler will be ignored in all cases.

Note: If the error handler is coded in the form

```
int my_errhandler(dacs_error_t error)
```

then write the registration as

```
dacs_rc=dacs_errhandler_reg((dacs_error_handler_t)&my_errhandler,0);
```

where `dacs_rc` has been declared as a variable of type `DACS_ERROR_T`.

RETURN VALUE

The dacs_errhandler_reg service returns an error indicator defined as:

- DACS_SUCCESS: normal return.
- DACS_ERR_INVALID_ADDR: the pointer is invalid.
- DACS_ERR_INVALID_ATTR: the flag or enumerated constant is invalid.
- DACS_ERR_NO_RESOURCE: unable to allocate required resources.

SEE ALSO

dacs_strerror(3), dacs_error_num(3), dacs_error_code(3), dacs_error_str(3), dacs_error_de(3), dacs_error_pid(3)

dacs_strerror

NAME

dacs_strerror - Return a pointer to a string describing an error.

SYNOPSIS

const char * dacs_strerror (DACS_ERR_T *errcode* **)**

Call parameter

errcode	An error code that was returned by a DaCS API.

DESCRIPTION

The dacs_strerror service returns a pointer to the error string for the given error code. The input error code can be any error returned by the DaCS API.

RETURN VALUE

The dacs_strerror service returns the error string for the given error code, or NULL if no string was found.

SEE ALSO

dacs_errhandler_reg(3), dacs_error_num(3), dacs_error_code(3), dacs_error_str(3), dacs_error_de(3), dacs_error_pid(3)

dacs_error_num

NAME

dacs_error_num - Return the error code for the specified error handle.

SYNOPSIS

DACS_ERR_T dacs_error_num (dacs_error_t *error* **)**

Call parameter

`error`	An error handle.

DESCRIPTION

The `dacs_error_num` service returns the error code associated with the specified error handle.

RETURN VALUE

The `dacs_error_num` service returns a DaCS error code, or `DACS_ERR_INVALID_HANDLE` if the given handle does not refer to a valid error object.

SEE ALSO

dacs_errhandler_reg(3), dacs_strerror(3), dacs_error_code(3), dacs_error_str(3), dacs_error_de(3), dacs_error_pid(3)

dacs_error_code

NAME

dacs_error_code - Retrieve the extended error code from the specified error object.

SYNOPSIS

DACS_ERR_T dacs_error_code (dacs_error_t *error* **, uint32_t** **code* **)**

Call parameter

`error`	An error handle.

Return parameter

`*code`	A pointer to the error code.

DESCRIPTION

The `dacs_error_code` service retrieves the platform-specific extended error code from the specified error object.

RETURN VALUE

The `dacs_error_code` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return; error code is returned in *code*.
- `DACS_ERR_INVALID_HANDLE`: the error handle is invalid.
- `DACS_ERR_INVALID_ADDR`: the pointer is invalid.

SEE ALSO

dacs_errhandler_reg(3), dacs_strerror(3), dacs_error_num(3), dacs_error_str(3), dacs_error_de(3), dacs_error_pid(3)

dacs_error_str

NAME

dacs_error_str - Retrieve the error string for the specified error object.

SYNOPSIS

DACS_ERR_T dacs_error_str (dacs_error_t *error***, const char** ***errstr*)**

Call parameter

`error`	An error handle.

Return parameter

`**errstr`	A pointer to the error string.

DESCRIPTION

The `dacs_error_str` service returns the error string associated with the specified error. This is the string that is returned from `dacs_strerror()`.

RETURN VALUE

The `dacs_error_str` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return: a pointer to the error string is passed back in *errstr*.
- `DACS_ERR_INVALID_HANDLE`: the specified error handle is invalid.
- `DACS_ERR_INVALID_ADDR`: the pointer is invalid.

SEE ALSO

dacs_errhandler_reg(3), dacs_strerror(3), dacs_error_num(3), dacs_error_code(3), dacs_error_de(3), dacs_error_pid(3)

dacs_error_de

NAME

dacs_error_de - Retrieve the originating DE for the specified error object.

SYNOPSIS

DACS_ERR_T dacs_error_de (dacs_error_t *error*, **de_id_t** **de* **)**

Call parameter

`error`	An error handle.

Return parameter

`*de`	A pointer indicating the DE which was the source of the error.

DESCRIPTION

The `dacs_error_de` service returns the originating DE for the specified error object.

RETURN VALUE

The `dacs_error_de` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return: the originating DE is passed back in *de*.
- `DACS_ERR_INVALID_HANDLE`: the specified error handle is invalid.
- `DACS_ERR_INVALID_ADDR`: the pointer is invalid.

SEE ALSO

dacs_errhandler_reg(3), dacs_strerror(3), dacs_error_num(3), dacs_error_code(3), dacs_error_str(3), dacs_error_pid(3)

dacs_error_pid

NAME

dacs_error_pid - Retrieve the originating PID for the specified error object.

SYNOPSIS

DACS_ERR_T dacs_error_pid (dacs_error_t *error***, dacs_process_id_t** ******pid* **)**

Call parameter

`error`	An error handle.

Return parameter

`*pid`	A pointer indicating the PID which was the source of the error.

DESCRIPTION

The `dacs_error_pid` service returns the originating PID for the specified error object.

RETURN VALUE

The `dacs_error_pid` service returns an error indicator defined as:

- `DACS_SUCCESS`: normal return; the originating PID is passed back in *pid*.
- `DACS_ERR_INVALID_HANDLE`: the specified error handle is invalid.

SEE ALSO

dacs_errhandler_reg(3), dacs_strerror(3), dacs_error_num(3), dacs_error_code(3), dacs_error_str(3), dacs_error_de(3)

Appendix A. Data types

Data type declarations in this document follow the C99 (ISO/IEC 9899:1999) convention. In addition, the following data types are defined in `dacs.h`:

dacs_remote_mem_t
A handle to a memory region specified for use by other remote processes

dacs_dma_list_t
This structure describes a `dma_list_element` in 64 bit addressing mode

- `uint64_t offset`: 64-bit offset into the `dacs_remote_mem_t` block
- `uint64_t size`: size of the buffer to be transferred, in bytes

```
typedef  struct dma_list
{
    uint64_t_t offset;
    uint64_t size;
} dacs_dma_list_t;
```

dacs_error_t
This is an opaque handle which refers to an error object. A handle of this type is passed to the user-registered handler.

int (*dacs_error_handler_t)(dacs_error_t *error* **)**
The user-registered handler must accept a handle to an error object and return 1 or 0 to indicate whether the error is deemed fatal.

Appendix B. DaCS DE types

The current DaCS Element (DE) types in the current supported DaCS topology are listed below.

DACS_DE_SYSTEMX
The supervising host for a node.

DACS_DE_CELL_BLADE
An entire Cell BE blade. If a program is run on this DE, it has 16 SPE children, and the DACS_DE_CBE elements are not allowed to execute any processes. Some applications may find this configuration useful.

DACS_DE_CBE
Cell BE Blade Engine. A Cell BE Blade contains two of these. If used this way, a Cell BE has 8 SPE children. As with the `DACS_DE_CELL_BLADE`, if processes are running on a `DACS_DE_CBE` element, no processes are allowed on the parent `DACS_DE_CELL_BLADE`. Running processes on a Cell BE node allows finer control of memory and processor affinity and may increase performance.

DACS_DE_SPE
Cell BE Synergistic Processing Element.

Appendix C. DaCS debugging

This chapter explains some of the alternatives provided within the SDK to debug a Hybrid DaCS application. The standard methods of using `GDB` or `printf` can still be used, but these have some unique considerations. The Hybrid DaCS daemons, which manage the Hybrid DaCS processes, provide logs and methods of retaining runtime information, such as core dumps and the contents of the current working directory. Hybrid DaCS also provides three different versions of the library with different levels of error checking. The base version is optimized for performance and provides limited error checking and no tracing. The trace version provides tracing support and the debug version provides error checking (such as parameter verification on all the APIs).

printf considerations

The easiest and most well known way to debug a program is to add `printf` statements at strategic points. This method can be useful in hybrid application debug provided the developer understands the following considerations:

- `printf` output may be interleaved between host and accelerator application output, and may not be in exact time sequence order of invocation between the two (or more) applications running;
- DaCS buffers the `stderr` and `stdout` streams of the accelerator. The buffers are generally flushed when a newline character is introduced into the stream. Flushing the stream directly may have little or no impact on displaying the data because of this behavior.

Debugging with GDB

Even though a comprehensive debugger is not available, `gdb` and `gdbserver` may be used. However, for debugging applications on the PPU the two debuggers provided by the SDK, `ppu-gdb` and `ppu-gdbserver`, should be used. These debuggers provide the same options and capabilities as the normal `gdb` programs but are specifically targeted for the PPU architecture.

To debug a hybrid PPU application you have a number of options.

1. If the process is running, attach to the process and debug. The process id can be found by using executing `ps -ef` on the command line of the PPU:

   ```
   ppu-gdb <program name> <process id>
   ```

2. If the process is failing use one of the following techniques to attach the debugger to the process prior to the program ending:
   a. Use the facilities provided by DaCS to start a debugging session with `ppu-gdbserver`. In order to do this an environment variable needs to be set either prior to launching the host application or within the application.

      `The DACS_START_PARENT` environment variable allows you to change the program that is launched on the PPU. Substitution variables can be used within the command:

      %e the accelerator executable name, and

      %a arguments to be passed to the executable.

      For example:

```
export DACS_START_PARENT="/usr/bin/ppu-gdbserver localhost:5678  %e %a"
```

Once the application is started the accelerator application will wait for a ppu-gdb client to connect to it. (This assumes that the debugging is being performed on the PPU client, and that the client source code is available on the PPU.) For example:

```
> ppu-gdb program
(gdb) target remote localhost:5678
(gdb) <debug as usual>
```

If debugging remotely, for example from an x86 client, it will be necessary to find the proper levels of code and library that are installed on the PPU for proper debugging. It will be easier to start by debugging directly on the PPU. Refer to the gdb documentation for setting the shared library and source code paths.

b. Add a sleep() call of long enough duration so that the debugger can be started up and attached to the process.

c. Include a global variable and strategic while loop in the code to halt the program so that gdb can be attached, for example:

   Program:

```
int  gdbwait = 1;

int main(int argc, char* argv[])
{
    .
    .
    while(gdbwait);
    .
    .
}
```

   Command line:

```
> ppu-gdb program 23423
(gdb) set gdbwait=0
(gdb) c
```

d. Include code to use sigwait to wait for the user to attach, setting the ACCEL_DEBUG_START environment variable for the host process and then passing it to the child using either dacs_runtime_init() or dacs_de_start() and its envp parameter, or set the the DACS_START_ENV_LIST environment variable

```
DACS_START_ENV_LIST="ACCEL_DEBUG_START=Y"
```

   before running the host process. Once the remote process has started it waits until you attach to it using a debugger, for example ppu-gdb -p <*pid*>. If ACCEL_DEBUG_START is not set the process executes normally.

Example:

```
#include <signal.h>
#include <syscall.h>
...
/*
In the case of ACCEL_DEBUG_START, actually wait until
the user *has* attached a debugger to this thread.
This is done here by doing an sigwait on the empty set,
which will return with EINTR after the debugger has attached.
*/
if ( getenv("ACCEL_DEBUG_START")) {
int my_pid = getpid();
fprintf(stdout,"\nPPU64: ACCEL_DEBUG_START ...
                attach debugger to pid %d\n", my_pid);
fflush(stdout); sigset_t set; sigemptyset (&set);
```

```
/* Use syscall to avoid glibc looping on EINTR. */
syscall (__NR_rt_sigtimedwait, &set, (void *) 0, (void *) 0,
         _NSIG / 8);
}
```

Daemon Support

The Hybrid DaCS library has multiple daemons monitoring the running DaCS applications. The daemons log errors and informational messages to specific system logs. The daemons provides the capability of capturing core files that may be generated on catastrophic failure and may retain the current working directory on the accelerator for later examination. These are the main features that will be used when debugging applications, but the daemons support other configuration options which may be useful in debugging certain types of problems. These options are documented in the /etc/dacsd.conf file. The following sections discuss the main features listed above.

Logs

The Hybrid DaCS daemon logs may contain invaluable information for debugging problems. The logs are located in

- /var/log/hdacsd.log on the host, and
- /var/log/adacsd.log on the accelerator

by default. These locations may be overridden in the daemon configuration file located in /etc/dacsd.conf.

The logs require `root` authority to view.

The daemons support more detailed logging by setting the environment variable `DACS_HYBRID_DEBUG=Y` when launching the application. This variable will also be passed on to the accelerator daemon as well. The `DACS_HYBRID_DEBUG` environment variable increases the log level in `hdacsd` and `adacsd` for the duration of the application, and also creates a DaCSd SPI log for the HE and AE applications in the /tmp directory on the host and the accelerator. The log file names are /tmp/dacsd_spi_<pid>.log, where <pid> is the process id of the host or accelerator application.

Failures of a DaCS application often occur within the first few DaCS functions called. The logs may provide detailed information as to the reason of the failure. Some typical errors are:

- `dacs_runtime_init()` - failures during this call are usually related to incompatibilities between a Hybrid DaCS application and the daemons installed on the system. A message in the logs will indicate this failure:

  ```
  SocketSrv    init: version mismatch
  ```

- `dacs_reserve_children()` - failures during this call can usually be tracked back to errors in the /etc/dacs_topology.config file. The IP addresses and reservation visibility should be verified. For more information on the configuration file refer to the installation guide shipped with the SDK.

  The actual number of accelerators allocated by this function may not match the number requested; in particular ″zero″ available accelerators may be returned with an empty DE list. This function does not return a failure if no accelerators are available. The user must check the return values of this function before proceeding.

-

dacs_de_start() - failures during this call are typically program and library path related issues.

– verify that the program name being passed is a full path name to the executable, and that the executable exists on the target if the creation flag passed is DACS_PROC_REMOTE_FILE, or on the local host if DACS_PROCESS_LOCAL_FILE.
– verify that the shared libraries can be found correctly on the accelerator. This may be done in several ways.
  - Use RPATH when linking the accelerator application, where the RPATH points to the exact location of the libraries on the accelerator.
  - Use LD_LIBRARY_PATH. Since a user's profile is not set up when the accelerator application launches you must specify the LD_LIBRARY_PATH in the DACS_START_ENV_LIST environment variable to correctly find all of the libraries.
  - Use ldconfig on the accelerator to cache the proper location of the shared libraries.
  - Pass all of the libraries down with the accelerator application into the same working directory using the DACS_PROC_LOCAL_FILE_LIST creation flag and a file list that contains the absolute path of the program and each library needed to run.

Core files

The adacsd daemon has a configuration option to specify the generation of core files. The configuration file is found in /etc/dacsd.conf. The following is an excerpt of the relevant portion of this configuration file.

```
# Set curlimit on core dump resource limit for AE application.
# The curlimit is a soft limit and is less than the max limit,
# which is a hard limit.
# If a core dump is larger than the curlimit the dump will not occur.
# If child_rlimit_core=0, the current resource limit is NOT changed
#  for the AE child
# If child_rlimit_core=value>0 the current resource limit will be
# changed to min(value, hard_limit).
# If child_rlimit_core=-1 the resource limit will be set to the hard
# limit--which could be infinite

        child_rlimit_core=0
```

If this value is changed the daemon must re-read the configuration file as described below.

Saving to the CWD

The adacsd daemon configuration file also supports keeping the current working directory (CWD) after the process has executed on the accelerator. This can be specified in the /etc/dacsd.conf file. The relevant excerpt is shown below:

```
# Normally the AE Current Working Directory and its contents
# are deleted when the AE process terminates.
# Set ae_cwd_keep=true if you want to prevent the
# AE Current Working Directory from being deleted.

    ae_cwd_keep=false
```

If this value is changed the daemon must re-read the configuration file as described below.

To find where the core file is being written, issue the command:

```
cat /proc/sys/kernel/core_pattern
```

If the result is `core` then the core file is written in the current working directory. Since the current working directory is by default removed on termination, core files will be lost without further changes. You are recommended to change this by:

```
echo "/tmp/core-%t-%e.%p" > /proc/sys/kernel/core_pattern
```

which will write any core dumps into the /tmp directory with a name of `core-<timestamp>-<executable>.<pid>`.

Making daemon configuration changes take effect

On reboot the `adacsd` will re-read the configuration file and the changes will take effect. The changes can be made effective immediately by sending a `SIGHUP` signal to the `adacsd` daemon. For example, run these commands on the CBE platform command line

```
> ps aux | grep dacsd  # find the process ID
> kill -s SIGHUP <dacsd_process_ID>
```

The process ID may be found in the `pidfile` as well. See the line for `ADACSD_ARGS` in dacsd.conf :

```
ADACSD_ARGS="--log /var/log/adacsd.log --pidfile /var/run/adacsd.pid"
```

and `cat /var/run/adacsd.pid`

DaCS library versions

The optimized version of `libdacs_hybrid` is installed in /opt/cell/sdk/prototype/usr/lib64 and will normally be used in production. Two other libraries are also available for development purposes; each library provides a different set of functionality to help in analyzing an application. To use a library temporarily `LD_LIBRARY_PATH` can be set in the local environment, and also on the accelerator by using the `DACS_START_ENV_LIST` environment variable. An example of this is:

```
export LD_LIBRARY_PATH=/opt/cell/sdk/prototype/usr/lib64/dacs/debug
export DACS_START_ENV="LD_LIBRARY_PATH=${LD_LIBRARY_PATH}"
```

Note: The other versions of the library must be installed on the accelerator, or the `dacs_de_start()` call will fail.

Error Checking Library

Hybrid DaCS provides an error checking library to enable additional error checking, such as validation of parameters on the DaCS APIs. The error checking library is found in directory /opt/cell/sdk/prototype/usr/lib64/dacs/debug.

It is recommended that this library is used when first developing a DaCS application. Once the application is running successfully the developer can then use the regular runtime library.

Trace enabled Library

Hybrid DaCS provides a tracing and debug library to track DaCS library calls. The trace library is found in directory /opt/cell/sdk/prototype/usr/lib64/dacs/trace.

Linking with this library instead of the production or debug library will provide additional traces that can be used to debug where a program is failing by seeing what calls are made, their arguments, and the return value associated with the call. Refer to the PDT users guide for additional capabilities of this library and environment.

Appendix D. Performance and debug trace

The Performance Debugging Tool (PDT) provides trace data necessary to debug functional and performance problems for applications using the DaCS library.

Versions of the DaCS libraries built with PDT trace hooks enabled are delivered with SDK 3.0.

Installing and running the PDT

The libraries with the trace hooks enabled are packaged in separate `-trace` named packages. The trace enabled libraries install to a subdirectory named `dacs/trace` in the library install directory. These packages and the PDT are included in the SDK 3.0 package but may not be installed by default. Please refer to the PDT user's guide for full instructions on how to install PDT, and how to set the correct environment variables to cause trace events to be generated. Included in the DaCS trace package is an example PDT configuration file which shows the available trace events that can be enabled or disabled.

Trace control

In the hybrid environment, PDT functions the same as it does in the single-system environment: When a PDT-enabled application starts, PDT reads its configuration from a file. For a distributed DaCS application you can distribute the PDT configuration with each job by specifying it as one of the DACS_START_FILES (see "dacs_de_start" on page 22). The PDT configuration for DaCS is separate from the configuration for your job.

Environment variable

PDT supports an environment variable (`PDT_CONFIG_FILE`) which allows you to specify the relative or full path to a configuration file. DaCS will ship an example configuration file which lists all of the DaCS groups and events and allows you to turn selected items on or off as desired. This will be shipped as:

```
/usr/share/pdt/config/pdt_dacs_config_hybrid.xml
```

In order to see the trace events the application must be built with the trace-enabled libraries. To see SPE events the application's SPE code must be rebuilt with special compile settings (see the PDT User's Guide for specifics) and needs to be linked with /usr/spu/lib/dacs/trace/libdacs.a, the trace-enabled DaCS SPU library code. To see PPE events the application must use the trace-enabled DaCS PPU code. If the application is using the static PPU library then it must be re-linked with /usr/lib64/dacs/trace/libdacs.a, the trace-enabled DaCS PPU library code. If the application was built using the shared PPU library then no re-linking is needed. In that case the library path must be changed to point to the trace-enabled PPU code as well as the PDT trace library, by setting the environment before running the application:

```
LD_LIBRARY_PATH=/usr/lib64/dacs/trace:/usr/lib64/trace
```

Appendix E. DaCS trace events

Where inputs or outputs are pointers to scalar types, both the pointer and the contents will be traced. To avoid any extra overhead of checking for NULL pointers, the trace code will only trace contents for pointers that are either required to be non-NULL by the API spec. or already have appropriate checks in the library. The contents of aggregate types will not be traced unless the entire object is passed in as an argument.

In general, there will be two trace hooks per API. The first will trace the input parameters and the second will trace the output values as well as the time interval of the API call. The performance hooks will generally have entry and exit hooks so the post-processing tools can show the time deltas. Note that the performance hooks are also debug hooks and will be enabled when either category is enabled.

DaCS API hooks

Table 3. Trace hooks enabled by LIBDACS group (0x04) in the config file.

Hook identifier	Traced values
_DACS_BARRIER_WAIT_ENTRY	group
_DACS_BARRIER_WAIT_EXIT_INTERVAL	retcode
_DACS_DE_KILL_ENTRY	deid, pid
_DACS_DE_KILL_EXIT_INTERVAL	retcode
_DACS_DE_START_ENTRY	deid, text, argv, envv, creation_flags, p_pid
_DACS_DE_START_EXIT_INTERVAL	retcode, pid
_DACS_DE_TEST_ENTRY	deid, pid, p_exit_status
_DACS_DE_TEST_EXIT_INTERVAL	retcode, exit_status
_DACS_DE_WAIT_ENTRY	deid, pid, p_exit_status
_DACS_DE_WAIT_EXIT_INTERVAL	retcode, exit_status
_DACS_GENERIC_DEBUG	long1, long2, long3, long4, long5, long6, long7, long8, long9, long10
_DACS_GET_ENTRY	dst_addr, src, src_offset, size, wid, order_attr, swap
_DACS_GET_EXIT_INTERVAL	retcode
_DACS_GET_LIST_ENTRY	dst_addr, dst_dma_list, dst_list_size, src_remote_mem, src_dma_list, src_list_size, wid, order_attr, swap
_DACS_GET_LIST_EXIT_INTERVAL	retcode
_DACS_MBOX_READ_ENTRY	msg, src_de, src_pid
_DACS_MBOX_READ_EXIT_INTERVAL	retcode
_DACS_MBOX_TEST_ENTRY	rw_flag, deid, pid, p_mbox_status
_DACS_MBOX_TEST_EXIT_INTERVAL	retcode, result
_DACS_MBOX_WRITE_ENTRY	msg, dst_de, dst_pid
_DACS_MBOX_WRITE_EXIT_INTERVAL	retcode
_DACS_MUTEX_ACCEPT_ENTRY	deid, pid, mutex
_DACS_MUTEX_ACCEPT_EXIT_INTERVAL	retcode

Table 3. Trace hooks enabled by LIBDACS group (0x04) in the config file. (continued)

Hook identifier	Traced values
_DACS_MUTEX_DESTROY_ENTRY	mutex
_DACS_MUTEX_DESTROY_EXIT_INTERVAL	retcode
_DACS_MUTEX_INIT_ENTRY	mutex
_DACS_MUTEX_INIT_EXIT_INTERVAL	retcode
_DACS_MUTEX_LOCK_ENTRY	mutex
_DACS_MUTEX_LOCK_EXIT_INTERVAL	retcode
_DACS_MUTEX_RELEASE_ENTRY	mutex
_DACS_MUTEX_RELEASE_EXIT_INTERVAL	retcode
_DACS_MUTEX_SHARE_ENTRY	deid, pid, mutex
_DACS_MUTEX_SHARE_EXIT_INTERVAL	retcode
_DACS_MUTEX_TRY_LOCK_ENTRY	mutex
_DACS_MUTEX_TRY_LOCK_EXIT_INTERVAL	retcode
_DACS_MUTEX_UNLOCK_ENTRY	mutex
_DACS_MUTEX_UNLOCK_EXIT_INTERVAL	retcode
_DACS_PUT_ENTRY	dst, dst_offset, src_addr, size, wid, order_attr, swap
_DACS_PUT_EXIT_INTERVAL	retcode
_DACS_PUT_LIST_ENTRY	dst, dst_dma_list, dma_list_size, src_addr, src_dma_list, src_list_size, wid, order_attr, swap
_DACS_PUT_LIST_EXIT_INTERVAL	retcode
_DACS_RMEM_ACCEPT_ENTRY	src_de, src_pid, remote_mem
_DACS_RMEM_ACCEPT_EXIT_INTERVAL	retcode
_DACS_RMEM_CREATE_ENTRY	addr, size, mode, local_mem
_DACS_RMEM_CREATE_EXIT_INTERVAL	retcode
_DACS_RMEM_DESTROY_ENTRY	remote_mem
_DACS_RMEM_DESTROY_EXIT_INTERVAL	retcode
_DACS_RMEM_RELEASE_ENTRY	remote_mem
_DACS_RMEM_RELEASE_EXIT_INTERVAL	retcode
_DACS_RMEM_SHARE_ENTRY	dst, dst_pid, local_mem
_DACS_RMEM_SHARE_EXIT_INTERVAL	retcode
_DACS_RUNTIME_EXIT_ENTRY	zero
_DACS_RUNTIME_EXIT_EXIT_INTERVAL	retcode
_DACS_RUNTIME_INIT_ENTRY	argp, envp
_DACS_RUNTIME_INIT_EXIT_INTERVAL	retcode

DaCS performance hooks

The `COUNTERS` and `TIMERS` hooks contain data that are accumulated during the DaCS calls. These data and trace events are reported by the `dacs_runtime_exit()` function.

Table 4. Trace hooks enabled by LIBDACS_GROUP group (0x06) in the config file.

Hook identifier	Traced values
_DACS_COUNTERS1	dacs_de_starts, dacs_de_waits, dacs_put_count, dacs_get_count, dacs_put_bytes, dacs_get_bytes, dacs_send_count, dacs_recv_count, dacs_send_bytes, dacs_recv_bytes
_DACS_COUNTERS2	dacs_mutex_try_success, dacs_mutex_try_failure, dacs_x1, dacs_x2
_DACS_HOST_MUTEX_INIT	lock
_DACS_HOST_MUTEX_LOCK	lock, miss
_DACS_HOST_MUTEX_TRYLOCK	lock, ret
_DACS_HOST_MUTEX_UNLOCK	lock
_DACS_PERF_GENERIC_DEBUG	long1, long2, long3, long4, long5, long6, long7, long8, long9, long10
_DACS_SPE_MUTEX_INIT	lock
_DACS_SPE_MUTEX_LOCK	lock, miss
_DACS_SPE_MUTEX_TRYLOCK	lock, ret
_DACS_SPE_MUTEX_UNLOCK	lock
_DACS_TIMERS	dacs_put, dacs_put_list, dacs_wait, dacs_send, dacs_recv, dacs_mutex_lock, dacs_barrier_wait, dacs_mbox_read, dacs_mbox_write, dacs_x

Appendix F. Error codes

This section describes the DaCS error codes

All error codes which may be issued by DaCS APIs are listed here:

DACS_ERR_BUF_OVERFLOW: Buffer overflow
- the specified offset or size exceed the bounds of the target buffer.

DACS_ERR_BYTESWAP_MISMATCH: The byte swap flags on the source and target do not match.

DACS_ERR_DACSD_FAILURE: Unable to communicate with DaCSd.

DACS_ERR_GROUP_CLOSED: The group is closed.

DACS_ERR_GROUP_DUPLICATE: The specified process is already a member of the specified group.

DACS_ERR_GROUP_OPEN: The group has not been closed.

DACS_ERR_INITIALIZED: DaCS is already initialized.

DACS_ERR_INVALID_ARGV: The value of argv is too large or invalid.

DACS_ERR_INVALID_ADDR: The pointer is invalid.

DACS_ERR_INVALID_ATTR: The flag or enumerated constant is invalid.

DACS_ERR_INVALID_DE: The specified DE is either invalid or not reserved.

DACS_ERR_INVALID_ENV: The value of env is too large or invalid.

DACS_ERR_INVALID_HANDLE: The handle is invalid.

DACS_ERR_INVALID_PID: The specified PID does not refer to a valid process.

DACS_ERR_INVALID_PROG: Unable to execute the specified program.

DACS_ERR_INVALID_SIZE: The size is zero or is not supported by the platform.

DACS_ERR_INVALID_STREAM: The stream identifier is invalid.

DACS_ERR_INVALID_TARGET: This operation is not allowed for the target DE or process.

DACS_ERR_INVALID_WID: The wait identifier is invalid.

DACS_ERR_MUTEX_BUSY: The mutex is not available.

DACS_ERR_NO_PERM: The process does not have the appropriate privilege or the resource attributes do not allow the operation.

DACS_ERR_NO_RESOURCE: Unable to allocate required resources.

DACS_ERR_NO_WIDS: No more wait identifiers are available to be reserved.

DACS_ERR_NOT_ALIGNED: The buffer is incorrectly aligned for the size of the data.

DACS_ERR_NOT_INITIALIZED: DaCS has not been initialized.

DACS_ERR_NOT_OWNER: This operation is only permitted for the owner of the resource.

DACS_ERR_OWNER: This operation is not permitted for the owner of the resource.

DACS_ERR_PROC_LIMIT: The maximum number of processes supported has been reached.

DACS_ERR_PROHIBITED: This operation is prohibited by the implementation.

DACS_ERR_RESOURCE_BUSY: The specified resource is in use.

DACS_ERR_SYSTEM: A system error was encountered.
This often indicates an executable file was not found on the remote system.

DACS_ERR_VERSION_MISMATCH: Version mismatch between library and DaCSd.

DACS_ERR_WID_ACTIVE: A data transfer involving the wait identifier is still active.

DACS_ERR_WID_NOT_ACTIVE: There are no outstanding transfers to test.

DACS_STS_PROC_ABORTED: The process terminated abnormally.

DACS_STS_PROC_FAILED: The process exited with a failure.

DACS_STS_PROC_FINISHED: The process finished execution without error.

DACS_STS_PROC_RUNNING: The process is still running.

DACS_SUCCESS: The API returned successfully.

DACS_WID_READY: All data transfers have completed.

DACS_WID_BUSY: One or more data transfers have not completed.

DACS_WID_NOT_ACTIVE: There are no outstanding transfers to test.

Appendix G. Accessibility features

IBM® and accessibility

See the IBM Accessibility Center at http://www.ibm.com/able/ for more information about the commitment that IBM has to accessibility.

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Related documentation

This topic helps you find related information.

Document location

Links to documentation for the SDK are provided on the developerWorks® Web site located at:

`http://www-128.ibm.com/developerworks/power/cell/`

Click on the **Docs** tab.

The following documents are available, organized by category:

Architecture

- *Cell Broadband Engine Architecture*
- *Cell Broadband Engine Registers*
- *SPU Instruction Set Architecture*

Standards

- *C/C++ Language Extensions for Cell Broadband Engine Architecture*
- *SPU Assembly Language Specification*
- *SPU Application Binary Interface Specification*
- *SIMD Math Library Specification for Cell Broadband Engine Architecture*
- *Cell Broadband Engine Linux Reference Implementation Application Binary Interface Specification*

Programming

- *Cell Broadband Engine Programming Handbook*
- *Programming Tutorial*
- *SDK for Multicore Acceleration Version 3.0 Programmer's Guide*

Library

- *SPE Runtime Management library*
- *SPE Runtime Management library Version 1.2 to Version 2.0 Migration Guide*
- *Accelerated Library Framework for Cell Programmer's Guide and API Reference*
- *Accelerated Library Framework for Hybrid-x86 Programmer's Guide and API Reference*
- *Data Communication and Synchronization for Cell Programmer's Guide and API Reference*
- *Data Communication and Synchronization for Hybrid-x86 Programmer's Guide and API Reference*
- *SIMD Math Library Specification*
- *Monte Carlo Library API Reference Manual (Prototype)*

Installation

- *SDK for Multicore Acceleration Version 3.0 Installation Guide*

IBM XL C/C++ Compiler and IBM XL Fortran Compiler

Detail about documentation for the compilers is available on the developerWorks Web site.

Draft comment
Should we name the documentation here? What is it?

IBM Full-System Simulator and debugging documentation

Detail about documentation for the simulator and debugging tools is available on the developerWorks Web site.

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PowerPC Base

- *PowerPC Architecture™ Book, Version 2.02*
  - *Book I: PowerPC User Instruction Set Architecture*
  - *Book II: PowerPC Virtual Environment Architecture*
  - *Book III: PowerPC Operating Environment Architecture*
- *PowerPC Microprocessor Family: Vector/SIMD Multimedia Extension Technology Programming Environments Manual Version 2.07c*

Glossary

Accelerator

General or special purpose processing element in a hybrid system. An accelerator might have a multi-level architecture with both host elements and accelerator elements. An accelerator, as defined here, is a hierarchy with potentially multiple layers of hosts and accelerators. An accelerator element is always associated with one host. Aside from its direct host, an accelerator cannot communicate with other processing elements in the system. The memory subsystem of the accelerator can be viewed as distinct and independent from a host. This is referred to as the subordinate in a cluster collective.

All-reduce operation

Output from multiple accelerators is reduced and combined into one output.

cluster

A collection of nodes.

Compute kernel

Part of the accelerator code that does stateless computation task on one piece of input data and generates corresponding output results.

Compute task

An accelerator execution image that consists of a compute kernel linked with the accelerated library framework accelerator runtime library.

DaCS Element

A general or special purpose processing element in a topology. This refers specifically to the physical unit in the topology. A DE can serve as a Host or an Accelerator.

DE

See DaCS element.

de_id

A unique number assigned to the physical processing element in a topology. The `de_id` is usually assigned (or derived) when the node is powered up. It should not change until the node is powered down again.

group

A group construct specifies a collection of DaCS DEs and processes in a system.

handle

A handle is an abstraction of a data object; usually a pointer to a structure.

Host

A general purpose processing element in a hybrid system. A host can have multiple accelerators attached to it. This is often referred to as the master node in a cluster collective.

Hybrid

A 64 bit x86 system using a Cell BE as an accelerator.

Main thread

The main thread of the application. In many cases, Cell/B.E. architecture programs are multi-threaded using multiple SPEs running concurrently. A typical scenario is that the application consists of a main thread that creates as many SPE threads as needed and the application organizes them.

node

A node is a functional unit in the system topology, consisting of one host together with all the accelerators connected as children in the topology (this includes any children of accelerators).

parent

The parent of a DE is the DE that resides immediately above it in the topology tree.

PPE

PowerPC Processor Element. The general-purpose processor in the Cell/B.E. processor.

process

A process is a standard UNIX-type process with a separate address space.

SIMD

Single Instruction Multiple Data. Processing in which a single instruction operates on multiple data elements that make up a vector data-type. Also known as vector processing. This style of programming implements data-level parallelism.

SPMD

Single Program Multiple Data. A common style of parallel computing. All processes use the same program, but each has its own data.

SPE

Synergistic Processor Element. Extends the PowerPC 64 architecture by acting as cooperative offload processors (synergistic processors), with the direct memory access (DMA) and synchronization mechanisms to communicate with them (memory flow control), and with enhancements for real-time management. There are 8 SPEs on each Cell/B.E. processor.

SPU

Synergistic Processor Unit. The part of an SPE that executes instructions from its local store (LS).

System X

This is a project-neutral description of the supervising system for a node.

thread

A sequence of instructions executed within the global context (shared memory space and other global resources) of a process that has created (spawned) the thread. Multiple threads (including multiple instances of the same sequence of instructions) can run simultaneously if each thread has its own architectural state (registers, program counter, flags, and other program-visible state). Each SPE can support only a single thread at any one time. Multiple SPEs can simultaneously support multiple threads. The PPE supports two threads at any one time, without the need for software to create the threads. It does this by duplicating the architectural state. A thread is typically created by the `pthreads` library.

topology

A topology is a configuration of DaCS elements in a system. The topology specifies how the different processing elements in a system are related to each other. DaCS assumes a tree topology: each DE has at most one parent.

Work block

A basic unit of data to be managed by the framework. It consists of one piece of the partitioned data, the corresponding output buffer, and related parameters. A work block is associated with a task. A task can have as many work blocks as necessary.

Work queue

An internal data structure of the accelerated library framework that holds the lists of work blocks to be processed by the active instances of the compute task.

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