PolyORB High Integrity User's Guide

C Edition
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About This Guide

This document describes PolyORB High-Integrity C (PolyORB-HI-C), a reduced version of the PolyORB schizophrenic middleware (`http://libre.adacore/com/polyorb`) for High-Integrity systems.

There are two versions of PolyORB High Integrity. The first, written in Ada is called PolyORB-HI-Ada, and the other, written in C, is called PolyORB-HI-C. The following manual focuses on PolyORB-HI-C.

What This Guide Contains

This guide contains the following chapters:

- Chapter 1 [Introduction to PolyORB-HI-C], page 3 provides a brief description of middleware and PolyORB-HI-C's architecture.
- Chapter 2 [Configuration], page 5 details how to configure PolyORB-HI-C.
- Chapter 3 [Building a system], page 9 details how to build a distributed system from its AADL description.
- Appendix A [Supported features], page 15 details the features that are available in PolyORB-HI-C,as well as the restrictions on the language it follows.
- Appendix B [AADL to C transformations], page 17 details the mapping rules to map an AADL model onto a High-Integrity Distributed System.
- Appendix C [PolyORB-HI-C API], page 47 provides an overview of PolyORB-HI-C API.
- Appendix D [References], page 75 provides a list of useful references to complete this documentation.
- Appendix E [GNU Free Documentation License], page 77 contains the text of the license under which this document is being distributed.

Conventions

Following are examples of the typographical and graphic conventions used in this guide:

- `Functions`, `utility program names`, `standard names`, and `classes`.
- '`Option flags`'
- '`File Names`', '`button names`', and '`field names`'.
- *Variables*.
- *Emphasis*.
- [optional information or parameters]
- Examples are described by text

```
and then shown this way.
```

Commands that are entered by the user are preceded in this manual by the characters "`$` " (dollar sign followed by space). If your system uses this sequence as a prompt, then the commands will appear exactly as you see them in the manual. If your system uses some other prompt, then the command will appear with the `$` replaced by whatever prompt character you are using.

Full file names are shown with the "/" character as the directory separator; e.g., '`parent-dir/subdir/myfile.c`'. If you are working on a Windows platform, please note that the "\" character should be used instead.

1 Introduction to PolyORB-HI-C

PolyORB-HI-C is a middleware for High-Integrity Systems, it inherits most concepts of the schizophrenic middleware *PolyORB* while being based on a complete new source code base, compatible with the Ravenscar profile and the restrictions for High-Integrity systems.

In order to ease the construction of Distributed High-Integrity Systems, PolyORB-HI-C relies on the AADL language and the Ocarina toolsuite (*[VZH06]*) to allocate all required ressources and generate stubs, skeletons, marshallers and concurrent structures.

Ocarina/PolyORB-HI-C supports both AADLv1 and AADLv2 as input models.

This manual describes the different elements parts of PolyORB-HI-C.

2 Configuration

2.1 Supported Platforms

PolyORB-HI-C has been compiled and sucessfully tested on

- native platforms
  - Linux
  - Mac OS X
  - Solaris
  - FreeBSD
  - Windows
- embedded platforms
  - RTLinx, using Elinos
  - Linux embedded, specific version for the TASTE toolset.
  - Nintendo DS (tm) (Linux) - see http://www.dslinux.org
  - Nokia 770 (Linux) - see http://www.maemo.org
  - LEON (SPARC-like CPU) (RTEMS)
  - Spif (PowerPC CPU) (RTEMS) - see http://www.enst.fr/~spif/

When you are using RTEMS operating system, you have to define the `RTEMS_MAKEFILE_PATH` environment variable. This variable must point to the directory that contains the `Makefile.inc` file relevant to your platform. In a similar way, when you are using the linux distribution specific to *TASTE*, you have to set the variable `LINUXTASTE_PATH`. This variable should point to the directory where the linux-specific distribution was built. To be sure that the variable is well defined, you can check that the directory `$LINUXTASTE_PATH/output/staging/usr/bin/` exists and that the `$LINUXTASTE_PATH/output/staging/usr/bin/i386-linux-gcc` file exists and is executable (it corresponds to the cross-compiler for this distribution).

Note: PolyORB-HI-C should compile and run on every POSIX-compliant system.

2.2 Tree structure

PolyORB-HI-C has the following tree structure:

- '`doc/`': documentation,
- '`examples/`': set of examples to test PolyORB-HI-C
- '`share/`': common files (aadl files used by Ocarina, makefiles, ...)
- '`src/`': core of PolyORB-HI
- '`src/drivers`': device drivers supported by PolyORB-HI-C
- '`tools/`': some script to handle the packaging and a verification tool to check if the binaries are compliant with the POSIX restrictions.
- '`ChangeLog`': release information,
- '`COPYING`': GPLv2 licence document,

- '`README`': short description of the distribution.

When installed with Ocarina, in '`$OCARINA_PATH`' directory (you can use the '`ocarina-config --prefix`' command to get the installation directory).

- docutmentation is in '`$OCARINA_PATH/share/doc/ocarina`';
- examples are in '`$OCARINA_PATH/examples/ocarina/polyorb-hi-c/`': set of examples to test PolyORB-HI-C
- runtime files are in '`$OCARINA_PATH/include/ocarina/runtime/polyorb-hi-c/`'.

2.3 Build requirements

To be compiled, PolyORB-HI-C requires the following tools:

- a C compiler that produces binaries for the target architecture. If you are running applications on topof Linux, a regular gcc installation should be sufficient (packages provided by most Linux distributions would be sufficient). If you are trying to compile for another architecture, you would need a cross-compiler tool.
- a standard C-library, for common functions like `socket()` or `pthread_create()`.

Note: For each tested bare board, the toolchains provides Makefiles to configure additional environment variables

PolyORB-HI-C also relies on AADL-to-C code generation provided by Ocarina. Therefore, it is important to select a version of Ocarina that is compatible with this version of PolyORB-HI-C. Whenever possible, pick a unified archive that contains both tools.

2.4 Configuration instructions

To install PolyORB-HI-C, please observe the following steps:

- Install your C compiler and Ocarina as specified by their respective documentations and make sure their 'bin/' installation directories are located at the top of your PATH environment variable.
- Issue `./configure`. The `configure` script can take several options: issue `./configure --help` to have a quick overview of them. For examples. `./configure --enable-debug` will configure the software to be built with all debug options (mainly additional output). Also `./configure --enable-lua` will enable the LUA scripting engine within PolyORB-HI-C. At the end of the configuration process, a file with all parameters is created ('`include/po_hi_config.h`'. If this file is not created, the compilation is not possible.

  For having all the configuration options, you can invoke the `configure` script with the `--help` switch : `./configure --help`.
- Issue `make && make install`

2.4.1 Examples of configuration

2.4.1.1 Configure the framework for the LEON platform (case of cross-compilation)

In this example, we want configure the framework for the LEON platform and the RTEMS operating system. The LEON architecture is similar to the SPARC. In other words, we

have to use a compiler that is different from the one used to compile native binaries. In our case, the compiler is called `sparc-rtems-gcc`. Consequently, the host name will be `sparc-rtems`.

Note: If you use RTEMS, you have to define the `RTEMS_MAKEFILE_PATH` *as RTEMS documentation describe it. Generally, you have to follow all instructions that are described with the system you will use.*

2.5 Build instructions

PolyORB-HI-C must be installed correctly in order to be able to build examples.

To compile all examples, simply issue `make examples` from the main source directory. To clean the examples, issue `make clean-examples` from the main source directory.

The examples may be built with the debug information. This is the default behavior of the `make examples` command. If the user wants to make the examples without any debug information and any GNAT check, he should use the `make examples 'BUILD=Release'` command instead. The footprint of the generated executable will be reduced considerably.

Each example uses a makefile.

For each example, a makefile is provided with the following rules:

- `build-all`: generate code from the example and compile it;
- `clean`: clean all generated files;

3 Building a system

In this chapter, we discuss the construction of an application, using PolyORB-HI-C and an AADL model of the application.

3.1 Building examples

Each example provide a makefile that does the following steps:

1. parse the AADL model;
2. generate C code from the AADL model;
3. compile each node

PolyORB-HI-C comes with different examples and configurations, please refer to '`examples/README`' and subsequent documentation files for more details.

3.2 Building a new system

To build your own system, you have two choices: using a scenario file or the command line.

- To use a scenario file, please follow these instructions
  1. build a scenario file, a scenario file is an AADL file containing a system describing your applications (AADL files, code generator that has to be used, needed Ocarina non-standard property sets:

```
system mysystem
properties
  Ocarina_Config::AADL_Files           =>
    ("mymodel1.aadl", "mymodel2.aadl");
  Ocarina_Config::Generator            => polyorb_hi_c;
  Ocarina_Config::Needed_Property_Sets =>
    (ARAO, Cheddar_Properties);
end mysystem;

system implementation mysystem.Impl
end  mysystem.Impl;
```

  2. issue the command `ocarina -b -x <scenario-file>`
- To use command line, please follow these instructions
  1. issue the command `ocarina -g polyorb_hi_c <list-of-aadl-files>`

For a list of ALL supported flags, please refere to the *Ocarina User's Guide*. There are some PolyORB-HI-C specific flags :

1. **-perf** : enable performance traces. Using this flag, PolyORB-HI-C will execute your application during a fixed amount of time and then, produce a performance analysis (indicating the Worst-Case Execution Time (WCET) and call traces (which functions was executed and when).

4 Porting PolyORB-HI-C to another architecture

This section gives some hints to help the developer to port PolyORB-HI-C. We will give the name of the files you need to change and what part of them should be modified to support new architectures and operating systems.

4.1 POSIX compliance

PolyORB-HI-C is POSIX compliant. It means that all the functions used in the framework should be available if your operating system is POSIX compliant. Even this compliance, you will probably need to make some changes and for each new architecture or operating system, you have to create a specific Makefile, as described in the thrid section.

4.2 Architecture-dependent files

If you need to port the framework on another architecture, some files don't need to be changed. Porting efforts will be focused on the following files :

- `po_hi_task.c` : Create tasks and handle their properties (period, priority, ...). At this time, this file contains only POSIX calls to create and manage thread.
- `po_hi_time.c` : Handle time and provide some functions to wait until an absolute time. The functions defined in this file make calls to POSIX functions like `clock_gettime()`.
- `po_hi_transport_sockets.c` : All the functions defined in this file are used to send or receive data through sockets. It creates a task to receive data and put them on a stack. All the functions made calls to POSIX-compliant functions like `socket()`, `listen` or `bind`.

4.3 Declare a new supported system

In all files that contain architecture-dependent, we need to split code for each system. We make it with MACCRO and include the code for the used architecture when we compile it. At this time, two systems are supported : `POSIX` and `RTEMS_POSIX`. Even if RTEMS use the POSIX implementation, there are some differences between that needs to declare another system.

If you want to support a new architecture, you need to declare a new maccro which will be used to differenciate the code for your architecture from other parts of the code. Then, this maccro will be included in the `CFLAGS` variable in the Makefile created for your architecture.

4.4 Define the compilation process

Each architecture has its own Makefile. It is used to define the compiler name, the linker name and some maccros to compile the code with a specific architecture.

All Makefiles are stored in the `share/make` directory. Each Makefile follow the following naming rule : `Makefile.arch.ostype`. For example, the Makefile created for the LEON architecture with the RTEMS OS has the name `Makefile.leon.rtems`. You need to create a Makefile with name that follow the naming rule and fill it with the rights `CFLAGS` and `CC` for the sytem you port.

4.5 Device Drivers

PolyORB-HI-C supports a set of predefined drivers. It relies on the `device` component of AADL models. You can see the code of all available drivers in the '`src/drivers`' directory.

4.5.1 Supported devices drivers

Actually, PolyORB-HI-C supports the following devices

1. **sockets**: a socket interface that uses PolyORB marshallers to send data accross an ethernet network. It relies on the TCP/IP protocol and uses POSIX functions to send and receive data.
2. **Linux serial**: provides function to send data accross the serial bus on a Linux host.
3. **RASTA serial**: is the same than Linux serial but for LEON/Rasta software. It also uses PolyORB-HI-C marshallers. It requires that you use the RTEMS executive.
4. **RASTA spacewire**: sends data accross a Spacewire bus. It works on top of the RTEMS operating system.
5. **RASTA 1553**: sends data accross a 1553 bus. It provides functions to use the bus as a controller or a terminal (monitor mode not yet implemented).
6. **LEON serial**: provides ability to use the serial port of a LEON board under RTEMS 4.8. This driver supports only a speed of 38400 bauds.
7. **Exarm**: a driver that implements a network protocol dedicated to the EXARM project. You can find more information about this project on `http://www.esa.int/TEC/Robotics/SEMA9EVHESE_0.html`.
8. **NI 6071E**: driver for the National Instrument 6071E card. See `http://sine.ni.com/nips/cds/view/p/la` The driver was designed for the EXARM project. To be able to use it, you must use the LINUX TASTE specific distribution that embedds the low-level driver for the card. For that, the underlying operating system must be set to x86.linuxtaste.

4.5.2 Drivers configuration

The configuration of drivers is specified in AADL models using the `Deployment::Config` property. This property is a string that is later translated into code used by PolyORB-HI-C to configure the drivers. The code created consists in an array (`__po_hi_devices_naming`) that contains the strings specified using the AADL property.

The following list summarizes how device driver configuration should be written in the `Deployment::Config` property and so, how PolyORB-HI-C understands drivers configuration.

- **Ethernet driver for Linux and NE2000 driver for RTEMS**: the configuration should be written like that :

  `ip XXX.XXX.XXX.XXX NNN`

  Where `XXX.XXX.XXX.XXX` corresponds to the IP address associated to the interface and `NNN` the port bound to the generated application (produced programs will listen on this port for incoming requests/data).
- **Serial driver for LEON2/LEON3 on RTEMS and serial driver for i386 on Linux and RTEMS**: the configuration should be written like this: `dev=accessed_device speed=baudrate`

  For example:

- On RTEMS/LEON, a valid configuration that accesses the second serial port would be: `dev=/dev/console_b speed=34600`
- On RTEMS/LEON with a RASTA board, a valid configuration that accesses the first serial port of the RASTA rack would be: `dev=/dev/apburasta0 speed=19200`
- On Linux/x86, a valid configuration that accesses the first serial COM port would be: `dev=/dev/ttyS0 speed=115200`

Note that the RTEMS/LEON driver supports only a speed of 34600 bauds. Other specified values will raise an error at run-time.

Also, when the speed of the driver is not specified, the driver automatically fallback to a default speed, which is 34600.

- **Spacewire for LEON2/LEON3 with RTEMS**: the configuration is composed of one number that corresponds to the node identifier of the device. You directly write in the configuration the node number associated with the device.

4.5.3 Adding a new driver

To add a new driver, you need to add a file in the '`src/drivers`' directory. It would basically contain the implementation of your driver. Then, since all files are compiled, you need to add some C macro that will indicate that your file will be compiled only under some circumstances (when the device is used in the model). To do so, the code generator automatically generates a maccro called `__PO_HI_NEED_XXX` where `XXX` is the driver name in uppercase. The driver name is specified in AADL models using the `Deployment::Driver_Name` property.

If you are implementing your own driver, you can take existing drivers as an example.

4.5.4 Add your files to the list of compiled files

To get your driver compiled with PolyORB-HI-C services, you need to edit the '`share/make/Makefile.common`' file and add your to the list of compiled files (the `PO_HI_OBJS` variable). Then, don't forget to install your modified version of the file before testing it.

4.5.5 Retrieve driver configuration

In AADL models, the configuration of the device is specified using the `Deployment::Configuration` property. It describes configuration concerns (IP address of the device and so on). It is useful to configure and initialize your driver. To get this information in your driver code, you can use the `__po_hi_get_device_naming()` function from the transport layer. This function takes one **device-id** that corresponds to the identifier of your device in the AADL model. However, this **device-id** is automatically passed to the initialization function of your driver in the generated code so that you can easily get configuration strings.

Appendix A Supported features

A.1 C constructions and restrictions

PolyORB-HI-C introduces Ravenscar-like restrictions on C concurrent features.

Moreover, the code is compliant with the Application Environment Profile (AEP) defined by the OMG. If these constructions are warrant on the underlying middleware, it does not apply on the user code. In other words, the code provided by the user and used by the generated code must be written carefully.

If you want to check that your application if compliant with the AEP profile, use the `check-symbols` tool, available in the '`tools`' directory.

A.2 AADL features

POlyORB-HI acts as an AADLv1 or AADLv2 runtime. AADL is a complete description language. Some features cannot be implemented or supported by restricted HI runtimes.

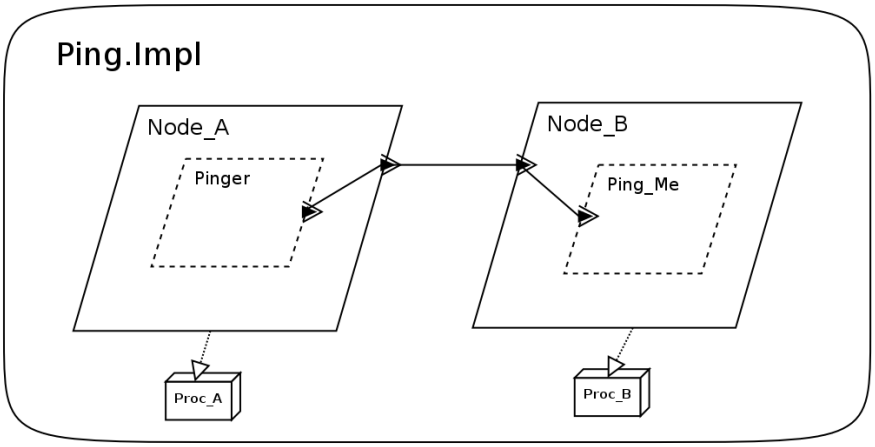
This section lists AADL features supported by PolyORB-HI-C:

- asynchronous, oneway calls;
- data component types of statically bounded size;
- all compile-time and run-time restrictions enforced as part of the compilation process;
- PolyORB-HI-Ada can use different transport infrastructures:
  - on native platform, distribution can be tested using the native socket library.
  - user-provided transport layer can be used, provided they follow guidelines discussed in section **XXX**.

Appendix B AADL to C transformations

In the following, and for each component of the distributed application, we give the AADL entities that are used to model this component, and then the transformation rules used by the code generator to generate C code from these entities.

The mapping rules will be illustrated using the following simple example of a distributed application:



The figure above shows the architecture of the *Ping* example: a client, which is a process containing one single *periodic* thread, sends a message to the server which is a process containing one *aperiodic cyclic* thread that handles incoming ping messages from the client. Each node of the *Ping* application runs on a different machine.

B.1 Whole distributed application

A distributed application is an application which is composed by interacting nodes. In this section, we give the AADL entities used to model a distributed application. Then, we give the rules applied to map AADL entities onto instances VM-level container, expressed as C code.

In the following, we detail only the rules that are directly related to the distributed application as a whole system. The rules that are specific to the components of the distributed application are explained in the sections that deals with these respective components.

B.1.1 AADL entities

To model a distributed application in AADL we use the `system` component. The system implementation shown on the following example models such system.

```
system PING
end PING;

system implementation PING.Impl
subcomponents
  -- Nodes
  Node_A : process A.Impl;
```

```
  Node_B : process B.Impl {ARAO::port_number => 12002;};

  --  Processors
  --  ...
connections
  --  ...
properties
  --  ...
end PING.Impl;
```

For each node (process) of the distributed application, we instantiate a subcomponent in the system implementation.

We use the `properties` section of the AADL `system` (see Section B.3 [Hosts], page 24 for more details) to map the different nodes on the different platforms of the distributed application. The `connections` section of the system implementation models the connections between the different nodes of the application.

B.1.2 C mapping rules

A distributed application is mapped into a hierarchy of directories:

- the root directory of the distributed application which has the same name as the system implementation that model the application, in lower case, all dot being converted into underscores. This directory is the root of the directory hierarchy of the generated C distributed application.
- for each node of the distributed application, a child directory having the same name as the corresponding process subcomponent (in lower case) is created inside the root directory. This child directory will contain all the code generated for the particular node it was created for (see Section B.2 [Distributed application nodes], page 18 for more details).

B.2 Distributed application nodes (processes)

In this section, we give the AADL entities used to model a node of distributed application. Then, we give the rules applied to map C code from these AADL entities. Only rules that are related directly to a node as a whole subsystem are listed here. The rules that are specific to the sub-components of a node are explained in the sections that deal with these respective sub-components.

B.2.1 AADL entities

To model a distributed application node in AADL we use the `process` component. The process implementation shown in the listing below shows such system. For each node of the distributed application, we add a process instantiation as subcomponent in the system implementation that models the distributed application.

```
process A
features
  Out_Port : out event data port Simple_Type;
end A;

process implementation A.Impl
```

```
subcomponents
  Pinger : thread P.Impl;
connections
  event data port Pinger.Data_Source -> Out_Port;
end A.Impl;
```

For each thread that belongs to a node of the distributed application, we instantiate a subcomponent in the process implementation. For each connection between a node and another, a `port` feature has to be added to both nodes with the direction `out` for the source and `in` for the destination (see Section B.5 [Connections], page 33 for more details on connections mapping).

B.2.2 C mapping rules

All the C entities mapped from a distributed application node, are created in a child directory of the directory mapped from the distributed application. This directory has the same name as the process *subcomponent* instance relative to the handled node in the system implementation that model the distributed application, in lower case.

For example, all the entities relative to the process `A` of the `Ping` example are generated in the directory `ping_impl/node_a`.

The following paragraphs list the C compilation units that are created for each node of the distributed application.

B.2.2.1 Marshallers functions

The marshallers functions are used to put all request and types values in a message in order to send them through a network connections. All marshalling functions are declared in the file `marshallers.c`.

However, PolyORB-HI-C can also use third-party marshallers. It can rely on the marshallers generated for ASN1 encoding. Details about ASN1 marshallers are provided in the next section.

B.2.2.2 Using ASN1 marshallers

With the ASN1 tools from Semantix (see. `http://www.semantix.gr/assert/`), you can convert ASN1 declarations into AADL models. Then, these models can be used with AADL components and PolyORB-HI-C relies on Semantix tools to automatically generates C code that implements the ASN1 types.

For that purpose, you need to install the program `asn2aadlPlus` and `asn1cc`. These programs are freely available on `http://www.semantix.gr/assert/`. Then, when you use ASN1 types with your AADL model (with the AADL files generated with `asn2aadlPlus`), PolyORB-HI-C uses the generated code from ASN1 descriptions and integrate it to marshall data.

B.2.2.3 Node activity

We denote “activity” the set of the actions performed by one particular node which are not triggered by other nodes. All the periodic threads of a node are part of the node activity.

The code related to the node activity is generated in an C file with the name ‘`activity.c`’. An example is shown below :

```
#include <po_hi_types.h>
#include <po_hi_gqueue.h>
#include <request.h>
#include <deployment.h>
#include <types.h>
#include <subprograms.h>
#include <po_hi_task.h>
#include <po_hi_main.h>
#include <marshallers.h>
extern __po_hi_entity_t __po_hi_port_global_to_entity[__PO_HI_NB_PORTS];
extern __po_hi_port_t __po_hi_port_global_to_local[__PO_HI_NB_PORTS];
__po_hi_int8_t __po_hi_data_source_local_destinations[1] = {ping_me_global_data_sink};
__po_hi_uint8_t __po_hi_pinger_woffsets[__po_hi_pinger_nb_ports];
__po_hi_uint8_t __po_hi_pinger_offsets[__po_hi_pinger_nb_ports];
__po_hi_uint8_t __po_hi_pinger_used_size[__po_hi_pinger_nb_ports];
__po_hi_uint8_t __po_hi_pinger_empties[__po_hi_pinger_nb_ports];
__po_hi_uint8_t __po_hi_pinger_first[__po_hi_pinger_nb_ports];
__po_hi_uint8_t __po_hi_pinger_recent[__po_hi_pinger_nb_ports * sizeof(__po_hi_request_t)];
__po_hi_uint8_t __po_hi_pinger_queue[0 * sizeof(__po_hi_request_t)];
__po_hi_uint16_t __po_hi_pinger_total_fifo_size = 0;
__po_hi_port_t __po_hi_pinger_history[0];
__po_hi_uint8_t __po_hi_pinger_n_dest[__po_hi_pinger_nb_ports] = {1};
__po_hi_int8_t __po_hi_pinger_fifo_size[__po_hi_pinger_nb_ports] = {__PO_HI_GQUEUE_FIFO_OUT};
__po_hi_uint8_t* __po_hi_pinger_destinations[__po_hi_pinger_nb_ports] = {__po_hi_data_source_local_destin
/*  Periodic task : Pinger*/

/****************/
/* pinger_job   */
/****************/

void* pinger_job ()
{
   simple_type data_source_request_var;
   __po_hi_request_t data_source_request;

   __po_hi_gqueue_init(node_a_pinger_k,__po_hi_pinger_nb_ports,__po_hi_pinger_queue,__po_hi_pinger_fifo_s
   __po_hi_wait_initialization();
   while (1)
   {
      /*  Call implementation*/
      do_ping_spg(&(data_source_request_var));
      /*  Set the OUT port values*/
      data_source_request.vars.pinger_global_data_source.pinger_global_data_source = data_source_request_
      data_source_request.port = data_source_request_var;
      __po_hi_gqueue_store_out(node_a_pinger_k,pinger_local_data_source,&(data_source_request));
      /*  Send the OUT ports*/
      __po_hi_gqueue_send_output(node_a_pinger_k,pinger_global_data_source);
      __po_hi_wait_for_next_period(node_a_pinger_k);
   }
}


/*************************/
/* __po_hi_main_deliver   */
/*************************/

void __po_hi_main_deliver
```

```
      (__po_hi_msg_t* message)
{
   __po_hi_request_t request;
   __po_hi_entity_t entity;

   __po_hi_unmarshall_request(&(request),message);
   entity = __po_hi_port_global_to_entity[request.port];
   switch (entity)
   {
      default:
      {
         break;
      }
   }
}
```

All the naming rules explained in Section B.1 [Whole distributed application], page 17 are also applied to map the package name. This file contains all the routines mapped from the periodic threads that belong to the handled node (see Section B.4 [Threads], page 25 for more details on thread mapping). This package contains also the instances of shared objects used in this node (see Section B.7 [Data], page 38 for more details). If the node does not contain any *periodic* thread nor shared objects, there is no '`activity.c`' file generated for this node. Thus, the node `B` in the `Ping` example does not have a '`activity.c`' package.

B.2.2.4 Data types

All the data types mapped from AADL data components and used by a particular node of a distributed application are gathered in a separate C file called '`types.h`'.

For more detail on the mapping of data components, see Section B.7 [Data], page 38.

B.2.2.5 Subprograms

The mapping of all AADL subprogram components used by a particular node is generated in a separate file called '`subprograms.c`'. The content of the file is shown in the following example:

For more detail on the mapping of subprogram components, see Section B.6 [Subprograms], page 37.

B.2.2.6 Deployment information

The deployment information is the information each node has on the other nodes in the distributed applications. This information is used, to send a request to another node or to receive a request from another node. The deployment information is generated for each node in two C files : '`deployment.h`' and '`deployment.c`'.

The file '`deployment.h`' contains the following types

- a first type called `__po_hi_node_t`. For each node in the application we create an enum whose name is mapped from the node "instance" declared in the system implementation to which we concatenate the string "_k". All the naming rules listed in Section B.1 [Whole distributed application], page 17 have to be respected.

- a second type called `__po_hi_entity_t`. For each thread in the the application, we declare an enum.
- a third type called `__po_hi_task_id`. For each thread that run on the current node.
- a fourth type called `__po_hi_entity_server_t`. For each node that may communicate with the current node, we add a value in this enum. It will be used by the transport layer. Please note that at least one server is declared : the value `invalid_server`.
- a fifth type called `__po_hi_port_t` that contains all global port identifier.

More, this file contains the following maccros :

- `__PO_HI_NB_ENTITIES` is the number of entities in the whole distributed system.
- `__PO_HI_NB_TASKS` is the number of the tasks that will be started on the current node
- `__PO_HI_NB_NODES` is the number of nodes in the distributed system.
- `__PO_HI_PROTECTED` is the number of protected objects use on the current node.
- `__PO_HI_NB_PORTS` that represent the total number of ports in the whole distributed system.
- `__PO_HI_NB_DEVICES` that represent the total number of devices in the whole distributed system.

The file '`deployment.c`' contains the following variables :

- `mynode` variable which has the value of the handled node.
- `__po_hi_entity_table` variable is used to know on which node an entity runs.
- `__po_hi_port_global_to_local` variable is used to convert a global port identifier to a local port identifier
- `__po_hi_port_global_to_entity` variable is used to know on which entity a given port is. This table is used convert a global port identifier to an entity identifier.
- `__po_hi_uint8_t __po_hi_deployment_endiannesses` variable details which the endianess of each node. It is an array which size is `__PO_HI_NB_NODES`.
- `__po_hi_port_to_device` is an array which size is `__PO_HI_NB_PORTS`. For each port, it indicates the value of the device identifier that handles it.
- `__po_hi_port_global_model_names` is an array which size is `__PO_HI_NB_PORTS`. For each port, it contains the name of the port.
- `__po_hi_port_global_names` is an array which size is `__PO_HI_NB_PORTS`. For each port, it contains the name generated by the code generator.
- `__po_hi_devices_naming` is an array which size is `__PO_HI_NB_DEVICES`. For each deivce, it contains all relevant information for their configuration. The configuration string is deduced from the `Configuration` property associated with the device.

The following example shows the `Deployment` package relative to the node `A` of the `Ping` example:

```
#ifndef __DEPLOYMENT_H_
#define __DEPLOYMENT_H_
#include <po_hi_protected.h>
typedef enum
{
   pinger_local_data_source = 0
```

```
} __po_hi_pinger_t;

#define __po_hi_pinger_nb_ports 1

typedef enum
{
   ping_me_local_data_sink = 0
} __po_hi_ping_me_t;

#define __po_hi_ping_me_nb_ports 1

/*  For each node in the distributed application add an enumerator*/

typedef enum
{
   node_a_k = 0,
   node_b_k = 1
} __po_hi_node_t;

/*  For each thread in the distributed application nodes, add an enumerator*/

typedef enum
{
   node_a_pinger_k_entity = 0,
   node_b_ping_me_k_entity = 1
} __po_hi_entity_t;

typedef enum
{
   node_a_pinger_k = 0
} __po_hi_task_id;

#define __PO_HI_NB_TASKS 1

/*  For each thread in the distributed application nodes THAT MAY COMMUNICATE*/
/*   with the current node, add an enumerator*/

typedef enum
{
   invalid_server = -1
} __po_hi_entity_server_t;

#define __PO_HI_NB_SERVERS 0

#define __PO_HI_NB_PROTECTED 0

#define __PO_HI_NB_NODES 2

#define __PO_HI_NB_ENTITIES 2

#define __PO_HI_NB_PORTS 2

typedef enum
{
   pinger_global_data_source = 0,
   ping_me_global_data_sink = 1
} __po_hi_port_t;
```

```
#endif
```

B.3 Hosts

A host is the set formed by a processor and an operating system (or real-time kernel).

In this section we present the AADL entities used to model a host. Then, we give the mapping rules used to generate C code expressing that a node runs on a particular host.

B.3.1 AADL entities

To model both the processor and the OS, we use the `processor` AADL component. The characteristics of the processor are defined using the AADL properties. For example, if our distributed application uses an IP based network to make its node communicate, then each host must have an IP address. Each host must also precise its platform (native, LEON...). The listing following example shows how to express this using a custom property set.

```
processor the_processor
properties
  ARAO::location           => "127.0.0.1";
  ARAO::Execution_Platform => Native;
end the_processor;
```

To map an application node (processor) to a particular host, we use the `Actual_Processor_Binding` property. The following example shows how the node `Node_A` is mapped to the processor `Proc_A` in the `Ping` example.

```
system PING
end PING;

system implementation PING.Impl
subcomponents
  -- Nodes
  Node_A : process A.Impl;
  Node_B : process B.Impl {ARAO::port_number => 12002;};

  -- Processors
  CPU_A  : processor the_processor;
  CPU_B  : processor the_processor;
connections
  -- ...
properties
  -- Processor bindings
  actual_processor_binding => reference CPU_A applies to Node_A;
  actual_processor_binding => reference CPU_B applies to Node_B;
end PING.Impl;
```

B.3.2 C mapping rules

The C generated code concerning the code generation to model host mapping is located in the '`naming.c`' file. More precisely, the `node_addr` and `node_port` contains, for each node, the information related to its host. These information are dependant on the transport mechanism used in the distributed application.

B.4 Threads

The threads are the active part of the distributed application. A node must contain at least one thread and may contain more than one thread. In this section, we give the AADL entities used to model threads. Then, we give the mapping rule to generate C code corresponding to the periodic and aperiodic threads.

The rules are listed relatively to the packages generated for the nodes and for the distributed application (see Section B.2 [Distributed application nodes], page 18 and Section B.1 [Whole distributed application], page 17). Only rules that are related directly to a thread as a whole subsystem are listed here.

B.4.1 AADL entities

The `thread` AADL components are used to model threads in the distributed application. The `features` section of the thread component declaration describe the thread interface (the ports that may be connected to the ports of other threads). The `properties` section of the thread implementation lists the properties of the thread such as its priority, its nature (periodic, sporadic) and many other properties ares expressed using AADL properties. The `calls` section of the thread implementation contains the sequences of subprograms the thread may call during its job (see Section B.6 [Subprograms], page 37 for more details on the subprogram mapping). If the thread job consist of calling more than one subprogram, it is **mandatory** to encapsulate these calls inside a single subprogram which will consist the thread job. The `connections` section of a thread implementation connects the parameters of the subprograms called by the thread to the ports of the threads or to the parameters of other called subprograms in the same thread.

```
thread P
features
  Data_Source : event out data port Simple_Type;
end P;

thread implementation P.Impl
calls {
  --  ...
};
connections
  --  ...
properties
  Dispatch_Protocol => Periodic;
  Period            => 1000 Ms;
end P.Impl;
```

The listing above shows the thread `P` which belongs to the process `A` in the `Ping` example. We can see that `P` is a periodic thread with a period of $1000ms$, that this thread has a unique `out event data port` and that at each period, the thread performs a call to the `Do_Ping_Spg` subprogram whose `out parameter` is connected to the thread port.

B.4.2 C mapping rules for periodic threads

Periodic threads are cyclic threads that are triggered by and only by a periodic time event. between two time events the periodic threads do a non blocking job and then they sleep waiting for the next time event.

B.4.2.1 Node activity

The majority of the code generated for the periodic threads is put in the '`activity.c`' file generated for the application node containing the handled thread. Each periodic thread is created in the main function ('`main.c`' file) with the `__po_hi_create_periodic_task` function-call.

The generated code in the '`activity.c`' file is a parameterless function that represents the thread job. The defining identifier of the function is mapped from the thread instance name in the process that models the node, to which we append the string "`_job`". All the naming rules listed in Section B.1 [Whole distributed application], page 17 have to be respected. The body of this subprogram calls the subprograms mapped from the subprogram calls the thread performs. Then, it sends the request to the remote threads it may be connected to. Finally, at the end of the function, we make a call to the `__po_hi_wait_next_period()` with the task identifier as parameter. This call ensure that we wait the next period before we start the function again.

The generated code in '`main.c`' file is a function-call that creates a periodic task. The task is created with the function `__po_hi_create_periodic_task`. This creates a periodic task with the wanted properties at the elaboration time of the node. The package instantiation name is mapped from the thread instance name in the process that model the node, to which we append the string "`_k`". All the naming rules listed in Section B.1 [Whole distributed application], page 17 have to be respected. The function-call takes the following parameters:

- the enumerator corresponding to the thread
- the task period,
- the task priority. If the user did not specify a priority, then `__PO_HI_DEFAULT_PRIORITY` is used,
- the task job which corresponds to the subprogram `<Thread_Name>_job`.

The following example shows the generated code for the periodic thread `Pinger` from the node `Node_A` of the `Ping` example:

```
#include <po_hi_types.h>
#include <po_hi_gqueue.h>
#include <request.h>
#include <deployment.h>
#include <types.h>
#include <subprograms.h>
#include <po_hi_task.h>
#include <po_hi_main.h>
#include <marshallers.h>
extern __po_hi_entity_t __po_hi_port_global_to_entity[__PO_HI_NB_PORTS];
extern __po_hi_port_t __po_hi_port_global_to_local[__PO_HI_NB_PORTS];
__po_hi_int8_t __po_hi_data_source_local_destinations[1] = {ping_me_global_data_sink};
__po_hi_uint8_t __po_hi_pinger_woffsets[__po_hi_pinger_nb_ports];
```

```
__po_hi_uint8_t __po_hi_pinger_offsets[__po_hi_pinger_nb_ports];
__po_hi_uint8_t __po_hi_pinger_used_size[__po_hi_pinger_nb_ports];
__po_hi_uint8_t __po_hi_pinger_empties[__po_hi_pinger_nb_ports];
__po_hi_uint8_t __po_hi_pinger_first[__po_hi_pinger_nb_ports];
__po_hi_uint8_t __po_hi_pinger_recent[__po_hi_pinger_nb_ports * sizeof(__po_hi_request_t)];
__po_hi_uint8_t __po_hi_pinger_queue[0 * sizeof(__po_hi_request_t)];
__po_hi_uint16_t __po_hi_pinger_total_fifo_size = 0;
__po_hi_port_t __po_hi_pinger_history[0];
__po_hi_uint8_t __po_hi_pinger_n_dest[__po_hi_pinger_nb_ports] = {1};
__po_hi_int8_t __po_hi_pinger_fifo_size[__po_hi_pinger_nb_ports] = {__PO_HI_GQUEUE_FIFO_OUT};
__po_hi_uint8_t* __po_hi_pinger_destinations[__po_hi_pinger_nb_ports] = {__po_hi_data_source_local_destin
/*  Periodic task : Pinger*/

/****************/
/* pinger_job   */
/****************/

void* pinger_job ()
{
   simple_type data_source_request_var;
   __po_hi_request_t data_source_request;

   __po_hi_gqueue_init(node_a_pinger_k,__po_hi_pinger_nb_ports,__po_hi_pinger_queue,__po_hi_pinger_fifo_s
   __po_hi_wait_initialization();
   while (1)
   {
      /*  Call implementation*/
      do_ping_spg(&(data_source_request_var));
      /*  Set the OUT port values*/
      data_source_request.vars.pinger_global_data_source.pinger_global_data_source = data_source_request_
      data_source_request.port = data_source_request_var;
      __po_hi_gqueue_store_out(node_a_pinger_k,pinger_local_data_source,&(data_source_request));
      /*  Send the OUT ports*/
      __po_hi_gqueue_send_output(node_a_pinger_k,pinger_global_data_source);
      __po_hi_wait_for_next_period(node_a_pinger_k);
   }
}


/*************************/
/* __po_hi_main_deliver   */
/*************************/

void __po_hi_main_deliver
      (__po_hi_msg_t* message)
{
   __po_hi_request_t request;
   __po_hi_entity_t entity;

   __po_hi_unmarshall_request(&(request),message);
   entity = __po_hi_port_global_to_entity[request.port];
   switch (entity)
   {
      default:
      {
         break;
      }
   }
```

```
}
```

B.4.3 C mapping rules for sporadic threads

Sporadic threads are *cyclic* threads that are triggered by an sporadic event. The minimum inter-arrival time between two sporadic event is called the period of the sporadic thread.

B.4.3.1 Node activity

The majority of the code generated for the sporadic threads is put in the 'activity.c' file generated for the application node containing the handled thread. Each periodic thread is created in the main function ('main.c' file) with the __po_hi_create_sporadic_task function-call.

The generated code in the 'activity.c' file is a parameterless function that represents the thread job. The defining identifier of the function is mapped from the thread instance name in the process that models the node, to which we append the string "_job". All the naming rules listed in Section B.1 [Whole distributed application], page 17 have to be respected. In the body of the function, the thread will wait for an event (most of the time : a message from another entity).

The generated code in 'main.c' file is a function-call that creates the sporadic task. The task is created with the function __po_hi_create_sporadic_task. This creates a sporadic task with the wanted properties at the elaboration time of the node. The package instantiation name is mapped from the thread instance name in the process that model the node, to which we append the string "_k". All the naming rules listed in Section B.1 [Whole distributed application], page 17 have to be respected. The function-call takes the following parameters:

- the enumerator corresponding to the thread
- the task priority. If the user did not specify a priority, then __PO_HI_DEFAULT_PRIORITY is used,
- the task job which corresponds to the subprogram <Thread_Name>_job.

The following example shows the generated code for the sporadic thread Ping_Me from the node Node_B of the Ping example.

```
#include <po_hi_gqueue.h>
#include <po_hi_types.h>
#include <request.h>
#include <deployment.h>
#include <po_hi_task.h>
#include <subprograms.h>
#include <po_hi_main.h>
#include <marshallers.h>
extern __po_hi_entity_t __po_hi_port_global_to_entity[__PO_HI_NB_PORTS];
extern __po_hi_port_t __po_hi_port_global_to_local[__PO_HI_NB_PORTS];
__po_hi_uint8_t __po_hi_ping_me_woffsets[__po_hi_ping_me_nb_ports];
__po_hi_uint8_t __po_hi_ping_me_offsets[__po_hi_ping_me_nb_ports];
__po_hi_uint8_t __po_hi_ping_me_used_size[__po_hi_ping_me_nb_ports];
__po_hi_uint8_t __po_hi_ping_me_empties[__po_hi_ping_me_nb_ports];
__po_hi_uint8_t __po_hi_ping_me_first[__po_hi_ping_me_nb_ports];
```

```
__po_hi_uint8_t __po_hi_ping_me_recent[__po_hi_ping_me_nb_ports * sizeof(__po_hi_request_t)];
__po_hi_uint8_t __po_hi_ping_me_queue[16 * sizeof(__po_hi_request_t)];
__po_hi_uint16_t __po_hi_ping_me_total_fifo_size = 16;
__po_hi_port_t __po_hi_ping_me_history[16];
__po_hi_uint8_t __po_hi_ping_me_n_dest[__po_hi_ping_me_nb_ports] = {0};
__po_hi_int8_t __po_hi_ping_me_fifo_size[__po_hi_ping_me_nb_ports] = {16};
__po_hi_uint8_t* __po_hi_ping_me_destinations[__po_hi_ping_me_nb_ports] = {NULL};

/*********************/
/* ping_me_deliver   */
/*********************/

void ping_me_deliver
      (__po_hi_request_t* request)
{

   switch (request->port)
   {
      case ping_me_global_data_sink:
      {
         __po_hi_gqueue_store_in(node_b_ping_me_k,ping_me_local_data_sink,request);

         break;
      }
      default:
      {
         break;
      }
   }
}

/*  Sporadic task : Ping_Me*/
/*  Get the IN ports values*/

/*****************/
/* ping_me_job   */
/*****************/

void* ping_me_job ()
{
   __po_hi_port_t port;
   __po_hi_request_t data_sink_request;

   __po_hi_gqueue_init(node_b_ping_me_k,__po_hi_ping_me_nb_ports,__po_hi_ping_me_queue,__po_hi_ping_me_fi
   __po_hi_wait_initialization();
   while (1)
   {
      __po_hi_gqueue_wait_for_incoming_event(node_b_ping_me_k,&(port));
      __po_hi_compute_next_period(node_b_ping_me_k);
      if (__po_hi_gqueue_get_count(node_b_ping_me_k,ping_me_local_data_sink))
      {
               __po_hi_gqueue_get_value(node_b_ping_me_k,ping_me_local_data_sink,&(data_sink_request));
         __po_hi_gqueue_next_value(node_b_ping_me_k,ping_me_local_data_sink);

      }
      /*  Call implementation*/
      ping_spg(data_sink_request.vars.ping_me_global_data_sink.ping_me_global_data_sink);
      __po_hi_wait_for_next_period(node_b_ping_me_k);
```

```
   }
}


/*************************/
/* __po_hi_main_deliver   */
/*************************/

void __po_hi_main_deliver
      (__po_hi_msg_t* message)
{
   __po_hi_request_t request;
   __po_hi_entity_t entity;

   __po_hi_unmarshall_request(&(request),message);
   entity = __po_hi_port_global_to_entity[request.port];
   switch (entity)
   {
      case node_b_ping_me_k_entity:
      {
         ping_me_deliver(&(request));

         break;
      }
      default:
      {
         break;
      }
   }
}
```

B.4.4 Deployment information

As said in Section B.2 [Distributed application nodes], page 18, the files '`deployment.h`' and '`deployment.c`' are generated for each node in the distributed application. For each thread port in the whole distributed application, we declare an enumerator in this type. The defining identifier of the enumerator is mapped from the process subcomponent name and the thread subcomponent name as follows: `<Node_Name>_<Thread_Name>_K`. For each that that may communicate, we generate the following elements

- A variable called `__po_hi_<thread_name>_local_to_global` (in `deployment.c`) that is used to convert a local port identifier of the thread to a global one.
- A type `__po_hi_<thread_name>_t` that will contain on local port identifier.
- A macro `__po_hi_<thread_name>_nb_ports` that will contain the number of ports for the thread.

For these elements, all the naming rules listed in Section B.1 [Whole distributed application], page 17 must be respected.

```
#ifndef __DEPLOYMENT_H_
#define __DEPLOYMENT_H_
#include <po_hi_protected.h>
typedef enum
```

```
{
   pinger_local_data_source = 0
} __po_hi_pinger_t;

#define __po_hi_pinger_nb_ports 1

typedef enum
{
   ping_me_local_data_sink = 0
} __po_hi_ping_me_t;

#define __po_hi_ping_me_nb_ports 1

/*  For each node in the distributed application add an enumerator*/

typedef enum
{
   node_a_k = 0,
   node_b_k = 1
} __po_hi_node_t;

/*  For each thread in the distributed application nodes, add an enumerator*/

typedef enum
{
   node_a_pinger_k_entity = 0,
   node_b_ping_me_k_entity = 1
} __po_hi_entity_t;

typedef enum
{
   node_a_pinger_k = 0
} __po_hi_task_id;

#define __PO_HI_NB_TASKS 1

/*  For each thread in the distributed application nodes THAT MAY COMMUNICATE*/
/*   with the current node, add an enumerator*/

typedef enum
{
   invalid_server = -1
} __po_hi_entity_server_t;

#define __PO_HI_NB_SERVERS 0

#define __PO_HI_NB_PROTECTED 0

#define __PO_HI_NB_NODES 2

#define __PO_HI_NB_ENTITIES 2

#define __PO_HI_NB_PORTS 2

typedef enum
{
   pinger_global_data_source = 0,
   ping_me_global_data_sink = 1
```

```
} __po_hi_port_t;

#endif


#include <deployment.h>
__po_hi_entity_server_t server_entity_table[__PO_HI_NB_ENTITIES] = {invalid_server,invalid_server};
__po_hi_node_t entity_table[__PO_HI_NB_ENTITIES] = {node_a_k,node_b_k};
__po_hi_node_t mynode = node_a_k;
```

The listing above shows the generated `__po_hi_entity_server_t` and `entity_table` for the nodes `B` from the `Ping` example.

B.4.5 Port mapping

Threads can contain one or several ports. To handle them, we declared several arrays in the `activity.c`

- `__po_hi_<port_name>_destinations` : array for each port of the thread which contains all destinations of the port.
- `__po_hi_<thread_name>_woffsets` : array (size = number of ports in the thread) used by \pohic for the global queue of the thread.
- `__po_hi_<thread_name>_offsets` : array (size = number of ports in the thread) used by \pohic for the global queue of the thread.
- `__po_hi_<thread_name>_used_size` : array (size = number of ports in the thread) used by \pohic for the global queue of the thread.
- `__po_hi_<thread_name>_empties` : array (size = number of ports in the thread) used by \pohic for the global queue of the thread.
- `__po_hi_<thread_name>_first` : array (size = number of ports in the thread) used by \pohic for the global queue of the thread.
- `__po_hi_<thread_name>_recent` : array (size = number of ports in the thread) used by \pohic for the global queue of the thread.
- `__po_hi_<thread_name>_queue` : array (size = size of the global queue for the thread) used by \pohic to handle the global queue.
- `__po_hi_<thread_name>_total_fifo_size` : variable that contains the size of the global queue. It is the sum of all port size for the thread.
- `__po_hi_<thread_name>_history` : array (size = number of ports in the thread) used by \pohic for the global queue of the thread.
- `__po_hi_<thread_name>_n_dest` : array (size = number of ports in the thread) used by \pohic for the global queue of the thread. It contains the number of destinations for each port of the thread.
- `__po_hi_<thread_name>_fifo_size` : array (size = number of ports in the thread) used by \pohic for the global queue of the thread.
- `__po_hi_<thread_name>_destinations` : array (size = number of ports in the thread) that contains all destinations for each port.

B.5 Connections

The connections are entities that support communication between the application nodes. In this section, we present the AADL entities used to model connection between nodes. There is no implicit mapping rules for AADL connections, they just help to know the data flow (in case of data connections) and some aspects of the control flow (event connections) in the distributed application. In this section, we will talk about how data are sended (marshall functions) and which functions are used to send and receive data.

B.5.1 AADL entities

As said in Section B.2 [Distributed application nodes], page 18 and Section B.1 [Whole distributed application], page 17 a connection between two nodes of the distributed application is modeled by:

- The `ports` features that exist on each one of the nodes. Ports can be declared inside processes or threads. The direction of the port (`in`, `out` or `in out`) indicates the direction of the information flow.
- The `connections` section in the system implementation relative to the distributed application and in the process and thread implementations.

```
system PING
end PING;

system implementation PING.Impl
subcomponents
  -- Nodes
  Node_A : process A.Impl;
  Node_B : process B.Impl {ARAO::port_number => 12002;};

  -- Processors
  CPU_A  : processor the_processor;
  CPU_B  : processor the_processor;
connections
  -- Port connections
  event data port Node_A.Out_Port -> Node_B.In_Port;
properties
  -- Processor bindings
  actual_processor_binding => reference CPU_A applies to Node_A;
  actual_processor_binding => reference CPU_B applies to Node_B;
end PING.Impl;
```

The listing above shows the connection between the node `A` and `B` in the system implementation.

The nature of the `port` (*event port*, *data port* or *event data port*) depends on the nature of the connection between the two nodes:

- if the message sent from one node to another node is only a triggering event and contains no data, we create an *event* port.
- if the message sent from one node to another node is a data message but it does not trigger the receiver thread, we create a *data* port.
- if the message sent from one node to another node is a data message that triggers the receiver thread, we create an *event data* port.

B.5.2 Marshallers

In a distributed system, when we send any data to a node, we need to put them in a stream. We call that the marshall operation. On the other hand, find data in a stream is called the unmarshall operation. In each distributed application, we generate marshallers for each types and request. These functions will marshall/unmarshall data in/from a message.

All marshallers functions are generated in a file called '`marshallers.c`'. The marshall (or unmarshall) functions for request are prefixed by the string `__po_hi_marshall_request_` (or `__po_hi_unmarshall_request_`). Marshall (or unmarshall) functions for types are prefixed by the string `__po_hi_marshall_type_` (or `__po_hi_unmarshall_type_`). Each function has the name of the type or the request it marshalls.

Finally, a function `__po_hi_marshall_request` and `__po_hi_unmarshall_request` is generated to handle all requests. Then, is called the appropriate function to call to marshall or unmarshall the data.

```
#include <types.h>
#include <po_hi_types.h>
#include <po_hi_marshallers.h>

/**************************************/
/* __po_hi_marshall_type_simple_type   */
/**************************************/

void __po_hi_marshall_type_simple_type
      (simple_type value,
      __po_hi_msg_t* message,
      __po_hi_uint16_t* offset)
{

   __po_hi_marshall_int(value,message,offset);
}


/**************************************/
/* __po_hi_unmarshall_type_simple_type   */
/**************************************/

void __po_hi_unmarshall_type_simple_type
      (simple_type* value,
      __po_hi_msg_t* message,
      __po_hi_uint16_t* offset)
{

   __po_hi_unmarshall_int(value,message,offset);
}


/*********************************************/
/* __po_hi_marshall_request_ping_me_data_sink   */
/*********************************************/

void __po_hi_marshall_request_ping_me_data_sink
      (__po_hi_request_t* request,
      __po_hi_msg_t* message,
      __po_hi_uint16_t* offset)
```

```
{

   __po_hi_marshall_type_simple_type(request->vars.ping_me_global_data_sink.ping_me_global_data_sink,mess
}


/***********************************************/
/* __po_hi_unmarshall_request_ping_me_data_sink   */
/***********************************************/

void __po_hi_unmarshall_request_ping_me_data_sink
      (__po_hi_request_t* request,
      __po_hi_msg_t* message,
      __po_hi_uint16_t* offset)
{

   __po_hi_unmarshall_type_simple_type(&(request->vars.ping_me_global_data_sink.ping_me_global_data_sink)
}


/***********************************************/
/* __po_hi_marshall_request_pinger_data_source   */
/***********************************************/

void __po_hi_marshall_request_pinger_data_source
      (__po_hi_request_t* request,
      __po_hi_msg_t* message,
      __po_hi_uint16_t* offset)
{

   __po_hi_marshall_type_simple_type(request->vars.pinger_global_data_source.pinger_global_data_source,me
}


/*************************************************/
/* __po_hi_unmarshall_request_pinger_data_source   */
/*************************************************/

void __po_hi_unmarshall_request_pinger_data_source
      (__po_hi_request_t* request,
      __po_hi_msg_t* message,
      __po_hi_uint16_t* offset)
{

   __po_hi_unmarshall_type_simple_type(&(request->vars.pinger_global_data_source.pinger_global_data_sourc
}


/*****************************/
/* __po_hi_marshall_request   */
/*****************************/

void __po_hi_marshall_request
      (__po_hi_request_t* request,
      __po_hi_msg_t* message)
{
   __po_hi_uint16_t offset;
```

```
   offset = 0;
   __po_hi_marshall_port(request->port,message);
   switch (request->port)
   {
      case ping_me_global_data_sink:
      {
         __po_hi_marshall_request_ping_me_data_sink(request,message,&(offset));

         break;
      }
      case pinger_global_data_source:
      {
         __po_hi_marshall_request_pinger_data_source(request,message,&(offset));

         break;
      }
      default:
      {
         break;
      }
   }
}


/*******************************/
/* __po_hi_unmarshall_request   */
/*******************************/

void __po_hi_unmarshall_request
      (__po_hi_request_t* request,
      __po_hi_msg_t* message)
{
   __po_hi_uint16_t offset;

   offset = 0;
   __po_hi_unmarshall_port(&(request->port),message);
   switch (request->port)
   {
      case ping_me_global_data_sink:
      {
         __po_hi_unmarshall_request_ping_me_data_sink(request,message,&(offset));

         break;
      }
      case pinger_global_data_source:
      {
         __po_hi_unmarshall_request_pinger_data_source(request,message,&(offset));

         break;
      }
      default:
      {
         break;
      }
   }
}
```

B.6 Subprograms

Subprograms are used to encapsulate behavioural aspects of the distributed application. In this section, we give the AADL entities used to model subprograms. Then we present the C mapping rules to generate code for the modeled subprograms.

B.6.1 AADL entities

To *declare* a subprogram, we use the `subprogram` AADL component. The parameters of the subprogram are specified in the `features` section of the component declaration. If the subprogram does only the job of calling other declared subprograms, then the `calls` section of the subprogram implementation has to contain such calls. To point to the *real* implementation of the subprogram, we use the AADL properties. The following example shows the AADL model for the `Do_Ping_Spg` from the `Ping` example. It precises that the C implementation of the subprogram is located in the function `user_ping`. The file which contains this function must be stored with the aadl model.

Subprograms are generally called by threads or by other subprograms. To express this, we use the `calls` section of a component implementation. Then we perform all the connections between the called subprograms *parameters* and the caller components *ports* (or *parameters* if the caller is a subprogram).

The following listing shows the calls and connections sections of the periodic thread `P` in the `Ping` example.

```
subprogram Do_Ping_Spg
features
  Data_Source : out parameter Simple_Type;
properties
  source_language => C;
  source_name     => "user_ping";
end Do_Ping_Spg;
```

B.6.2 C mapping rules for subprogram components

B.6.2.1 The subprograms package

Each subprogram instance modelize a hand-written function. In the '`subprograms.c`' file, we declare the definition of this function and we generate a new one that will call the one provided by the user.

The following listing shows the calls and connections sections of the subprogram `ping_spg` in the `Ping` example.

```
#include <types.h>
#include <subprograms.h>
void user_do_ping_spg
      (simple_type* data_source);
/*****************/
/* do_ping_spg */
/*****************/
```

```
void do_ping_spg
      (simple_type* data_source)
{

   user_do_ping_spg(data_source);
}
```

B.6.3 C mapping rules for subprogram calls

For each subprogram call in a thread, we generate an C subprogram call to the subprogram implementing the thread and given by mean of the AADL properties.

On the client side, A thread `sth_Job` begin by calling the subprogram in its call sequence. then it calls the stubs of all the subprogram it is connected to.

On the server side, and in the function of the `process_request`, the subprogram implementation corresponding to the operation (coded in the message) is called.

B.7 Data

The data are the messages exchanged amongst the nodes of the distributed application. In this section, we present the AADL constructs used to model data. Then we give the C mapping rules to generate code from these constructs.

B.7.1 AADL entities

AADL `data` components are used to model data exchanged in the distributed application. Properties are used to precise the nature of the data.

To model a data structure (which contains fields of others data types) we use data component implementation and we add a subcomponent for each field of the structure.

The simple data types that can be modeled using AADL are (See example below):

- Booleans
- Integers
- Fixed point types
- Characters
- Wide characters

```
-- Boolean type

data Boolean_Data
properties
  ARAO::Data_Type  => Boolean;
end Boolean_Data;

-- Integer type

data Integer_Data
properties
  ARAO::Data_Type  => Integer;
```

```
end Integer_Data;

--  Fixed point type

data Fixed_Point_Type
properties
  ARAO::Data_Type    => Fixed;

  ARAO::Data_Digits  => 10;
  --  The total number of digits is 10

  ARAO::Data_Scale   => 4;
  --  The precision is 10**(-4)
end Fixed_Point_Type;

--  Character type

data Character_Data
properties
  ARAO::Data_Type  => Character;
end Character_Data;

--  Wide character type

data W_Character_Data
properties
  ARAO::Data_Type  => Wide_Character;
end W_Character_Data;
```

The complex data types that can be modeled using AADL are (See example below):

- Bounded strings
- Bounded wide strings
- Bounded arrays of a type that can be modeled
- Structure where the fields types are types that can be modeled

```
-- Bounded string type

data String_Data
properties
  ARAO::Data_Type  => String;
  ARAO::Max_Length => <User_Defined_Length>;
end String_Data;

-- Bounded wide string type

data W_String_Data
properties
  ARAO::Data_Type  => Wide_String;
  ARAO::Max_Length => <User_Defined_Length>;
end W_String_Data;

-- Bounded array type: Only the component implementation should be
-- used in the ports or parameters!

data Data_Array
```

```
properties
  ARAO::Length => <User_Defined_Length>;
end Data_Array;

data implementation Data_Array.i;
subcomponents
  -- Only one subcomponent
  Element : data String_Data;
end Data_Array.i;

-- Data structure type: Only the component implementation should be
-- used in the ports or parameters!

data Data_Structure
end Data_Structure;

data implementation Data_Structure.i;
subcomponents
  Component_1 : data String_Data;
  Component_2 : data W_String_Data;
  Component_3 : data Data_Array.i;
end Data_Structure.i;
```

Data components may also contain subprogram features. Depending on the AADL properties given by the user. These component may denote a protected object or a non protected object. In either case, they are used to model a data structure that can be handled only by the subprograms it exports (which are the feature of the data structure).

```
--  Data type of object field

data Field_Type
properties
  ARAO::Data_Type  => Integer;
end Field_Type;

--  Protected data type

data Protected_Object
features
  Update : subprogram Protected_Update;
  Read   : subprogram Protected_Read;
properties
  ARAO::Object_Kind => Protected;
  --  This property tells that we have a protected object type
end Protected_Object;

--  The implementation of the protected object

data implementation Protected_Object.Impl
subcomponents
  Field : data Field_Type;
end Protected_Object.Impl;

--  Subprograms

subprogram Protected_Update
features
```

```
  this : requires data access Protected_Object.Impl
  {required_access => access Read_Write;}; --  Mandatory
  P    : in parameter Field_Type;
properties
  source_language => Ada95;
  source_name     => "Repository";
end Protected_Update;

subprogram Protected_Read
features
  this : requires data access Protected_Object.Impl
  {required_access => access Read_Only;}; --  Mandatory
  P    : out parameter Field_Type;
properties
  source_language => Ada95;
  source_name     => "Repository";
end Protected_Read;
```

The example above shows an example of a protected data component (`Protected_Object.Impl`). The object has a single field (subcomponent) which is a simple data component. Note that the description of the feature subprograms of these data component is a little bit different from the description of classic subprograms: each feature subprogram must have a full access to the internal structure of the object type. To achieve this, we use the `require data access` facility of AADL. To model a non protected data component, user should simply change the `ARAO::Object_Kind => Protected;` into `ARAO::Object_Kind => Non_Protected;` in the implementation of data component.

B.7.2 C mapping rules

Data component declaration are mapped into C type declaration in the file `types.h`. In the following we give the C type corresponding to each data component type that could be modeled.

B.7.2.1 Simple types

Simple data components are mapped into an C type definition whose defining identifier is mapped from the component declaration identifier (with respect to the naming rules listed in Section B.1 [Whole distributed application], page 17) and whose parent subtypes is:

- `int` for boolean data types
- `int` for integer data types
- `float` for fixed point types
- `chat` for character data types

B.7.2.2 Bounded strings and wide strings

Bounded strings and wide strings are not supported in the C generator at this time.

B.7.2.3 Bounded arrays

Bounded arrays and wide strings are not supported in the C generator at this time.

B.7.2.4 Data structures

Data structures are mapped into a C structure defined in the file '`types.h`'. The identifier of the record type is mapped from the data component name with respect to the naming rules given in Section B.1 [Whole distributed application], page 17. Each field defining identifier is mapped from the subcomponent name given in the data component implementation with the same naming rules. The type of the field is the C type mapped from the data corresponding component. The following example shows the C mapping of the data structure defined given earlier in this part.

```
typedef struct
{
   pos_internal_type field1;
   pos_internal_type field2;

} pos_impl;
```

B.7.2.5 Object types

Protected object types are mapped into an a C structure. We add automatically a member in the structure with the type `__po_hi_protected_id` and the name `protected_id`. This member will identify the protected type in the distributed system. All other members of the object are declared as in Data Structures (see previous subsection). The features subprograms of the object types are declared in the '`types.h`' file, whereas the body of these functions are defined in the '`types.c`' file. Moreover, the value of the `protected_id` must be initialized. This is done in the main function ('`main.c`'), before the initialization. All the naming conventions given in Section B.1 [Whole distributed application], page 17 have to be respected. The following example shows the specification of the protected type mapped from the `Protected_Object.Impl` shown earlier in this part. We show the files '`types.h`', '`types.c`' and '`main.c`' (that initialize the `protected_id` member of the structure.

```
#ifndef __TYPES_H_
#define __TYPES_H_
#include <po_hi_types.h>
#include <po_hi_protected.h>
typedef int pos_internal_type;

typedef struct
{
   __po_hi_protected_t protected_id;

   pos_internal_type field;

} pos_impl;

void pos_impl_update
      (pos_impl* value);

void pos_impl_read
      (pos_impl* value);

#endif
```

```
#include <po_hi_protected.h>
#include <subprograms.h>
/**********************/
/* pos_impl_update */
/**********************/

void pos_impl_update
      (pos_impl* value)
{

   __po_hi_protected_lock(value->protected_id);
   update(&(value->field));
   __po_hi_protected_unlock(value->protected_id);
}

/********************/
/* pos_impl_read */
/********************/

void pos_impl_read
      (pos_impl* value)
{

   __po_hi_protected_lock(value->protected_id);
   read(&(value->field));
   __po_hi_protected_unlock(value->protected_id);
}
```

```
#include <activity.h>
#include <po_hi_common.h>
#include <po_hi_main.h>
#include <po_hi_time.h>
#include <po_hi_task.h>
#include <types.h>
extern pos_impl pos_data;
/************************/
/* __PO_HI_MAIN_NAME */
/************************/

__PO_HI_MAIN_TYPE __PO_HI_MAIN_NAME ()
{

   __po_hi_initialize();
   __po_hi_create_periodic_task(gnc_tmtc_pos_gnc_th_k,__po_hi_milliseconds(1000),250,gnc_th_job);
   __po_hi_create_periodic_task(gnc_tmtc_pos_tmtc_th_k,__po_hi_milliseconds(100),190,tmtc_th_job);
   pos_data.protected_id = 0;
   __po_hi_wait_initialization();
   __po_hi_wait_for_tasks();
   return (__PO_HI_MAIN_RETURN);
}
```

Non protected object types are mapped similarly to protected object types. The only difference, is that instead of creating a protected type, we create a generic parameterless nested package.

B.8 Devices

Devices access buses and gives the ability to communicate with other application nodes. They access buses, such as Ethernet networks. For each device, we expect that they are associated with a bus. Then, the device must specify its implementation internals in an **abstract** component.

This abstract component can contain other subcomponents that will be integrated in the system. In addition, if you want to specify the **sending function** of the device, you have to do that with a subprogram subcomponent called **sender**. In the example below, this function is described and associated with an AADL subprogram.

Also, you can specify an initialization function for your device. In that case, you should associate an AADL subprogram with your device using the `Initialize_Entrypoint` property. This subprogram will then be called at the initialization of the system. The signature of your subprogram should be :

```
void __my_init_function (__po_hi_device_id id);
```

In this function, the parameter `id` corresponds to the identifier bound to the device. It could then be used to retrieve configuration parameters using the `__po_hi_get_device_naming` function of PolyORB.

The following example illustrates the modeling of device drivers. It describes a serial device. It calls an initialization function when the system is initialized. It also specify device drivers internals with an abstract device. This driver is composed of a **sending** function to send data across a bus, as well as a **poller** thread that receives incoming data.

```
package devices

device serial_port_raw
features
   serial_line : requires bus access buses::serial.i;
properties
   Provided_Virtual_Bus_Class => (classifier (protocols::dummy.i));
end serial_port_raw;

device implementation serial_port_raw.linux
properties
   Deployment::Driver_Name => "serial_linux";
   Device_Driver => classifier (devices::serial_driver.linux);
   Initialize_Entrypoint => classifier (devices::spg_serial_init_linux);
end serial_port_raw.linux;


subprogram spg_serial_poller_linux
properties
Source_Language => C;
Source_Name => "__po_hi_c_driver_serial_linux_poller";
end spg_serial_poller_linux;

subprogram spg_serial_sender_linux
```

```
properties
Source_Language => C;
Source_Name => "__po_hi_c_driver_serial_linux_sender";
end spg_serial_sender_linux;

subprogram spg_serial_init_linux
features
   data_source : out parameter types::int.i;
properties
Source_Language => C;
Source_Name => "__po_hi_c_driver_serial_linux_init";
end spg_serial_init_linux;

thread serial_poller
end serial_poller;

thread implementation serial_poller.linux
calls
mycall : {
  pspg : subprogram spg_serial_poller_linux;
};
properties
   Period => 1000ms;
   Dispatch_Protocol => Periodic;
end serial_poller.linux;


thread implementation serial_poller.rasta
calls
mycall : {
  pspg : subprogram spg_serial_poller_rasta;
};
properties
   Period => 1000ms;
   Dispatch_Protocol => Periodic;
end serial_poller.rasta;

abstract serial_driver
end serial_driver;

abstract implementation serial_driver.linux
subcomponents
   receiver : thread serial_poller.linux;
   sender   : subprogram spg_serial_sender_linux;
end serial_driver.linux;

abstract implementation serial_driver.rasta
subcomponents
   receiver : thread serial_poller.rasta;
   sender   : subprogram spg_serial_sender_rasta;
end serial_driver.rasta;

end devices;
```

Appendix C PolyORB-HI-C API

This section lists the API of PolyORB-HI-C, used to support the basics of distribution features and concurrent interactions.

C.1 po_hi_task.h

```
/*
 * This is a part of PolyORB-HI-C distribution, a minimal
 * middleware written for generated code from AADL models.
 * You should use it with the Ocarina toolsuite.
 *
 * For more informations, please visit http://assert-project.net/taste
 *
 * Copyright (C) 2010-2012 ESA & ISAE.
 */

#ifndef __PO_HI_TASK_H__
#define __PO_HI_TASK_H__

/*
 * Define some values that are dependant of the
 * underlying executive.
 */
#if defined(POSIX) || defined (XENO_POSIX)
   #include <stdlib.h>
   #include <stdio.h>
   #define __PO_HI_MAIN_NAME main
   #define __PO_HI_MAIN_TYPE int
   #define __PO_HI_MAIN_ARGS int argc , char *argv[] , char **arge
   #define __PO_HI_MAIN_RETURN EXIT_SUCCESS
   #define __ERRORMSG(s, args...) fprintf(stderr, s, ##args)
#elif defined(_WIN32)
   #include <tchar.h>
   #include <windows.h>
   #include <stdlib.h>
   #include <stdio.h>
   #define __PO_HI_MAIN_NAME _tmain
   #define __PO_HI_MAIN_TYPE int
   #define __PO_HI_MAIN_ARGS
   #define __PO_HI_MAIN_RETURN EXIT_SUCCESS
   #define __ERRORMSG(s, args...) fprintf(stderr, s, ##args)
#elif defined (XENO_NATIVE)
   #include <native/task.h>
   #include <native/timer.h>
   #define __PO_HI_MAIN_NAME main
   #define __PO_HI_MAIN_TYPE int
   #define __PO_HI_MAIN_ARGS int argc , char *argv[] , char **arge
   #define __PO_HI_MAIN_RETURN 0
   #define __ERRORMSG(s, args...) fprintf(stderr, s, ##args)
#elif defined(RTEMS_PURE)
   #define __PO_HI_MAIN_NAME Init
   #define __PO_HI_MAIN_TYPE rtems_task
   #define __PO_HI_MAIN_ARGS rtems_task_argument argument
   #define __PO_HI_MAIN_RETURN 0
   #define __ERRORMSG(s, args...) fprintf(stderr, s, ##args)
#elif defined(RTEMS_POSIX)
```

```
   #define __PO_HI_MAIN_NAME POSIX_Init
   #define __PO_HI_MAIN_TYPE int
   #define __PO_HI_MAIN_ARGS
   #define __PO_HI_MAIN_RETURN 0
   #define __ERRORMSG(s, args...) fprintf(stderr, s, ##args)
#endif



#if defined(POSIX) || defined (RTEMS_POSIX) || defined (XENO_POSIX)
   #include <semaphore.h>
   #include <po_hi_time.h>
   #include <pthread.h>
   #include <sched.h>
   #define __PO_HI_MAX_PRIORITY sched_get_priority_max(SCHED_FIFO)
   #define __PO_HI_MIN_PRIORITY sched_get_priority_min(SCHED_FIFO)
   #define __PO_HI_DEFAULT_PRIORITY ((sched_get_priority_min(SCHED_FIFO) + sched_get_priority_max(SCHED_F
#elif defined(_WIN32)
   #include <inttypes.h>
   #include <po_hi_time.h>
   #define __PO_HI_DEFAULT_PRIORITY 0
   #define __PO_HI_MAX_PRIORITY 2
   #define __PO_HI_MIN_PRIORITY 0

#elif defined(RTEMS_PURE)
   #include <rtems.h>
   #include <inttypes.h>
   #include <po_hi_time.h>
   #define __PO_HI_DEFAULT_PRIORITY RTEMS_NO_PRIORITY
   #define __PO_HI_MAX_PRIORITY RTEMS_NO_PRIORITY
   #define __PO_HI_MIN_PRIORITY RTEMS_NO_PRIORITY
#elif defined(XENO_NATIVE)
   #include <inttypes.h>
   #include <po_hi_time.h>
   #define __PO_HI_DEFAULT_PRIORITY 50
   #define __PO_HI_MAX_PRIORITY 99
   #define __PO_HI_MIN_PRIORITY 0
#endif

#include <po_hi_types.h>
#include <deployment.h>

typedef __po_hi_uint16_t __po_hi_priority_t;
typedef size_t __po_hi_stack_t;

/*
 * Initialize tasking entities
 * Returns SUCCESS if there is no error.
 */
int __po_hi_initialize_tasking(void);

/*
 * Create a periodic task.
 *
 * The task created have the identifier given by the first
 * parameter. It is created according to the period created
 * with __po_hi_* functions (like __po_hi_milliseconds())
 * and priority parameters (use the OS priority). The task execute
```

```
 * periodically start_routine.
 *
 * This function returns SUCCESS if there is no error. Else,
 * it returns the negative value ERROR_CREATE_TASK.
 */
int __po_hi_create_periodic_task (const __po_hi_task_id      id,
                                  const __po_hi_time_t*      period,
                                  const __po_hi_priority_t   priority,
                                  const __po_hi_stack_t      stack_size,
                                  void*                (*start_routine)(void));

/*
 * Create a sporadic task.
 *
 * The identifier of the task is the first parameter. The period and
 * the priority of the task are stored in the second and third
 * parameter.  The code executed by the task is stored in the
 * start_routine pointer.
 *
 * Returns SUCCESS value if there is no error. Else, returns the negative
 * value ERROR_CREATE_TASK
 */
int __po_hi_create_sporadic_task (const __po_hi_task_id      id,
                      const __po_hi_time_t*      period,
                                  const __po_hi_priority_t   priority,
                                  const __po_hi_stack_t      stack_size,
                                  void*                      (*start_routine)(void));

/*
 * Create a generic task
 *
 * The identifier of the task is the first parameter. The period and
 * the priority of the task are stored in the second and third
 * parameter.  The code executed by the task is stored in the
 * start_routine pointer.
 *
 * Returns SUCCESS value if there is no error. Else, returns the negative
 * value ERROR_CREATE_TASK
 */
int __po_hi_create_generic_task (const __po_hi_task_id      id,
                                 const __po_hi_time_t*      period,
                                 const __po_hi_priority_t   priority,
                                 const __po_hi_stack_t      stack_size,
                                 void*                      (*start_routine)(void),
                                 void*                      arg);

/*
 * Wait the end of all tasks.
 * This function typically never ends, because all tasks
 * are doing an infinite loop and never ends. It just
 * used to avoid an infinite loop in the main thread.
 */
void __po_hi_wait_for_tasks (void);

/*
 * Called by a periodic task, to wait for its next period
 * The argument is the task identifier
 * Returns SUCCESS value, and if fails, returns a negative value
```

```
 */
int __po_hi_wait_for_next_period (__po_hi_task_id task);

/*
 * Sleep until the time given in argument. The second
 * argument is the task identifier which will sleep.
 * Return SUCCESS if there is no error. Else, it returns
 * a negative value : ERROR_CLOCK or ERROR_PTHREAD_COND
 */
 int __po_hi_task_delay_until (__po_hi_time_t* time, __po_hi_task_id task);

/*
 * Computer the next period for a task, according to the period
 * argument given at initialization time. The argument task
 * is the task-identifier in the node (__po_hi_task_id type).
 */
 int __po_hi_compute_next_period (__po_hi_task_id task);

 /*
  * Delete all the tasks that were created within the system.
  */
void __po_hi_tasks_killall (void);

 /*
  * Wait a given amount of time.
  */
void __po_hi_task_wait_offset (const __po_hi_time_t* time);


#endif /* __PO_HI_TASK_H__ */
```

C.2 po_hi_time.h

```
/*
 * This is a part of PolyORB-HI-C distribution, a minimal
 * middleware written for generated code from AADL models.
 * You should use it with the Ocarina toolsuite.
 *
 * For more informations, please visit http://assert-project.net/taste
 *
 * Copyright (C) 2007-2009 Telecom ParisTech, 2010-2012 ESA & ISAE.
 */

#ifndef __PO_HI_TIME_H__
#define __PO_HI_TIME_H__

#include <po_hi_types.h>

#ifndef HAVE_CLOCK_GETTIME
#include <time.h>
#endif

#ifdef XENO_NATIVE
#include <native/timer.h>
#include <native/task.h>
#endif
```

```
#ifdef _WIN32
#include <tchar.h>
#include <windows.h>

/*
 * Win32 helper functions to convert __po_hi_time_t to a representation
 * that would be suitable for Windows.
 */
unsigned __po_hi_windows_tick_to_unix_seconds(long long win_ticks);
LARGE_INTEGER __po_hi_unix_seconds_to_windows_tick(unsigned sec, unsigned nsec);
#endif


typedef struct
{
   __po_hi_uint32_t     sec;     /* amount of second     */
   __po_hi_uint32_t     nsec;    /* amount of nanosecond */
}__po_hi_time_t;
/*
 * Represent the time in PolyORB-HI.
 *
 * The value stored in this type depends on the system : on POSIX, it
 * is the epoch (time since 1970), on other systems, it can be the
 * number of elapsed ticks since the beginning of the program.
 *
 * The granularity of the time is in microsecond (10^-6)
 */

#define __PO_HI_TIME_TO_US(value) ((value.sec*1000000)+(value.nsec / 1000))

#define __PO_HI_TIME_TO_MS(value) ((value.sec*1000)+(value.nsec / 1000000))

int __po_hi_get_time (__po_hi_time_t* mytime);
/*
 * Get the current time and store informations
 * in the structure mytime.
 * If there is an error, returns a negative value
 * (ERROR_CLOCK). Else, returns a positive value.
 */

int __po_hi_add_times (__po_hi_time_t* result,
                       const __po_hi_time_t* left,
                       const __po_hi_time_t* right);
/*
 * Add the two structures given in parameter. The returned
 * value is the result of the operation.
 */

int __po_hi_seconds (__po_hi_time_t* time,
                     const __po_hi_uint32_t seconds);
/*
 * Build a __po_hi_time_t value which contains the
 * amount of time (in seconds) represented by the
 * argument seconds.
 */
```

```
int __po_hi_milliseconds  (__po_hi_time_t* time,
                           const __po_hi_uint32_t milliseconds);
/*
 * Build a __po_hi_time_t value which contains the
 * amount of time (in milliseconds) represented by the
 * argument milliseconds.
 */

int __po_hi_microseconds  (__po_hi_time_t* time,
                           const __po_hi_uint32_t microseconds);
/*
 * Build a __po_hi_time_t value which contains the
 * amount of time (in microseconds) represented by the
 * argument microseconds.
 */

int __po_hi_delay_until (const __po_hi_time_t* time);
/*
 * sleep until the time given in argument.
 * Return SUCCESS if there is no error. Else, it returns
 * a negative value : ERROR_CLOCK or ERROR_PTHREAD_COND
 */

int __po_hi_time_copy (__po_hi_time_t* dst, const __po_hi_time_t* src);
/*
 * Copy a time value from src to dst.
 * Returns __PO_HI_SUCCESS if successful.
 */


#ifdef NEED_CLOCK_GETTIME
#define CLOCK_REALTIME 0
int clock_gettime(int clk_id, struct timespec *tp);
#endif
/*
 * If the system doesn't support the clock_gettime function, we
 * emulate it. For example, Darwin does not support it
 */


int __po_hi_time_is_greater (const __po_hi_time_t* value, const __po_hi_time_t* limit);
/*
 * Indicates if a time value is greater than an other.
 * Returns 1 if value is greater than limit.
 * Returns 0 otherwise.
 */

#include <errno.h>
#ifndef ETIMEDOUT
#define ETIMEDOUT 60
#endif
/*
 * Ensure that ETIMEDOUT is defined
 * Workaround for bug #286
 */

#endif /* __PO_HI_TIME_H__ */
```

C.3 po_hi_marshallers.h

```
/*
 * This is a part of PolyORB-HI-C distribution, a minimal
 * middleware written for generated code from AADL models.
 * You should use it with the Ocarina toolsuite.
 *
 * For more informations, please visit http://assert-project.net/taste
 *
 * Copyright (C) 2007-2009 Telecom ParisTech, 2010-2012 ESA & ISAE.
 */

#ifndef __PO_HI_MARSHALLERS_H_
#define __PO_HI_MARSHALLERS_H_

#include <deployment.h>
#include <request.h>
#include <po_hi_messages.h>

/*
 * Basic marshallers functions. These functions are then
 * reused in the generated code to marshall application data.
 */

void __po_hi_marshall_port (__po_hi_port_t value, __po_hi_msg_t* msg);
void __po_hi_unmarshall_port (__po_hi_port_t* value, __po_hi_msg_t* msg);

void __po_hi_marshall_array (void* value, __po_hi_msg_t* msg,__po_hi_uint32_t size, __po_hi_uint32_t* offs
void __po_hi_unmarshall_array (void* value, __po_hi_msg_t* msg,__po_hi_uint32_t size, __po_hi_uint32_t* o

void __po_hi_marshall_bool (__po_hi_bool_t value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);
void __po_hi_unmarshall_bool (__po_hi_bool_t* value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);

void __po_hi_marshall_char (char value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);
void __po_hi_unmarshall_char (char* value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);

void __po_hi_marshall_int (int value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);
void __po_hi_unmarshall_int (int* value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);

void __po_hi_marshall_float (float value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);
void __po_hi_unmarshall_float (float* value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);

void __po_hi_marshall_float32 (__po_hi_float32_t value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);
void __po_hi_unmarshall_float32 (__po_hi_float32_t* value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);

void __po_hi_marshall_float64 (__po_hi_float64_t value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);
void __po_hi_unmarshall_float64 (__po_hi_float64_t* value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);

void __po_hi_marshall_int8 (__po_hi_int8_t value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);
void __po_hi_unmarshall_int8 (__po_hi_int8_t* value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);

void __po_hi_marshall_int16 (__po_hi_int16_t value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);
void __po_hi_unmarshall_int16 (__po_hi_int16_t* value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);

void __po_hi_marshall_int32 (__po_hi_int32_t value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);
void __po_hi_unmarshall_int32 (__po_hi_int32_t* value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);

#ifndef COMPCERT
```

```
void __po_hi_marshall_int64 (__po_hi_int64_t value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);
void __po_hi_unmarshall_int64 (__po_hi_int64_t* value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);
#endif

void __po_hi_marshall_uint8 (__po_hi_uint8_t value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);
void __po_hi_unmarshall_uint8 (__po_hi_uint8_t* value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);

void __po_hi_marshall_uint16 (__po_hi_uint16_t value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);
void __po_hi_unmarshall_uint16 (__po_hi_uint16_t* value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);

void __po_hi_marshall_uint32 (__po_hi_uint32_t value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);
void __po_hi_unmarshall_uint32 (__po_hi_uint32_t* value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);

#ifndef COMPCERT
void __po_hi_marshall_uint64 (__po_hi_uint64_t value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);
void __po_hi_unmarshall_uint64 (__po_hi_uint64_t* value, __po_hi_msg_t* msg,__po_hi_uint32_t* offset);
#endif

#ifdef PO_HI_USE_ASN1
#include <asn1_deployment.h>
#define __PO_HI_ASN1_PKT_SIZE Pkt_REQUIRED_BYTES_FOR_ENCODING
#define __po_hi_asn1_buffer_t __po_hi_byte_t*
#define __po_hi_asn1_pkt_t    Pkt
#endif

#endif /* __PO_HI_MARSHALLERS_H_ */
```

C.4 po_hi_giop.h

```
/*
 * This is a part of PolyORB-HI-C distribution, a minimal
 * middleware written for generated code from AADL models.
 * You should use it with the Ocarina toolsuite.
 *
 * For more informations, please visit http://assert-project.net/taste
 *
 * Copyright (C) 2007-2009 Telecom ParisTech, 2010-2012 ESA & ISAE.
 */

#ifdef __PO_HI_USE_GIOP

#ifndef __PO_HI_GIOP_H__
#define __PO_HI_GIOP_H__

#include <po_hi_types.h>
#include <po_hi_messages.h>
#include <deployment.h>
#include <string.h>

/*
 * This file defines the structures and functions to support the GIOP
 * protocol. The supported verrsion of GIOP is the 1.3.
 *
 * This implementation was made according to the CORBA 3.1, Part 2,
 * chapter 9 specifications.
 */
```

```
#define __PO_HI_GIOP_MSGTYPE_REQUEST           0
#define __PO_HI_GIOP_MSGTYPE_REPLY             1
#define __PO_HI_GIOP_MSGTYPE_CANCELREQUEST     2
#define __PO_HI_GIOP_MSGTYPE_LOCATEREQUEST     3
#define __PO_HI_GIOP_MSGTYPE_LOCATEREPLY       4
#define __PO_HI_GIOP_MSGTYPE_CLOSECONNECTION   5
#define __PO_HI_GIOP_MSGTYPE_MESSAGEERROR      6
#define __PO_HI_GIOP_MSGTYPE_FRAGMENT          7

#define __PO_HI_GIOP_VERSION_MAJOR             1
#define __PO_HI_GIOP_VERSION_MINOR             3

#define __PO_HI_GIOP_MAGIC                     "GIOP"

#define __PO_HI_GIOP_OPERATION_MAX_SIZE        100

#define __PO_HI_GIOP_MAGIC_SIZE                4

#define __PO_HI_GIOP_DISPOSITION_KEY           0
#define __PO_HI_GIOP_DISPOSITION_PROFILE       1
#define __PO_HI_GIOP_DISPOSITION_REFERENCE     2

#define __PO_HI_GIOP_HAS_MORE_MESSAGES         300

typedef struct
{
  char              magic[4];
  struct {
    __po_hi_uint8_t major; /* __PO_HI_GIOP_VERSION_MAJOR */
    __po_hi_uint8_t minor; /* __PO_HI_GIOP_VERSION_MINOR */
  } version;
  __po_hi_uint8_t   flags;
  __po_hi_uint8_t   message_type;
  __po_hi_uint32_t  message_size;
}__po_hi_giop_msg_hdr_t;

/* The __po_hi_giop_msg_hdr_t gives a structure to fill a message header */
/* for the GIOP protocol. The flags (8 bits) are organized like this :   */
/*  0  0  0  0  0  0  0  0                                               */
/*                    |  |----- byte order : 1 for little-endian         */
/*                    |                      0 for big-endian            */
/* The message_type should be a value of __PO_HI_GIOP_MSGTYPE*           */

typedef struct
{
  __po_hi_uint16_t              disposition;
  union
  {
    struct
    {
      __po_hi_uint32_t              object_size;
      __po_hi_uint32_t              object_addr;
    }key;

    struct
    {
      __po_hi_uint32_t              profile_id;
```

```
      __po_hi_uint32_t              profile_length;
      __po_hi_uint32_t              profile_data;
    }profile;

    struct
    {
      __po_hi_uint32_t              profile_index;
      __po_hi_uint32_t              full_ior;
    }reference;
  } values;
}__po_hi_giop_request_target_t;
/*
 * Note: for now, we only support object target. The object-id will
 * always be set to 0.
 */

typedef struct
{
        __po_hi_uint32_t               request_id;
        __po_hi_uint8_t                response_flags;
        __po_hi_uint8_t                reserved[3];
        __po_hi_giop_request_target_t  target;
        __po_hi_uint32_t               operation_length;
        char                           operation[__PO_HI_GIOP_OPERATION_MAX_SIZE];
        __po_hi_uint32_t               nb_scontext;
}__po_hi_giop_request_hdr_t;
/*
 * The operation is set the a maximum length of 100
 */

void __po_hi_giop_msg_hdr_init (__po_hi_giop_msg_hdr_t* msg_hdr);
/*
 * Initialize the message header, set the magic number, the version
 * and all other needed variables
 */

void __po_hi_giop_msg_hdr_set_message_type (__po_hi_giop_msg_hdr_t* msg_hdr,
                                            __po_hi_uint8_t msg_type);
/*
 * Set the message type in the header. We only support request, so the
 * type should be always __PO_HI_GIOP_MSG_REQUEST
 */

void __po_hi_giop_msg_hdr_set_message_size (__po_hi_giop_msg_hdr_t* msg_hdr,
                                            __po_hi_uint32_t msg_size);

void __po_hi_giop_request_hdr_init (__po_hi_giop_request_hdr_t* request_hdr);

void __po_hi_giop_request_hdr_set_operation (__po_hi_giop_request_hdr_t* request_hdr,
                                             const char* request_name);

int __po_hi_giop_send (__po_hi_entity_t from,
                       __po_hi_entity_t to,
                       __po_hi_msg_t*   msg);

int __po_hi_giop_decode_msg (__po_hi_msg_t* network_flow,
                             __po_hi_msg_t* output_msg,
                             __po_hi_uint32_t* has_more);
```

```
#ifdef __PO_HI_DEBUG
void __po_hi_giop_print_msg( __po_hi_msg_t* msg);
#endif

#endif /* __PO_HI_GIOP_H__ */

#endif /* __PO_HI_USE_GIOP */
```

C.5 po_hi_messages.h

```
/*
 * This is a part of PolyORB-HI-C distribution, a minimal
 * middleware written for generated code from AADL models.
 * You should use it with the Ocarina toolsuite.
 *
 * For more informations, please visit http://assert-project.net/taste
 *
 * Copyright (C) 2007-2009 Telecom ParisTech, 2010-2012 ESA & ISAE.
 */

#ifndef __PO_HI_MESSAGES_H_
#define __PO_HI_MESSAGES_H_

#include <po_hi_config.h>
#include <po_hi_types.h>

#include <request.h>
/* This file may not be generated. However, using messages implies
   using request. */

#ifdef __PO_HI_USE_GIOP
#define __PO_HI_MESSAGES_MAX_SIZE (int) sizeof(__po_hi_request_t) + 200
#else
#define __PO_HI_MESSAGES_MAX_SIZE (int) sizeof(__po_hi_request_t) + 4
/* XXX Why + 4 ? to be investigated */
#endif

#define __PO_HI_MESSAGES_CONTENT_BIGENDIAN      1
#define __PO_HI_MESSAGES_CONTENT_LITTLEENDIAN   2

typedef struct
{
  __po_hi_uint8_t   content[__PO_HI_MESSAGES_MAX_SIZE]; /* Content of the message */
  __po_hi_uint32_t  length;
  __po_hi_uint8_t   flags;
} __po_hi_msg_t;


void __po_hi_msg_reallocate (__po_hi_msg_t* message);
/*
 * Reset the message given in parameter
 */

void __po_hi_msg_write (__po_hi_msg_t*  msg,
void*           data,
```

```
__po_hi_uint32_t len);
/*
 * Write the data at the beginning of the specified message.  Length
 * of the data are specified by the parameter len
 */

void __po_hi_msg_read (__po_hi_msg_t*  msg,
       void*           data,
       __po_hi_uint32_t len);
/*
 * Read the data in the specified message. The data are taken from the
 * message and copied into the variable data.  Length of the data are
 * specified by the parameter len
 */

int __po_hi_msg_length (__po_hi_msg_t* msg);
/*
 * Return the length is the message
 */

void __po_hi_msg_copy (__po_hi_msg_t* dest,
       __po_hi_msg_t* src);
/*
 * Copy a message. The first argument is the message destination
 * whereas the second argument is the message source
 */

void __po_hi_msg_append_data (__po_hi_msg_t* msg, void* data, __po_hi_uint32_t length);
/*
 * Append data to a message. The first argument is the message which
 * will contain all the data. The second argument is a pointer to the
 * data and the third argument (length) is the size of the data in
 * byte.
 */

void __po_hi_msg_append_msg (__po_hi_msg_t* dest, __po_hi_msg_t* source);
/*
 * Append a message to another message. The first argument is the
 * message in which we will append the data. The second argument is
 * the source of the data.
 */

void __po_hi_msg_get_data (void* dest, __po_hi_msg_t* source,
                           __po_hi_uint32_t index,
                           __po_hi_uint32_t size);
/*
 * Get data from a message at index 'index', and copy it to the dest
 * argument It will copy size bytes from the messages.
 */

void __po_hi_msg_move (__po_hi_msg_t* msg, __po_hi_uint32_t length);
/*
 * Move a part of the message to the beginning. This function will put
 * the part (starting from the length argument) to the beginning of
 * the message.
 */

#ifdef __PO_HI_USE_GIOP
```

```
int __po_hi_msg_should_swap (__po_hi_msg_t* msg);
/*
 * The __po_hi_msg_should_swap return 1 if the endianness of the
 * current processor differs with the endianness of the message. Else,
 * it returns 0.
 */

void __po_hi_msg_swap_value (void* from, void* dest, __po_hi_uint8_t size);
/*
 * The function __po_hi_msg_swap_value swap the bytes of the from
 * value and put it to the dest argument. The size of the value is
 * designed by the third argument.
 */
#endif /* __PO_HI_USE_GIOP */

#ifdef __PO_HI_DEBUG
void __po_hi_messages_debug (__po_hi_msg_t* msg);
#endif

#endif /* __PO_HI_MESSAGES_H_ */
```

C.6 po_hi_transport.h

```
/*
 * This is a part of PolyORB-HI-C distribution, a minimal
 * middleware written for generated code from AADL models.
 * You should use it with the Ocarina toolsuite.
 *
 * For more informations, please visit http://assert-project.net/taste
 *
 * Copyright (C) 2007-2009 Telecom ParisTech, 2010-2012 ESA & ISAE.
 */

#ifndef __PO_HI_TRANSPORT__
#define __PO_HI_TRANSPORT__

#include <po_hi_messages.h>
#include <deployment.h>
#include <request.h>

#define __PO_HI_BIGENDIAN     0
#define __PO_HI_LITTLEENDIAN  1

#ifndef __PO_HI_NB_PROTOCOLS
#define __PO_HI_NB_PROTOCOLS 0
#endif

typedef struct
{
      void (*marshaller)   (void*, void*, int*);
      void (*unmarshaller) (void*, void*, int);
}__po_hi_protocol_conf_t;


#if __PO_HI_NB_PORTS > 0
```

```
typedef int (*__po_hi_transport_sending_func)(__po_hi_task_id, __po_hi_port_t);

typedef uint8_t __po_hi_queue_id;

/**
 * \fn __po_hi_transport_get_n_accessed_buses
 *
 * \brief Return the number of buses associated with a device.
 * If no bus is connected to the device or if the device
 * is invalid, the function returns 0. Otherwise, a positive value is
 * returned.
 */
uint32_t __po_hi_transport_get_n_accessed_buses (const __po_hi_device_id device);

/**
 * \fn __po_hi_transport_get_accessed_buses
 *
 * \brief Return a pointer to an array that contains all buses identifiers
 * accessed by the device passed as argument. If the argument is an invalid
 * device-id or if the device does not access any bus, NULL is returned.
 * The size of the array can be retrieved by the __po_hi_get_n_accessed_buses
 * function.
 */
__po_hi_bus_id* __po_hi_transport_get_accessed_buses (const __po_hi_device_id device);


/**
 * \fn __po_hi_transport_share_bus
 *
 * \brief Returns 1 if two devices share a common bus, 0 otherwise.
 */
int __po_hi_transport_share_bus (const __po_hi_device_id, const __po_hi_device_id);

/**
 * \fn __po_hi_get_node_from_entity
 *
 * \brief Returns the node identifier that corresponds to an entity.
 */
__po_hi_node_t    __po_hi_transport_get_node_from_entity (const __po_hi_entity_t entity);

/*
 * \fn __po_hi_get_entity_from_global_port
 *
 * \brief Return the entity identifier that own the port in parameters.
 */
__po_hi_entity_t  __po_hi_get_entity_from_global_port (const __po_hi_port_t port);

/*
 * \fn            __po_hi_transport_send_default
 * \brief         Default transport layer function.
 */
int               __po_hi_transport_send (__po_hi_task_id id, __po_hi_port_t port);

#define __po_hi_transport_send_default __po_hi_transport_send
#define __po_hi_send_output            __po_hi_transport_send


/*
```

```
 * \fn      __po_hi_get_port_name
 * \brief   Return the name of the port similar to the name within the AADL model.
 */
char* __po_hi_get_port_model_name (const __po_hi_port_t port);

/*
 * \fn      __po_hi_get_port_name
 * \brief   Return the name of the port according to mapping rules.
 */
char* __po_hi_get_port_name (const __po_hi_port_t port);

/*
 * \fn      __po_hi_get_local_port_from_local_port
 * \brief   Return the local port identifier of the given global port to handle data on the node.
 */

__po_hi_local_port_t __po_hi_get_local_port_from_global_port (const __po_hi_port_t global_port);

/*
 * \fn      __po_hi_get_endianness
 * \brief   Return the endianness of the node given in parameter.
 *
 * The resulting value is either __PO_HI_BIGENDIAN  or __PO_HI_LITTLEENDIAN.
 */
__po_hi_uint8_t  __po_hi_get_endianness (const __po_hi_node_t node);

/*
 * \fn      __po_hi_get_device_from_port
 * \brief   Return the device associated with a given port.
 *
 * The resulting value is a device identifier generated in deployment.h.
 * If no device is associated with the port, it returns the constant
 * value invalid_device_id.
 */
__po_hi_device_id __po_hi_get_device_from_port (const __po_hi_port_t port);


char* __po_hi_get_device_naming (const __po_hi_device_id dev);

/*
 * \fn      __po_hi_get_device_configuration
 * \brief   Returns a pointer to the configuration data of the device.
 *
 * The configuration data can be either a string of a more complex
 * data structure, such as an instance of an ASN1 type.
 */
__po_hi_uint32_t* __po_hi_get_device_configuration (const __po_hi_device_id);


/*
 * \fn      __po_hi_transport_get_data_size
 * \brief   Returns the size of the data stored in the port given as parameter.
 */
__po_hi_uint32_t __po_hi_transport_get_data_size (const __po_hi_port_t portno);


/*
 * \fn      __po_hi_transport_get_queue_size
```

```
 * \brief   Return the size of the queue associated with the port.
 *
 * The size if specified as the number of request the port can store,
 * this is NOT the number of bytes that can be stored.
 */
__po_hi_uint32_t __po_hi_transport_get_queue_size (const __po_hi_port_t portno);

/*
 * \fn      __po_hi_transport_get_port_kind
 * \brief   Indicate the kind of the port given in parameter or __PO_HI_INVALID_PORT_KIND when not approp
 *
 * The values that are returned indicate if the port is a pure event
 * port, if it has a data associated and if it is an inter-process
 * port or not.
 *
 * Potential return values are:
 *
 *  __PO_HI_IN_DATA_INTER_PROCESS
 *  __PO_HI_OUT_DATA_INTER_PROCESS
 *  __PO_HI_IN_DATA_INTRA_PROCESS
 *  __PO_HI_OUT_DATA_INTRA_PROCESS
 *  __PO_HI_IN_EVENT_DATA_INTER_PROCESS
 *  __PO_HI_OUT_EVENT_DATA_INTER_PROCESS
 *  __PO_HI_IN_EVENT_DATA_INTRA_PROCESS
 *  __PO_HI_OUT_EVENT_DATA_INTRA_PROCESS
 *  __PO_HI_IN_EVENT_INTER_PROCESS
 *  __PO_HI_OUT_EVENT_INTER_PROCESS
 *  __PO_HI_IN_EVENT_INTRA_PROCESS
 *  __PO_HI_OUT_EVENT_INTRA_PROCESS
 *  __PO_HI_INVALID_PORT_KIND
 */
__po_hi_port_kind_t __po_hi_transport_get_port_kind (const __po_hi_port_t portno);


/*
 * \fn      __po_hi_transport_get_model_name
 * \brief   Return the name of the port given in parameter.
 */

char*             __po_hi_transport_get_model_name (const __po_hi_port_t portno);


/* \fn      __po_hi_transport_get_mynode
 * \brief   Return the node identifier of the node that executes the current system.
 */
__po_hi_node_t    __po_hi_transport_get_mynode (void);

/* \fn      __po_hi_transport_get_node_from_device
 * \brief   Return the node identifier associated with the device given in parameter.
 */
__po_hi_node_t    __po_hi_transport_get_node_from_device (const __po_hi_device_id device);


/* \fn      __po_hi_transport_associate_port_bus
 * \brief   Associate a port to a bus. Return 1 on success, 0 otherwise.
 *
 * When calling this function, you have to be very careful and make sure
 * that the bus you are passing by argument is connected to the node
```

```
 * that actually host this port.
 * Definition of port and bus values are enclosed in the deployment.h
 * file generated by Ocarina.
 */

int __po_hi_transport_associate_port_bus (const __po_hi_port_t port, const __po_hi_bus_id bus);

/*
 * \fn      __po_hi_transport_get_protocol
 * \brief   Return the protocol identifier that is used between port src and port dst.
 *
 * Get the protocol identifier used to communicate
 * between port src and port dst. It returns a protocol
 * identifier generated in deployment.h.
 * If no specific protocol is used, it returns the value
 * invalid_protocol.
 */
__po_hi_protocol_t         __po_hi_transport_get_protocol (const __po_hi_port_t src, const __po_hi_port_t

/*
 * \fn      __po_hi_transport_get_protocol_configuration
 * \brief   Retrieve the configuration of the given protocol identifier. Returns a pointer on the conf or
 *
 *
 * Protocol identifier can be retrieve in the generated deployment.h file
 * under the type __po_hi_protocol_t. Invalid protocol identifier
 * will result in returning NULL.
 */
__po_hi_protocol_conf_t*   __po_hi_transport_get_protocol_configuration (const __po_hi_protocol_t p);


/*
 * \fn      __po_hi_transport_set_sending_func
 * \brief   Set the sending function to be called to send data using a particular device.
 *
 *
 * The first argument is device that would be used to send the data while the
 * second is the function that would be called.
 *
 * The function returns __PO_HI_SUCCESS when the new calling function
 * is successfully set. Otherwise, returns __PO_HI_UNAVAILABLE.
 */
int __po_hi_transport_set_sending_func (const __po_hi_device_id device, const __po_hi_transport_sending_fu

/*
 * \fn      __po_hi_transport_call_sending_func_by_device
 * \brief   Call the sending function to send data from a port associated to a
 *          task.
 *
 * First argument is the device that would be used to send the data. The second
 * argument is the task that is sending the data while th third argument
 * is the port identifier that contain the data to be sent.
 *
 * The function returns  __PO_HI_UNAVAILABLE is no sending function
 * has been set for this device or if the device identifier is invalid.
 * Otherwise, it returns the value returned by the sending function
 * associated to the device.
 */
```

```
int __po_hi_transport_call_sending_func_by_device (const __po_hi_device_id, __po_hi_task_id, __po_hi_port_

/*
 * \fn      __po_hi_transport_call_sending_func
 * \brief   Call the sending function to send data from a port associated to a
 *          task. The function to call is retrieved using the port.
 *
 * First argument is the task that is sending the data. The second
 * is the port associated with the task and the device. The device
 * to call is deduced from the port.
 *
 * The function returns  __PO_HI_UNAVAILABLE is no sending function
 * has been set for this device or if the device identifier is invalid.
 * Otherwise, it returns the value returned by the sending function
 * associated to the device.
 */
int __po_hi_transport_call_sending_func_by_port (__po_hi_task_id, __po_hi_port_t);



/*
 * \fn      __po_hi_transport_get_sending_func
 * \brief   Get the sending function to be called to send data using a device
 *
 *
 * The first argument is device that would be used to send the data.
 * Returns NULL if the device identifier is incorrect or no function
 * has been set.
 */

__po_hi_transport_sending_func __po_hi_transport_get_sending_func (const __po_hi_device_id device);


#ifdef XM3_RTEMS_MODE
void __po_hi_transport_xtratum_port_init (const __po_hi_port_t portno, int val);
int __po_hi_transport_xtratum_get_port (const __po_hi_port_t portno);
#endif



#endif /* __PO_HI_NB_PORTS > 0 */



#endif /* __PO_HI_TRANSPORT__ */
```

C.7 po_hi_protected.h

```
/*
 * This is a part of PolyORB-HI-C distribution, a minimal
 * middleware written for generated code from AADL models.
 * You should use it with the Ocarina toolsuite.
 *
 * For more informations, please visit http://assert-project.net/taste
 *
 * Copyright (C) 2007-2009 Telecom ParisTech, 2010-2012 ESA & ISAE.
```

```
 */

#ifndef __PO_HI_PROTECTED_H__
#define __PO_HI_PROTECTED_H__

#include <stdint.h>
#include <deployment.h>

#define __PO_HI_PROTECTED_TYPE_REGULAR    0
#define __PO_HI_PROTECTED_TYPE_PIP        1
#define __PO_HI_PROTECTED_TYPE_PCP        2

#if defined (POSIX) || defined (RTEMS_POSIX) || defined (XENO_POSIX)
   #include <stdlib.h>
   #include <stdint.h>
   #include <time.h>
   #include <pthread.h>
#endif

#if defined (RTEMS_PURE)
   #include <rtems.h>
#endif

#if defined (XENO_NATIVE)
   #include <native/mutex.h>
#endif

#ifdef _WIN32
#include <windows.h>
#endif



typedef enum
{
   __PO_HI_PROTECTED_REGULAR     = 1,
   __PO_HI_MUTEX_REGULAR         = 1,
   __PO_HI_PROTECTED_PIP         = 2,
   __PO_HI_MUTEX_PIP             = 2,
   __PO_HI_PROTECTED_PCP         = 3,
   __PO_HI_MUTEX_PCP             = 3,
   __PO_HI_PROTECTED_IPCP        = 4,
   __PO_HI_MUTEX_IPCP            = 4,
   __PO_HI_PROTECTED_INVALID     = 1
}__po_hi_protected_protocol_t;

typedef __po_hi_protected_protocol_t __po_hi_mutex_protocol_t;


typedef struct
{
   __po_hi_mutex_protocol_t   protocol;
   int                        priority;
#if defined (POSIX) || defined (RTEMS_POSIX) || defined (XENO_POSIX)
   pthread_mutex_t      posix_mutex;
   pthread_mutexattr_t  posix_mutexattr;
#endif
#if defined (RTEMS_PURE)
```

```
   rtems_id             rtems_mutex;
#endif
#if defined (XENO_NATIVE)
   RT_MUTEX             xeno_mutex;
#endif
#if defined (_WIN32)
   HANDLE               win32_mutex;
#endif
}__po_hi_mutex_t;



typedef uint8_t __po_hi_protected_t;

/*
 * \fn __po_hi_protected_lock
 *
 * \brief Lock the variable which has he id given by the argument.
 *
 * Return __PO_HI_SUCCESS if it is successfull.  If there is an error,
 * it can return __PO_HI_ERROR_PTHREAD_MUTEX value
 */
int __po_hi_protected_lock (__po_hi_protected_t protected_id);

/**
 * \fn __po_hi_protected_lock
 *
 * Unlock the variable which has he id given
 * by the argument.
 * Return __PO_HI_SUCCESS if it is successfull.
 * If there is an error, it can return
 * __PO_HI_ERROR_PTHREAD_MUTEX value
 */
int __po_hi_protected_unlock (__po_hi_protected_t protected_id);

/**
 * \fn __po_hi_protected_init
 *
 * \brief Initialize all variables to handle protected objects in PolyORB-HI-C
 */
int __po_hi_protected_init (void);


/**
 * \fn __po_hi_mutex_init
 *
 * \brief Initialize a mutex no matter the underlying executive
 *
 * This function allocate all the resources to the mutex so that it can be
 * used with __po_hi_mutex_lock() and __po_hi_mutex_unlock(). The second
 * parameter is the locking protocol of the mutex that is mapped on the
 * appropriate underlyign OS directives if supported. The third argument
 * is the priority ceiling used, only relevant if the protocol
 * needs such an option. Otherwise, any value can be used.
 *
 * Upon success, the function returns __PO_HI_SUCCESS.
 * It returns the following potential values:
```

```
 *  - __PO_HI_SUCCESS: successful operation
 *  - __PO_HI_TOOMANY: too many resources allocated at this time
 *  - __PO_HI_INVALID: supplied argument value (memory error)
 */
int __po_hi_mutex_init (__po_hi_mutex_t* mutex, const __po_hi_mutex_protocol_t protocol, const int priorit

/**
 * \fn __po_hi_mutex_lock
 *
 * \brief Lock a mutex no matter the underlying executive
 *
 * This function locks the mutex so that it ensures that only one task
 * acquired it. Note that if the mutex was previously acquired, the caller
 * will be blocked until the mutex is released.
 *
 * Upon success, the function returns __PO_HI_SUCCESS.
 * It returns the following potential values:
 *  - __PO_HI_SUCCESS: successful operation
 *  - __PO_HI_INVALID: supplied argument value (memory error)
 *  - __PO_HI_NOTINITALIZED: supplied resources was not initialized
 */
int __po_hi_mutex_lock (__po_hi_mutex_t* mutex);

/**
 * \fn __po_hi_mutex_unlock
 *
 * \brief Unlock a mutex no matter the underlying executive
 *
 * This function unlocks the mutex so that other tasks can acquire it
 * again.
 *
 * Upon success, the function returns __PO_HI_SUCCESS.
 * It returns the following potential values:
 *  - __PO_HI_SUCCESS: successful operation
 *  - __PO_HI_INVALID: supplied argument value (memory error)
 *  - __PO_HI_NOTINITALIZED: supplied resources was not initialized
 */

int __po_hi_mutex_unlock (__po_hi_mutex_t* mutex);


#endif /*  __PO_HI_PROTECTED_H__ */
```

C.8 po_hi_gqueue.h

```
/*
 * This is a part of PolyORB-HI-C distribution, a minimal
 * middleware written for generated code from AADL models.
 * You should use it with the Ocarina toolsuite.
 *
 * For more informations, please visit http://assert-project.net/taste
 *
 * Copyright (C) 2007-2009 Telecom ParisTech, 2010-2012 ESA & ISAE.
 */

#ifndef __PO_HI_GQUEUE_H__
```

```
#define __PO_HI_GQUEUE_H__

#define __PO_HI_GQUEUE_FULL      10

#define __PO_HI_GQUEUE_FIFO_INDATA    -1
#define __PO_HI_GQUEUE_FIFO_OUT       -2

#define __PO_HI_GQUEUE_INVALID_PORT invalid_port_t
#define __PO_HI_GQUEUE_INVALID_LOCAL_PORT invalid_local_port_t

#include <deployment.h>
#include <request.h>
#include <po_hi_types.h>

void __po_hi_gqueue_init (__po_hi_task_id       id,
  __po_hi_uint8_t       nb_ports,
  __po_hi_port_t        queue[],
  __po_hi_int8_t        sizes[],
  __po_hi_uint8_t       first[],
  __po_hi_uint8_t       offsets[],
  __po_hi_uint8_t       woffsets[],
  __po_hi_uint8_t       n_dest[],
  __po_hi_port_t*       destinations[],
  __po_hi_uint8_t       used_size[],
  __po_hi_local_port_t  history[],
  __po_hi_request_t     recent[],
  __po_hi_uint8_t       empties[],
  __po_hi_uint16_t      total_fifo_size);
/*
 * Initialize a global queue. In a distributed system, each task has
 * its own global queue. This function is invoked by each thead to
 * create its global queue, according to its information (number of
 * ports, destination of each port ...).
 *
 * The first argument is the task-id in the distributed system. The
 * second argument is the number of ports for the task. The argument
 * sizes contains the size of the FIFO for each port. The offsets
 * argument contains the offset position for each queue in the global
 * queue.  The n_dest argument correspond to the number of
 * destinations for an OUT port. The argument destinations tells what
 * are the ports connected to an OUT port.  Finally, the argument
 * total_fifo_size gives the total size of the global queue
 */

void __po_hi_gqueue_store_out (__po_hi_task_id id,
                               __po_hi_local_port_t port,
                               __po_hi_request_t* request);
/* Store a value for an OUT port.
 *
 * The id argument correspond to the task-id which own the global
 * queue. The second argument is the port that store the value. The
 * last argument is the request to store in the queue.
 */

int __po_hi_gqueue_send_output (__po_hi_task_id id,
                                __po_hi_port_t port);
/*
 * Send a value for an out port.
```

```
 *
 * The first argument is the id of the task which have the global
 * queue. The second argument is the number of port that will send the
 * data
 */


int __po_hi_gqueue_get_value(__po_hi_task_id id,
     __po_hi_local_port_t port,
     __po_hi_request_t* request);
/*
 * Get the value on the specified port.
 *
 * The id parameter corresponds to the task-id in the local
 * process. The port argument is the number of the port that received
 * the data. The request argument is a pointer to store the received
 * data. If the port is an output, this function will return nothing,
 * but will not produce an error.
 */

int __po_hi_gqueue_next_value(__po_hi_task_id id,
      __po_hi_local_port_t port);
/*
 * Dequeue the value on a port. The argument id is the task identifier
 * in the local process. The second argument is the port number for
 * the thread. This function should not be called several times, until
 * you know what you do.
 */

int __po_hi_gqueue_get_count(__po_hi_task_id id,
     __po_hi_local_port_t port);
/*
 * Return the number of events that are pending of a port. The first
 * argument is the task identifier in the local process. The second
 * argument is the port identifier (or port number) for the thread.
 */

void __po_hi_gqueue_wait_for_incoming_event(__po_hi_task_id id,
    __po_hi_local_port_t* port);
/*
 * Wait until an event is received on any port for a given thread. The
 * first argument is the thread identifier in the local process. The
 * second argument is a pointer to a port value. When the function
 * returns, the port argument will contrain the port-id that received
 * the event.
 */

__po_hi_uint8_t __po_hi_gqueue_store_in (__po_hi_task_id id,
 __po_hi_local_port_t port,
 __po_hi_request_t* request);
/*
 * Store a value in a IN port. The first argument is the task
 * identifier in the local process. The second argument is the port
 * identifier for the local thread. The request argument contrains the
 * request that will be stored in the queue.
 */

__po_hi_request_t*  __po_hi_gqueue_get_most_recent_value
```

```
         (const __po_hi_task_id task_id,
          const __po_hi_local_port_t local_port);


__po_hi_port_t __po_hi_gqueue_get_destination (const __po_hi_task_id task_id, const __po_hi_local_port_t
cal_port, const uint8_t destination_number);

uint8_t __po_hi_gqueue_get_destinations_number (const __po_hi_task_id task_id, const __po_hi_local_port_t


#endif /* __PO_HI_GQUEUE_H__ */
```

C.9 po_hi_types.h

```
/*
 * This is a part of PolyORB-HI-C distribution, a minimal
 * middleware written for generated code from AADL models.
 * You should use it with the Ocarina toolsuite.
 *
 * For more informations, please visit http://assert-project.net/taste
 *
 * Copyright (C) 2007-2009 Telecom ParisTech, 2010-2012 ESA & ISAE.
 */

#ifndef __PO_HI_TYPES_H_
#define __PO_HI_TYPES_H_

#include"po_hi_config.h"

#ifdef HAVE_STDINT_H
#include <stdint.h>
#endif

#ifdef HAVE_STDBOOL_H
#include <stdbool.h>
#endif

#define __PO_HI_UNUSED_NODE -1

/*
 * Types are configured according to the ones available
 * on the target host.
 */


#ifdef HAVE_STDBOOL_H
typedef bool __po_hi_bool_t;
#else
#error This configuration is not supported
#endif

typedef float  __po_hi_float32_t;
typedef double __po_hi_float64_t;

#ifdef HAVE_STDINT_H
  typedef int8_t     __po_hi_int8_t;
```

```
  typedef int16_t    __po_hi_int16_t;
  typedef int32_t    __po_hi_int32_t;
#ifndef COMPCERT
  typedef int64_t    __po_hi_int64_t;
#endif
  typedef uint8_t    __po_hi_uint8_t;
  typedef uint16_t   __po_hi_uint16_t;
  typedef uint32_t   __po_hi_uint32_t;
#ifndef COMPCERT
  typedef uint64_t   __po_hi_uint64_t;
#endif
#else

/*
 * Most modern compilers have stdint.h header file.
 */

#error This configuration is not supported

  #if SIZEOF_INT == 4
  typedef int                       __po_hi_int32_t;
  #elif SIZEOF_LONG_INT == 4
  typedef long int                  __po_hi_int32_t;
  #elif SIZEOF_SHORT_INT == 4
  typedef short int                 __po_hi_int32_t;
  #endif

  #if SIZEOF_INT == 2
  typedef int                       __po_hi_int16_t;
  typedef unsigned int              __po_hi_uint16_t;
  #elif SIZEOF_SHORT_INT == 2
  typedef short int                 __po_hi_int16_t;
  typedef unsigned short int        __po_hi_uint16_t;
  #elif SIZEOF_LONG_INT == 2
  typedef long int                  __po_hi_int16_t;
  typedef unsigned long int         __po_hi_uint16_t;
  #endif

  #if SIZEOF_CHAR == 1
    typedef char                    __po_hi_int8_t;
    typedef unsigned char           __po_hi_uint8_t;
  #endif
#endif

typedef unsigned char               __po_hi_byte_t;


typedef enum
{
   __PO_HI_IN_DATA_INTER_PROCESS             = 0,
   __PO_HI_OUT_DATA_INTER_PROCESS            = 2,
   __PO_HI_IN_DATA_INTRA_PROCESS             = 4,
   __PO_HI_OUT_DATA_INTRA_PROCESS            = 6,
   __PO_HI_IN_EVENT_DATA_INTER_PROCESS       = 8,
   __PO_HI_OUT_EVENT_DATA_INTER_PROCESS      = 10,
   __PO_HI_IN_EVENT_DATA_INTRA_PROCESS       = 12,
   __PO_HI_OUT_EVENT_DATA_INTRA_PROCESS      = 14,
   __PO_HI_IN_EVENT_INTER_PROCESS            = 16,
```

```
   __PO_HI_OUT_EVENT_INTER_PROCESS           = 18,
   __PO_HI_IN_EVENT_INTRA_PROCESS            = 20,
   __PO_HI_OUT_EVENT_INTRA_PROCESS           = 22,
   __PO_HI_INVALID_PORT_KIND                 = 50
}__po_hi_port_kind_t;

void __po_hi_copy_array (void* dst, void* src, __po_hi_uint16_t size);

#endif /* __PO_HI_TYPES_H_ */
```

C.10 po_hi_returns.h

```
/*
 * This is a part of PolyORB-HI-C distribution, a minimal
 * middleware written for generated code from AADL models.
 * You should use it with the Ocarina toolsuite.
 *
 * For more informations, please visit http://assert-project.net/taste
 *
 * Copyright (C) 2007-2009 Telecom ParisTech, 2010-2012 ESA & ISAE.
 */

#ifndef __PO_HI_RETURNS_H__
#define __PO_HI_RETURNS_H__

/* Success return code */
#define __PO_HI_SUCCESS                    1
#define __PO_HI_UNAVAILABLE                2
#define __PO_HI_INVALID                    5
#define __PO_HI_TOOMANY                    6

#define __PO_HI_NOTIMPLEMENTED             8

#define __PO_HI_NOTINITIALIZED             9

/* Errors from the API */
#define __PO_HI_ERROR_CREATE_TASK         -10
#define __PO_HI_ERROR_TASK_PERIOD         -11
#define __PO_HI_ERROR_CLOCK               -15
#define __PO_HI_ERROR_QUEUE_FULL          -20

#define __PO_HI_ERROR_UNKNOWN             -30

/* Errors related to the pthread library */
#define __PO_HI_ERROR_PTHREAD_COND        -50
#define __PO_HI_ERROR_PTHREAD_MUTEX       -51
#define __PO_HI_ERROR_PTHREAD_CREATE      -52
#define __PO_HI_ERROR_PTHREAD_ATTR        -53
#define __PO_HI_ERROR_PTHREAD_SCHED       -54
#define __PO_HI_ERROR_TRANSPORT_SEND      -55
#define __PO_HI_ERROR_PTHREAD_BARRIER     -56

#define __PO_HI_ERROR_PROTECTED_LOCK      -60
#define __PO_HI_ERROR_PROTECTED_UNLOCK    -61
#define __PO_HI_ERROR_PROTECTED_CREATE    -62
```

```
#define __PO_HI_ERROR_MUTEX_LOCK          -60
#define __PO_HI_ERROR_MUTEX_UNLOCK        -61
#define __PO_HI_ERROR_MUTEX_CREATE        -62

/* GIOP error code */
#define __PO_HI_GIOP_INVALID_SIZE         -100
#define __PO_HI_GIOP_INVALID_VERSION      -120
#define __PO_HI_GIOP_INVALID_REQUEST_TYPE -150
#define __PO_HI_GIOP_INVALID_OPERATION    -180
#define __PO_HI_GIOP_UNSUPPORTED          -200

#define __PO_HI_ERROR_EXISTS              -80
#define __PO_HI_ERROR_NOEXISTS            -81

#endif /* __RETURNS_H__ */
```

Appendix D References

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2. [ISO05] ISO/IEC. *TR 24718:2005 — Guide for the use of the Ada Ravenscar Profile in high integrity systems*, 2005. Based on the University of York Technical Report YCS-2003-348 (2003).
3. [VZH06] T. Vergnaud, B. Zalila, and J. Hugues. Ocarina: a Compiler for the AADL. Technical report, Telecom Paris, 2006.

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