CHARON^{TM} CHAPI for Windows

Version: 4.2

CHAPI Design Manual

User Manual for CHARON^{TM} W32, an API based system emulator for 32 bit Windows host systems.

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STROMASYS
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Preface

The PDP11 and VAX systems from Digital Equipment Corporation made a major contribution to the 'boom' of the minicomputer market in the 1980's. Not only provided these systems cost-effective and modular computing blocks, their open architecture allowed many third parties to design new interfaces and other product extensions.

Stromasys provides since many years emulators based on the CHARON™ technology, which accurately represents system hardware by means of software models, so that unmodified legacy software can continue to be used.

The CHARON-VAX and CHARON-PDP emulators provide complete system emulation, designed to replace many different PDP11 or VAX hardware systems. Where custom peripheral hardware is involved, replacement by emulation becomes more complex. Such systems often remain in place as redesign or emulation is deemed too costly.

For such complex systems, CHARON was developed as an adaptable emulator platform. In addition to its kernel (with enough functionality to run a basic VAX or PDP-11 configuration), it provides a standard bus interface (the CHARON API: CHAPI). The CHAPI connects emulated peripherals that are designed as external code modules to the emulator kernel. Without the need to change the emulator kernel, this allows to modify the peripheral functionality of the emulated system, as can be required in industrial or process control systems.

With the CHAPI, custom peripheral hardware can be emulated and connected to the emulator kernel. With the developer in mind, the CHAPI development wizard has templates for parallel, serial, disk and tape controllers. The CHAPI library functions provide the standard elements (registers, interrupt logic, etc) common to all interfaces.

The CHAPI is implemented as a C++ library with the components needed to dynamically link additional emulated peripheral modules to the core emulator kernel. For third parties that develop and sell CHAPI modules (which are effectively the emulated equivalents of hardware peripherals designed for a MicroVAX or PDP-11 system), the CHAPI contains a product licensing subsystem. The current CHAPI interface definition, libraries and design information are described in this manual. Source code samples to assist in device modifications and new design are available on request.

Geneva,14 December 2007.

Summary

CHAPI system components and libraries

- Basic CHAPI interface
- General CHAPI support library
- Serial I/O CHAPI support library
- Parallel I/O CHAPI support library
- Disk/Tape I/O CHAPI support library
- Industrial I/O CHAPI support library

CHAPI based perefpheral devices

- Serial line controllers DHV11, DL11, DZ11, LPV11 printer port.
- Parralel interfaces DRV11, DRV11-WA via HW adapter
- QBUS interface via HW adapters
- Sync serial interface DPV11 via HW adapter
- Industrial DAC/ADC via HW adapter
- Serial line ports (Host COM port, Telnet and E2S mode)
- Exact Real-time line / programmable clocks

CHAPI functional examples (unsupported,provoded in binary form):

- The DHV11/DHU11, DH11, DL11/DLV11 serial adapters
- The DRV11-WA, DR11(C)/DRV11 parallel controllers using the Sensoray 621.
- TSV05/TS11 tape subsystem emulation.
- Emulation of the RL01/RL02 disk controllers.
- LPV11 printer port sample.
- An implementation of the VCB02 video subsystem.
- VT30-H video subsystem

- DPV11 synchronous serial I/O adapter mapped to SEALEVEL-5102S
- MRV11 Universal programmable read-only memory
- IAV1S-AA(IAV1S-C/CA), IAV1S-B industrial ADC/DAC

This manual is for...

This manual assumes familiarity with the setup and installation of the CHARON-VAX or CHARON-PDP emulators. It is intended for Resellers and end-users who plan to emulate complex VAX or PDP-11 configurations that might required custom emulator components.

Extending the emulated system environment with custom components or modifying existing emulated peripheral components with the CHAPI demands significant software development capabilities. Designing an emulated peripheral requires a thorough understanding of Qbus or Unibus hardware, bus protocols, peripheral hardware documentation, C/C++ programming and development experience for the Windows operating system.

When modifying I/O subsystem emulation to meet protocol or timing requirements, the appropriate test equipment and software and the separate development / tracing facilities in CHAPI should be used.

Stromasys can be contacted for the development specific emulator extensions on a custom project basis.

Conventions

The following conventions are used in this manual:

Notation	***Description***
`$ or >`	The dollar sign or the right angle bracket in interactive examples indicates operating system prompt.
`User Input`	Bold monospace type in interactive examples indicates typed user input.
`<path>`	Bold monospace type enclosed by angle brackets indicates command parameters and parameter values.
`Output`	Monospace type in interactive examples indicates the output the command responds with.
[]	In syntax definitions, brackets indicate items that are optional.
…	In syntax definitions, a horizontal ellipsis indicates that the preceding item can be repeated one or more times.

1.CHAPI functionality

1.1 CHAPI overview

CHARON-PDP / CHARON-VAX is a hardware abstraction layer to replace multiple - architecturally related - legacy systems. The CHAPI functionality is limited to QBUS/UNIBUS

An essential part of CHARON-VAX/CHARON-PDP emulators / W32 is the design environment for the CHARON API (CHAPI) through which additional run-time components (in the form of Windows DLLs) can be added to the emulated system. This permits to modify the emulation of existing peripheral emulator components or to design custom components. Such components can be sold by VARs as product add-ons and licensed via the CHARON license key.

The CHAPI implementation is optimized for low latency access to the emulator core. This is important for the replacement of real-time and embedded hardware systems, with further optimizations possible by modifying device emulation code. To cover a wide range of possible QBUS/UNIBUS connections, two methods are available:

- A set of library components that provide the typical elements in a QBUS/UNIBUS device: I/O registers, interrupt vectors and DMA. These components are used to emulate individual bus devices. Both the I/O address space and the memory address space can be accessed this way.

- A more specific set of functions for so called CHARON deep integration, that permits direct access to the CHARON core modules. Using those functionality might make Stromasys involvement necessary on a project basis.

CHAPI functions are available to access the CHARON license key number or use the encrypt/decrypt facility of the key.

Several CHAPI development support libraries are available to assist in the development of new functions (see further on in this chapter).

1.2 The CHARON CHAPI system components

The included CHAPI modules extend the functionality, but these modules can be replaced or modified without an impact on the emulator core. Internal components cannot be modified, but if an equivalent CHAPI component is available, a loadable internal peripheral emulator component can be removed by not loading it in the configuration file.

1.2.1 CHAPI components shared by CHARON-VAX and CHARON-PDP emulators:

CHAPI(D).DLL – general CHAPI support library and its debug version;

CHAPI_DH11.DLL – full functional CHAPI implementation of DH11/DM11 serial multiplexer with ability to map its ports to: 1) Standard COM port; 2) TCP/IP link; 3) MOXA NPort 5210 port;

CHAPI_DHV11.DLL – full functional CHAPI implementation of DHV11 serial multiplexer with ability to map its ports to: 1) Standard COM port; 2) TCP/IP link; 3) MOXA NPort 5210 port;

CHAPI_DLV11.DLL – full functional CHAPI implementation of DLV11 serial controller with ability to map its port to: 1) Standard COM port; 2) TCP/IP link; 3) MOXA NPort 5210 port;

CHAPI_DPV11.DLL – A CHAPI implementation of synchronous DPV11 adapter. Appropriate port is implemented in CHAPI_SERIAL.DLL;

CHAPI_DR11.DLL – A CHAPI implementation of DR11(C) /DRV11 parallel interface;

CHAPI_DR11_621_PORT.DLL – A parallel digital IO card port for CHAPI_DR11.DLL mapped to Sensoray 621 digital IO card;

CHAPI_DRV11WA.DLL – A complete CHAPI implementation of a DRV11-WA parallel I/O QBUS board based on the TLC DCI-1100 PCI adapter;

CHAPI_DRV11WA_621.DLL – A complete CHAPI implementation of a DRV11-WA parallel I/O QBUS board based on the Sensoray 620 digital IO card;

CHAPI_DRV11WA_621_PORT.DLL – A parallel digital IO card port for the CHAPI_DRV11WA_621.DLL mapped to the Sensoray 621 digital IO card;

CHAPI_HTIME.DLL – A special CHAPI device to get host system time from RSX11 system; The HTIM.TSK RSX11 task is distributed with this device far a complete solution;

CHAPI_HW(D).DLL – Hardware substitution library and its debug version;

CHAPI_MRV11.DLL – Universal programmable read-only memory device.

CHAPI_IAV1S_AA.DLL - full functional CHAPI implementation for QBUS IAV1S-AA/C/CA industrial DAC. It uses CHAPI industrial IO library CHAPI_INDIO.DLL

CHAPI_IAV1S_B.DLL - full functional CHAPI implementation for QBUS IAV1S-D industrial DAC. It uses CHAPI industrial IO library CHAPI_INDIO.DLL

CHAPI_PARALLEL(D).DLL – Parallel I/O CHAPI support library and its debug version;

CHAPI_QBUS.DLL – CHAPI implementation of bus adapter link to external QBUS cage using BCI-2104 bus adapter;

CHAPI_S3QBUS.DLL – CHAPI implementation of bus adapter link to external QBUS cage using CESYS PCIS3BASE bus adapter;

CHAPI_RLV12.DLL – full functional CHAPI implementation for UNIBUS RL11 / QBUS RLV12 disk controllers supporting RL01/RL02 disk drives; It is possible to map mentioned controllers' disk units to the disk image container or to raw physical disk drive via windows driver container– these containers are implemented within the "Storage CHAPI support" library;

CHAPI_INDIO.DLL – industrial I/O CHAPI support library; It supports industrial ADC/DAC mapped to SENSORAY Ethernet board model 2601/2608;

CHAPI_SERIAL(D).DLL – serial I/O CHAPI support library and its debug version; It support three different kind of ports: 1) Standard COM port; 2) TCP/IP link; 3) MOXA NPort 5210 port; All these ports can be used from any new CHAPI serial line multiplexer developed in accordance with the "Serial I/O CHAPI support" library rules;

This library contains addition 'seasync' port implemented. This port can be used only with CHAPI_DPV11 device implementation;

CHAPI_STORAGE(D).DLL – "Storage I/O CHAPI support" library and its debug version; It provides three tape containers which can be easily reused in newly created tape controllers to map there units to: 1) Tape image file in MTD format; 2) SCSI tape connected to the system; 3) Windows tape driver supported hardware tape like \\.\TapeK connected to the system. Two disk containers are provided for the moment in this library – Disk image file and raw physical disk drive via windows driver supported hardware disks like \\.\PhysicalDrive0 connected to the system.

CHAPI_TSV05.DLL – full functional CHAPI implementation for QBUS TSV11/TSV05 and UNIBUS TS11 tape controllers; It allows to map tape unit to one of selected containers provided by means of "Storage I/O CHAPI support" library: 1) Tape image file in MTD format; 2) SCSI tape connected to the system; 3) Windows tape driver supported hardware tape like \\.\TapeK connected to the system;

CHAPI_UNIBUS - CHAPI implementation of bus adapter link to external UNIBUS cage using BCI-2004 bus adapter;

CHAPI_VCB02.DLL – A CHAPI implementation of the VCB02 video subsystem;

CHAPI_VT30H.DLL --- full functional CHAPI implementation for QBUS/UNIBUS VT30-H graphics display controller.

LPV11.DLL – The CHAPI implementation of the LPV11 parallel port controller;

1.2.2 CHAPI Development libraries

CHAPI.LIB – The library to link with in case the components described in the CHAPI_LIB.H header file are used for a particular CHAPI module implementation; it should be used in a release build of a CHAPI device;

CHAPID.LIB – The debug version of the CHAPI.LIB library; it should be used in a debug build of a CHAPI device;

CHAPI_SERIAL.LIB – The library to link with in case the base classes for a serial line controller/port implementation are used for a particular CHAPI module implementation; it should be used in a release build of the CHAPI device;

CHAPI_SERIALD.LIB – The debug version of CHAPI_SERIAL.LIB; it should be used in a debug build of a CHAPI device;

CHAPI_PARALLEL.LIB – The library to link with in case the base classes for a parallel controller/port implementation are used for a particular CHAPI module implementation; it should be used in a release build of the CHAPI device;

CHAPI_SERIALD.LIB – The debug version of CHAPI_PARALLEL.LIB; it should be used in a debug build of a CHAPI device;

CHAPI_STORAGE.LIB - The library to link with in case the base classes for a disk/tape controller/unit implementation are used for a particular CHAPI module implementation; it should be used in a release build of a CHAPI device;

CHAPI_STORAGED.LIB – The debug version of CHAPI_STORAGE.LIB; it should be used in a debug build of a CHAPI device;

1.2.3 The CHARON drivers used by CHAPI modules

These drivers are provided 'as is':

- BCI2X0X.SYS – The BCI-2104/BCI-2004 bus adapter driver used by the CHAPI_QBUS and CHAPI_UNIBUS examples. This is a proof of concept as the BCI-2x04 products are end of life.
- S3QBUS_PPT.SYS – The S3QBUS (based on the CESYS PCIS3BASE board) bus adapter driver used by the CHAPI_S3QBUS.
- DCI1100.SYS – The DCI-1100 adapter driver used by the CHAPI_DRV11WA example. This is a proof of concept as the DCI-1100 is end of life.
- PPT.SYS – A generic PCI 'Pass-through' device driver that is used for CHAPI_DR11©/DRV11, CHAPI_DRV11-WA ports mapped to a Sensoray 621

digital I/O board and CHAPI_DPV11 mapped to SEALEVEL SYNC SERIAL BOARD 5102S board.

1.3 The CHAPI CHARON utilities

1.3.1 The CHARON CHAPI device creation wizard

The CHAPI device creation wizard is designed to simplify the creation of a CHAPI device: it is a sequence of GUI dialogs that leads the designer to a Visual Studio C++ project. The following features are supported:

- Project type selection (General CHAPI device, Serial I/O multiplexer / Port, Disk controller / container, Tape controller / Container, CHAPI Bus / Bus adapter, PCI replacement hardware based controller / adapter, etc…)
- Selection of the required parameters using GUI dialogs related to the selected project type;
- Generation of Visual Studio C++ project files and parameters for the component under design. The generated project is buildable and satisfies the requirements for selected type of CHAPI device and the CHAPI support libraries;

1.3.2 HOSTprint

This utility prints data supplied by the emulated printer ports (CHAPI LPV11) of PDP-11/VAX systems using specified host system printer through a TCP/IP socket (see example of device which uses HOSTprint).

1.4 CHARON-PDP and CHARON-VAX with CHAPI support.

In CHARON the interface (CHAPI) to peripheral components behaves as a software replica of the QBUS bus.

The CHAPI standard facilitates the design, modification and exchange of emulated peripheral devices without requiring a change in the emulator kernel. This opens the way for third parties to adapt the emulator to specific needs, for instance to add the emulation of a custom peripheral by building a software replica of the original module.

CHARON emulators with CHAPI is both a production emulator and a test and development environment for functionality extensions. It includes a design environment, which supports the replacement, modification, design and test of new components. Most library functions in the design environment are provided in both a debug and a release version, and templates for specific device types support rapid development. The CHAPI can access the CHARON/VAX or CHARON-PDP license key and use its encryption capabilities for licensing such external components.

1.5 CHAPI based components provided with CHARON-VAX or CHARON-PDP.

CHARON kits contains a number of CHAPI based components that are provided on an 'as is' basis. Some of these components are provided in source code to help a developer to modify or create new CHAPI based devices. The supplied examples are chosen to reflect the aspects of general device using CHAPI, they do not necessarily suggest an optimal implementation for a specific project.

1.5.1 Loading the CHAPI components

Any CHAPI component created in accordance with the CHAPI specification is represented by a dynamically linked library (DLL). Such a component is loaded with the emulator kernel by specifying it - with an arbitrary logical name - in the configuration file. Each such DLL can have its parameters set using the standard set command syntax:

```
// Load a user created CHAPI device, implemented as chapi_dev.dll
// Identified as <dev_name>, specify its bus address,
// interrupt vector and user defined parameters.
load chapi <dev_name> dll = chapi_dev.dll
set <dev_name> address = <device_bus_address>
set <dev_name> vector = <device_interrupt_vector>
set <dev_name> trace_level = <trace_level>
set <dev_name> par1[N]=val1 par2[N]=val2 … parK[N] = valK
```

Parameters ‘`address`’, ‘`vector`’ and ‘`trace_level`’ are common for any kind of CHAPI bus device. The implementation specific parameters can be passed to the CHAPI device in two different ways:

1) By means of a single string parameter called ‘parameter’ – this method, used in the first implementation of CHAPI is only retained for compatibility reasons and not recommended. The CHAPI examples in this manual do not use this method.

2) By specifying a 'set' command for any of the user defined configuration parameters created during the CHAPI device initialization. These configuration options are specified in the following lines of the configuration file, after the ‘`dll`’ load command has associated the device with its given logical name '`<dev_name>'`.

The details of the CHAPI API, and how to use user defined configuration options are described later in this document. Usage examples are also supplied.

1.5.2 The CHAPI device list

DH11

The CHAPI DH11 UNIBUS serial line multiplexer is implemented as the CHAPI_DH11.DLL and uses CHAPI_SERIAL.DLL and CHAPI.DLL for its implementation.

It is provided in binary form. The implementation supports the following methods to implement its serial lines:

1. As a standard PC COM port
2. As a TCP/IP port;
3. As a RS232 port on the MOXA Nport 5210 family of Ethernet serial line multiplexers.

The implementation is based on the general Serial I/O CHAPI support library (see 5.2).

Note: The CHAPI DH11 device cannot be configured using the legacy '`parameter`' configuration method. The CHAPI DH11 device is configured as follows (in this example the logical name for the device is YHA. Note that this name is only valid in this configuration file context, and does not define how the device appears in the OS running on CHARON, which is defined by that OS based on how it recognizes the emulated hardware):

```
load chapi YHA dll=chapi_dh11.dll
set YHA address=<address> vector=<vector> trace_level=<level>
set YHA line_dll[x]=<serial library dll file>
set YHA line_cfg[x]=<name of the port to load>
set YHA line_is_terminal[x]=<do we need force XON/XOFF flow control>
set YHA line_param[x]="<string of parameters for the line>"
```

- **x** – is a number of configured line (can be in range [0, MAX_CONTROLLER_LINES - 1])
- **line_dll[x]** – DLL file name to load CHAPI serial line port implementation from – can be omitted – CHAPI_SERIAL.DLL will be used by default;
- **line_cfg[x]** – name of the port to load, can be:
    - **moxa** – MOXA NPort 5210 port
    - **tcpip** –TCP/IP port
    - **com** – standard PC COM port

  The 'line_cfg[x]' parameter can be omitted – 'tcpip' will be used by default;
- **line_is_terminal[x]** – must be set to true to force XON/XOFF flow control
- **line_param[x]** – a string that contains the parameters for the line. They can be:
    - In case of a MOXA NPort 5210 port:
        - **ip**=<NPort5210 IP address>;
        - **port**=<RS232 port of a NPort5210>, (1, 2, …);
    - In case of a TCP/IP port:

        - **port**=<IP port for connection to or listen to>;
        - **application**=”<application to start>”;
        - **ip**=<IP address to connect to>. If this parameter is present, the line will try to connect to this IP address. If this parameter is not present, the line will accept connections
    - In case of a standard COM port:
        - **com**=<COM port number>, (1, 2, …)

Example:

```
load chapi YHA dll=chapi_dh11.dll
set YHA address= 017760020 vector=0310 trace_level=0

#LINE[0] IS SERVER
set YHA line_dll[0]=chapi_serial line_cfg[0]=tcpip
set YHA line_is_terminal[0]=true line_param[0]="port=10020 application=txa0.ht"

set YHA line_dll[1]=chapi_serial line_cfg[1]=com
set YHA line_is_terminal[1]=true line_param[1]="com=1"

set YHA line_dll[2]=chapi_serial line_cfg[2]=moxa
set YHA line_is_terminal[2]=true line_param[2]="ip=192.168.127.254 port=1"

set YHA line_dll[3]=chapi_serial line_cfg[3]=moxa
set YHA line_param[3]="ip=192.168.127.254 port=2"

#LINE[4] IS CLIENT
set YHA line_dll[4]=chapi_serial line_cfg[4]=tcpip
set TXA line_param[4]="ip=192.168.1.1 port=10055"
```

DHV11

The CHAPI DHV11 QBUS serial line multiplexer is implemented as the CHAPI_DHV11.DLL and uses CHAPI_SERIAL.DLL and CHAPI.DLL for its implementation. It is provided in binary form. The implementation supports the following methods to implement its serial lines:

1. As a standard PC COM port
2. As a TCP/IP port;
3. As a RS232 port on the MOXA Nport 5210 family of Ethernet serial line multiplexers.

The implementation is based on the general Serial I/O CHAPI support library (see 5.2).

Note: The CHAPI DHV11 device cannot be configured using the legacy '`parameter`' configuration method. The CHAPI DHV11 device is configured as follows (in this example the logical name for the device is TXA. Note that this name is only valid in this configuration file context, and does not define how the device appears in the OS running on CHARON, which is defined by that OS based on how it recognizes the emulated hardware):

```
load chapi TXA dll=chapi_dhv11.dll
set TXA address=<address> vector=<vector> trace_level=<level>
set TXA line_dll[x]=<serial library dll file>
set TXA line_cfg[x]=<name of the port to load>
set TXA line_is_terminal[x]=<do we need force XON/XOFF flow control>
set TXA line_param[x]="<string of parameters for the line>"
```

Where :

- **x** – is a number of configured line (can be in range [0, MAX_CONTROLLER_LINES - 1])
- **line_dll[x]** – DLL file name to load CHAPI serial line port implementation from – can be omitted – CHAPI_SERIAL.DLL will be used by default;
- **line_cfg[x]** – name of the port to load, can be:
    - **moxa** – MOXA NPort 5210 port
    - **tcpip** –TCP/IP port
    - **com** – standard PC COM port

  The 'line_cfg[x]' parameter can be omitted – 'tcpip' will be used by default;
- **line_is_terminal[x]** – must be set to true to force XON/XOFF flow control
- **line_param[x]** – a string that contains the parameters for the line. They can be:
    - In case of a MOXA NPort 5210 port:
        - **ip**=<NPort5210 IP address>;
        - **port**=<RS232 port of a NPort5210>, (1, 2, …);
    - In case of a TCP/IP port:
        - **port**=<IP port for connection to or listen to>;
        - **application**="<application to start>";
        - **ip**=<IP address to connect to>. If this parameter is present, the line will try to connect to this IP address. If this parameter is not present, the line will accept connections
    - In case of a standard COM port:
        - **com**=<COM port number>, (1, 2, …)

Example:

```
load chapi TXA dll=chapi_dhv11.dll
set TXA address=017760520 vector=0340 trace_level=1

#LINE[0] IS SERVER
set TXA line_dll[0]=chapi_serial line_cfg[0]=tcpip
set TXA line_is_terminal[0]=true line_param[0]="port=10020 application=txa0.ht"

set TXA line_dll[1]=chapi_serial line_cfg[1]=com
set TXA line_is_terminal[1]=true line_param[1]="com=1"

set TXA line_dll[2]=chapi_serial line_cfg[2]=moxa
set TXA line_is_terminal[2]=true line_param[2]="ip=192.168.127.254 port=1"

set TXA line_dll[3]=chapi_serial line_cfg[3]=moxa
set TXA line_param[3]="ip=192.168.127.254 port=2"

#LINE[4] IS CLIENT
set TXA line_dll[4]=chapi_serial line_cfg[4]=tcpip
set TXA line_param[4]="ip=192.168.1.1 port=10055"
```

DLV11

The CHAPI DLV11 QBUS / DL11 UNIBUS devices are implemented with CHAPI_DLV11.DLL and use CHAPI_SERIAL.DLL and CHAPI.DLL for its implementation. The DLL is available in both binary and source code (source code is listed in document #30-09-06). This implementation can map its line to:

1. A standard PC COM port;
2. A TCP/IP port;
3. A port on a MOXA Nport 5210 family Ethernet serial line multiplexer.

The DL(V)11 is implemented using the serial I/O CHAPI support library (see 5.2).

This device cannot be configured using the legacy '`parameter`' configuration method. The configuration options are as follows:

```
load chapi TT1 dll=chapi_dlv11.dll
set TT1 address=<address> vector=<vector> trace_level=<level>
set TT1 line_dll=<serial library dll file>
set TT1 line_cfg=<name of the port to load>
set TT1 line_is_terminal=<do we need force XON/XOFF flow control>
set TT1 line_param="<string of parameters for the line>"
set TT1 baud_rate=<preselected baud rate of the line>
set TT1 baudselen=<must be true to enable program baud rate selection>
set TT1 dtr=<must be true to force set DTR signal ON>
set TT1 rts=<must be true to force set RTS signal ON>
set TT1 mode="<DLV11-E or DLV11-F>"
set TT1 breaken=<must be true to enable break signal generation>
set TT1 erroren=<must be true to enable RX error notification>
set TT1 char_len=<character's bit length>
set TT1 stop_len=<stop bit length>
set TT1 parity="<parity control>"
```

Where :

- **line_dll** – The DLL file name to load CHAPI serial line port from. If omitted CHAPI_SERIAL.DLL will be used by default;
- **line_cfg** – The name of the port to load. The options are:
    - **moxa** – a MOXA NPort 5210 port
    - **tcpip** – a TCP/IP port
    - **com** – a standard host PC COM port

  If the line_cfg parameter is omitted, the the port name tcpip will be used.
- **line_is_terminal** – This must be set to true to force XON/XOFF flow control
- **line_param** – A string that contains the line parameters for the line. The options are:
    - In case of a MOXA NPort 5210 port:
        - **ip**= the NPort 5210 IP address;
        - **port**= The RS232 port number on the NPort5210, (1, 2, …);
    - In case of a TCP/IP port:
        - **port**=The IP port to connect to or to listen to;
        - **application**="<application to start>";
        - **ip**= The IP address to connect to. If this parameter is present, the emulated serial line will try to connect to this address. If this parameter is not present, the line will accept connections.
    - In case of a standard COM port:
        - **com**=<COM port number>, (1, 2, …)
        - **baud_rate** – The baud rate at which the communication line operates.

- **baudselen** – must be true to enable OS baud rate selection
- **dtr** – must be true to force the DTR signal to ON.
- **rts** – must be true to force the RTS signal to ON.
- **mode** – Either '**E**' or '**F**' to select DLV11-E or DLV11-F functionality.
- **breaken** – must be true to enable break generation
- **erroren** – must be true to enable RX error notification
- **char_len** – the byte length of transmitted and received characters.
- **stop_len** – the number of stop bits to be used
- **parity** – Parity control: "none", "even", "odd", "mark" or "space"

Examples:

```
# DLV11-E connected to COM port
load chapi TT1 dll=chapi_dlv11.dll
set TT1 address=017760010 vector=0310 trace_level=1
set TT1 line_dll=chapi_serial
set TT1 line_cfg=com
set TT1 line_is_terminal=true
set TT1 line_param="com=1"
set TT1 baud_rate=9600
set TT1 baudselen=true
set TT1 dtr=true
set TT1 rts=true
set TT1 mode="e"
set TT1 breaken=true
set TT1 erroren=true
set TT1 char_len=8
set TT1 stop_len=1
set TT1 parity="none"

# DLV11-E connected to a MOXA NPort 5210, RS232 port 2
load chapi TT1 dll=chapi_dlv11.dll
set TT1 address=017760010 vector=0310 trace_level=1
set TT1 line_dll=chapi_serial
set TT1 line_cfg=moxa
set TT1 line_is_terminal=true
set TT1 line_param="ip=192.168.127.254 port=2"
set TT1 baud_rate=9600
set TT1 baudselen=true
set TT1 dtr=true
set TT1 rts=true
set TT1 mode="e"
set TT1 breaken=true
set TT1 erroren=true
set TT1 char_len=8
set TT1 stop_len=1
set TT1 parity=”none”


# DLV11-E connected to TCPIP, line is server
load chapi TT1 dll=chapi_dlv11.dll
set TT1 address=017760010 vector=0310 trace_level=1
set TT1 line_dll=chapi_serial
set TT1 line_cfg=tcpip
set TT1 line_is_terminal=true
set TT1 line_param=”port=10020 application=term.ht”
set TT1 mode=”e”

# DLV11-E connected to TCPIP, line is client
load chapi TT1 dll=chapi_dlv11.dll
set TT1 address=017760010 vector=0310 trace_level=1
set TT1 line_dll=chapi_serial
set TT1 line_cfg=tcpip
set TT1 line_is_terminal=true
set TT1 line_param=”ip=192.168.1.1 port=10020”
set TT1 mode=”e”
```

DPV11

The CHAPI DPV11 QBUS devices are implemented with CHAPI_DPV11.DLL and use CHAPI_SERIAL.DLL and CHAPI.DLL for its implementation. The DLL is available in binary only. This implementation can map its line to SEALEVEL SYNC SERIAL BOARD 5102S port.

This device cannot be configured using the legacy ‘`parameter`’ configuration method. The configuration options are as follows:

```
load chapi UF1 dll=chapi_dpv11.dll
set UF1 address=<address> vector=<vector> trace_level=<level>
set UF1 line_dll=<serial library dll file>
set UF1 line_cfg=<name of the port to load>
set UF1 bus_no=<SEALEVEL 5102S PCI bus number>
set UF1 device_no=<SEALEVEL 5102S PCI device number>
set UF1 function_no=<SEALEVEL 5102S PCI function number>
set UF1 rx_clock_direction=<RX sync clock source definition>
set UF1 tx_clock_direction=<TX sync clock source definition>
set UF1 interface_mode=<sync serial interface mode>
set UF1 clock_rate=<desired clock rate (for output clock direction)>
```

Where :

- **line_dll** – The DLL file name to load CHAPI serial line port from, must be chapi_serial only. If omitted CHAPI_SERIAL.DLL will be used by default;
- **trace_level** – Debug trace level (0 - 10), 0 for NO traces or 10 for MAX traces. If omitted zero will be used by default;
- **line_cfg** – The name of the port to load. Must be:
    - **seasync** – a SEALEVEL PCI 5102S board port

  If the line_cfg parameter is omitted, the port name seasync will be used.
- **bus_no** - SEALEVEL 5102 PCI bus number. If omitted zero will be used by default;
- **device_no** - SEALEVEL 5102 PCI device number. If omitted zero will be used by default;
- **function_no** - SEALEVEL 5102 PCI function number. If omitted zero will be used by default;
- **rx_clock_direction/tx_clock_direction** - Definitions of clock source for transmitting and receiving. Use IN if you want SEALEVEL 5102S to accept external clock. Use OUT if you want SEALEVEL 5102S to provide internal clock. If omitted IN will be used by default;
- **interface_mode** – SEALEVEL 5102S interface mode. Can be:
    - **none** – all pins are in high impedance;
    - **rs232** – for SYNC RS-232 interface;
    - **rs530_422** – for SYNC RS-530(422) interface;
    - **rs530a** – for SYNC RS-530A interface;
    - **v35** – for V.35 interface;

If omitted NONE will be used by default;

- **clock_rate** - desired clock rate (300baud – 128KBaud) if OUT direction is selected. If omitted 9600 will be used by default;

For information about SEALEVEL PCI 5102S sync serial board connector's pins definition please refer to its manual (www.sealevel.com).

Examples:

```
# DPV11, use SEALEVEL 5102S at PCI 1/7/0,
# RS-422(530), provide clock at 2.4 kHz, NO debug traces
load chapi UFA dll=chapi_dpv11.dll
set UFA line_cfg=seasync
set UFA bus_no=1 device_no=7 function_no=0
set UFA tx_clock_direction="out"
set UFA rx_clock_direction="out"
set UFA interface_mode="rs530_422"
set UFA trace_level=0
set UFA clock_rate=2400


# DPV11, use SEALEVEL 5102S at PCI 1/7/0,
# RS-232,NO debug traces, accept external clock
load chapi UFA dll=chapi_dpv11.dll
set UFA bus_no=1 device_no=7 function_no=0
set UFA interface_mode="rs232"


# DPV11, use SEALEVEL 5102S at PCI 1/7/0,
# RS-232, provide clock at 9.6 kHz, NO debug traces
load chapi UFA dll=chapi_dpv11.dll
set UFA bus_no=1 device_no=7 function_no=0
set UFA tx_clock_direction="out"
set UFA rx_clock_direction="out"
set UFA interface_mode="rs232"
```

DR11(C) / DRV11 via SENSORAY 621

The CHAPI DRV11 QBUS or DR11(C) UNIBUS device is based on the SENSORAY 621 PCI board, with the PPT.SYS device driver installed in the host system. It is implemented in the CHAPI_DR11.DLL and CHAPI_DR11_621_PORT.DLL and uses the CHAPI_PARALLEL.DLL and the CHAPI.DLL. The current CHAPI DR11(C)/DRV11 implementation requires a fast, low-latency host system.

For details about cables wiring from SENSORAY 621 connector to DR11(C)/DRV11 connectors see chapter 9.

The CHAPI DR11(C)/DRV11 device is configured as follows:

```
load chapi DR11 dll=chapi_dr11.dll trace_level=0
set DR11 address=...
set DR11 vector=...
set DR11 port_dll[0]= chapi_dr11_621_port.dll
set DR11 port[0]= dr11_621
set DR11 bus_no=...
set DR11 device_no=...
set DR11 function_no=...
set DR11 brq_priority=...
pulse_width=...
```

Where:

- **port_dll[0]** – is the name of DLL library from where the digital IO port for DR11(C)/DRV11 device emulation is loaded;
- **port[0]** – name of digital IO port for DR11(C)/DRV11 device emulation;
- **bus_no, device_no, function_no** - SENSORAY 621 PCI card location description. These numbers should be gathered from the Windows hardware wizard after Sensoray 621 PCI board installation.
- **brq_priority** - bus request priority level for DR11(C)/DRV11 device, If this parameter is omitted, 4 is used as default
- **pulse_width –** time length of **INIT** / **READ** / **WRITE** pulses in approximately 450ns units, If this parameter is omitted, 2 (i.e. 900ns) is used as default

Example:

```
load chapi DR11 dll=chapi_dr11.dll address=017767770 vector=0300 trace_level=0
set DR11 port_dll[0]=chapi_dr11_621_port.dll port[0]=dr11_621
set DR11 pulse_width=1 bus_no=1 device_no=7 function_no=0
```

DRV11-WA via SENSORAY 621

The CHAPI DRV11-WA QBUS device example is based on the SENSORAY 621 PCI board, with the PPT.SYS device driver installed in the host system. It is implemented in the CHAPI_DRV11WA_621.DLL and CHAPI_DRV11WA_621_PORT.DLL and uses CHAPI_PARALLEL.DLL the and the CHAPI.DLL. The current CHAPI DRV11-WA via SENSORAY 621 implementation requires a fast, low-latency host system.

For details about cables wiring from SENSORAY 621 connector to DR11(C)/DRV11 connectors see chapter 10.

The CHAPI DRV11-WA device is configured as follows:

```
load chapi IXA dll=chapi_drv11wa_621 trace_level=<trace_level>
set IXA address=... vector=...
set IXA port_dll= chapi_drv11wa_621_port.dll
set IXA port_name=drv11wa_621
set IXA bus_no=...
set IXA device_no=...
set IXA function_no=...
set IXA busy_lo_delay=... busy_hi_delay=...
```

Where,

- **port_dll** – is the name of DLL library from where the DRV11-WA device emulation is loaded. If this parameter is omitted, CHAPI_DRV11WA_621_PORT.DLL is used as default;
- **port_name** – the name of DRV-11WA replacement adapter connection module to load from the specified DLL library. If this parameter is omitted, 'drv11wa_621' will be used as default;
- **bus_no, device_no, function_no** – SENSORAY 621 PCI card location description. These numbers should be gathered from the Windows hardware wizard after Sensoray 621 PCI board installation.
- **busy_lo_delay** - BUSY signal delay in LOW level in approximately 450ns units. If this parameter is omitted, 0 is used as default
- **busy_hi_delay** - BUSY signal delay in HIGH level in approximately 450ns units. If this parameter is omitted, 0 is used as default

Example:

```
load chapi IXA dll=chapi_drv11wa_621.dll trace_level=0
set IXA bus_no=1 device_no=7 function_no=0
set IXA busy_lo_delay=0 busy_hi_delay=0
```

DRV11-WA

The CHAPI DRV11-WA QBUS device example is based on the DCI-1100 PCI board from The Logical Company, with the DCI1100.SYS device driver installed in the host system. It is implemented in the CHAPI_DRV11WA.DLL (in binary form) and uses the CHAPI_HW.DLL and the CHAPI.DLL. Note that the DCI-1100 is end of life as it does not meet the RoHS environmental requirements. The current CHAPI DRV11-WA implementation requires a fast, low-latency host system and is only provided as an example, instability has been observed in some test configurations. It is recommended to develop a custom parallel I/O CHAPI device with the appropriate host interface for a specific project.

The CHAPI DRV11-WA device is configured as follows:

```
load chapi IXA dll=chapi_drv11wa trace_level=<trace_level>
set IXA address=... vector=...
set IXA adapter_dll=chapi_hw
set IXA adapter_name=dci1100
set IXA adapter_instance=0
set IXA adapter_options=""
```

Where,

- **adapter_dll** – is the name of DLL library from where the DRV11-WA device emulation is loaded. If this parameter is omitted, chapi_hw.DLL is used as default;
- **adapter_name** – the name of DRV-11WA replacement adapter connection module to load from the specified DLL library. If this parameter is omitted, 'dci1100' will be used as default;
- **adapter_instance** – This is the instance number of the DRV11-WA replacement adapter to use, in case a number of the specified replacement adapters are installed on the PCI bus. If this parameter is omitted, 0 (i.e. The first instance) is used as default.
- **adapter_options** – any optional device parameters to be passed to the DRV11-WA replacement adapter connection module. No options are defined for dci1100 adapter implemented in the chapi_hw DLL library. If this parameter is omitted, an empty string is default;

HTIME

The CHAPI HTIME QBUS/UNIBUS device is a custom CHAPI implementation to obtain the host system date and time. It is implemented in the CHAPI_HTIME.DLL and uses the CHAPI.DLL. The device is provided in binary form; it is essentially designed to copy the host system time to the RSX11 system time, in combination with the RSX-11 HTIM task. Details are provided in (FIXME: add reference here).

The CHAPI HTIME device has no options and is configured as follows:

```
load chapi host_time dll=chapi_htime trace_level=<trace_level>
```

IAV1S-AA, IAV1S-C / IAV1S-CA

The CHAPI IAV1S-AA QBUS devices are implemented with CHAPI_IAV1S_AA.DLL and use CHAPI_INDIO.DLL and CHAPI.DLL for its implementation. The DLL is available in binary only. This implementation can map its ADC lines to SENSORAY 2601, 2608 ADC/DAC Ethernet boards.

This device cannot be configured using the legacy '`parameter`' configuration method. The configuration options are as follows:

```
load chapi ADC dll=chapi_iav1s_aa.dll address=<> vector=<>
set ADC trace_level=<trace_level>
set ADC port_dll="<port_dll>"
set ADC port_cfg="<port_cfg>"
set ADC port_param[x]="<IP address>"
set ADC port_offset[x]=<adc_offset>
set ADC bipolar=<bipolar>
```

Where :

- **port_dll** – The DLL file name to load CHAPI ADC port from. If omitted CHAPI_INDIO.DLL will be used by default;

- **trace_level** – Debug trace level (0 - 10), 0 for NO traces or 10 for MAX traces. If omitted zero will be used by default;

- **port_cfg** – The name of the port to load. Can be:

    - **2600** – a SENSORAY 2601/2608 Ethernet ADC/DAC board port

  If the port_cfg parameter is omitted, the port name "2600" will be used.

- **port_param[x]** – IP address of SENSORAY 2601 board (where desired SENSORAY 2608 is connected) where group <x> of 16 ADC channels (situated on the IAV1S-AA / IAV1S-C / IAV1S-CA devices) is to be mapped to, this parameter must not be omitted:

  - x = 0 for group of 16 ADC channels situated on the IAV1S-AA board;

  - x > 0 for group of 16 ADC channels situated on the IAV1S-C/IAV1S-CA MUX boards;

- **port_offset[x]** – offset for group of 16 ADC (situated on the IAV1S-AA / IAV1S-C / IAV1S-CA devices) on the SENSORAY 2601 board (selected by port_param[x]) to select desired SENSORAY 2608 board, this parameter must not be omitted:

  - x = 0 for group of 16 ADC channels situated on the IAV1S-AA board;

  - x > 0 for group of 16 ADC channels situated on the IAV1S-C/IAV1S-CA MUX boards;

- **bipolar** – set to TRUE for bipolar ADC. If omitted unipolar ADC will be used by default

For information about any technical information about SENSORAY 2601/2608 Ethernet boards please refer to its manual (www.sensoray.com).

Examples:

```
#load IAV1S-AA with one MUX boards
#two SENSORAY 2608 is connected to 2601 with IP 10.10.10.2
load chapi ADC1 dll=chapi_iav1s_aa.dll address=017761040 vector=0300
set ADC1 port_param[0]="10.10.10.2" port_offset[0]=0
#connect IAV1S-C/IAV1S-CA MUX
set ADC1 port_param[3]="10.10.10.2" port_offset[3]=16

#load IAV1S-AA without any MUX boards
#four SENSORAY 2608 is connected to 2601 with IP 10.10.10.2
#we will use the third 2608 board
load chapi ADC2 dll=chapi_iav1s_aa.dll address=017761050 vector=0320
set ADC2 bipolar=true
set ADC2 port_param[0]="10.10.10.2" port_offset[0]=32
```

IAV1S-B

The CHAPI IAV1S-B QBUS devices are implemented with CHAPI_IAV1S_B.DLL and use CHAPI_INDIO.DLL and CHAPI.DLL for its implementation. The DLL is available in binary only. This implementation can map its DAC lines to SENSORAY 2601, 2608 ADC/DAC Ethernet boards.

This device cannot be configured using the legacy '`parameter`' configuration method. The configuration options are as follows:

```
load chapi DAC dll=chapi_iav1s_b.dll address=<>
set DAC trace_level=<trace_level>
set DAC port_dll="<port_dll>"
set DAC port_cfg="<port_cfg>"
set DAC port_param[0]="<IP address>"
set DAC port_offset[0]=<adc_offset>
```

Where :

- **port_dll** – The DLL file name to load CHAPI DAC port from. If omitted CHAPI_INDIO.DLL will be used by default;
- **trace_level** – Debug trace level (0 - 10), 0 for NO traces or 10 for MAX traces. If omitted zero will be used by default;
- **port_cfg** – The name of the port to load. Can be:
    - **2600** – a SENSORAY 2601/2608 Ethernet ADC/DAC board port

  If the port_cfg parameter is omitted, the port name "2600" will be used.
- **port_param[0]** – IP address of SENSORAY 2601 board (where desired SENSORAY 2608 is connected) where group of 4 DAC channels (situated on the IAV1S-B device) is to be mapped to, this parameter must not be omitted;
- **port_offset[0]** – offset for group of 8 DAC (situated on the IAV1S-B device) on the SENSORAY 2601 board (selected by port_param[0]) to select desired SENSORAY 2608 board, this parameter must not be omitted:

For information about any technical information about SENSORAY 2601/2608 Ethernet boards please refer to its manual (www.sensoray.com).

Examples:

```
#load IAV1S-B
#two SENSORAY 2608 is connected to 2601 with IP 10.10.10.2
load chapi DAC dll=chapi_iav1s_b.dll address=017761060 trace_level=0
```

```
set DAC port_param[0]="10.10.10.2" port_offset[0]=8
```

MRV11

The CHAPI MRV11 QBUS/UNIBUS device are implemented with CHAPI_MRV11.DLL and use CHAPI.DLL for its implementation. MRV11 is universal programmable read-only memory.

The CHAPI MRV11 device is configured as follows:

```
load chapi MRVA dll=chapi_mrv trace_level=<trace_level>
set MRVA address=<device_address>
set MRVA chips_installed=<numer of chips installed on board>
set MRVA chip_capacity=<capacity measured>
set MRVA rom_file_name=<rom data file name>
set MRVA direct_mode=<enable/disable direct maping mode>
set MRVA direct_address=<direct maping address>
set MRVA window_mode=<enable/disable windows maping mode>
set MRVA window_address=<windows maping address>
set MRVA bootstrap=<enable/disable bootstrap mode>
set MRVA bootstrap_address=<bootstrap address>
```

Where:

- `chips_installed` – number of chips installed on board. This parameter must be multiply of powers of two and must be placed in segment from 1 to 32 (see MRV11 table).
- `chip_capacity` – capacity meshured of one chip in bytes. This parameter must be multiply of powers of two and must be placed in segment from 1 to 32 (see MRV11 table).
- `rom_file_name` – name of file which contain rom data.
- `direct_mode` – enable/disable direct maping mode (by default is enable (true)).
- `direct_address` – direct maping address (by default equals 0).

Number of Chips Installed	**Capacity Meshured (in Kbytes)**				
	2	**4**	**8**	**16**	**32**
2	4	8	16	32	64
4	8	16	32	64	128

6	12	24	48	96	196
8	16	32	64	128	256
10	20	40	80	160	320
12	24	48	96	192	384
14	28	56	112	224	448
16	32	64	128	256	512

- `window_mode` – enable/disable window maping mode (by default disable (false)).
- `window_address` – window maping_address (by default equals 0160000).
- `bootstrap` – enable/disable bootstrap mode (by default is enable (true)).
- `bootstrap _address` – bootstrap_address (by default equals 0).

Examples:

# CHAPI MRV11 example

```
load chapi MRVA dll=chapi_mrv
set MRVA address=177000
# Total ROM capacity 6*2 KBytes = 12KBytes
set MRVA chips_installed=6
set MRVA chip_capacity=2
#ROM data file
set MRVA rom_file_name=”my_rom.rom”
#Diaseble direct mode, address do not use
#set MRVA direct_address=020000
#Enable window maping mode
set MRVA window_mode= false
set MRVA window_address=0160000
set MRVA bootstrap=true
set MRVA bootstrap_address=173000
```

QBUS adapter based on BCI-2104 PCI board

A generic Qbus extension, the CHAPI_QBUS device is implemented in the CHAPI_QBUS.DLL and uses the CHAPI.DLL and the CHAPI_HW.DLL. This device is implemented as an interconnection adapter to connect the emulated Qbus to an external physical Qbus by means of an adapter board. With such connection, the hardware on the external Qbus is visible to the emulated CPU and can be used in a combination with the emulated devices.

This example is based on the BCI-2104 Qbus adapter board from The Logical Company. Note that the BCI-2104 is end of life as it does not meet the RoHS environmental requirements, and this implementation is only provided as a demonstration example.

The CHAPI_QBUS device is provided in binary form. A source code listing can be provided by on special request to assist in the development of interconnections to a physical Qbus or to (emulated) devices that represent themselves as a Qbus segment. Chapter 5 provides more information about the development of such bus connection.

The CHAPI_QBUS device is loaded and configured as follows:

```
load chapi chapi_qbus dll=chapi_qbus.dll trace_level=<trace_level>
set chapi_qbus adapter_dll=chapi_hw
set chapi_qbus adapter_name=bci
set chapi_qbus adapter_instance=0
set chapi_qbus adapter_options=””
```

where:

- **dll** and **trace_level** parameters are common for any CHAPI device;
- **adapter_dll** – is the name of DLL from which to load a specific low level bus adapter model. If this parameter is omitted, 'chapi_hw' is used as default;
- **adapter_name** – is the name of the low level bus adapter implementation to load from the specified DLL library; If this parameter is omitted, bci is used as default;
- **adapter_instance** – is the instance number of the bus adapter to use, when a number of adapters are installed on the PCI bus. If this parameter is omitted, the first instance (0) is used as default;
- **adapter_options** – any option to be passed to the specified low level bus adapter implementation. No options are defined for the BCI-2104 adapter connection in the chapi_hw DLL. If this parameter is omitted, an empty string is used as default;

QBUS adapter based on PCIS3BASE PCI board

A generic Qbus extension, the CHAPI_S3QBUS device is implemented in the CHAPI_S3QBUS.DLL and uses the CHAPI.DLL and the FPGA design binary file s3qbus_design.bin. This device is implemented as an interconnection adapter to connect the emulated Qbus to an external physical Qbus by means of an adapter board based on the FPGA with our custom design. With such connection, the hardware on the external Qbus is visible to the emulated CPU and can be used in a combination with the emulated devices.

The CHAPI_S3QBUS device is provided in binary form. To use PCIS3BASE adapter you have to install s3qbus_ppt.sys driver from the CHARON kit. After successful driver installation you need to obtain bus_no, device_no, function_no options from the driver properties.

The CHAPI_S3QBUS device is loaded and configured as follows:

```
load chapi S3QBUS dll=chapi_s3qbus.dll trace_level=0
set S3QBUS bus_no= <PCIS3BASE bus number option>
set S3QBUS device_no= <PCIS3BASE device number option >
set S3QBUS function_no= <PCIS3BASE function number option >
set S3QBUS design_file= <FPGA desing binary file name with path>
```

where:

- **dll** and **trace_level** parameters are common for any CHAPI device;
- **bus_no** – PCIS3BASE PCI bus number. If omitted zero will be used by default; This number should be gathered from the Windows driver properties after PCIS3BASE board installation.
- **device_no** – PCIS3BASE PCI device number. If omitted zero will be used by default; This number should be gathered from the Windows driver properties after PCIS3BASE board installation.
- **function_no** – PCIS3BASE PCI function number. If omitted zero will be used by default; This number should be gathered from the Windows driver properties after PCIS3BASE board installation.
- **design_file** – PCIS3BASE board FPGA design file name to load.; this FPGA design file s3qbus_design.bin is provided with the CHARON kit.

Example:

```
# CHAPI S3QBUS configuration example
load chapi S3QBUS dll=chapi_s3qbus.dll trace_level=0
set S3QBUS bus_no=1 device_no=7 function_no=0
set S3QBUS design_file="s3qbus_design.bin"
```

RL11/RLV12

CHAPI RL11 UNIBUS / RLV12 QBUS devices are implemented in CHAPI_RLV12.DLL library and use CHAPI_STORAGE.DLL and CHAPI.DLL libraries. It is provided only in binaries and allows mapping its disk drive to disk image file. CHAPI RLV12 device can control up to 4 disk drives (0, 1, 2 and 3). CHAPI RLV12 device can be configured by means of user defined configuration options as follows:

```
load chapi DLA dll=chapi_rlv12.dll
set DLA address=<address> vector=<vector> trace_level=<level>
set DLA disk_dll[x]=<storage library dll file>
set DLA disk_cfg[x]=<disk drive configuration>
set DLA disk_param[x]="<string of parameters for the disk drive>"
set DLA rl_type[x]="string of disk drive type"
```

Where :

- **disk_dll[x]** – DLL file name to load CHAPI disk drive **[x]** from; this parameter can be omitted – chapi_storage is used as default in this case;

- **disk_cfg[x]** – name of disk drive **[x]** to load, can be:

    - **file** – for disk drive **[x]** mapped to disk image file;

    - **phys** – for disk drive[x] mapped to raw physical disk;

    This option can be omitted – file is used as default in this case;

- **disk_param[x]** – string, that contains parameters for the disk drive **[x]**, must be:

    - for disk drive mapped to disk image file - name of the target file;

    - for disk drive mapped to raw physical disk – system name of the target disk like "\\.\PhysicalDrive0";

- **rl_type[x]** – disk drive type for disk drive mapped to raw physical disk, can be:

    - **rl01;**

    - **rl02;**

    This option can be omitted – "**rl01**" is used as default in this case;

Example:

```
#
# CHAPI RL01/RL02 disk controller
#
load chapi DLA dll=chapi_rlv12.dll trace_level=1

# Disk drive[0] configuration
set DLA disk_dll[0]="chapi_storage"
set DLA disk_cfg[0]="file"
set DLA disk_param[0]="somefile_0.vdisk"

# Disk drive[1] configuration
set DLA disk_dll[1]="chapi_storage"
set DLA disk_cfg[1]="phys"
set DLA disk_param[1]=" \\.\PhysicalDrive7"
set DLA rl_type[1]="rl02"

# Disk drive[2] configuration
set DLA disk_dll[2]="chapi_storage"
set DLA disk_cfg[2]="file"
set DLA disk_param[2]="somefile_2.vdisk"

# Disk drive[3] configuration
set DLA disk_dll[3]="chapi_storage"
set DLA disk_cfg[3]="file"
set DLA disk_param[3]="somefile_3.vdisk"
```

TS11/TSV05

The CHAPI TSV05/TS11 Qbus/UNIbus device is implemented in the CHAPI_TSV05.DLL library and use the CHAPI_STORAGE.DLL and CHAPI.DLL libraries. The implementation is provided in binary form and allows mapping the emulated tape transport mechanism to a tape image (*.mtd file), a SCSI port on the host system (for connection to a physical SCSI tape drive) or the Windows tape driver (for a host system tape drive). The CHAPI TSV05/TS11 implementation detects the bus type and works by default as a TSV05 on the Qbus and a TS11 on the UNIbus.

The CHAPI TSV05 device can be configured by means of user defined configuration options as follows:

```
load chapi MSA dll=chapi_tsv05.dll
set MSA address=<address> vector=<vector> trace_level=<level>
set MSA tape_dll[0]=<storage library dll file>
set MSA tape_cfg[0]=<tape transport configuration>
set MSA tape_param[0]=”<string of parameters for the tape transport>”
set MSA extended_mode[0]=<enable TS11 mode>
set MSA use_wtm_trick[0]=<enable WriteTapeMark trick>
```

Where :

- **tape_dll[0]** – DLL file name from where to load the CHAPI tape transport emulation. If this parameter is omitted, 'chapi_storage' will be used as default;

- **tape_cfg[0]** – is the type of the tape transport target. Options are:

    - **mtd** – for tape transport mapped to a tape image (*.mtd) file;

    - **scsi** – for tape transport mapped to a host SCSI interface;

    - **driver** – for tape transport mapped to a host tape driver;

  If this parameter is omitted, 'mtd' will be used as default;

- **tape_param[0]** – is a string specifying the tape transport. It must be one of the following:

    - for a tape transport mapped to an .mtd file: the name of the target file;

    - for a tape transport mapped to SCSI – the target SCSI name;

    - for a tape transport mapped to a host tape driver – the Windows device name;

- **extended_mode[0]** – This must be set to false to force TS11 tape drive emulation in an emulated Qbus mode (e.g. on a UNIbus PDP-11 system converted to Qbus);

- **use_wtm_trick[0]** – This must be set to true then tape transport mapped to real physical tape drive to avoid RSX TS11/TSV05 driver WTM timeouts.

Examples:

```
load chapi MSA0 dll=chapi_tsv05.dll trace_level=0

#force TS11 mode
#set MSA0 extended_mode[0]=false
```

```
#set tape transport as a tape image file on the host system
#set MSA0 tape_dll[0]=chapi_storage
#set MSA0 tape_cfg[0]=mtd
#set MSA0 tape_param[0]="somefile.mtd"

#set tape transport to connect to a physical SCSI device
#set MSA0 tape_dll[0]=chapi_storage
#set MSA0 tape_cfg[0]=scsi
#set MSA0 tape_param[0]= \\.\SCSI1:0:1
#to avoid RSX TS11/TSV05 driver WTM timeouts
#set MSA0 use_wtm_trick[0]=true


#set tape transport to a Windows tape drive with dsriver installed.
#set MSA0 tape_dll[0]=chapi_storage
#set MSA0 tape_cfg[0]=driver
#set MSA0 tape_param[0]= \\.\Tape0
```

VT30-H

The CHAPI VT30-H QBUS/UNIBUS device implemented in CHAPI_VT30H.DLL libraly and uses CHAPI.DLL libraly in its implementation. The VT30-H Graphics Display Controller enables one to connect a color television monitor to a PDP-11 processor. Information is displayed on the screen in the form of rows of characters in up to seven colors.

The CHAPI VT30H device can be configured by means of user defined configuration options as follows:

```
load chapi VTA dll=chapi_vt30h.dll
set VTA address=<address> vector=<vector> trace_level=<level>
set VTA display="<string of display param>"
set VTA mode_525_line=<do we need enable 525-line mode>
```

Where:

- **display ---** is string specifying connection with VT30-VT params. Options are
    - **port** --- to listen for.
- **mode_525_line** --- is bool param specifying VT30-TV terminal 525-line mode.

Example:

```
# CHAPI VT30-H
load chapi VTA dll=chapi_vt30h.dll
set VTA address=017764000 vector=0170 trace_level=0
set VTA display="port=10020"
set VTA mode_525_line=false
```

VT30-TV

The CHAPI VT30-TV implemented in **vt30-tv.exe**. The VT30-TV virtual color television monitor should be connected to a PDP-11 via VT30-H. It shoud be started with desktop color quality equally 8-bit, 16-bit or 32-bit.

The CHAPI VT30-TV can be started by means of user defined configuration options as follows:

```
vt30-tv.exe --address=<host(vt30-h) IP address> --port=<host(vt30-h) IP port> --
     log=<log file name> --trace_level=<level>
```

- **address** – IP address for connection to VT30-H.
- **port** --- IP port for conectio to VT30-H.

Example:

```
chapi_vt30tv.exe --address=127.0.0.1 --port=10020 --log="chapi_vt30tv.log" --
     trace_level=0
```

The Unibus adapter

The CHAPI_UNIBUS device is implemented in the CHAPI_UNIBUS.DLL library and uses the CHAPI.DLL and CHAPI_HW.DLL libraries in its implementation. This demonstrates how CHAPI can connect an external (physical) UNIbus via an adapter. The CHAPI_UNIBUS implementation is written for the BCI-2004 PCI adapter made by "The logical company". The hardware installed on the external UNIbus is added to the emulated peripherals and can be used in combination with the emulated devices.

The CHAPI_UNIBUS device is provided in binary form. Device sources can be provided on special request to assist in bus adapter development. Note that the BCI-2004 is end-of-line as it is not RoHS compatible. In principle, the CHAPI_UNIBUS device can be modified to work with other bus adapter designs. See chapter (5.3).

The CHAPI_UNIBUS device can be loaded and configured as follows:

```
load chapi chapi_unibus dll=chapi_unibus.dll trace_level=<trace_level>
set chapi_unibus adapter_dll=chapi_hw
set chapi_unibus adapter_name=bci
set chapi_unibus adapter_instance=0
set chapi_unibus adapter_options=""
```

where:

- **dll** and **trace_level** parameters are common to any CHAPI device;

- **adapter_dll** – is the name of DLL library to load a particular low level bus adapter implementation from. If this parameter is omitted, 'chapi_hw' will be used as default;

- **adapter_name** – is the name of the specific low level bus adapter implementation to load from the specified DLL library. If this parameter is omitted, 'bci' will be used as default;

- **adapter_instance** – is the instance number of the adapter to use. This parameter is relevant when multiple adapters are installed. If this parameter is omitted, 0 will be the default;

- **adapter_options** – specifies any options for a low level bus adapter module. The demo implementation for the bci adapter implemented within the chapi_hw DLL library does not require options. If this parameter is omitted, an empty string is default;

The VCB02 graphic controller

CHAPI VCB02 QBUS device is implemented in CHAPI_VCB02.DLL library and uses CHAPI.DLL library for its implementation. This device is provided only in binaries.

CHAPI_VCB02 device can be loaded and configured in configuration file as follows:

```
load chapi XAA dll=chapi_vbc02 address=<bus_address> trace_level=<level>
set XAA display=<display_type>
set XAA beep_enable=<true|false>
```

Where,

- **display** – is the type of used display for VCB02. The following strings can be specified for the moment: 1) “window” – use window for VCB02 output; 2) “hardware”, “full” – run VCB02 in full-screen mode;

- **beep_enable** – enable or disable beeping during the output in console mode;

The LPV11

The CHAPI LPV11 is implemented in the LPV11.DLL library and uses the CHAPI.DLL library for its implementation. This device is provided din binary form (source code available on request). When used with the HOSTprint utility supplied with CHARON, it can print from the emulated system to the default Windows host system printer. Printing to a locally attached printer on an LPT: port is also possible.

The LPV11 CHAPI device can be configured using as follows:

```
load chapi LPA dll=lpv11.dll address=<address> vector=<vec> trace_level=<level>
set LPA host="<host_name_or_ip>" port=<port_number> application="<application to
start>" file="<file_name_to_print>"
```

Where:

- **host** - is a host name or IP addres. If this parameter is omitted, localhost is used as defualt value;
- **port** - is the port number to connect to on the specified host;
- **application** – The name of application to start. The LPV11 device starts the specified application and tries to connect to the specified TCP/IP socket.
- **file** – The file name to print to. This option replaces the host/port/application triplet. This option allows to print to a local local file or a LPTn port. The latter allows to print directly to a physical printer without requiring a Windows driver.

When the CHAPI LPV11 device is used together with HOSTprint, it is configured as follows:

```
load chapi LPA dll=lpv11.dll
set LPA host="localhost" port=10004 application="HOSTprint -port=10004 -
printer=[<windows printer name>] –fontsize=10 –font=\Arial Bold\"
```

This will force LPV11 to start HOSTprint on the local node with port #10004 and connect to the port created by the HOSTprint tool. In this case, printing to the specified host system printer will be done directly from the PDP-11/VAX operating system.

In case when printing to the local text file is required, use the following configuration:

```
load  chapi LPA dll=lpv11.dll
set LPA file="some_text_file.txt"
```

IWhen a local printer is attached to the port LPTn, the following configuration prints directly to this printer:

```
load  chapi LPA dll=lpv11.dll
set LPA file="LPTn:"
```
5.3

2.CHAPI programming concepts

2.1 Overview

The CHAPI interface provides the ability to load dynamically (at run-time, during the configuration phase) additional emulator components that implement customer specific devices (for QBUS and UNIBUS in the version discussed in this release). The CHAPI architecture defines a programming interface of communication between such a loadable component and the core of CHARON. This interface must contain the following elements:

- Inform the loadable component when it is necessary to create, initialize, terminate, and destroy instances of a device.
- Provide a means of configuring instances of a device as specified in the emulated system configuration.
- Deliver bus signals (such as BUS RESET, IRQ ACKNOWLEDGE) to instances of a device.
- Provide access of the emulated CPU to device control/status registers for each instance of device.
- Deliver bus requests (interrupt requests) on behalf of an instance of a device.
- Provide a means of reading/writing memory for DMA capable devices.
- Provide a means of license verification in order to protect the loadable component from uncontrolled distribution.
- Provide a means of message logging coordinated with message logging of the CHARON itself.

To meet the above needs the loadable components are implemented as .DLL modules in the Windows host platform of CHARON. They define a set of procedures, data structures, and behaviors that allow the core of CHARON and the loadable component to communicate as required.

2.2 Loadable component naming conventions

Each loadable component must have a name, typically assigned by the developer of the component. This name must be sufficiently unique to allow users to identify the component. As far as the loadable component usually represents a class of peripheral devices, it is recommended to derive the name of the loadable component from the name of the device class.

The name of the .DLL module is constructed as follows:

***<COMPONENT-NAME>*.DLL**

where *<COMPONENT-NAME>* represents the name of the loadable component. The use of delimiting characters in *<COMPONENT-NAME>* (spaces, tabs, and other “invisible” characters) is not allowed. In case when component is already implemented in CHARON core and has the name like <COMPONENT-NAME>.DLL but customer wants to create its own implementation, the following naming convention should be used:

CHAPI_***<COMPONENT-NAME>*.DLL**

2.3 Component loading and initialization

CHARON handles the loading of a component DLL through the Win32 API. This is implemented by processing a pair of **load** and **set** directives in the corresponding configuration file:

```
load chapi <CFG-NAME>
set <CFG-NAME> dll=<PATH-TO-DLL>
```

where *<CFG-NAME>* and *<PATH-TO-DLL>* are the relevant values for the component. After loading the module into memory, the CHARON core creates the necessary context and calls the module initialization routine.

Note that if a particular CHAPI loadable component is configured to load more than once, the corresponding .DLL module is loaded only once, but the initialization routine is called for each configured instance. For example, suppose the configuration file contains the following lines:

```
load chapi TTA
set TTA dll=dl11.dll
load chapi TTB
set TTB dll=dl11.dll
```

Processing the above lines, the CHARON loads the DL11.DLL once, and then calls the corresponding initialization routine first for logical device TTA and then for TTB.

The moment of calling the initialization routine corresponds to the processing of the **set** command, when the value *<PATH-TO-DLL>* (**dl11.dll** in this case) is assigned to the dll parameter.

The module initialization routine has a predefined name and calling conventions, and must be declared in the source code (assuming the Visual C++ programming language) as follows:

```
__declspec(dllexport)
void * __cdecl <COMPONENT-NAME>_INIT
    (const chapi_in * ci, chapi_out * co, const char * instance_name);
```

where *<COMPONENT-NAME>* represents the name of the loadable component (see also “Loadable component naming conventions” above). Note that the name of the initialization routine must be converted to upper case. For example, the loadable module called dl11.dll shall declare its initialization procedure as follows:

```
__declspec(dllexport)
void * __cdecl DL11_INIT
    (const chapi_in * ci, chapi_out * co, const char * instance_name);
```

The moment when CHARON calls the component initialization routine shall be considered by the loadable component as a request to confirm the creation of a new instance of the device provided by the component.

The component initialization routine responds to the confirmation request with its return value. CHARON considers any value other than zero as a confirmation, and a zero value as a rejection. In case of confirmation, CHARON uses this value as an opaque identifier. Later it passes this identifier as an additional parameter to certain procedures of the CHAPI protocol.

2.4 Communication context binding

The CHAPI protocol defines a communication channel between the CHARON core and the loadable component. Since the emulator can load multiple loadable components, and each component can create several instances of devices, this can result in many communication channels.

Each communication channel binds the CHARON core to one instance of a device provided by a loadable component. This communication channel is described at each end by the communication contexts. Each side of the communication is responsible for creating and supporting its own contexts and setting up those contexts on behalf of the other side. The CHAPI protocol defines a set of rules of this context setup and support, which is called context binding.

CHARON creates its own communication context when processing the load command to load its configuration. It creates a descriptor of the chapi_in communication context (the chapi_in descriptor for short), fills it with zeros, and then fills certain fields with non-zero values. It also creates a descriptor of the chapi_out communication context (the chapi_out descriptor) and fills it with zeros. At that moment the CHARON core is ready to issue a creation confirmation request by calling the component initialization routine.

The loadable component shall create its own contexts (if any) in its initialization routine, just before confirming the creation of a new device instance. The loadable component shall fill all required fields of the provided descriptor of the chapi_out communication context with their respective values.

The loadable component can store the data path to both the chapi_in and the chapi_out descriptors provided to the component by the CHARON core. However, the loadable component is not allowed to modify any fields in the descriptor of the chapi_in communication context that is provided to the component by CHARON.

Upon receiving a confirmation, the CHARON core completes the establishment of its own context by filling the remaining fields of the descriptor of the chapi_in communication context. When receiving a rejection from the initialization routine of the loadable component, CHARON can terminate the establishment of its contexts.

This contexts binding process shall be considered done if, and only if:

- The whole configuration has been loaded, and
- The loadable component has confirmed the creation of a device instance.

2.5 Run-time communication

The run-time communication over the CHAPI communication channel is defined in terms of operations or transactions. Each operation is either initiated by the CHARON core or by the instance of the device provided by a loadable component. The side originating the operation is called the initiator of the operation. Each operation must be processed by the other side of the communication channel, which is called the target of the operation.

Both CHARON and a loadable component are / must be designed to work in a multi-threaded environment. Therefore no assumptions shall be made regarding the thread in which any particular operation is initiated. Nevertheless, certain operations put some restrictions on the way in which both sides of the CHAPI communication are allowed to initiate those operations.

Before the operation is initiated, the initiator shall prepare the operation context. When prepared, the initiator calls the corresponding routine provided by the counterpart to process the operation. Entry points to these routines are supplied in the corresponding fields of the chapi_in and the chapi_out descriptors by both sides of the CHAPI communication.

The CHAPI introduces the following types of operations:

- Access to the device IO addres space and memory address space. Such an operation is only initiated by the CPU emulation thread. Therefore the target shall finish processing such an operation as soon as possible. Note that the CHARON can run several CPU emulation threads.

- Setup bus requests. Such an operation is only initiated by CHARON core with loadable device as a target. CHARON core notify loadable component that it is a right time to setup bus requests, i.e. connect them to the bus for service.

- Set/initiate the interrupt on the bus. Such an operation is only initiated by the device instance. The target of the operation must remember the bus interrupt request.

- Request for a bus interrupt acknowledge. Such an operation is only initiated by the CPU emulation thread. Therefore the target shall finish processing such an operation as soon as possible.

- Direct memory access. Such an operation is only initiated by the device instance. Note that it is just DMA emulation, really it is just one or several memcpy to or from CHARON core.

- Synchronization request. Such an operation is only initiated by the device instance. The target of the operation must remember the synchronization request.

- Synchronization request acknowledgment. Such an operation is only initiated by the CPU emulation thread. Therefore the target shall finish processing such an operation as soon as possible.

- A request for processing bus power events.

- A request for processing bus reset events.

- A request to process loadable component defined configuration options. Can only be initiated by device and processed by CHARON core.

- A request for changing the configuration and support requests.

- A message log request.

- Protection and license verification.

- Bus adapter support requests (could require Stromasys consulting).

- Replacement hardware support requests (could require Stromasys consulting).

- Versioning information support requests.

The side of the CHAPI communication that is a target of a transaction have to provides a routine for processing the transaction. This routine is identified by an entry point stored in either the chapi_in or the chapi_out descriptors, depending on the operation. Thus transactions initiated by the CHARON core are processed by routines specified in the chapi_out descriptor, and transactions initiated by the device instance are processed by routines specified in the chapi_in descriptor. This is why a device instance must store the data path to at least the chapi_in descriptor.

Both CHARON and the loadable component are allowed to omit (i.e. set to 0) some or all entry points in the chapi_in and the chapi_out descriptors respectively. An entry point set to zero is considered absent. An absent entry point for a certain operation means that the operation is not supported and shall not be initiated by the counterpart.

2.6 Notes on threading

Any threading model maybe used in third party CHAPI device. The only restriction is to follow the rules of calling CHAPI procedures – many of them require certain call conditions (see 2.5, 3.4 for details). In general:

1) It is reasonable to perform any kind of I/O communication in one or a number of separate backgroung threads depending on device specific;

2) It is reasonable to perform some kind of heavy calculations (packet processing for network adapters, graphical processing for video adapters, etc) in a separate dedicated background thread.

3.The CHAPI communication context descriptors

The part covers the details of the communication context descriptors and the component initialization process.

3.1 The CHAPI_IN communication context descriptor

The chapi_in descriptor contains entry points to routines provided by the CHARON core, as well as base address of control and status registers (CSRs) and base interrupt vector, which might be specified in the configuration file (see below). The chapi_in descriptor structure is defined basically as follows:

```
typedef struct __chapi_in {
    __chapi_in_context_p context;

    unsigned int base_b_address;
    unsigned int base_i_vector;

    // Synchronization calls
    __chapi_put_ast_procedure_p put_ast;
    __chapi_put_sst_procedure_p put_sst;

    // Old way of IRQ processing calls
    __chapi_put_irq_procedure_p put_irq;
    __chapi_clear_irq_procedure_p clear_irq;

    // New way of IRQ processing calls
    __chapi_connect_bus_request_p connect_bus_request;
    __chapi_set_bus_request_p set_bus_request;
    __chapi_clear_bus_request_p clear_bus_request;
    __chapi_enable_bus_request_p enable_bus_request;
    __chapi_set_bus_request_affinity_p set_bus_request_affinity;
    __chapi_set_affinity_callback_p set_affinity_callback;
    __chapi_get_vector_p get_vector;

    // IRQ processing support for hardware replacement boards
    // NOTE: THIS IS CHARON DEEP INTEGRATION
    __chapi_get_bus_server_mask_p get_bus_server_mask;
    __chapi_get_attention_objects_p get_attention_objects;
    __chapi_get_brq_objects_p get_brq_objects;

    // Emulated DMA calls
    __chapi_read_mem_procedure_p read_mem;
    __chapi_write_mem_procedure_p write_mem;

    // Address spaces handling calls
    __chapi_create_io_space_procedure_p create_io_space;
    __chapi_move_io_space_procedure_p move_io_space;
    __chapi_destroy_io_space_procedure_p destroy_io_space;

    // Licensing calls
    __chapi_get_license_no_procedure_p get_license_no;
    __chapi_encrypt_data_block_procedure_p encrypt_data_block;
    __chapi_decrypt_data_block_procedure_p decrypt_data_block;

    // Message logging calls
    __chapi_log_message_procedure_p log_message;
    __chapi_log_message_ex_procedure_p log_message_ex;
    __chapi_debug_trace_procedure_p debug_trace;
```

```
// Configuration option processing calls
__chapi_add_config_option_p add_config_option;
__chapi_set_option_value_p set_option_value;
__chapi_undo_option_value_p undo_option_value;
__chapi_commit_option_value_p commit_option_value;
__chapi_is_option_value_specified_p is_option_value_specified;
__chapi_is_option_value_changed_p is_option_value_changed;
__chapi_option_value_change_ack_p option_value_change_ack;

// Bus adapter calls
// NOTE: THIS IS CHARON DEEP INTEGRATION
__chapi_intercept_bus_address_space_p intercept_bus_address_space;
__chapi_release_bus_address_space_p release_bus_address_space;
__chapi_get_configured_ram_size_p get_configured_ram_size;
__chapi_get_ram_segment_p get_ram_segment;

__chapi_read_bus_timeout_p read_bus_timeout;
__chapi_read_bus_abort_p read_bus_abort;
__chapi_write_bus_timeout_p write_bus_timeout;
__chapi_write_bus_abort_p write_bus_abort;

// New way of IRQ processing calls continuation ...

//
// This method is used in order to change interrupt vector for specified
// bus request.
//
__chapi_set_brq_vector_p set_brq_vector;

//
// This method is used in order to translate specified bus address into the
// emulated system RAM address.
//
// NOTE: THIS IS CHARON DEEP INTEGRATION

__chapi_translate_for_dma_p translate_for_dma;

//
// This method is used to get bus type of the device owning bus.
// This is required to support different bus types within the single
// implementational module, e.g. QBUS device very often have its UNIBUS
// equivalent with almost the same functionality, but address processing is
// different, so we have to know bus type we are connected to at runtine.
//
__chapi_get_bus_type_p get_bus_type;

//
// Simple extension of configuration options interface which allows
// disabling/freezing of option values. This is required in the light
// of access to CHARON interactive console which requires protection
// of option values even of CHAPI devices...
//
__chapi_set_and_disable_option_value_p set_and_disable_option_value;
__chapi_enable_option_value_p enable_option_value;
__chapi_freeze_option_value_p freeze_option_value;
__chapi_disable_option_value_p disable_option_value;
__chapi_is_option_value_hidden_p is_option_value_hidden;

// Product versioning information
__chapi_get_product_ident_p get_product_ident;
__chapi_get_hardware_model_p get_hardware_model;
__chapi_get_hardware_name_p get_hardware_name;
__chapi_get_product_copyright_p get_product_copyright;
__chapi_get_product_custom_string_p get_product_custom_string;
__chapi_get_product_major_version_p get_product_major_version;
__chapi_get_product_minor_version_p get_product_minor_version;
__chapi_get_product_build_version_p get_product_build_version;
```

```
    __chapi_get_chapi_major_version_p get_chapi_major_version;
    __chapi_get_chapi_minor_version_p get_chapi_minor_version;

    // I/O spaces processing extension
    __chapi_connect_io_space_procedure_p connect_io_space;
    __chapi_disconnect_io_space_procedure_p disconnect_io_space;

    //
    // All new methods/data have to be added to the end of this structure,
otherwise
    // all customer chapi devices have to be rebuilt with the new header file!!!
    //

} chapi_in;
```

where:

```
#if defined(_MSC_VER)
#define CHAPI __cdecl
#if defined(__cplusplus)
#define CHAPI_INIT(n) extern "C" \
__declspec(dllexport) void * __cdecl n##_INIT
#else // defined(__cplusplus)
#define CHAPI_INIT(n) \
__declspec(dllexport) void * __cdecl n##_INIT
#endif // defined(__cplusplus)
#else // defined(_MSC_VER)
#define CHAPI
#endif

#if defined(__cplusplus)
extern "C" {
#endif // defined(__cplusplus)


//==============================================================================
// Definition of CHAPI input context
//

#if !defined(__chapi_in_context_p)
typedef void * const __chapi_in_context_p;
#endif // !defined(__chapi_in_context_p)


//------------------------------------------------------------------------------
// AST/SST relative stuff
//
typedef void (CHAPI * __chapi_ast_handler_p)
    (void * arg1, int arg2);

#if !defined(ast_handler)
#define ast_handler __chapi_ast_handler_p
#endif // !defined(ast_handler)

typedef int (CHAPI * __chapi_put_ast_procedure_p)
    (const struct __chapi_in * ci,
     unsigned long delay,
     __chapi_ast_handler_p fun, void * arg1, int arg2);

typedef void (CHAPI * __chapi_sst_handler_p)
    (void * arg1, int arg2);

#if !defined(sst_handler)
#define sst_handler __chapi_sst_handler_p
#endif // !defined(sst_handler)

typedef int (CHAPI * __chapi_put_sst_procedure_p)
```

```
    (const struct __chapi_in * ci,
     unsigned long delay,
     __chapi_sst_handler_p fun, void * arg1, int arg2);


//-----------------------------------------------------------------------------
// IRQ/BRQ relative stuff.
//
typedef int (CHAPI * __chapi_irq_handler_p)
    (void * arg1, int arg2);

#if !defined(irq_handler)
#define irq_handler __chapi_irq_handler_p
#endif // !defined(irq_handler)

//
// Obsolete way to handle IRQ - left only to support old applications.
// This interface uses internal IRQ queues which makes differencies with the
// actual way of interrupts processing in hardware. Use new interface defined
// below.
//
typedef int (CHAPI * __chapi_put_irq_procedure_p)
    (const struct __chapi_in * ci,
     unsigned int vec, unsigned long delay,
     __chapi_irq_handler_p fun, void * arg1, int arg2);

typedef void (CHAPI * __chapi_clear_irq_procedure_p)
    (const struct __chapi_in * ci,
     unsigned int vec);

//
// New way to handle IRQ - no queues.
// This way should be used for newly developed applications in a couple with
// chapi_brq_t class defined in chapi_lib.h header which wrappes interface
// conveniently.
//
typedef unsigned int brq_handle_t;
typedef __chapi_irq_handler_p __chapi_brq_acknowledge_p;

#if !defined(brq_acknowledge)
#define brq_acknowledge __chapi_brq_acknowledge_p
#endif // !defined(brq_acknowledge)

typedef int (CHAPI * __chapi_sa_handler_p)
    (void * arg1, int arg2, int c_no);


typedef brq_handle_t (CHAPI * __chapi_connect_bus_request_p)
    (const struct __chapi_in * ci, int vector, int ipl,
     __chapi_brq_acknowledge_p brq_ack, void *arg1, int arg2);

typedef void (CHAPI * __chapi_set_bus_request_p)
    (const struct __chapi_in * ci, brq_handle_t brq_handle);

typedef void (CHAPI * __chapi_clear_bus_request_p)
    (const struct __chapi_in * ci, brq_handle_t brq_handle);

typedef void (CHAPI * __chapi_enable_bus_request_p)
    (const struct __chapi_in * ci, brq_handle_t brq_handle, bool enable);

typedef void (CHAPI * __chapi_set_bus_request_affinity_p)
    (const struct __chapi_in * ci, brq_handle_t brq_handle, unsigned int mask);

typedef void (CHAPI * __chapi_set_affinity_callback_p)
    (const struct __chapi_in * ci, brq_handle_t brq_handle,
    __chapi_sa_handler_p sa_callback, void *arg1, int arg2);

typedef unsigned int (CHAPI * __chapi_get_bus_server_mask_p)
```

```
    (const struct __chapi_in * ci, brq_handle_t brq_handle);

typedef bool (CHAPI * __chapi_get_attention_objects_p)
    (const struct __chapi_in * ci, brq_handle_t brq_handle, int cpu_no,
    volatile unsigned long *& attention_object, unsigned long &
attention_value);

typedef bool (CHAPI * __chapi_get_brq_objects_p)
    (const struct __chapi_in * ci, brq_handle_t brq_handle, int cpu_no,
    volatile unsigned long *& brq_object, unsigned long & brq_mask);

typedef int (CHAPI * __chapi_get_vector_p)
    (const struct __chapi_in * ci, int vector);

typedef void (CHAPI * __chapi_set_brq_vector_p)
    (const struct __chapi_in * ci, brq_handle_t brq_handle, int vector);


//------------------------------------------------------------------------------
// Memory access methods.
//

typedef unsigned int (CHAPI * __chapi_read_mem_procedure_p)
    (const struct __chapi_in * ci,
     unsigned int addr, unsigned int len,
     char * buf);

typedef unsigned int (CHAPI * __chapi_write_mem_procedure_p)
    (const struct __chapi_in * ci,
     unsigned int addr, unsigned int len,
     const char * buf);

#if !defined(__chapi_io_space_id_t)
typedef void * __chapi_io_space_id_t;
#endif // !defined(__chapi_io_space_id_t)

typedef __chapi_io_space_id_t (CHAPI * __chapi_create_io_space_procedure_p)
    (const struct __chapi_in * ci,
     unsigned int addr, unsigned int len);

typedef void (CHAPI * __chapi_move_io_space_procedure_p)
    (const struct __chapi_in * ci,
     __chapi_io_space_id_t space_id,
     unsigned int addr, unsigned int len);

typedef void (CHAPI * __chapi_destroy_io_space_procedure_p)
    (const struct __chapi_in * ci,
     __chapi_io_space_id_t space_id);

//
// Connects already created and than disconnected I/O space
// Required for example when different devices response the same
// I/O windows in different conditions which can be changed at
// runtime.
//
typedef void (CHAPI * __chapi_connect_io_space_procedure_p)
    (const struct __chapi_in * ci,
     __chapi_io_space_id_t space_id,
     unsigned int addr, unsigned int len);

// Disconnect I/O space w/o distroying it.
typedef void (CHAPI * __chapi_disconnect_io_space_procedure_p)
    (const struct __chapi_in * ci,
     __chapi_io_space_id_t space_id);

//------------------------------------------------------------------------------
// Licensing routines
//
```

```
typedef bool (CHAPI * __chapi_get_license_no_procedure_p)
    (const struct __chapi_in * ci,
     unsigned int *license_serial_no);

typedef void (CHAPI * __chapi_decrypt_data_block_procedure_p)
    (const struct __chapi_in * ci,
     void * buf, unsigned int len);

typedef void (CHAPI * __chapi_encrypt_data_block_procedure_p)
    (const struct __chapi_in * ci,
     void * buf, unsigned int len);

//------------------------------------------------------------------------------
// Message logging / debugging routines
//

// Possible types of messages to log
typedef enum _log_message_type_t {
    error_msg_type,
    warning_msg_type,
    info_msg_type
} log_message_type_t;

//
// CHAPI message code decoding. CHAPI message code is used as subcode within
// CHARON message preallocated for CHAPI use... the format is as follows:
//
// 31        24 23        16 15         0
// <vendor_id> <device_id> <message_id>
//
// Note: CHAPI messages subcoding is used now to distinguish between different
//       CHAPI messages mapped to single CHARON message code from message
database.
//       It is planned in the future to add some kind of CHAPI message database
//       and primitives to get the message from that database in different
languages
//       instead of hardcoding these messages withing the device code like it is
//       done for the moment.
//
typedef unsigned int log_message_id_t;

// vendor_id = 0 is reserved for STROMASYS devices
enum {
    VENDOR_ID_SRI    =    0
};

// A few STROMASYS device ids - some for libraries, others for devices...
enum {
        DEVICE_ID_HW          =    0,  // CHAPI_HW.DLL objects
    DEVICE_ID_SERIAL,              // CHAPI_SERIAL.DLL objects
    DEVICE_ID_STORAGE,             // CHAPI_STORAGE.DLL objects
    DEVICE_ID_PARALLEL,            // CHAPI_PARALLEL.DLL objects
    DEVICE_ID_QBUS,                // CHAPI QBUS adapter implementatiion
    DEVICE_ID_UNIBUS,              // CHAPI UNIBUS adapter implementatiion
    DEVICE_ID_DHV11,               // CHAPI DHV11 device implementation
    DEVICE_ID_DLV11,               // CHAPI DLV11/DL11 devices implementation
    DEVICE_ID_DRV11,               // CHAPI DRV11/DR11-C devices implementation
    DEVICE_ID_DRV11_621_PORT,      // CHAPI DRV11/DR11-C port mapped to SENSORAY
621 adapter
    DEVICE_ID_DRV11WA,             // CHAPI DCI-1100 based DRV11-WA implementation
    DEVICE_ID_DRV11WA_621,         // CHAPI DRV11WA mapped to SENSORAY 621 adapter
    DEVICE_ID_DRV11WA_621_PORT,  // CHAPI DRV11WA port mapped to SENSORAY 621
adapter
    DEVICE_ID_HTIME,               // CHAPI HTIME pseudo device
    DEVICE_ID_RLV12,               // CHAPI RL11/RLV12 devices implementation
    DEVICE_ID_TSV05,               // CHAPI TS11/TSV05 devices implementation
    DEVICE_ID_VCB02,               // CHAPI VCB02 device implementation
    DEVICE_ID_LPV11,            // CHAPI LP11/LPV11 device implementation
    DEVICE_ID_SDZV11,           // CHAPI_SHELL_DZV11
    DEVICE_ID_DH11,             // CHAPI DH11 devices implementation
    DEVICE_ID_VT30H,            // CHAPI VT30-H devices implementation
    DEVICE_ID_MRV11,            // CHAPI MRV11-C(D) devices implementation
    DEVICE_ID_DPV11,            // CHAPI DPV11 devices implementation
    DEVICE_ID_IAV1S_AA,         // CHAPI IAV1S-AA(-CA) devices implementation
    DEVICE_ID_IAV1S_B,          // CHAPI IAV1S-B devices implementation
    DEVICE_ID_INDIO,            // CHAPI industrial IO implementation
};


// Generates message code from its components.
#define CHAPI_MSG_ID(vendor, device, code)  ((vendor << 24) | (device << 16) |
code)


typedef void (CHAPI * __chapi_log_message_procedure_p)
    (const struct __chapi_in * ci,
     const char * buf, unsigned int len);

typedef void (CHAPI * __chapi_log_message_ex_procedure_p)
    (const struct __chapi_in * ci, log_message_type_t log_msg_type,
    const char *file, int line, log_message_id_t log_msg_id, const char *fmt,
...);

// Trace level will be in range [0, 10]
typedef unsigned char trace_level_t;

typedef void (CHAPI * __chapi_debug_trace_procedure_p)
    (const struct __chapi_in * ci,
     trace_level_t trace_level, const char *fmt, ...);


//--------------------------------------------------------------------------------
// Configuration options relative routines
//

// Possible types of configuration options
typedef enum _config_option_t {
    option_type_integer,
    option_type_boolean,
    option_type_string
} config_option_t;

typedef void (CHAPI * __chapi_add_config_option_p)
    (const struct __chapi_in * ci,
     const char *opt_name, config_option_t opt_type, int opt_vals_count,
     void *opt_buffer, size_t opt_size);

typedef bool (CHAPI * __chapi_set_option_value_p)
    (const struct __chapi_in * ci, const char *opt_name, int opt_val_idx,
    void *val);

typedef bool (CHAPI * __chapi_set_and_disable_option_value_p)
    (const struct __chapi_in * ci, const char *opt_name, int opt_val_idx,
    void *val);

typedef void (CHAPI * __chapi_undo_option_value_p)
    (const struct __chapi_in * ci, const char *opt_name, int opt_val_idx);

typedef void (CHAPI * __chapi_commit_option_value_p)
    (const struct __chapi_in * ci, const char *opt_name, int opt_val_idx);

typedef bool (CHAPI * __chapi_is_option_value_specified_p)
    (const struct __chapi_in * ci, const char *opt_name, int opt_val_idx);
```

```
typedef bool (CHAPI * __chapi_is_option_value_changed_p)
    (const struct __chapi_in * ci, const char *opt_name, int opt_val_idx);

typedef void (CHAPI * __chapi_option_value_change_ack_p)
    (const struct __chapi_in * ci, const char *opt_name, int opt_val_idx);

typedef void (CHAPI * __chapi_enable_option_value_p)
    (const struct __chapi_in * ci, const char *opt_name, int opt_val_idx, bool
force);

typedef void (CHAPI * __chapi_freeze_option_value_p)
    (const struct __chapi_in * ci, const char *opt_name, int opt_val_idx);

typedef void (CHAPI * __chapi_disable_option_value_p)
    (const struct __chapi_in * ci, const char *opt_name, int opt_val_idx);

typedef bool (CHAPI * __chapi_is_option_value_hidden_p)
    (const struct __chapi_in * ci, const char *opt_name, int opt_val_idx);


//-----------------------------------------------------------------------------
// Product versioning information stuff
//

// Get product identification string
typedef const char* (CHAPI * __chapi_get_product_ident_p)
    (const struct __chapi_in * ci);

// Get harware model
typedef const char* (CHAPI * __chapi_get_hardware_model_p)
    (const struct __chapi_in * ci);

// Get harware name
typedef const char* (CHAPI * __chapi_get_hardware_name_p)
    (const struct __chapi_in * ci);

// Get product Copyright string
typedef const char* (CHAPI * __chapi_get_product_copyright_p)
    (const struct __chapi_in * ci);

// Get product custom string
typedef const char* (CHAPI * __chapi_get_product_custom_string_p)
    (const struct __chapi_in * ci);

// Get major version number for the product
typedef int (CHAPI * __chapi_get_product_major_version_p)
    (const struct __chapi_in * ci);

// Get minor version number of the product
typedef int (CHAPI * __chapi_get_product_minor_version_p)
    (const struct __chapi_in * ci);

// Get build number for the project
typedef int (CHAPI * __chapi_get_product_build_version_p)
    (const struct __chapi_in * ci);

// Get major version number for the CHAPI supported by the product
typedef int (CHAPI * __chapi_get_chapi_major_version_p)
    (const struct __chapi_in * ci);

// Get minor version number for the CHAPI supported by the product
typedef int (CHAPI * __chapi_get_chapi_minor_version_p)
    (const struct __chapi_in * ci);


//-----------------------------------------------------------------------------
// Support for bus adapter
// NOTE: THIS IS CHARON DEEP INTEGRATION
```

```
typedef bool (CHAPI * __chapi_intercept_bus_address_space_p)
    (const struct __chapi_in * ci);

typedef void (CHAPI * __chapi_release_bus_address_space_p)
    (const struct __chapi_in * ci);

typedef unsigned int (CHAPI * __chapi_get_configured_ram_size_p)
    (const struct __chapi_in * ci);

typedef unsigned int (CHAPI * __chapi_get_ram_segment_p)
    (const struct __chapi_in * ci, int n_of_segment, unsigned int &addr,
        char * &base);

typedef void (CHAPI * __chapi_read_bus_timeout_p)
    (const struct __chapi_in * ci);

typedef void (CHAPI * __chapi_read_bus_abort_p)
    (const struct __chapi_in * ci);

typedef void (CHAPI * __chapi_write_bus_timeout_p)
    (const struct __chapi_in * ci);

typedef void (CHAPI * __chapi_write_bus_abort_p)
    (const struct __chapi_in * ci);

typedef unsigned int (CHAPI * __chapi_translate_for_dma_p)
    (const struct __chapi_in * ci, unsigned int addr, unsigned int len,
    char *& buf);


//----------------------------------------------------------------------------
// Support for different buses.
//

// Supported buses
typedef enum _supported_buses_t {
    UNKNOWN_BUS     =   0x00000000,
    QBUS            =   0x00000001,
    UNIBUS          =   0x00000002
} supported_buses_t;

enum {
    QBUS_IO_OFFSET      =   0x3FE000,
    QBUS_IO_SIZE        =   0x002000,
    QBUS_IOP_OFF_MASK   =   0x001FFF,

    UNIBUS_IO_OFFSET    =   0x03E000,
    UNIBUS_IO_SIZE      =   0x002000,
    UNIBUS_IOP_OFF_MASK =   0x001FFF,

    QBUS_IO_LAST        =   QBUS_IO_OFFSET + QBUS_IO_SIZE - 1,
    QU_IO_SHIFT         =   - QBUS_IO_OFFSET + UNIBUS_IO_OFFSET,

    UNIBUS_IO_LAST      =   UNIBUS_IO_OFFSET + UNIBUS_IO_SIZE - 1,
    UQ_IO_SHIFT         =   - UNIBUS_IO_OFFSET + QBUS_IO_OFFSET
};

typedef supported_buses_t (CHAPI * __chapi_get_bus_type_p)

    (const struct __chapi_in * ci);
```

The **context** field is defined by the CHAPI and initialized by the CHARON solely for its own use and shall not be changed as well as used by the component in any way.

The **base_b_address** field contains the starting bus address of the device instance I/O region. Usually it is an address of the device's control and status register (CSR). The CHARON core provides a value in this field upon completion loading the configuration. Initially it is set to 0. The CHAPI allows the user to override this value with configuration parameters (see below).

The **base_i_vector** field contains the starting interrupt vector address, assigned to the device. The CHARON core provides a value in this field upon completion loading the configuration. Initially it is set to 0. The CHAPI allows the user to override this value with configuration parameters (see below).

The **put_ast** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field. The delay parameter means number of processor instructions before calling the function specified in "**fun".**

The **put_sst** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field. The delay parameter means number of processor instructions before calling the function specified in "**fun".**

The **put_irq** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field. The delay parameter means number of processor instructions before calling the function specified in "**fun".**

The **clear_irq** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **connect_bus_request** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **set_bus_request** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **clear_bus_request** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **enable_bus_request** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **set_bus_request_affinity** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **set_affinity_callback** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **get_vector** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **get_bus_server_mask** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **get_attention_objects** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **get_brq_objects** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **read_mem** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine the CHARON core is allowed to put non-zero value into the field.

The **write_mem** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **create_io_space** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **move_io_space** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **destroy_io_space** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **get_license_no** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **encrypt_data_block** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **decrypt_data_block** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **log_message** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **log_message_ex** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **debug_trace** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **add_config_option** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **set_option_value** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **undo_option_value** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **commit_option_value** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **is_option_value_specified** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **is_option_value_changed** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **option_value_change_ack** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **intercept_bus_address_space** field contains an entry point to the corresponding routine. It could require Stromasys consulting. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **release_bus_address_space** field contains an entry point to the corresponding routine. It could require Stromasys consulting. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **get_configured_ram_size** field contains an entry point to the corresponding routine. Using this function could require Stromasys consulting.The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **get_ram_segment** field contains an entry point to the corresponding routine. Using this function could require Stromasys consulting. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **read_bus_timeout** field contains an entry point to the corresponding routine. Using this function could require Stromasys consulting.The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **read_bus_abort** field contains an entry point to the corresponding routine. Using this function could require Stromasys consulting.The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **write_bus_timeout** field contains an entry point to the corresponding routine. Using this function could require Stromasys consulting.The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **write_bus_abort** field contains an entry point to the corresponding routine. Using this function could require Stromasys consulting.The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **set_brq_vector** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **translate_for_dma** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **get_bus_type** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **set_and_disable_option_value** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **enable_option_value** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **freeze_option_value** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **disable_option_value** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **is_option_value_hidden** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **get_product_ident** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **get_hardware_model** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **get_hardware_name** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **get_product_copyright** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **get_product_custom_string** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **get_product_major_version** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **get_product_minor_version** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **get_product_build_version** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **get_chapi_major_version** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **get_chapi_minor_version** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **connect_io_space** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

The **disconnect_io_space** field contains an entry point to the corresponding routine. The CHARON core provides a value in this field before calling the loadable component initialization routine. Initially set to 0. Later, but before calling the initialization routine, the CHARON core is allowed to put a non-zero value into the field.

Note that the CHARON core is not required to initialize all the fields of the **chapi_in** communication context descriptor before calling the initialization routine. The CHARON core is allowed to initialize these fields later. More details follow.

3.2 The CHAPI_OUT communication context descriptor

The chapi_out descriptor contains entry points to routines provided by the loadable component, as well as address range of control and status register I/O space and number of interrupt vectors. The chapi_out descriptor structure is defined as follows:

```
typedef struct __chapi_out {
    __chapi_out_context_p context;

    unsigned int base_b_address;
    unsigned int b_address_range;
    unsigned int base_i_vector;
    unsigned int n_of_i_vector;
    unsigned int i_priority;

    __chapi_start_procedure_p start;
    __chapi_stop_procedure_p stop;
    __chapi_reset_procedure_p reset;
    __chapi_read_procedure_p read;
    __chapi_write_procedure_p write;

    __chapi_mapping_register_updated_p mapping_register_updated;

    __chapi_set_configuration_procedure_p set_configuration;
    __chapi_set_configuration_ex_procedure_p set_configuration_ex;

    __chapi_setup_bus_requests_procedure_p setup_bus_requests;

    __chapi_run_interactive_command_procedure_p run_interactive_command;

    //
    // Almost the same device (functionally the same) may have different
    // address range of their I/O page window, e.g. RL11 has 4 registers and
    // 8 bytes window range while RLV11 has 5 registers and 16 bytes window
range.
    // This makes sense to ask device for address range dynamically depending on
    // bus type this device is connected (when device supports a number of
different
    // buses).
    //
    __chapi_get_bus_address_range_procedure_p get_bus_address_range;

    // This data member defines supported buses
    unsigned int supported_buses;

    //
    // All new methods/data have to be added to the end of this structure,
otherwise
```

```
    // all customer chapi devices have to be rebuilt with the new header file!!!
    //

   } chapi_out;
```

where:

```
#if !defined(__chapi_out_context_p)
typedef void * __chapi_out_context_p;
#endif // !defined(__chapi_out_context_p)

typedef void (CHAPI * __chapi_start_procedure_p)
    (const struct __chapi_out * co);

typedef void (CHAPI * __chapi_stop_procedure_p)
    (const struct __chapi_out * co);

typedef void (CHAPI * __chapi_reset_procedure_p)
    (const struct __chapi_out * co);

typedef int (CHAPI * __chapi_read_procedure_p)
    (const struct __chapi_out * co,
     unsigned int addr,
     bool is_byte);

typedef void (CHAPI * __chapi_write_procedure_p)
    (const struct __chapi_out * co,
     unsigned int addr,
     int val,
     bool is_byte);

// NOTE: THIS IS CHARON DEEP INTEGRATION
typedef void (CHAPI * __chapi_mapping_register_updated_p)
    (const struct __chapi_out * co,
     int reg_set, int reg_no, int val);

typedef int (CHAPI * __chapi_set_configuration_procedure_p)
    (const struct __chapi_out * co,
     const char * parameters);

typedef int (CHAPI * __chapi_set_configuration_ex_procedure_p)
    (const struct __chapi_out * co);

typedef void (CHAPI * __chapi_setup_bus_requests_procedure_p)
    (const struct __chapi_out * co);

typedef int (CHAPI * __chapi_run_interactive_command_procedure_p)
    (const struct __chapi_out * co, const char *commandverb, char *parameters);

typedef unsigned int (CHAPI * __chapi_get_bus_address_range_procedure_p)

    (const struct __chapi_out * co, supported_buses_t owning_bus_type);
```

The **context** field is defined by the CHAPI solely for use by the loadable component. The CHARON core initializes the field with 0. Later it updates the field with the value returned by the component initialization routine. Afterwards the CHARON core does not make any attempts to use the value of the field in any way. The loadable component is supposed to use the **context** field to bind the communication context to private data structures.

The **b_address_range** field contains the length of the I/O space in bytes the CHARON core shall reserve for control and status registers of the device instance. The field is obligatory. So the loadable component shall provide a non-zero value in this field when processing the request to confirm the creation of a device (i.e. in the corresponding ***<COMPONENT_NAME>*_INIT** routine). The combination of the **base_b_address** and **b_address_range** shall meet the following two requirements:

- The length of address range must be a power of two. Or more formally:

  (b_address_range & (b_address_range - 1)) == 0

- The address range shall be naturally aligned. Which means that the **base_b_address** shall be aligned to a boundary that is a multiple of **b_address_range**. Or more formally:

  (base_b_address + (b_address_range - 1))

  == (base_b_address | (b_address_range - 1))

The **n_of_i_vector** field contains the number of interrupt vectors the CHARON core shall allocate for the device instance. The field is obligatory, and the loadable component shall provide a non-zero value in this field when processing the request to confirm creation of the device (i.e. in the corresponding ***<COMPONENT_NAME>*_INIT** routine).

The **i_priority** field contains a priority at which the CHARON core shall process the interrupt requests originated by the device instance. This field is required if the **n_of_i_vector** field is non-zero, otherwise this field might be left unspecified. So the loadable component shall provide a non-zero value in this field if necessary when processing a request to confirm the creation of a device (i.e. in the corresponding ***<COMPONENT_NAME>*_INIT** routine).

The **stop** field contains an entry point to the corresponding routine. This field is optional. The loadable component provides a value in this field when processing the request to confirm the creation of a device (i.e. in the corresponding ***<COMPONENT_NAME>*_INIT** routine).

The **start** field contains an entry point to the corresponding routine. This field is optional. The loadable component provides a value in this field when processing the request to confirm the creation of a device (i.e. in the corresponding ***<COMPONENT_NAME>*_INIT** routine).

The **reset** field contains an entry point to the corresponding routine. This field is optional. The loadable component provides a value in this field when processing the request to confirm the creation of a device (i.e. in the corresponding ***<COMPONENT_NAME>*_INIT** routine).

The **write** field contains an entry point to the corresponding routine. This field is optional. The loadable component provides a value in this field when processing the request to confirm the creation of a device (i.e. in the corresponding ***<COMPONENT_NAME>*_INIT** routine).

The **read** field contains an entry point to the corresponding routine. This field is optional. The loadable component provides a value in this field when processing the request to confirm the creation of a device (i.e. in the corresponding ***<COMPONENT_NAME>*_INIT** routine).

The **mapping_register_updated** field contains an entry point to the corresponding routine. Using this function could require Stromasys consulting. This field is optional. The loadable component provides a value in this field when processing the request to confirm the creation of a device (i.e. in the corresponding ***<COMPONENT_NAME>*_INIT** routine).

The **set_configuration** field contains an entry point to the corresponding routine. This field is optional. The loadable component provides a value in this field when processing the request to confirm the creation of a device (i.e. in the corresponding ***<COMPONENT_NAME>*_INIT** routine).

The **set_configuration_ex** field contains an entry point to the corresponding routine. This field is optional. The loadable component provides a value in this field when processing the request to confirm the creation of a device (i.e. in the corresponding ***<COMPONENT_NAME>*_INIT** routine).

The **setup_bus_requests** field contains an entry point to the corresponding routine. This field is optional. The loadable component provides a value in this field when processing the request to confirm the creation of a device (i.e. in the corresponding ***<COMPONENT_NAME>*_INIT** routine).

The **run_interactive_command** field contains an entry point to the corresponding routine. This field is optional. The loadable component provides a value in this field when processing the request to confirm the creation of a device (i.e. in the corresponding ***<COMPONENT_NAME>*_INIT** routine).

The **get_bus_address_range** field contains an entry point to the corresponding routine. This field is optional. The loadable component provides a value in this field when processing the request to confirm the creation of a device (i.e. in the corresponding ***<COMPONENT_NAME>*_INIT** routine).

The **supported_buses** field contains the mask of supported buses by the component. The field is obligatory, and the loadable component shall provide a non-zero value in this field when processing the request to confirm creation of the device (i.e. in the corresponding ***<COMPONENT_NAME>*_INIT** routine). Possible values to be used in this mask are described above during the chapi_in descriptor definition.

Note that the component initialization routine is required to properly initialize the **b_address_range**, **n_of_i_vector**, **i_priority**, **supported_buses**, **start**, and **stop** fields of the chapi_out communication context descriptor. Other fields might be setup later.

3.3 Initialization steps

When the structure of the communication contexts is available, it is time to present more information about the component initialization process. The initialization steps are as follows:

1. As soon as the CHARON core has finished processing the load command, it creates the necessary internal structures representing the device and allocates resources for both the **chapi_in** and the **chapi_out** communication context descriptors.

2. The communication context descriptors are all initialized with all zeros.

3. The CHARON core then creates all required private data structures and binds the communication context to them properly initializing the **context** field of the **chapi_in** communication context descriptor.

4. If the corresponding routines are supported, the CHARON core initializes the **get_license_no, encrypt_data_block, decrypt_data_block, add_config_option, debug_trace** and the **log_message(_ex)** fields of the **chapi_in** communication context descriptor, so that the component initialization routine can use them.

5. As soon as the CHARON core assigns a value to the **dll** parameter, it loads the .DLL module, if necessary, and calls the component initialization routine.

6. As soon as the component initialization routine returns, the value returned is checked against zero. If the value is zero, then the CHARON core considers the initialization as failed, releases all the so far allocated resources (if any), and reports an error. Otherwise the CHARON core updates the context field of the **chapi_out** communication context descriptor with this value and proceeds with the initialization.

3.4 Run-time execution contexts

The CHAPI is based on a multi-threaded software execution model. This means that procedures defined by the CHAPI run in different threads. The CHAPI selects the CPU emulator thread as a special execution context, so that all the procedures invoked in that thread are invoked in the execution context synchronized to the CPU emulator thread.

The CHAPI restricts the use of certain procedures to the execution context in the following way:

- All the procedures identified by entry points stored in the **put_sst**, **put_irq**, **clear_irq**, and **move_io_space** fields of a chapi_in communication context descriptor shall be invoked in the execution context synchronized to the CPU emulator thread.

- Procedure identified by entry point **connect_bus_request** in the **chapi_in** communication context descriptor shall be invoked from the routine identified by **setup_bus_requests** entry in **chapi_out** communication context descriptor.

- All the procedures identified by entry points stored in the **create_io_space** and **destroy_io_space** fields of a **chapi_in** communication context descriptor shall be invoked in the same execution context. Therefore the loadable component shall call these routines only from the routines identified by the **start** and the **stop** fields of the **chapi_out** communication context descriptor.

- Procedure identified by entry point **add_config_option** in the **chapi_in** communication context descriptor shall be invoked from the loadable component initialization routine (***<COMPONENT_NAME>*_INIT**). In this case newly added configuration options will be available in configuration file at any line going after **dll** parameter specification for the loadable component.

- All the procedures identified by entry points stored in the **read_bus_timeout** and **read_bus_abort** fields of a **chapi_in** communication context descriptor shall be called by loadable component only from the routine identified by the **read** field of the **chapi_out** communication context descriptor. Using this function could require Stromasys consulting.

- All the procedures identified by entry points stored in the **write_bus_timeout** and **write_bus_abort** fields of a **chapi_in** communication context descriptor shall be called by loadable component only from the routine identified by the **write** field of the **chapi_out** communication context descriptor. Using this function could require Stromasys consulting.

The CHAPI also guarantees that:

- All the procedures identified by entry points stored in **read**, **write**, and **reset** fields of a **chapi_out** communication context descriptor are invoked in the execution context synchronized to the CPU emulator thread.

- All the procedures identified by the **fun** argument in the procedure calls to **put_ast**, **put_sst**, and **put_irq** procedures, identified by corresponding fields of a **chapi_in** communication context descriptor, are invoked in the execution context synchronized to the CPU emulator thread.

- All the procedures identified by entry points stored in **start** and **stop** fields of a **chapi_out** communication context are invoked in the same execution context.

- Procedure identified by the entry point stored in the **set_configuration** field of a **chapi_out** communication context is called each time **parameter** configuration option of loadable component is modified in the CHARON configuration file.

- Procedure identified by the entry point stored in the **set_configuration_ex** field of a **chapi_out** communication context is called each time when one of the options added by the loadable component using procedure specified by the entry point **add_config_option** of a **chapi_in** communication context is modified in the CHARON configuration file.
- Any procedure call does not change the execution context.
- Each thread has its own execution context.

4.CHAPI operation

4.1 Reading the device control and status register

The operation of reading a device control and status register belongs to the class of operations previously called “Access to device control and status registers”. The CHARON core initiates such an operation. More precisely, one of the CPU instruction interpretation threads is the initiator. The device is considered to be a target of the operation.

In order to perform the operation, the initiator invokes a routine identified by the **read** field of the **chapi_out** descriptor. The initiator provides in the **addr** parameter a bus address of the register to read from, and in the **is_byte** parameter the length of the transaction. The procedure is invoked as follows:

```
const chapi_out * co = …;
if (co->read) {
    val = co->read(co, addr, is_byte);
}
```

The example above shows that the device is not obliged to support the indicated operation.

4.2 Writing device control and status register

The operation of writing device control and status register belongs to the class of operations previously called “Access to device control and status registers”. The CHARON core initiates such an operation. More precisely, one of the CPU instruction interpretation threads is the initiator. The device is defined as the target of the operation.

In order to perform the operation, the initiator invokes a routine identified by the **write** field of the **chapi_out** descriptor. The initiator provides in the **addr** parameter a bus address of the register to read from, in the **val** parameter a value to be written, and in the **is_byte** parameter the length of the transaction. The procedure is invoked as follows:

```
const chapi_out * co = …;
if (co->write) {
    co->write(co, addr, val, is_byte);
}
```

The example above shows that the device is not obliged to support the indicated operation.

4.3 Creating additional I/O space

The operation of creating additional I/O space belongs to the class of operations previously called “Access to device control and status registers”. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation.

In order to perform the operation, the initiator invokes a routine identified by the **create_io_space** field of the **chapi_in** descriptor. The initiator is to provide the initial bus location of the I/O space in the **addr** and the **len** arguments. The combination of the **addr** and the **len** shall meet the following requirements:

- The length of address range indicated by the **len** must be a power of two. Or more formally:

  ```
  (len & (len - 1)) == 0
  ```

- The address range shall be naturally aligned. Which means that the **addr** shall be aligned to a boundary that is a multiple of **len**. Or more formally:

  ```
  (addr + (len - 1)) == (addr | (len - 1))
  ```

The procedure is invoked as follows:

```
io_space_id_t sid = 0;
const chapi_in * ci = …;
if (ci->create_io_space) {
    sid = ci->create_io_space(ci, addr, len);
}
if (sid == 0) {
    /* failed to create the io space*/
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. Also it gives a clue why the device instance is supposed to remember the **chapi_in** descriptor.

In the example above the device is supposed to store the (non-zero) result of the **create_io_space** procedure. Later this value is to be used as I/O space identifier for subsequent calls (if any) to the **move_io_space** and **destroy_io_space** procedures.

The device is to make sure that any additional I/O space created by the CHARON core on behalf of the device is destroyed with the **destroy_io_space** procedure (see below). The suggested behavior is to create additional I/O spaces (if necessary) when processing a bus power-up condition and destroy it when processing a bus power-down condition (see below).

4.4 Destroying I/O space

The operation of destroying (additional) I/O space belongs to the class of operations previously called “Access to device control and status registers”. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation.

In order to perform the operation, the initiator invokes a routine identified by the **destroy_io_space** field of the **chapi_in** descriptor. The initiator is to provide an I/O space identifier in the **sid** argument. The procedure is invoked as follows:

```
io_space_id_t sid = …;
const chapi_in * ci = …;
if (ci->destroy_io_space) {
   ci->destroy_io_space(ci, sid);
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. But nevertheless it is guaranteed that the CHARON core does either support both the **create_io_space** and the **destroy_io_space** procedures, or does not support any of them. Also, it gives a clue why the device instance is supposed to remember the I/O space identifier returned in the previous call to **create_io_space** procedure (see above), and the chapi_in descriptor.

4.5 Changing I/O space bus location

The operation of changing (additional) I/O space bus location belongs to the class of operations previously called "Access to device control and status registers". Such an operation is initiated by the device instance when it is in the execution context synchronized to the CPU instruction interpretation thread. The CHARON core is defined as the target of the operation.

In order to perform the operation, the initiator invokes a routine identified by the **move_io_space** field of the **chapi_in** descriptor. The initiator is to provide an I/O space identifier in the **sid** argument and new bus location of the I/O space in the **addr** and the **len** arguments. The combination of the **addr** and the **len** shall meet the following requirements:

- The length of the address range indicated by the len must be a power of two. Or more formally:

  ```
  (len & (len - 1)) == 0
  ```

- The address range shall be naturally aligned. Which means that the **addr** shall be aligned to a boundary that is multiple of the **len**. Or more formally:

  ```
  (addr + (len - 1)) == (addr | (len - 1))
  ```

The procedure is invoked as follows:

```
io_space_id_t sid = …;
const chapi_in * ci = …;
if (ci->move_io_space) {
   ci->move_io_space(ci, sid, addr, len);
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. Also, it gives a clue why the device instance is supposed to remember the I/O space identifier returned in the previous call to **create_io_space** procedure (see above), and the **chapi_in** descriptor.

4.6 Disconnecting I/O space

The operation of disconnecting (additional) I/O space belongs to the class of operations previously called "Access to device control and status registers". Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. Such kind of operation required in case when more than 1 device uses the same address range depending on some runtime conditions and space should be disconnected/connected again periodically at runtime.

In order to perform the operation, the initiator invokes a routine identified by the **disconnect_io_space** field of the **chapi_in** descriptor. The initiator is to provide an I/O space identifier in the **sid** argument. The procedure is invoked as follows:

```
io_space_id_t sid = …;
const chapi_in * ci = …;
if (ci->disconnect_io_space) {
   ci->disconnect_io_space(ci, sid);
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. But nevertheless it is guaranteed that the CHARON core does either support both the **connect_io_space** and the **disconnect_io_space** procedures, or does not support any of them. Also, it gives a clue why the device instance is supposed to remember the I/O space identifier returned in the previous call to **create_io_space** procedure (see above), and the chapi_in descriptor.

4.7 Connecting I/O space

The operation of connecting (additional) I/O space bus location belongs to the class of operations previously called "Access to device control and status registers". Such an operation is initiated by the device instance when it is in the execution context synchronized to the CPU instruction interpretation thread. The CHARON core is defined as the target of the operation. Such kind of operation required in case when more than 1 device uses the same address range depending on some runtime conditions and space should be disconnected/connected again periodically at runtime.

In order to perform the operation, the initiator invokes a routine identified by the **connect_io_space** field of the **chapi_in** descriptor. The initiator is to provide an I/O space identifier in the **sid** argument and bus location of the I/O space in the **addr** and the **len** arguments. The combination of the **addr** and the **len** shall meet the following requirements:

- The length of the address range indicated by the **len** must be a power of two. Or more formally:

```
(len & (len - 1)) == 0
```

- The address range shall be naturally aligned. Which means that the **addr** shall be aligned to a boundary that is multiple of the **len**. Or more formally:

  ```
  (addr + (len - 1)) == (addr | (len - 1))
  ```

The procedure is invoked as follows:

```
io_space_id_t sid = …;
const chapi_in * ci = …;
if (ci->connect_io_space) {
   ci->connect_io_space(ci, sid, addr, len);
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. Also, it gives a clue why the device instance is supposed to remember the I/O space identifier returned in the previous call to **create_io_space** procedure (see above), and the **chapi_in** descriptor.

4.8 The legacy way to process interrupts

The operations described in this section are only listed for compatibility reasons with a prior implementation of CHAPI. While these methods are supported in the current release, they should not be used in a new development using CHAPI. See the next section for the recommended methods.

4.8.1 Requesting a bus interrupt

The operation of requesting a bus interrupt belongs to the group of operations previously called "Request for bus interrupt". Such an operation is initiated by the device instance when it is in execution context synchronized to the CPU instruction interpretation thread. The CHARON core is defined as the target of the operation. Actually the CPU instruction interpretation thread is supposed to respond to the bus interrupt request.

In order to perform the operation, the initiator invokes a routine identified by the **put_irq** field of the **chapi_in** descriptor. The procedure is invoked as follows:

```
const chapi_in * ci = …;
if (ci->put_irq) {
   ci->put_irq(ci, vec, delay, fun, arg1, arg2);
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It also indicates why the device instance should remember the **chapi_in** descriptor.

4.8.2 Removing a bus interrupt request

Removing a bus interrupt request belongs to the "Request for bus interrupt" group of operations. Such an operation is initiated by the device instance when it is in execution context synchronized to the CPU instruction interpretation thread. The CHARON core is defined as the target of the operation. It is the task of the CPU instruction interpretation thread to respond to the operation of removing the bus interrupt request.

To perform the operation, the initiator invokes a routine identified by the **clear_irq** field of the **chapi_in** descriptor. The initiator shall indicate through the **vec** parameter the vector of the interrupt requests to clear. The target shall clear all the interrupt requests previously originated by the initiator through the vector supplied. The procedure is invoked as follows:

```
const chapi_in * ci = …;
if (ci->clear_irq) {
   ci->clear_irq(ci, vec);
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It also indicates why the device instance should retain the **chapi_in** descriptor.

4.8.3 Bus interrupt acknowledge

Acknowledging the bus interrupt request is currently the only operation defined within the group of operations called “Request for bus interrupt acknowledge”. The CHARON core (one of the CPU instruction interpretation threads) initiates such an operation. The device instance is defined as a target of the operation.

In order to perform the operation, the initiator invokes a routine identified by the **fun** parameter, supplied during the corresponding request for a bus interrupt. See the “Requesting a bus interrupt” above. The procedure is invoked as follows:

```
irq_handler fun = …;
if (fun) {
   vec = fun(arg1, arg2);
}
```

The example above shows that the device is not obliged to support the indicated operation. Which means that it is allowed to supply 0 for the **fun** parameter when requesting a bus interrupt through the **put_irq** entry point of the **chapi_in** descriptor. Note that the CHAPI defines an additional argument, supplied through the **arg1** and the **arg2** parameters, to help the target dispatching requests.

The bus interrupt acknowledge procedure indicated by the **fun** parameter must return the interrupt vector in case of acknowledgement. In this case the CHARON core uses the returned value as the interrupt vector instead of the vector supplied through the previous call to the **put_irq** procedure. If the bus interrupt is not acknowledged, the bus interrupt acknowledge procedure shall return zero (0) indicating that the interrupt vector is not valid.

The CHAPI guarantees that the bus interrupt acknowledge procedure identified by the **fun** argument is invoked in the execution context synchronized to the CPU instruction interpretation thread.

4.9 The recommended way to process interrupts

This methods described in this section are the recommended way to process interrupts in a CHAPI implementation. They interact more efficiently with the CHARON kernel. See section (5.1) for description of the appropriate C++ wrapper for that part of CHAPI.

4.9.1 Connect bus request to the bus

Connecting a bus request to the bus belongs to the “Request for bus interrupt” group of operations. Such an operation is initiated by the device instance and CHARON core is defined as the target of the operation. All bus requests required for loadable module should be connected to the bus in order to have possibility for their processing. The right place to call for this operation is a routine identified by the **setup_bus_requests** field of **chapi_out** communication context descriptor.

To perform the operation, the initiator invokes a routine identified by the **connect_bus_request** field of the **chapi_in** descriptor. The initiator shall indicate in the **vector** parameter the vector of the bus requests to connect in the **ipl** parameter the level at which bus request should be processed by the bus server, in the **brq_ack** the bus request acknowledge procedure which is called in context of CPU thread when bus request is acknowledged, in the **arg1** and **arg2** parameters to pass to the bus request acknowledge routine. The target shall connect bus request with supplied parameters to the bus. The procedure is invoked as follows:

```
brq_handle_t  brq;
some_data_type *data;
const chapi_in * ci = …;
if (ci->connect_bus_request) {
   // Pointer to some kind of data and 0 will be passed to
   // the brq_ack routine when it is called.
   brq = ci->connect_bus_request(ci, 0154, 04, brq_ack, data, 0);
   if(!brq) {
         // It was unable to connect bus request to the bus…
         // Further operation with this request is impossible
   }
   else {
         // Ok, bus request successfully connected…
   }
}
int brq_ack(void *data, int something)
{
   // Usually bus request is cleared here because this is
   // responsibility of device and device interrupt vector is returned…
}
```

In case of success routine returns bus request handle which should be saved for the further operations with bus request – each of them requires this identifier.

The example above shows that the CHARON core is not obliged to support the indicated operation. It also indicates why the device instance should retain the **chapi_in** descriptor.

4.9.2 Set bus request

The operation of setting a bus request belongs to the group of operations previously called "Request for bus interrupt". Such an operation is initiated by the device instance when it is in execution context synchronized to the CPU instruction interpretation thread. The CHARON core is defined as the target of the operation. Actually the CPU instruction interpretation thread is supposed to respond to the bus request.

In order to perform the operation, the initiator invokes a routine identified by the **set_bus_request** field of the **chapi_in** descriptor supplying in the parameter **brq_handle** the identifier of bus request to set. The procedure is invoked as follows:

```
brq_handle_t brq_handle;
const chapi_in * ci = …;
…
// Connect bus request to the bus getting brq_handle
…
if (ci->set_bus_request) {
   ci->set_bus_request(ci, brq_handle);
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It also indicates why the device instance should remember the **chapi_in** descriptor.

4.9.3 Clear bus request

The operation of clearing a bus request belongs to the group of operations previously called "Request for bus interrupt". Such an operation is initiated by the device instance when it is in execution context synchronized to the CPU instruction interpretation thread. The CHARON core is defined as the target of the operation. Actually the CPU instruction interpretation thread is supposed to respond to the bus request clearing.

In order to perform the operation, the initiator invokes a routine identified by the **clear_bus_request** field of the **chapi_in** descriptor supplying in the parameter **brq_handle** the identifier of bus request to clear. The procedure is invoked as follows:

```
brq_handle_t brq_handle;
const chapi_in * ci = …;
…
// Connect bus request to the bus getting brq_handle
…
// Set bus request somewhere in the right place
…
if (ci->clear_bus_request) {
   ci->clear_bus_request(ci, brq_handle);
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It also indicates why the device instance should remember the **chapi_in** descriptor.

4.9.4 Enable/disable bus request

The operation of enabling/disabling a bus request belongs to the group of operations previously called "Request for bus interrupt". Such an operation is initiated by the device instance and CHARON core is defined as the target of the operation. Actually the CPU instruction interpretation thread is supposed to respond to the bus request enabling/disabling. When particular bus request is disabled it is just ignored by the bus server when set and processed and the same situation when enabled.

In order to perform the operation, the initiator invokes a routine identified by the **enable_bus_request** field of the **chapi_in** descriptor supplying in the parameter **brq_handle** the identifier of bus request to enable/disable and in the parameter **enable** the type of operation (**true** – enable, **false** - disable). The procedure is invoked as follows:

```
brq_handle_t brq_handle;
const chapi_in * ci = …;
…
// Connect bus request to the bus getting brq_handle as in previous example
…
// Lets assume that some kind of interrupt enable bit is updated for
// the device and (CSR & IE_BIT) give us the new value…
if (ci->enable_bus_request) {
   ci->enable_bus_request(ci, brq_handle, CSR & IE_BIT);
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It also indicates why the device instance should remember the **chapi_in** descriptor.

4.9.5 Get interrupt vector

The operation of getting an interrupt vector belongs to the group of operations previously called "Request for a bus interrupt acknowledge". Such an operation is initiated by the device instance and CHARON core is defined as the target of the operation. This routine should be used to get appropriate interrupt vector for the bus server using particular emulated device interrupt vector – these vector can be different, e.g. for the VAX QBUS system appropriate interrupt vector which should be passed to the bus server is calculated as <emulated_device_interrupt_vector> + 0x200.

In order to perform the operation, the initiator invokes a routine identified by the **get_vector** field of the **chapi_in** descriptor supplying in the parameter **vector** the vector in terms of emulated device. The procedure is invoked as follows:

```
// The common place to use get_vector routine is bus request
// acknowledge routine which should return correct interrupt vector
// to be used by the bus server…
int brq_ack(void *dev_inst, int arg2) {
   my_dev_t *dev = (my_dev_t*)dev_inst;
   if (dev->ci->get_vector) {
         return dev->ci->get_vector(dev->ci, dev->vector);
   }
   else {
         return dev->vector;
   }
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It also indicates why the device instance should remember the **chapi_in** descriptor.

4.9.6 Set interrupt vector

The operation of setting an interrupt vector belongs to the group of operations previously called "Request for a bus interrupt acknowledge". Such an operation is initiated by the device instance and CHARON core is defined as the target of the operation. This routine should be used to set interrupt vector for particular bus request in case when it is set programmatically for particular device.

In order to perform the operation, the initiator invokes a routine identified by the **set_brq_vector** field of the **chapi_in** descriptor supplying in the parameter **brq_handle** the handle of bus request to set vector for and in the parameter **vector** the vector in terms of emulated device. The procedure is invoked as follows:

```
// The common place to use set_brq_vector routine is writing to device
// register containing BRQ vector for the device
   if (dev->ci->set_brq_vector) {
         dev->ci->set_brq_vector(dev->ci, brq_handle, REG & REG_VEC_MASK);
   }
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It also indicates why the device instance should remember the chapi_in descriptor.

4.9.7 Set bus request affinity mask

The operation of setting bus request affinity mask belongs to the group of operations previously called "Request for bus interrupt". Such an operation is initiated by the device instance or CHARON core but only CHARON core is defined as the target of the operation. This routine has sense only for the case of multi CPU emulated system and defines bit mask specifying which bus server (CPU) can handle bus request.

In order to perform the operation, the initiator invokes a routine identified by the **set_bus_request_affinity** field of the **chapi_in** descriptor supplying in the parameter **brq_handle** the identifier of bus request to set affinity mask for and in the parameter **mask** the affinity mask to set. Affinity mask is a bit mask where each particular bit is designated to particular emulated CPU – lowest bit to the first CPU and so on. The procedure is invoked as follows:

```
brq_handle_t brq_handle;
const chapi_in * ci = …;
…
// Connect bus request to the bus getting brq_handle as in previous example
…
// Only first CPU will be allowed to process bus request
// identified by brq_handle
if (ci->set_bus_request_affinity) {
   ci->set_bus_request_affinity (ci, brq_handle, 0x01);
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It also indicates why the device instance should remember the **chapi_in** descriptor.

4.9.8 Set bus request affinity callback

The operation of setting bus request affinity callback belongs to the group of operations previously called "Request for bus interrupt". Such an operation is initiated by the device instance and CHARON core is defined as the target of the operation. This routine has sense only for the case of multi CPU emulated system and defines callback routine which will notify loadable device that bus request affinity mask is modified for some bus request.

In order to perform the operation, the initiator invokes a routine identified by the **set_affinity_callback** field of the **chapi_in** descriptor supplying in the parameter **brq_handle** the identifier of bus request to set affinity callback for, in the parameter **sa_callback** the pointer to callback routine to set and in the parameters **arg1, arg2** the parameters to be passed to specified callback routine during its execution. The procedure is invoked as follows:

```
void sa_procedure(void *arg1, int arg2, int c_no)
{
   // Do something here ... c_no is CPU with the lowest number
   // among all CPUs specified in affinity mask and used as bus servers
}


…
brq_handle_t brq_handle;
const chapi_in * ci = …;
…
// Connect bus request to the bus getting brq_handle as in previous example
…
// Setup affinity callback routine
```

```
if (ci->set_affinity_callback) {
   ci->set_affinity_callback (ci, brq_handle, sa_procedure, <some pointer>,
<some integer>);
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It also indicates why the device instance should remember the **chapi_in** descriptor.

4.9.9 Get bus server mask for the bus request (could require Stromasys consulting)

The operation of getting bus request server mask belongs to the group of operations previously called “Request for bus interrupt”. Such an operation is initiated by the device instance and CHARON core is defined as the target of the operation. This routine has sense only for the case of multi CPU emulated system and returns the bus server mask (CPU mask) which can process bus request.

In order to perform the operation, the initiator invokes a routine identified by the **get_bus_server_mask** field of the **chapi_in** descriptor supplying in the parameter **brq_handle** the identifier of bus request to get bus server mask for. The procedure is invoked as follows:

```
brq_handle_t brq_handle;
const chapi_in * ci = …;
…
// Connect bus request to the bus getting brq_handle as in previous example
…
// Ask for bus server mask for some reason
if (ci->get_bus_server_mask) {
   unsigned int cpu_mask = ci->get_bus_server_mask (ci, brq_handle);
   // Process cpu_mask somehow here …
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It also indicates why the device instance should remember the **chapi_in** descriptor.

4.9.10 Get attention objects for the bus server (could require Stromasys consulting)

The operation of getting attention objects for the bus server belongs to the group of operations previously called “Replacement hardware support requests”, using this function could require Stromasys consulting. Such an operation is initiated by the device instance and CHARON core is defined as the target of the operation. This routine can be used when working with replacement hardware and interrupts. It should not be used during the general loadable component development. Attention objects in a couple with the bus requests objects give developers efficient mechanism to interrupt CHARON emulators from hardware device drivers.

In order to perform the operation, the initiator invokes a routine identified by the **get_attention_objects** field of the **chapi_in** descriptor supplying in the parameter **brq_handle** the identifier of bus request to get attention objects for, int the parameter **cpu_no** the number of CPU which attention objects should be retrieved, in the parameter **attention_object** the pointer which will be updated with the pointer to attention object and in the parameter **attention_value** the reference where attention value will be stored. Attention value should be written to attention object in order to interrupt bus server. Invocation example is shown in the chapter below.

4.9.11 Get bus request objects for the bus server (CHARON deep inegration)

The operation of getting bus request objects for the bus server belongs to the group of operations previously called "Replacement hardware support requests", using this function could require Stromasys consulting.. Such an operation is initiated by the device instance and CHARON core is defined as the target of the operation. This routine can be used when working with replacement hardware and interrupts. It should not be used during the general loadable component development. Bus request objects in a couple with the attention objects give developers efficient mechanism to interrupt CHARON emulators from hardware device drivers.

In order to perform the operation, the initiator invokes a routine identified by the **get_brq_ objects** field of the **chapi_in** descriptor supplying in the parameter **brq_handle** the identifier of bus request to get objects for, int the parameter **cpu_no** the number of CPU which bus request objects should be retrieved, in the parameter **brq_object** the pointer which will be updated with the pointer to bus request object and in the parameter **brq_mask** the reference where bus request mask will be stored. Bus request mask identifies the bit in bus request object responsible for particular bus request identified bu **brq_handle** parameter. The procedure is invoked as follows:

```
brq_handle_t brq_handle;
const chapi_in * ci = …;
…
// Connect bus request to the bus getting brq_handle as in previous example
…
// Ask for attention objects of the first CPU during the initialization.
volatile unsigned long *attention_object = NULL;
volatile unsigned long *brq_object = NULL;
unsigned long attention_value;
unsigned long brq_mask;
if (ci->get_attention_objects) {
    if(!ci->get_attention_objects(ci,    brq_handle,    0,    attention_object,
attention_value)) {
          // Failure - report error message here
    }
}
if (ci->get_brq_objects) {
    if(!ci->get_brq_objects(ci, brq_handle, 0, brq_object, brq_mask)) {
          // Failure - report error message here
    }
}

// Set bus request and interrupt bus server (CPU) to process it
if(attention_object && brq_object) {
    *brq_object |= brq_mask;
    *attention_object = attention_value;
}
…
// Clear bus request as follows
if(brq_object) {
    *brq_object &= ~brq_mask;
}
```

The example above shows that the CHARON core is not obliged to support the indicated operations. It also indicates why the device instance should remember the **chapi_in** descriptor.

4.9.12 Setup device bus requests

Setup device bus requests operation belongs to the class of operations called “Request to setup bus requests”. The CHARON core initiates such an operation when the time to setup bus requests achieved.

To perform the operation, the initiator invokes a routine identified by the **setup_bus_requests** field of the **chapi_out** descriptor. The procedure is invoked as follows:

```
    const chapi_out * co = …;
    if (co->setup_bus_requests) {
        co->setup_bus_requests (co);
    }
```

The example above shows that the device is not obliged to support the indicated operation.

4.9.13 Bus request acknowledge

Acknowledging the bus interrupt request is currently the only operation defined within the group of operations called “Request for bus interrupt acknowledge”. The CHARON core (one of the CPU instruction interpretation threads) initiates such an operation. The device instance is defined as a target of the operation.

In order to perform the operation, the initiator invokes a routine identified by the **brq_ack** parameter, supplied during the setup of corresponding bus request (). The procedure is invoked as follows:

```
    brq_acknowledge brq_ack = …;
    if (brq_ack) {
        vec = brq_ack (arg1, arg2);
```

```
}
```

The example above shows that the device is not obliged to support the indicated operation. Which means that it is allowed to supply 0 for the **brq_ack** parameter when connecting a bus interrupt to the bus through the **connect_bus_request** entry point of the **chapi_in** descriptor. Note that the CHAPI defines an additional argument, supplied through the **arg1** and the **arg2** parameters, to help the target dispatching requests.

The bus request acknowledge procedure indicated by the **brq_ack** parameter must return the interrupt vector in case of acknowledgement. In this case the CHARON core uses the returned value as the interrupt vector instead of the vector supplied through the previous call to the **connect_bus_request** procedure. If the bus request is not acknowledged, the bus request acknowledge procedure shall return zero (0) indicating that the interrupt vector is not valid.

The CHAPI guarantees that the bus request acknowledge procedure identified by the **brq_ack** argument is invoked in the execution context synchronized to the CPU instruction interpretation thread.

4.10 Reading emulator memory (DATA-OUT DMA)

Reading CHARON memory belongs to the “Direct Memory Access” class of operations. This operation is initiated by the device instance. The CHARON core is defined as the target of the operation. Really it does one or several memcpy from CHARON core to provided buffer.

To perform the operation, the initiator invokes a routine identified by the **read_mem** field of the **chapi_in** descriptor. The initiator provides in the **addr** parameter a starting bus address of the memory region to read from, in the **len** parameter the length of transaction (length of transfer), and in the **buf** parameter the address of the private buffer to transfer to. The procedure is invoked as follows:

```
const chapi_in * ci = …;
if (ci->read_mem) {
    unsigned int t_len = ci->read_mem(ci, addr, len, buf);
    if (t_len < len) {
    }
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It shows why the device instance must remember the **chapi_in** descriptor. Note the processing of the result in the example above. The condition **(t_len < len)** might be considered by the initiator as an attempt to read non-existent memory.

4.11 Writing emulator memory (DATA-IN DMA)

Writing CHARON memory belongs to the “Direct Memory Access” class of operations. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. Really it does one or several memcpy to CHARON core from provided buffer.

To perform the operation, the initiator invokes a routine identified by the **write_mem** field of the chapi_in descriptor. The initiator provides in the **addr** parameter a starting bus address of the memory region to write to, in the **len** parameter the length of transaction (length of transfer), and in the **buf** parameter the address of private buffer to transfer from. The procedure is invoked as follows:

```
const chapi_in * ci = …;
if (ci->write_mem) {
    unsigned int t_len = ci->write_mem(ci, addr, len, buf);
    if (t_len < len) {
    }
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It indicates why the device instance must remember the chapi_in descriptor. Note the processing of the result in the example above. The condition **(t_len < len)** might be considered by the initiator as an attempt to write non-existent memory.

4.12 Synchronizing execution with the CPU thread

Synchronizing execution with the CPU instruction interpretation thread belongs to the “Synchronization request” class of operations. Such an operation is initiated by the device instance. The CHARON core is defined as the target of the operation. More precisely the CPU instruction interpretation thread is required to respond to the operation.

To perform the operation, the initiator invokes a routine identified by the **put_ast** field of the chapi_in descriptor. The initiator provides in the **fun** argument an entry point to the procedure to be synchronized with the CPU instruction interpretation thread, and in the **arg1** and the **arg2** arguments additional parameters to be passed later on to that procedure. The “fun” procedure will be executed after certain number of emulated CPU instructions, specified in “delay”. The procedure is invoked as follows:

```
const chapi_in * ci = …;
if (ci->put_ast) {
    ci->put_ast(ci, delay, fun, arg1, arg2);
}
```

The example above shows that the CHARON core is not required to support the indicated operation. It also shows why the device instance must memorize the chapi_in descriptor.

4.13 Synchronized invocation with the CPU thread(s)

Synchronized invocation (with the CPU instruction interpretation thread) belongs to the class of operations called “Synchronization request acknowledge”.The CHARON core initiates such an operation. The device instance is defined as the target of the operation.

To perform the operation, the initiator invokes a routine identified by the **fun** argument previously supplied in the corresponding request for synchronizing execution to the CPU instruction interpretation thread(s). The initiator provides in the **arg1** and the **arg2** arguments additional parameters previously supplied together with the **fun** argument requesting for synchronizing execution to the CPU instruction interpretation thread(s). The procedure is invoked as follows:

```
ast_handler fun = …;
if (fun) {
    fun(arg1, arg2);
}
```

The example above shows that the device is not obliged to support the indicated operation. It is allowed to supply 0 for the **fun** parameter when requesting synchronizing execution with the CPU instruction interpretation thread(s). Note that the CHAPI defines additional parameters supplied through the **arg1** and the **arg2** arguments to help the target dispatching requests.

The device shall consider the synchronized invocation request as a reaction of the CPU instruction interpretation thread of the CHARON core to the previously issued request for "Synchronizing execution".

The CHAPI guarantees that the procedure identified by the **fun** argument is invoked in the execution context synchronized with the CPU instruction interpretation thread.

4.14 Delaying synchronized execution

Delaying synchronized (with the CPU instruction interpretation thread) execution belongs to the "Synchronization request" class of operations. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. More precisely the CPU instruction interpretation thread is required to respond to the operation.

To perform the operation, the initiator invokes a routine identified by the **put_sst** field of the **chapi_in** descriptor. The initiator provides in the **delay** argument a number of CPU instructions to interpret, in the **fun** argument an entry point to the procedure to be synchronized with the CPU instruction interpretation thread after the specified number of CPU instructions are interpreted ("delay" parameter), and in the **arg1** and the **arg2** arguments additional parameters to be passed later on to that procedure. The **put_sst** routine is invoked as follows:

```
const chapi_in * ci = …;
if (ci->put_sst) {
    ci->put_sst(ci, delay, fun, arg1, arg2);
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. Also it gives an indication why the device instance is supposed to remember the **chapi_in** descriptor.

4.15 Delayed synchronized invocation

The operation of delayed invocation is part of the class of operations called “Synchronization request acknowledge”. The CHARON core initiates such an operation. The device instance is defined as the target of the operation.

In order to perform the operation, the initiator invokes a routine identified by the **fun** argument - previously supplied in the corresponding request - delaying synchronized (with the CPU instruction interpretation thread) execution. The initiator provides in the **arg1** and **arg2** arguments additional parameters previously supplied together with the **fun** argument requesting delaying synchronized (with the CPU instruction interpretation thread) execution. The procedure is invoked as follows:

```
sst_handler fun = …;
if (fun) {
    fun(arg1, arg2);
}
```

The example above shows that the device is not obliged to support the indicated operation. This implies that it is allowed to supply 0 for the **fun** argument when requesting delaying synchronized (to the CPU instruction interpretation thread) execution. Note that the CHAPI defines additional parameters supplied through the **arg1** and **arg2** arguments to help the target dispatching requests.

The device shall consider the delayed synchronized invocation request as a reaction of the CPU instruction interpretation thread of the CHARON core to the previously issued request for “Delaying synchronized execution”.

The CHAPI guarantees that the procedure identified by the **fun** argument is invoked in the execution context synchronized to the CPU instruction interpretation thread.

4.16 Processing a bus power-up condition

Handling the bus power-up condition belongs to the class of operations called “Request for processing bus power events”. The CHARON core initiates such an operation when “powering” up the configured node.

In order to perform the operation, the initiator invokes a routine identified by the **start** field of the **chapi_out** descriptor. The procedure is invoked as follows:

```
const chapi_out * co = …;
if (co->start) {
    co->start(co);
}
```

The example above shows that the device is not obliged to support the indicated operation.

4.17 Processing a bus power-down condition

Handling the bus power-down condition belongs to the class of operations called “Request for processing bus power events”.. The CHARON core initiates such an operation when “powering” down the configured node.

In order to perform the operation, the initiator invokes a routine identified by the **stop** field of the **chapi_out** descriptor. The procedure is invoked as follows:

```
const chapi_out * co = …;
if (co->stop) {
   co->stop(co);
}
```

The example above shows that the device is not obliged to support the indicated operation.

4.18 Processing a bus reset condition

Handling the bus reset condition is currently the only operation defined within the class of operations called “Request for processing bus reset events”. CHARON initiates such an operation when resetting the I/O subsystem of the configured node. A CPU instruction interpretation thread is likely (but not necessarily) the initiator of such an operation.

In order to perform the operation, the initiator invokes a routine identified by the **reset** field of the **chapi_out** descriptor. The procedure is invoked as follows:

```
const chapi_out * co = …;
if (co->reset) {
   co->reset(co);
}
```

The example above shows that the device is not obliged to support the indicated operation.

4.19 Working with configuration options

This set of operations allows loadable component to add required number of different configuration options which are visible for this particular loadable component in the CHARON configuration file. See chapter (5.1) for description of convenient C++ wrappers for configuration option part of CHAPI protocol – they simplify device configuration gratefully.

4.19.1 Adding configuration option

Adding configuration option belongs to the “A request to process loadable component defined configuration options” class of operations. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation.

To perform the operation, the initiator invokes a routine identified by the **add_config_option** field of the **chapi_in** descriptor. The initiator provides in the **opt_name** parameter the name of configuration option to create, in the **opt_type** parameter the type of configuration option to create (**option_type_integer**, **option_type_boolean** and **option_type_string** types are supported), in the **opt_vals_count** the number of values in the option, in the **opt_buffer** parameter the pointer to address where option value should be stored, and in **opt_size** parameter the size of single option value. The size of whole storage, supplied in **opt_buffer** is calculated as **opt_vals_count * opt_size**. The procedure is invoked as follows:

```
// Define option storage somewhere in loadable component implementation
int my_int_opt;
bool my_bool_opt[3];
char my_str_opt[256];
…
const chapi_in * ci = …;
if (ci->add_config_option) {
   // Add scalar integer option
   ci->add_config_option(ci, "int_opt", option_type_integer, 1, &my_int_opt,
sizeof(my_int_opt));
   // Add boolean option with three values
   ci->add_config_option(ci, "bool_opt", option_type_boolean, 3,
         &my_bool_opt, sizeof(my_bool_opt));
   // Add scalar string option
   ci->add_config_option(ci, "str_opt", option_type_string, 1,
         &my_str_opt[0], sizeof(my_str_opt));
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It indicates why the device instance must remember the **chapi_in** descriptor. The valid place to call described operation is loadable device initialization routine. Created configuration options become available in configuration file (see 4.20.2 for example).

4.19.2 Setting option value

Setting option value belongs to the “A request to process loadable component defined configuration options” class of operations. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation.

To perform the operation, the initiator invokes a routine identified by the **set_option_value** field of the **chapi_in** descriptor. The initiator provides in the **opt_name** parameter the name of configuration option to set, in the **opt_val_idx** the index of option value to set (from 0 to **opt_vals_count** - 1) and in the **val** parameter the address of buffer where the option value to set is located. The procedure is invoked as follows assuming that described in the previous chapter options are added during the loadable module initialization:

```
// Define option storage somewhere in loadable component implementation
int my_int_opt;
bool my_bool_opt[3];
char my_str_opt[256];
```

```
…
const chapi_in * ci = …;
if (ci->set_option_value) {
   my_int_opt = 10;
   if(ci->set_option_value(ci, "int_opt", 0, &my_int_opt)) {
         // Ok, new option value is set. It is usually used to set defaults
when no values is
         // specified in configuration file.
         …
   }
   my_bool_opt[1] = true;
   if(ci->set_option_value(ci, "bool_opt", 1, &my_bool_opt[1])) {
         // Ok, new option value is set for the second value of
         // 'bool_opt' option. It is usually used to set defaults when
         // no values is specified in configuration file.
         …
   }
   if(ci->set_option_value(ci, "str_opt", 0, "Some new string value")) {
         // Ok, new option value is set. It is usually used to set
         // defaults when no values is specified in configuration file.
         …
   }
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It indicates why the device instance must remember the **chapi_in** descriptor.

4.19.3 Undoing last change of configuration option value

Undoing option value belongs to the "A request to process loadable component defined configuration options" class of operations. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation.

To perform the operation, the initiator invokes a routine identified by the **undo_option_value** field of the **chapi_in** descriptor. The initiator provides in the **opt_name** parameter the name of configuration option to undo value of and in the **opt_val_idx** the index of option value to undo (from 0 to **opt_vals_count** - 1). The procedure is invoked as follows assuming that described in the previous chapter options are added during the loadable module initialization:

```
// Define option storage somewhere in loadable component implementation
int my_int_opt;
bool my_bool_opt[3];
char my_str_opt[256];
…
const chapi_in * ci = …;
if (ci->undo_option_value) {
   // Undo last changes in bool_opt values for some reason
   for(int idx = 0; idx < 3; idx++) {
         ci->undo_option_value(ci, "bool_opt", idx);
```

```
        }
    }
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It indicates why the device instance must remember the **chapi_in** descriptor.

4.19.4 Committing last change of configuration option value

Committing option value belongs to the “A request to process loadable component defined configuration options” class of operations. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. Option value changed in configuration file has to be committed in order to update value in loadable component configuration option buffer.

To perform the operation, the initiator invokes a routine identified by the **commit_option_value** field of the **chapi_in** descriptor. The initiator provides in the **opt_name** parameter the name of configuration option to commit value of and in the **opt_val_idx** the index of option value to commit (from 0 to **opt_vals_count** - 1). The procedure is invoked as follows assuming that described in the previous chapter options are added during the loadable module initialization:

```
// Define option storage somewhere in loadable component implementation
int my_int_opt;
bool my_bool_opt[3];
char my_str_opt[256];
…
const chapi_in * ci = …;
if (ci->commit_option_value) {
   // Commit last changes in bool_opt values in order to
   // update our configuration buffers
   for(int idx = 0; idx < 3; idx++) {
         ci->commit_option_value(ci, "bool_opt", idx);

   }
 }
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It indicates why the device instance must remember the **chapi_in** descriptor.

4.19.5 Checking if configuration option value is specified

Checking if configuration option value is specified belongs to the “A request to process loadable component defined configuration options” class of operations. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. This operation is commonly used in order to check before the device start if all required option values are specified and set default values if not.

To perform the operation, the initiator invokes a routine identified by the **is_option_value_specified** field of the **chapi_in** descriptor. The initiator provides in the

opt_name parameter the name of configuration option to check and in the **opt_val_idx** the index of option value to check (from 0 to **opt_vals_count** - 1). The procedure is invoked as follows assuming that described in the previous chapter options are added during the loadable module initialization:

```
// Define option storage somewhere in loadable component implementation
int my_int_opt;
bool my_bool_opt[3];
char my_str_opt[256];
…
const chapi_in * ci = …;
if (ci->is_option_value_specified) {
   // Check if all values are specified and setup default values if not
   for(int idx = 0; idx < 3; idx++) {
         if(!ci->is_option_value_specified(ci, "bool_opt", idx)) {
               my_bool_opt[idx] = false;
               ci->set_option_value(ci, "bool_opt", idx, &my_bool_opt[idx]);
               ci->commit_option_value(ci, "bool_opt", idx);
               ci->option_value_change_ack(ci, "bool_opt", idx);
         }
   }
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It indicates why the device instance must remember the **chapi_in** descriptor.

4.19.6 Checking if configuration option value is changed

Checking if configuration option value is changed belongs to the “A request to process loadable component defined configuration options” class of operations. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. This operation is commonly used in routine identified by the **set_configuration_ex** entry in **chapi_out** communication context in order to identify the change in configuration parameter and update internal configuration option buffers.

To perform the operation, the initiator invokes a routine identified by the **is_option_value_changed** field of the **chapi_in** descriptor. The initiator provides in the **opt_name** parameter the name of configuration option to check and in the **opt_val_idx** parameter the index of option value to check (from 0 to **opt_vals_count** - 1). The procedure is invoked as follows assuming that described in the previous chapter options are added during the loadable module initialization:

```
// Define option storage somewhere in loadable component implementation
int my_int_opt;
bool my_bool_opt[3];
char my_str_opt[256];
…
const chapi_in * ci = …;
if (ci->is_option_value_changed) {
   // Check / commit values
   for(int idx = 0; idx < 3; idx++) {
         if(!ci->is_option_value_changed(ci, "bool_opt", idx)) {
               // Need to commit in order to see the change in
               // internal option buffer
               if(ci->commit_option_value) {
                     ci->commit_option_value(ci, "bool_opt", idx);
               }
               if(ci->option_value_change_ack) {
                     ci->option_value_change_ack(ci, "bool_opt", idx);
               }
         }
   }
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It indicates why the device instance must remember the **chapi_in** descriptor.

4.19.7 Acknowledging configuration option value changes

Acknowledging configuration option value change belongs to the "A request to process loadable component defined configuration options" class of operations. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. This operation is commonly used after the call to routine identified by the **commit_option_value** entry of **chapi_in** communication context in order to switch off the 'change' flag for the value.

To perform the operation, the initiator invokes a routine identified by the **option_value_change_ack** field of the **chapi_in** descriptor. The initiator provides in the **opt_name** parameter the name of configuration option to acknowledge the change for and in the **opt_val_idx** parameter the index of option value to acknowledge the change for (from 0 to **opt_vals_count** - 1). See invocation example in the chapter above.

The example above shows that the CHARON core is not obliged to support the indicated operation. It indicates why the device instance must remember the **chapi_in** descriptor.

4.19.8 Setting and disabling configuration option value

Setting and disabling configuration option value belongs to the "A request to process loadable component defined configuration options" class of operations. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. This operation is commonly used when option allows only predefined value with no possibility to change it. Further call to routine identified by the **commit_option_value** entry of **chapi_in** communication context will switch off the 'change' flag for the value and disable its further modification.

To perform the operation, the initiator invokes a routine identified by the **set_and_disable_option_value** field of the **chapi_in** descriptor. The initiator provides in the **opt_name** parameter the name of configuration option to set the value for, in the **opt_val_idx** parameter the index of option value to set value for (from 0 to **opt_vals_count** - 1) and value to set in the **val** parameter. See invocation example in the chapter 4.19.2 (just change the name of called entry from **set_option_value** to **set_and_disable_option_value**).

The example shows that the CHARON core is not obliged to support the indicated operation. It indicates why the device instance must remember the **chapi_in** descriptor.

4.19.9 Enabling option value

Enabling configuration option value belongs to the “A request to process loadable component defined configuration options” class of operations. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. This operation changes specified option value access level using the following rules: access level of the option value is changed to "enabled" whenever option value has not been hidden or forced enable is requested, otherwise the access level is not changed.

To perform the operation, the initiator invokes a routine identified by the **enable_option_value** field of the **chapi_in** descriptor. The initiator provides in the **opt_name** parameter the name of configuration option to change access level for, in the **opt_val_idx** parameter the index of option value to change access level for (from 0 to **opt_vals_count** - 1) and forced enable request in the **force** parameter. Invocation example is below:

```
// Define option storage somewhere in loadable component implementation
int my_int_opt;
bool my_bool_opt[3];
…
const chapi_in * ci = …;
if (ci->enable_option_value) {
   // Enable option values forcing it in case of hidden one
   for(int idx = 0; idx < 3; idx++) {
         ci->enable_option_value(ci, "bool_opt", idx, true);
   }

   // Enable option value only if it is not hidden - left disabled
   // otherwise
   ci->enable_option_value(ci, "int_opt", 0, false);

}
```

The example shows that the CHARON core is not obliged to support the indicated operation. It indicates why the device instance must remember the **chapi_in** descriptor.

4.19.10 Freezing option value

Freezing configuration option value belongs to the “A request to process loadable component defined configuration options” class of operations. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. This operation makes specified option value access level readonly.

To perform the operation, the initiator invokes a routine identified by the **freeze_option_value** field of the **chapi_in** descriptor. The initiator provides in the **opt_name** parameter the name of configuration option to change access level for and in the **opt_val_idx** parameter the index of option value to change access level for (from 0 to **opt_vals_count** - 1). Invocation example is below:

```
// Define option storage somewhere in loadable component implementation
int my_int_opt;
bool my_bool_opt[3];
…
const chapi_in * ci = …;
if (ci->freeze_option_value) {
   // Freeze all option values for the "bool_opt"
   for(int idx = 0; idx < 3; idx++) {
         ci->freeze_option_value(ci, "bool_opt", idx);
   }

}
```

The example shows that the CHARON core is not obliged to support the indicated operation. It indicates why the device instance must remember the **chapi_in** descriptor.

4.19.11 Disabling option value

Disabling configuration option value belongs to the “A request to process loadable component defined configuration options” class of operations. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. This operation makes specified option value hidden for the external entities.

To perform the operation, the initiator invokes a routine identified by the **disable_option_value** field of the **chapi_in** descriptor. The initiator provides in the **opt_name** parameter the name of configuration option to change access level for and in the **opt_val_idx** parameter the index of option value to change access level for (from 0 to **opt_vals_count** - 1). Invocation example is below:

```
// Define option storage somewhere in loadable component implementation
int my_int_opt;
bool my_bool_opt[3];
…
const chapi_in * ci = …;
if (ci->disable_option_value) {
   // Disable all option values for the “bool_opt”
   for(int idx = 0; idx < 3; idx++) {
         ci->disable_option_value(ci, “bool_opt”, idx);
   }
}
```

The example shows that the CHARON core is not obliged to support the indicated operation. It indicates why the device instance must remember the **chapi_in** descriptor.

4.19.12 Chacking if option value is hidden

Checking if configuration option value is hiodden belongs to the “A request to process loadable component defined configuration options” class of operations. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. This operation checks if specified value of specified configuration option is hidden from external entities or not.

To perform the operation, the initiator invokes a routine identified by the **is_option_value_hidden** field of the **chapi_in** descriptor. The initiator provides in the **opt_name** parameter the name of configuration option to check access level for and in the **opt_val_idx** parameter the index of option value to check access level for (from 0 to **opt_vals_count** - 1). Invocation example is below:

```
    // Define option storage somewhere in loadable component implementation
    int my_int_opt;
    bool my_bool_opt[3];
    …
    const chapi_in * ci = …;
    if (ci->is_option_value_hidden && ci->enable_option_value) {
        // Enable option values if they are hidden
        for(int idx = 0; idx < 3; idx++) {
              if(ci->is_option_value_hidden(ci, “bool_opt”, idx)) {
                    ci->enable_option_value(ci, “bool_opt”, idx, true);
              }
        }
    }
```

The example shows that the CHARON core is not obliged to support the indicated operation. It indicates why the device instance must remember the **chapi_in** descriptor.

4.20 Changing the configuration

There are two different ways to change configuration for the CHAPI device – the old one based on a single predefined configuration option **parameters** and the new way based on device defined configuration options. Both ways are described below but the new one is preferable.

4.20.1 The legacy way of changing the configuration

The legacy way of changing the configuration belongs to the class of operations called “Request for changing the configuration”. The CHARON core initiates such an operation when loading the configuration. The CHAPI defines the additional configuration option **parameters**, and passes the device specific configuration information to the device instance as indicated by the following example:

```
load chapi <CFG-NAME>
set <CFG-NAME> dll=<PATH-TO-DLL> parameters=”…”
```

To perform the operation, the initiator invokes a routine identified by the **set_configuration** field of the **chapi_out** descriptor. The initiator provides in the **parameters** argument a character string, as specified in the configuration for the **parameters** option. The procedure is invoked as follows:

```
const chapi_out * co = …;
if (co->set_configuration) {
   co->set_configuration(co, parameters);
}
```

The example above shows that the device is not obliged to support the indicated operation.

4.20.2 The recommended way of changing the configuration

The recommended way of changing the configuration belongs to the class of operations called “Request for changing the configuration”. The CHARON core initiates such an operation when loading the configuration. A loadable device can define its required configuration options during the initialization cycle (see section 4.19 for details and examples). These options become available in configuration file after that cycle and provide a more convenient way to configure a loadable device. There is a restriction how these options should be specified in configuration file: they have to be specified in after **dll** configuration option specification and not on the same line of the dll specification.

Assuming that a loadable component has defined three options as described above – **int_opt**, **bool_opt** and **str_opt**. It would be configured as follows:

```
load chapi <CFG-NAME>
// our options are not visible at the line below
set <CFG-NAME> dll=<PATH-TO-DLL>
// … but visible at the next line and any other one in configuration file
set <CFG-NAME> int_opt=<INTEGER_NUMBER> str_opt=<STRING_CONSTANT>
set <CFG-NAME> bool_opt[x]=<false|true>
```

To perform the operation, the initiator invokes a routine identified by the **set_configuration_ex** field of the **chapi_out** descriptor. This call notifies a loadable component that one of its configuration options are changed and should be processed somehow (see 4.19.2 for examples). The procedure is invoked as follows:

```
const chapi_out * co = …;
if (co->set_configuration_ex) {
   co->set_configuration_ex(co);
}
```

The example above shows that the device is not obliged to support the indicated operation.

4.21 Message logging

The legacy way to log messages has been preserved for compatibility reasons. The new method has two options to handle debug trace and messaging.

4.21.1 The legacy way of message logging

Message logging belongs to the class of operations called “Message log request”.

CHARON enables the component that logs messages in the emulator’s log file. Both the CHARON core and the loadable component may initiate such an operation, but only the emulator can be a target.

To perform the operation, the initiator invokes a routine identified by the **log_message** field of the **chapi_in** descriptor. The initiator provides a formatted message in a buffer, pointed to by the **buf** argument, of a length (in bytes) as indicated by the **len** argument. The procedure is invoked as follows:

```
const chapi_in * ci = …;
if (ci->log_message) {
   ci->log_message(ci, buf, len);
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It also shows why the loadable component instance must remember the **chapi_in** descriptor.

4.21.2 The recommended way for message logging

Message logging belongs to the class of operations called “Message log request”.

CHARON enables the component that logs messages in the emulator’s log file. Both the CHARON core and the loadable component may initiate such an operation, but only the emulator can be a target.

To perform the operation, the initiator invokes a routine identified by the **log_message_ex** field of the **chapi_in** descriptor. The initiator provides in the **log_msg_type** parameter the type of message to log (**error_msg_type**, **warning_msg_type** and **info_msg_type** can be used here), in the **file** parameter the name of the file where the message is coming from (**__FILE__** define should be passed there), in the **line** parameter the line of code where the message is logged from (**__LINE__** define should be passed there), in the **log_msg_id** parameter the identifier of the message to log and in the **fmt** parameter the format string like in **printf** C runtime call and variable number of parameters to be used in accordance with the **fmt** parameter. The procedure is invoked as follows:

```
const chapi_in * ci = …;
if (ci->log_message_ex) {
   ci->log_message_ex(ci, error_msg_type, __FILE__, __LINE__,
      msg_my_msg_id, "The call has failed with the code %d.",
      GetLastError());
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It also shows why the loadable component instance must remember the **chapi_in** descriptor.

Message identifiers definition for the CHAPI device

Each CHAPI device have to define a set of unique messages based on predefined rules. It is done to facilitate problem identification and allow per module multilanguage message support in the future – message codes it the first step – further features will be added in one of the next releases.

The following CHAPI message code format is proposed:

31 24 23 16 15 0

<vendor_id> <device_id> <message_id>

Unique vendor id should be assigned by Geneva to everyone who wants to develop using CHAPI. VENDOR_ID_SRI = 0 is reserved for STROMASYS developed CHAPI modules;

Device id should be unique for each device with the same vendor id. How to assign device id to particular device is up to its vendor;

Message id should be unique in scope of particular CHAPI module. Message ids assignement is up to module developer.

CHAPI_MSG_ID(vendor, device, code) macro is defined to construct complete message id based on its components.

Examples of message id definitions can be found in supplied example CHAPI modules sources.

4.21.3 Debug trace

Debug trace belongs to the class of operations called “Message log request”.

CHARON enables the component that logs debug trace messages in the emulator's log file. Both the CHARON core and the loadable component may initiate such an operation, but only the emulator can be a target.

To perform the operation, the initiator invokes a routine identified by the **debug_trace** field of the **chapi_in** descriptor. The initiator provides in the **trace_level** parameter the trace level for the message, in the **fmt** parameter the format string like in **printf** C runtime call and variable number of parameters to be used in accordance with the **fmt** parameter. The procedure is invoked as follows:

```
const chapi_in * ci = …;
if (ci->debug_trace) {
   ci->debug_trace(ci, 3, "%d bytes of %d requested are read.",
      bytes_read, total_bytes_to_read);
}
```

trace_level parameter allows to split debug message to different levels of details. Loadable device configuration parameter **trace_level** defines which messages are shown and which aren't using the following rule: shown only those messages which level is less or equal to the currently configured trace level, other ones aren't shown. This allows tuning debug trace messages without loadable component rebuild.

The example above shows that the CHARON core is not obliged to support the indicated operation. It also shows why the loadable component instance must remember the **chapi_in** descriptor.

4.22 Retrieving serial number of the license key

The operation of retrieving serial number of used license key belongs to the class of operations called "Protection and license verification". The CHARON core enables the component to know installed license number. Both the CHARON core and the loadable component may initiate such an operation, but only the emulator can be a target.

In order to perform the operation, the initiator invokes a routine identified by the **get_license_no** field of the **chapi_in** descriptor. The initiator provides a pointer to variable where to store the license serial number. This pointer corresponds to the **hl_serial_no** argument. The procedure is invoked as follows:

```
const chapi_in * ci = …;
unsigned int hl_serial_no;
if (ci->get_license_no) {
   if(ci->get_license_no(ci, &hl_serial_no)) {
         // Ok, license key serial number is stored in hl_serial_no
   }
   else {
         // Unable to get the license number - some problems with
         // license key!!!
   }
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It also shows why the loadable component instance must retain the **chapi_in** descriptor.

4.23 Encrypting critical data

The operation of encrypting protected data belongs to the class of operations called "Protection and license verification". The CHARON core enables the component encrypting critical data. Both the CHARON core and the loadable component may initiate such an operation, but only the emulator can be a target.

In order to perform the operation, the initiator invokes a routine identified by the **encrypt_data_block** field of the **chapi_in** descriptor. The initiator provides a buffer containing critical data. The length of the buffer (in bytes) must be a multiple of 8. The buffer's address and length are indicated by **buf** and **len** arguments respectively. Encrypted data will overwrite originally supplied data in buffer **buf**. The procedure is invoked as follows:

```
const chapi_in * ci = …;
if (ci->encrypt_data_block) {
   ci->encrypt_data_block(ci, buf, len);
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It also shows why the loadable component instance must retain the **chapi_in** descriptor.

4.24 Decrypting critical data

The operation of decrypting protected data belongs to the class of operations called "Protection and license verification". The CHARON core enables the component decrypting encrypted data. Both the CHARON core and the loadable component may initiate such an operation, but only the emulator can be a target.

In order to perform the operation, the initiator invokes a routine identified by the **decrypt_data_block** field of the **chapi_in** descriptor. The initiator provides a buffer containing encrypted data. The length of the buffer (in bytes) must be a multiple of 8. The buffer's address and length are indicated by **buf** and **len** arguments respectively. Decrypted data will overwrite originally supplied data in buffer **buf**. The procedure is invoked as follows:

```
const chapi_in * ci = …;
if (ci->decrypt_data_block) {
   ci->decrypt_data_block(ci, buf, len);
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It also shows why the loadable component instance must retain the **chapi_in** descriptor.

4.25 Intercept bus address space (CHARON deep integration)

The operation of intercepting bus address space belongs to the class of operations called “Bus adapter support requests”, Using this function could require Stromasys consulting. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. This operation is commonly used in bus adapter’s implementation when it is necessary to intercept the whole address space of particular bus.

In order to perform the operation, the initiator invokes a routine identified by the **intercept_bus_address_space** field of the **chapi_in** descriptor. The procedure is invoked as follows:

```
const chapi_in * ci = …;
if (ci->intercept_bus_address_space) {
   ci-> intercept_bus_address_space (ci);
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It also shows why the loadable component instance must retain the **chapi_in** descriptor.

4.26 Release bus address space (CHARON deep integration)

The operation of releasing bus address space belongs to the class of operations called “Bus adapter support requests”, Using this function could require Stromasys consulting. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. This operation is commonly used in bus adapter’s implementation when it is necessary to release intercepted bus address space of particular bus.

In order to perform the operation, the initiator invokes a routine identified by the **release_bus_address_space** field of the **chapi_in** descriptor. The procedure is invoked as follows:

```
const chapi_in * ci = …;
if (ci->release_bus_address_space) {
   ci->release_bus_address_space (ci);
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It also shows why the loadable component instance must retain the **chapi_in** descriptor.

4.27 Get configured RAM size

The operation of getting configured RAM size belongs to the class of operations called “Replacement hardware support requests”. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. This operation is used to define the size of configured memory in bytes.

In order to perform the operation, the initiator invokes a routine identified by the **get_configured_ram_size** field of the **chapi_in** descriptor. The procedure is invoked as follows:

```
const chapi_in * ci = …;
if (ci->get_configured_ram_size) {
   ci-> get_configured_ram_size (ci);
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It also shows why the loadable component instance must retain the **chapi_in** descriptor.

4.28 Get RAM segment information (CHARON deep integration)

The operation of getting RAM segment information belongs to the class of operations called "Replacement hardware support requests", Using this function could require Stromasys consulting. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. This operation is commonly used in different replacement DMA hardware to get required characteristics of RAM segment to map it for DMA.

In order to perform the operation, the initiator invokes a routine identified by the **get_ram_segment** field of the **chapi_in** descriptor. The initiator provides int the **n_of_segment** parameter the number of RAM segment to get information for (numeration is started from 0), in the **addr** parameter the reference where to store start RAM address of segment and in the **base** parameter the reference where to store the pointer to the start host virtual address of RAM segment. The procedure is invoked as follows:

```
const chapi_in * ci = …;
unsigned int seg_addr;
char *seg_base;
unsigned int seg_size;
…
// Check required entry in chapi_in structure
if(!ci || !ci->get_ram_segment) {
      return;
}

// Process all RAM segments one by one somehow...
int seg_num = 0;
while((seg_size = ci->get_ram_segment(ci, seg_num, seg_addr, seg_base))) {
      // Ok, next segment with seg_size bytes length retreived,
      // process it somehow and step to the next one while the
      // last is retreived.
      …
      seg_num++;
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It also shows why the loadable component instance must retain the **chapi_in** descriptor.

4.29 Translate emulator's memory for DMA (CHARON deep integration)

The operation of translating emulator's memory for DMA belongs to the class of operations called "Replacement hardware support requests", Using this function could require Stromasys consulting. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. This operation is commonly used when piece of emulator's memory have to be translated for DMA

In order to perform the operation, the initiator invokes a routine identified by the **translate_for_dma** field of the **chapi_in** descriptor. The initiator provides int the **addr** parameter the starting address within the particular bus, in the **len** parameter the length of memory to translate in bytes and in the **buf** parameter the location where to store starting address of translated block within the emulator process memory space. Number of bytes in contiguous translated block is returned as result. The procedure is invoked as follows:

```
const chapi_in * ci = …;
udword_t bus_addr;
char *seg_start;
unsigned int seg_size;
…
// Calculate bus_addr somehow …
bus_addr = …

// Check required entry in chapi_in structure
if(ci && ci->translate_for_dma) {
      seg_size = ci->translate_for_dma(ci, bus_addr, seg_start);
      if(seg_size > 0) {
           // Ok, success, see seg_start for start address of the block
      }
      else {
          // Failed to translate - report error somehow
          …
      }
}
```

The example above shows that the CHARON core is not obliged to support the indicated operation. It also shows why the loadable component instance must retain the chapi_in descriptor.

4.30 Generate bus events (CHARON deep integration)

This group of calls designated for the case when particular device wants to signal access to non-existent memory location. It might be the case when device register's set contains gaps or device implement some kind of bus adapter with the whole bus address space interception. All these calls belong to the group of operations called "Bus adapter support requests" ", Using this function could require Stromasys consulting. They are initiated by the device instance. The CHARON core is defined as a target of these operations. Particular event specific details are provided in chapters below.

4.30.1 read bus timeout

In order to perform the operation, the initiator invokes a routine identified by the **read_bus_timeout** field of the **chapi_in** descriptor. The procedure is invoked as follows:

```
const chapi_in * ci = …;
if (ci->read_bus_timeout) {
   ci-> read_bus_timeout (ci);
}
```

4.30.2 read bus abort

In order to perform the operation, the initiator invokes a routine identified by the **read_bus_abort** field of the **chapi_in** descriptor. The procedure is invoked as follows:

```
const chapi_in * ci = …;
if (ci->read_bus_abort) {
   ci-> read_bus_ abort (ci);

}
```

4.30.3 write bus timeout

In order to perform the operation, the initiator invokes a routine identified by the **write_bus_timeout** field of the **chapi_in** descriptor. The procedure is invoked as follows:

```
const chapi_in * ci = …;
if (ci->write_bus_timeout) {
   ci-> write_bus_timeout (ci);

}
```

4.30.4 write bus abort

In order to perform the operation, the initiator invokes a routine identified by the **write_bus_abort** field of the **chapi_in** descriptor. The procedure is invoked as follows:

```
const chapi_in * ci = …;

if (ci->write_bus_abort) {

   ci-> write_bus_abort (ci);

}
```

The examples above show that the CHARON core is not obliged to support the indicated operations. It also shows why the loadable component instance must retain the **chapi_in** descriptor.

4.31 Update of bus mapping registers (CHARON deep integration)

Update of bus mapping register belongs to the class of operations called “Replacement hardware support requests” ”, Using this function could require Stromasys consulting. The CHARON core initiates such an operation when particular bus mapping register is updated.

To perform the operation, the initiator invokes a routine identified by the **mapping_register_updated** field of the **chapi_out** descriptor. The initiator provides in the **reg_no** parameter a number of updated bus mapping register and in the **val** parameter the value written to the bus mapping register. The procedure is invoked as follows:

```
const chapi_out * co = …;
if (co->mapping_register_updated) {
   co-> mapping_register_updated (co, reg_no, val);
}
```

The example above shows that the device is not obliged to support the indicated operation.

4.32 Get bus type

The operation of getting bus type we are connected to belongs to the class of operations called “A request for changing the configuration and support requests”. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. This operation is commonly used by devices which implementation is almost but not exactly the same for different bus types (QBUS/UNIBUS) – it is possible to switch correctly from one bus specific to another in device implementation.

In order to perform the operation, the initiator invokes a routine identified by the **get_bus_type** field of the **chapi_in** descriptor. The procedure is invoked as follows:

```
void chapi_rlv12_t::start()
{
    int i;

…

    // Remember bus type we are connected to for the further usage
    if(ci && ci->get_bus_type){
        if(ci->get_bus_type(ci) == UNIBUS){
            bus_type = UNIBUS;
        }
        if(ci->get_bus_type(ci) == QBUS){
            bus_type = QBUS;
        }

    }

…

}
```

4.33 Get bus address range

The operation of getting bus address range belongs to the class of operations called "A request for changing the configuration and support requests". Such an operation is initiated by the CHARON core. The device instance is defined as a target of the operation. This operation is commonly used by devices which implementation is almost but not exactly the same for different bus types (QBUS/UNIBUS) – it is possible to inform CHARON core about particular bus register window size.

In order to perform the operation, the initiator invokes a routine identified by the **get_bus_address_range** field of the **chapi_out** descriptor. The procedure is invoked as follows from CHARON core when it connects default device address space to the bus:

```
//
// Address window size maybe different for different buses supported by the same
// device implementation. In this case device can give us appropriate range
// depending on bus type device is connected to.
//
if(communication_context.co.get_bus_address_range) {
    b_address_range = communication_context.co.get_bus_address_range(
       &communication_context.co, bus_type);

}
```

The example above shows that the device is not obliged to support the indicated operation.

4.34 Versioning information support requests

4.34.1 Getting product identification string

The operation of getting product identification string belongs to the class of operations called "Versioning information support requests". Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. This operation can be used when CHAPI device need to use product identification string somehow.

In order to perform the operation, the initiator invokes a routine identified by the **get_product_ident** field of the **chapi_in** descriptor. The procedure should be invoked like follows from device instance:

```
char *prod_id_str;
…
if(ci && ci->get_product_ident) {
      prod_id_str = ci->get_product_ident(ci);
}
else {
      // No valid communication context - issue error message if necessary
      prod_id_str = 0;
}
```

4.34.2 Getting running hardware model string

The operation of getting running hardware model string belongs to the class of operations called “Versioning information support requests”. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. This operation can be used when CHAPI device need to use running hardware model string somehow, e.g. to check that the running model is accepted for emulated device.

In order to perform the operation, the initiator invokes a routine identified by the **get_hardware_model** field of the **chapi_in** descriptor. The procedure should be invoked like follows from device instance:

```
char *hw_model_str;
…
if(ci && ci->get_hardware_model) {
      hw_model_str = ci->get_hardware_model(ci);
}
else {
      // No valid communication context - issue error message if necessary
      hw_model_str = 0;
}
```

4.34.3 Getting running hardware name string

The operation of getting running hardware name string belongs to the class of operations called “Versioning information support requests”. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. This operation can be used when CHAPI device need to use running hardware name string somehow.

In order to perform the operation, the initiator invokes a routine identified by the **get_hardware_name** field of the **chapi_in** descriptor. The procedure should be invoked like follows from device instance:

```
char *hw_name_str;
…
if(ci && ci->get_hardware_name) {
      hw_name_str = ci->get_hardware_name(ci);
}
else {
      // No valid communication context - issue error message if necessary
      hw_name_str = 0;
}
```

4.34.4 Getting product copyright string

The operation of getting product copyright string belongs to the class of operations called “Versioning information support requests”. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. This operation can be used when CHAPI device need to use product copyright string somehow, e.g. to make combined copyright string for developed CHAPI device.

In order to perform the operation, the initiator invokes a routine identified by the **get_product_copyright** field of the **chapi_in** descriptor. The procedure should be invoked like follows from device instance:

```
char *prod_copy_str;
…
if(ci && ci->get_product_copyright) {
      prod_copy_str = ci->get_product_copyright(ci);
}
else {
      // No valid communication context - issue error message if necessary
      prod_copy_str = 0;
}
```

4.34.5 Getting product custom string

The operation of getting product custom string belongs to the class of operations called "Versioning information support requests". Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. This operation can be used when CHAPI device need to use product custom string somehow.

In order to perform the operation, the initiator invokes a routine identified by the **get_product_custom_string** field of the **chapi_in** descriptor. The procedure should be invoked like follows from device instance:

```
char *prod_cust_str;
…
if(ci && ci->get_product_custom_string) {
      prod_cust_str = ci->get_product_custom_string(ci);
}
else {
      // No valid communication context - issue error message if necessary
      prod_cust_str = 0;
}
```

4.34.6 Getting product major version number

The operation of getting product major version number belongs to the class of operations called "Versioning information support requests". Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. This operation can be used when CHAPI device need to use product major number somehow, e.g. to check product version to be greater than something.

In order to perform the operation, the initiator invokes a routine identified by the **get_product_major_version** field of the **chapi_in** descriptor. Procedure invocation example will be given later.

4.34.7 Getting product minor version number

The operation of getting product minor version number belongs to the class of operations called "Versioning information support requests". Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. This operation can be used when CHAPI device need to use product minor number somehow, e.g. to check product version to be greater than something.

In order to perform the operation, the initiator invokes a routine identified by the **get_product_minor_version** field of the **chapi_in** descriptor. Procedure invocation example will be given later.

4.34.8 Getting product build number

The operation of getting product build version number belongs to the class of operations called "Versioning information support requests". Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. This operation can be used when CHAPI device need to use product build number somehow, e.g. to check product build to be greater than something.

In order to perform the operation, the initiator invokes a routine identified by the **get_product_build_version** field of the **chapi_in** descriptor. The example of invocation of three version number routines is bellow:

```
const int v_major = 1;
const int v_minor = 5;
const int v_build = 88;
…
if(ci && ci->get_product_buld_version &&
      v_build <= ci->get_product_build_no(ci))
{
      // Ok, build is ok, continue checking...
      if(ci->get_product_major_version && ci->get_product_minor_version) {
            v_prod_major = ci->get_product_major_version(ci);
            v_prod_minor = ci->get_product_minor_version(ci);
            if(v_prod_major >= v_major && v_prod_minor >= v_minor) {
                  // Ok, version checking done...
                  ...
            }
            else {
                  // Product version check failed - report error
                  ...
            }
      }
      else {
            // Product version check failed - report error
      }
}
else {
      // Product build number is less than required - report error
      ...
}
```

4.34.9 Getting CHAPI major version number

The operation of getting chapi major version number belongs to the class of operations called "Versioning information support requests". Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. This operation can be used when CHAPI device need to check that some functionality is supported by the running emulator CHAPI subsystem.

In order to perform the operation, the initiator invokes a routine identified by the **get_chapi_major_version** field of the **chapi_in** descriptor. Procedure invocation example will be given later.

4.34.10 Getting CHAPI minor version number

The operation of getting chapi minor version number belongs to the class of operations called “Versioning information support requests”. Such an operation is initiated by the device instance. The CHARON core is defined as a target of the operation. This operation can be used when CHAPI device need to check that some functionality is supported by the running emulator CHAPI subsystem.

In order to perform the operation, the initiator invokes a routine identified by the **get_chapi_minor_version** field of the **chapi_in** descriptor. Procedure invocation example is bellow.

```
// Check that CHAPI subsystem of running emulator version is greater or equal
// one used for CHAPI madule development
if(ci && ci->get_chapi_major_version && ci->get_chapi_minor_version) {
      int cv_major = ci->get_chapi_major_version(ci);
      int cv_minor = ci->get_chapi_minor_version(ci);
      if(cv_major < CHAPI_MAJOR_VERSION_NO ||
  (cv_major == CHAPI_MAJOR_VERSION_NO) && cv_minor < CHAPI_MINOR_VERSION_NO)
{
      // It means running emulator CHAPI subsystem has some previous
      // version than we’ve developed module for. Issue error for example
      …
}
else {
      // Version check succeeded - proceed to run…
      …
}
}
```

5.CHAPI support libraries

***Note:** While using any of mentioned below libraries be sure that correspondent DLL files are in the same location as CHAPI device DLL file and emulator executable or the path to these DLL files are added to the system PATH environment variable.*

5.1 General CHAPI support library

5.1.1 Library files

General CHAPI support library consists of:

1) Header file which contains all definitions – **chapi_lib.h**;
2) Library files to link with in order to use the library – release **chapi.lib, debug chapid.lib**;
3) Dynamically linked library, containing all implementation – release **chapi.dll**, debug chapid.dll

Library source codes aren't provided.

5.1.2 Library description

The main goal is to simplify usage of some CHAPI protocol parts by means of C++ wrappers. Current version of library contains some useful type definitions, registers access functions, wrappers to handle bus requests and configuration options, macros to log messages and debug trace messages conveniently and other useful things.

Type definitions

```
// typical lengths of io transactions on the emulated bus
enum io_size_t {
    io_byte_t = 0,      // LOG2(sizeof(byte_t))
    io_word_t = 1,      // LOG2(sizeof(word_t))
    io_dword_t = 2,     // LOG2(sizeof(dword_t))
    io_qword_t = 3,     // LOG2(sizeof(qword_t))
};

typedef char            byte_t;
typedef unsigned char   ubyte_t;

typedef short           word_t;
typedef unsigned short  uword_t;

typedef int             dword_t;
typedef unsigned int    udword_t;


// Some pointers to this types
typedef udword_t *      udword_lp_t;
typedef const udword_t * const_udword_lp_t;
typedef volatile udword_t * volatile_udword_lp_t;

// Some additional types using in chapi library
typedef unsigned int  chapi_timeout_t;
typedef unsigned long chapi_proc_t;
typedef HANDLE        chapi_handle_t;
typedef HANDLE        chapi_event_t;
```

Register access functions

word_t write_byte(int adr, byte_t byte, word_t word)

Where,

adr - is the address to write byte to;

byte - data to write to specified address;

word - word value to write data to;

This function is used to store specified byte properly in specified word. Specified address is used to define if odd or even location of the word should be used to store byte to. Return value represents the target word with properly written byte. This member is commonly used to implement proper byte addressing within the device registers.

word_t read_byte(int adr, word_t word)

Where,

adr - is the address to read byte from;

word - word value to read data from;

This function is used to read the byte properly from specified word. Specified address is used to define if odd or even location of the word should be used to read byte from. Properly read byte is returned as a result of this call. This member is commonly used to implement proper byte addressing within the device registers.

word_t read_reg(int adr, io_size_t type, word_t word)

Where,

adr - is the address of the register to read from;

type - the type of required access (see **io_size_t** definition above);

word - word value represented our register within the emulation;

This function is used to read value from specified word register using specified addressing mode (word or byte). Properly read byte or word is returned as a result of this call.

word_t write_reg(int adr, dword_t val, io_size_t type, word_t word)

Where,

adr - is the address of the register to write to;

val – is the data to write to specified location;

type - the type of required access (see **io_size_t** definition above);

word - word value represented our register within the emulation;

Macro definitions

A few macro definitions available in the library which simplifies messaging:

LOGMSG

The format is follows:

`LOGMSG((_ERR_MSG_, <message_id>, <format string>, ...))` `- log error message`

`LOGMSG((_WARN_MSG_, <message_id>, <format string>, ...))` `- log warning message`

`LOGMSG((_INFO_MSG_, <message_id>, <format string>, ...))` `- log information message`

TRACE

`TRACE((L(k), <format string>, ...)),`

where k in [0, 10] defines trace level.

All macro definitions can be redefined if necessary for particular device implementation.

C++ class templates

Only one class template is available for the moment **template <class t> class l2list.**

This template allows linking any particular C++ objects of the same type derived from this template. The common way to use this template is as follows:

```
class my_data_t : public l2list<my_data_t> {
public:
      my_data_t(my_data_t **list_entrance) {
            this->append(*list_entrance, list_entrance);
      }
```

```
        …
      protected:

        ...

      private:

        ...

      };
```

After that it is possible to link objects of **my_data_t** class together in bi-directional list as follows:

```
      …
      my_data_t *list_of_data = 0;
      …
      new_data *my_data_t = new my_data_t(&list_of_data);
```

C++ wrapper to work with bus requests

CHAPI protocol part relative to the new way of bus requests processing (see 4.9) is wrapped by the C++ class called **chapi_brq_t**. Below is a list of public methods of this wrapper:

Constructors:

```
chapi_brq_t();
chapi_brq_t(int ipl, chapi_brq_acknowledge_p brq_ack, void *arg1, int arg2 = 0);
```

where

ipl - priority at which created bus request sghould be processed;

brq_ack - bus request acknowledge procedure which will be called to acknowledge bus request;

arg1, **arg2** - arguments to be passed to bus request acknowledge procedure.

General public members:

```
bool connect(const struct __chapi_in *ci, int vector);
bool connect(const struct __chapi_in *ci, int ipl,
      chapi_brq_acknowledge_p brq_ack, void *arg1 = 0, int arg2 = 0);
bool connect(const struct __chapi_in *ci, int vector, int ipl,
      chapi_brq_acknowledge_p brq_ack, void *arg1 = 0, int arg2 = 0);
```

where

ci - CHAPI input context specified by the CHARON kernel;

vector - BRQ vector to use;

ipl	-	BRQ level to use;
brq_ack	-	BRQ acknowledge procedure;
arg1, arg2	-	BRQ acknowledge procedure arguments.

All of these members can be used to connect BRQ to the bus. All methods are mapped to the routine specified by the **connect_bus_request** entry in the **chapi_in** communication context. The best place to connect bus requests to the bus is the routine specified in the **setup_bus_requests** entry of **chapi_out** communication context.

```
void set();
```

This member is used in order to set connected bus request. It is mapped to the routine specified by the **set_bus_request** entry in the **chapi_in** communication context.

```
void clear();
```

This member is used in order to clear connected bus request. It is mapped to the routine specified by the **clear_bus_request** entry in the **chapi_in** communication context.

```
void enable(bool ena = true);
```

where

ena – enable BRQ if true, disable it otherwise.

This member is used in order to enable or disable bus request connected to the bus. It is mapped to the routine specified by the **enable_bus_request** entry in the **chapi_in** communication context.

```
void set_vector(int vector);
```

where

vector – is a BRQ vector to set.

This member is used in order to change the vector assigned with bus request.

```
void set_affinity_mask(unsigned int mask = 1);
```

where

mask – CPU affinity mask for specified BRQ.

This member is used in order to set bus request affinity mask which defines the set of bus servers which can process this particular bus request. It is mapped to the routine specified by the **set_affinity_mask** entry in the **chapi_in** communication context.

```
void set_affinity_callback(__chapi_sa_handler_p sa_callback,
        void *arg1, int arg2);
```

where

sa_callback - affinity change callback routine;

arg1 - first argument to the callback;

arg2 - second argument to the callback.

This member is used in order to setup bus request affinity callback which is called when bus request affinity is changed by CHARON core. The call is mapped to the routine identified by the **set_affinity_callback** entry of **chapi_in** communication context.

```
unsigned int get_bus_server_mask();
```

This method retreives bus server mask which specifies if particular CPU number is working as bus server. It is mapped to the routine identified by the **get_bus_server_mask** entry in the **chapi_in** communication context.

```
bool get_attention_objects(unsigned int cpu_no,
        volatile unsigned long *& attention_object,
        unsigned long & attention_value);
```

where

cpu_no - CPU number to get attention objects for;

attention_object - pointer to the location which should be written with specific value to force BRQ checking;

attention_value - value which should be written to specified above location in order to force BRQ checking by the CPU.

This method gets CPU attention objects for particular CPU in order to have possibility to interrupt CPU loop and force CPU to check for BRQs. Attention objects are represented by the pair {address, value to write}. This technique is designed for the case of hardware used in device emulation, pure emulation does not require this stuff. This method is mapped to the routine identified by the **get_attention_objects** entry of the **chapi_in** communication context descriptor

```
bool get_brq_objects(unsigned int cpu_no,
        volatile unsigned long  *& brq_object,
        unsigned long & brq_mask);
```

where

cpu_no - CPU number to get brq objects for;

brq_object - reference to the pointer which will be updated with the pointer to the bus requests mask of specified CPU;

brq_mask - reference to the bus request mask for particular bus request which defines the bit in bus requests server mask correspondent to the bus request.

This method is used to get CPU BRQ objects for particular CPU in order to have direct access to the CPU BRQ mask. This technique is designed for the case of hardware used in device emulation, pure emulation doesn't require this stuff. This method is mapped to the routine identified by the **get_brq_objects** entry of the **chapi_in** communication context.

C++ wrappers to work with configuration options

chapi_cfg_option_t

Basic functionality of option is defined by the class **chapi_cfg_option_t** which establishes constructors to wrap routine identified by the **add_config_option** entry of **chapi_in** communication context and encapsulates the list of option values. This class shouldn’t be used directly during the loadable components development. See description of derived classes below. Here is the list of public members:

```
chapi_cfg_option_t(const struct __chapi_in * ci, const char *opt_name,
      config_option_t opt_type, int opt_vals_count, int opt_size);
chapi_cfg_option_t(const chapi_cfg_option_t &option);
```

where

ci - pointer to the **chapi_in** communication context supplied for the device during the initialization;

opt_name - option name to create;

opt_type - the type of option to create (one of the following **opt_type_integer**, **opt_type_boolean**, **opt_type_ string**);

opt_vals_count - the number of option values supported by the option (>= 1);

opt_size - the size of one option value;

option - reference to the option object which should be used for initialization.

This is a set of constructors which are used to create the option for loadable device.

chapi_cfg_option_value_t

Basic functionality of option value is defined by the class **chapi_cfg_option_value_t** which establishes wrappers for the all CHAPI protocol routines relative to the option value processing. This class shouldn't be used directly during the loadable components development. See description of derived classes below. Here is the list of public members:

```
chapi_cfg_option_value_t(chapi_cfg_option_t *option, int opt_val_idx,
        void *opt_buffer);
```

where

option	-	pointer to the chapi option our option value belongs to;
opt_val_idx	-	option value index among the option values;
opt_buffer	-	pouinter to the buffer where option value is stored.

This constructor is used to specify parent option for the value, its index among the all option values and pointer to the buffer where option value will be stored.

```
virtual bool set(void *val);
```

where

val - pointer to the int, bool or character string, containing value to set.

This method is used to set the option value using supplied data. It wrappes routine identified by the **set_option_value** entry of **chapi_in** communication context.

```
virtual bool set_and_disable(void *val);
```

where

val - pointer to the int, bool or character string, containing value to set.

This method is used to set the option value using supplied with further disabling of this value during **commit()**. It wrappes routine identified by the **set_and_disable_option_value** entry of **chapi_in** communication context.

```
virtual void undo();
```

This method is used in order to undo option value change if any. It wraps routine identified by the **undo_option_value** entry of **chapi_in** communication context.

```
virtual void commit();
```

This method is used to commit option value change if any. It wrappes routine identified by the **commit_option_value** entry of **chapi_in** communication context.

```
virtual bool is_specified() const;
```

This method is used in order to define if specified value was mentioned in configuration file. It wraps routine identified by the **is_option_value_specified** entry of **chapi_in** communication context.

```
virtual bool is_changed() const;
```

This method is used in order to define if specified value was changed in configuration file since the last calls to commit()/change_ack(). This method wraps routine identified by the **is_option_value_changed** entry of **chapi_in** communication context.

```
virtual void change_ack();
```

This method is used to clear 'modify' flag for the option value. It wraps routine identified by the **option_value_change_ack** entry of **chapi_in** communication context.

```
virtual void enable(bool force = false);
```

where

force - is true in case if hidden option should be made accessible.

This method is used to enable freezed option to be changed, optionally makes hidden option value accessible. It wraps routine identified by the **enable_option_value** entry of **chapi_in** communication context.

```
virtual void freeze();
```

This method is used to protect option value from change. It wraps routine identified by the **freeze_option_value** entry of **chapi_in** communication context.

```
virtual void disable();
```

This method is used to make option value hidden, i.e. not accessible for view/change. It wraps routine identified by the **disable_option_value** entry of **chapi_in** communication context.

```
virtual bool is_hidden();
```

This method is used to define if option value is hidden, i.e. not accessible for view/change. It wraps routine identified by the **is_option_value_hidden** entry of **chapi_in** communication context.

chapi_cfg_option_t class derivatives

CHAPI protocol supports three different types of options: integer, boolean and string. For each kind of option dedicated wrapper is implemented.

Integer options are wrapped by the C++ class **chapi_integer_option_t** derived from the class **chapi_cfg_option_t**. The following public methods defined:

```
chapi_integer_option_t(const struct __chapi_in * ci, const char *opt_name,
        int opt_vals_count);
chapi_integer_option_t(const chapi_cfg_option_t &option);
```

where

ci	-	pointer to chapi_in communication context supplied during the loadable component initialization;
opt_name	-	option name to create;
opt_vals_count	-	the number of option values within the option;
option	-	reference to the option which should be used for initialization.

These constructors are used to create integer option.

```
chapi_integer_option_value_t & operator[] (int idx);
```

where

idx - index of option value to access.

This operator is used to access option values by index. Reference to the integer option value with specified index is returned.

Boolean options are wrapped by the C++ class **chapi_bool_option_t** derived from the class **chapi_cfg_option_t**. The following public methods defined:

```
chapi_bool_option_t(const struct __chapi_in * ci, const char *opt_name,
        int opt_vals_count);
chapi_bool_option_t(const chapi_cfg_option_t &option);
```

where

ci - pointer to chapi_in communication context supplied during the loadable component initialization;

opt_name - option name to create;

opt_vals_count - the number of option values within the option;

option - reference to the option which should be used for initialization.

This constructors are used to create integer option.

```
chapi_bool_option_value_t & operator[] (int idx);
```

where

idx - index of option value to access.

This operator is used to access option values by index. Reference to the boolean option value with specified index is returned.

String options are wrapped by the C++ class **chapi_string_option_t** derived from the class **chapi_cfg_option_t**. The following public methods defined:

```
chapi_string_option_t(const struct __chapi_in * ci, const char *opt_name,
        int opt_vals_count, int opt_size);
chapi_string_option_t(const chapi_cfg_option_t &option);
```

where

ci - pointer to chapi_in communication context supplied during the loadable component initialization;

opt_name - option name to create;

opt_vals_count - the number of option values within the option;

opt_size - maximum size for option value;

option - reference to the option which should be used for initialization.

This constructors are used to create integer option.

```
chapi_string_option_value_t & operator[] (int idx);
```

where

idx - index of option value to access.

This operator is used to access option values by index. Reference to the string option value with specified index is returned.

chapi_cfg_option_value_t class derivatives

All options can work with appropriate option values. Each option value type is wrapped by dedicated C++ class. Note that it is not necessary to create option values manually – they are created during the option creation and accessed like the follows: **opt[idx]**.

Integer option value is wrapped by C++ class **chapi_integer_option_value_t** derived from the class **chapi_cfg_option_value_t**. The following public methods are defined:

```
chapi_integer_option_value_t(chapi_cfg_option_t *option, int opt_val_idx,
      void *opt_buffer);
```

where

option	-	parent option for the value;
opt_val_idx	-	option value index among the all option values;
opt_buffer	-	option value buffer.

This constructor is used to initialize integer option value.

```
operator int ();
```

This operator converts integer option value to the int value.

```
bool set(int val);
```

where

`val`	–	value to set for the option.

This method is used to set the new value for the option value.

Boolean option value is wrapped by C++ class **chapi_bool_option_value_t** derived from the class **chapi_cfg_option_value_t**. The following public methods are defined:

```
chapi_bool_option_value_t(chapi_cfg_option_t *option, int opt_val_idx,
      void *opt_buffer);
```

where

option	-	parent option for the value;

opt_val_idx	-	option value index among the all option values;
opt_buffer	-	option value buffer.

This constructor is used to initialize integer option value.

```
operator bool ();
```

This operator converts boolean option value to the bool value.

```
bool set(bool val);
```

where

`val`	–	value to set for the option.

This method is used to set the new value for the option value.

String option value is wrapped by C++ class **chapi_string_option_value_t** derived from the class **chapi_cfg_option_value_t**. The following public methods are defined:

```
chapi_string_option_value_t(chapi_cfg_option_t *option, int opt_val_idx,
      void *opt_buffer);
```

where

option	-	parent option for the value;
opt_val_idx	-	option value index among the all option values;
opt_buffer	-	option value buffer.

This constructor is used to initialize integer option value.

```
operator char* ();
```

This operator converts string option value to the char* value.

```
bool set(char *val);
```

where

`val`	–	value to set for the option.

This method is used to set the new value for the option value.

C++ wrappers to work with critical section

The basic interface of critical section is defined in abstract class `chapi_critical_section_interface`. Here is the list of public members:

```
virtual bool try_enter() = 0;
```

Abstract method attempts to enter a critical section without blocking. If the call is successful, the calling thread takes ownership of the critical section and method return *"true"*, else return value shell be equal *"false"*.

```
virtual void enter() = 0;
```

Abstract method waits for ownership of the specified critical section object. The function returns when the calling thread is granted ownership.

```
virtual void leave() = 0;
```

Abstract method releases ownership of the specified critical section object.

Firts derived class from `chapi_critical_section_interface` is `chapi_stub_critical_section`. It is a stub class. All method will be execute sucsesful witout waiting other threads.

`chapi_mutex` implements `chapi_critical_section_interface` and for synchronization it uses *mutex*. if the critical section is unavailable, the calling thread execute wait operation on a semaphore associated with the critical section.

`chapi_spinlock` implements `chapi_critical_section_interface` and for synchronization uses *spinlock*. if the critical section is unavailable, the calling thread spin before performing a wait operation on a semaphore associated with the critical section.

C++ wrappers to work with threads

`chapi_task` class provide C++ wpapped to work with threads. Here is the list of public members:

```
static chapi_handle_t create(chapi_proc_t (stdcall * task_body)(void *task_arg),
                             void * task_arg);
```

where

`task_body`	–	pointer on thread main function.
`task_arg`	–	pointer on arguments of thread`s main function.

Create and execute new task. Returns `chapi_invalid_handle` if create task failed.

```
chapi_proc_t chapi_task::wait_for_result(chapi_handle_t the_task);
```

where

`the_task`	–	Task hendler.

This method waits for the task to complete, and returns the task's completion status.

```
template <class T>chapi_task_starter
```

where

`T`	-	class containing thread main method.

class is task utility provide starat new thread use as main functio a class method. For run task need use follow method:

```
static chapi_handle_t run_task(T * instance,
                               chapi_proc_t (T::* task_body)(void * task_arg),
                               void * task_arg = 0);
```

where

`instance`	-	pointer on instance of a class
`task_body`	-	pointer on start member method of class
`task_arg`	-	pointer on arguments of start method

CHAPI common containers

```
template<class Elem, udword_t max_buffer_size> class chapi_ring_buffer
```

where

`Elem`	-buffer element type

`max_buffer_size` -ring buffer is common container, it`s use FIFO strategy for contain elements. The following public methods are defined:

```
void clean()
```

Clean buffer

```
bool is_empty() const
```

This methos return true if buffer is empty else false.

```
bool is_full() const
```

This methos return true if buffer is full else false.

```
uword_t size() const
```

This methos return current buffers size.

```
void push(const Elem& elem)
```

where

elem - putted element

This methos puts elemt in end of buffer if buffer is not full else operation will be aborted.

```
Elem top()
```

Get first elemet from the buffer *(don't remove him from buffer)*, if buffer is empty return value of operation is unpredicateble.

```
void pop()
```

Remove first elem from buffer. If buffer is empty operation will be aborted.

5.1.3 Library usage examples

General CHAPI support library is used by all examples supplied with the product. Examples source code can be found in chapters (6.1, 6.2).

5.2 Serial I/O CHAPI support library

Note: *This library depends on CHAPI.DLL one.*

5.2.1 Library files

Serial I/O CHAPI support library consists of:

1) Header file which contains base class (**chapi_serial_device_interface**) for all CHAPI serial line controller (also chapi_dhv11.dll, chapi_dlv11.dll) that can work with CHAPI serial lines based on class **chapi_serial_line_interface** - **chapi_serial_device_iface.h;**

2) Header file which contains base class (**chapi_serial_line_interface**) for all CHAPI serial lines (also chapi_serial.dll) that can work with CHAPI serial lines controller based on class **chapi_serial_device_interface** - **chapi_serial_line_iface.h**;

3) Library file to link with in order to create new CHAPI serial lines library – release **chapi_serial.lib, debug chapi_seraild.lib**;

4) Dynamically linked library, containing all implementation of CHAPI serial lines – release **chapi_serial.dll, debug chapi_seriald.dll;**

5) Dynamically linked library, containing all implementation of CHAPI DHV11 – **chapi_dhv11.dll;**

6) Dynamically linked library, containing all implementation of CHAPI DLV11 – **chapi_dl11.dll;**

Library source codes aren’t provided.

5.2.2 Library description

The main goal is to describe methods for CHAPI serial line controllers and CHAPI serial lines, so all CHAPI serial line controllers can work with all CHAPI serial lines.

Definitions of standard CHAPI interface (like **read(...)**, **write(...)** …) will be skipped.

CHAPI serial line controller's methods

CHAPI serial line controller's methods described in class **chapi_serial_device_interface**, so all CHAPI serial line controllers' classes must be derived from the class **chapi_serial_device_interface.**

```
chapi_serial_line_interface * line[_MAX_SERIAL_LINE_NUMBER_];
```

Array of CHAPI serial line pointers, instances of CHAPI serial lines.

```
virtual int rx_done(unsigned int len, unsigned char line_id) = 0;
```

Callback function, serial line must call serial line controller's callback function **rx_done(...)** to notify controller about received data. So CHAPI serial line controller understand that CHAPI serial line has received data and must call CHAPI serial line's method **get_rx_char(...)** to obtain received data. Simple wrapper is implemented in class **chapi_serial_line_interface** for calling **rx_done(...)** function**.**

len - number of received data

line_id - line number

Return:

0 - No errors

```
virtual int tx_done(unsigned int len, unsigned char line_id) = 0;
```

Callback function, serial line must call serial line controller's callback function **tx_done(...)** to notify controller about completion of send operation (initiated by calling CHAPI serial line's method **do_tx(...)**). Simple wrapper is implemented in class **chapi_serial_line_interface** for calling this function**.**

len - number of sent data

line_id - line number

Return:

0 - No errors

```
virtual int get_tx_char(unsigned char & from_buf, unsigned char line_id) = 0;
```

Callback function, serial line must call serial line controller's callback function **get_tx_char(...)** to get data for transmission from serial line controller's TX buffer, ***CHAPI serial line***

controller must provide TX buffer. Simple wrapper is implemented in class **chapi_serial_line_interface** for calling this function**.**

from_buf - place to put char for transmission

line_id - line number

Return:

1 - No errors, you have got 1 char for transmission

-1 - No char for transmission, serial line controller’s TX buffer is empty

```
virtual int input_signal(unsigned char in_signal, unsigned char line_id) = 0;
```

Callback function, serial line must call serial line controller’s callback function **input_signal(...)** to notify controller about new input signals (modem). Simple wrapper is implemented in class **chapi_serial_line_interface** for calling this function**.**

in_signal - input signals

line_id - line number

Return:

0 - No errors

```
virtual int error_tx(unsigned char error, unsigned char line_id) = 0;
```

Callback function, serial line must call serial line controller’s callback function **error_tx(...)** to notify controller about transmission errors. Simple wrapper is implemented in class **chapi_serial_line_interface** for calling this function**.**

error - transmission error

line_id - line number

Return:

0 - No errors

```
virtual int error_rx(unsigned char error, unsigned char line_id) = 0;
```

Callback function, serial line must call serial line controller’s callback function **error_rx(...)** to notify controller about receive errors. Simple wrapper is implemented in class **chapi_serial_line_interface** for calling this function**.**

error - receive error

line_id - line number

Return:

0 - No errors

```
virtual int extra(void * extra, int arg, unsigned char line_id) = 0;
```

Callback function, serial line must call serial line controller's callback function **extra (...)** for extra features. Simple wrapper is implemented in class **chapi_serial_line_interface** for calling this function.

extra - void pointer

arg - integer argument

line_id - line number

Return: 0 - No errors

```
virtual void get_sys_err( unsigned long err ) = 0;
```

System error logging, also callback function, serial line must call serial line controller's callback **get_sys_err(...)** for system error logging. Simple wrapper is implemented in class **chapi_serial_line_interface** for calling this function.

err - system error number

```
void log_msg(log_message_type_t msg_type, const char *str);
```

Message logging, also callback function, serial line must call serial line controller's callback **log_msg(...)** for message logging. Simple wrapper is implemented in class **chapi_serial_line_interface** for calling this function.

msg_type - type of message

***str** - message

```
void debug_trace(unsigned char debug_level, const char *str);
```

Trace logging, also callback function, serial line must calls serial line controller's callback **debug_trace(...)** for trace logging. Simple wrapper is implemented in class **chapi_serial_line_interface** for calling this function.

debug_level - debug level

***str** - trace message

CHAPI serial line methods

CHAPI serial line's methods described in class **chapi_serial_line_interface**, so all CHAPI serial line classes must be derived from the class **chapi_serial_line_interface.**

```
chapi_serial_line_interface(void * ctrl, unsigned char line_id)
```
Constructor of CHAPI serial line instance.

ctrl - serial line controller instance (pointer)

line_id - current serial line instance number

```
virtual int start() = 0;
```
Start serial line.

Return:

0 - No errors

```
virtual int stop() = 0;
```
Stop serial line.

Return :

0 - No errors

```
virtual int setup_speed(unsigned int speed) = 0;
```
Setup serial line baud rate.

speed - baud rate

Return:

0 - No errors

```
virtual int setup_char_len(unsigned char char_len) = 0;
```
Setup serial line char bits length.

char_len - character bits length

Return:

0 - No errors

```
virtual int setup_stop_len(unsigned char stop_len) = 0;
```
Setup serial line stop bits length.

stop_len - stop bits length

Return:

0 - No errors

```
virtual int setup_parity(unsigned char parity) = 0;
```
Setup serial line parity control.

parity - parity control

Return :

0 - No errors

```
virtual int setup_flow_ctrl(unsigned char flow_ctrl) = 0;
```
Setup serial line flow control.

flow_ctrl - flow control

Return :

0 - No errors

```
virtual int send_ctrl_char(unsigned char ctrl_char) = 0;
```
Send special control character (w/o respond by CHAPI serial line controller's method **tx_done(...)**) ahead of any pending data in the output buffer.

ctrl_char - control character

Return :

0 - No errors

```
virtual int setup_output_signal(unsigned char out_signal) = 0;
```
Setup serial line output signals (modems).

out_signal - signals

Return :

0 - No errors

```
virtual int setup_break(unsigned char break_signal) = 0;
```

Setup serial line break transmission.

break_signal - start/stop break

Return:

0 - No errors

```
virtual int do_tx(unsigned int len) = 0;
```
Initiate transmission.

len - number of bytes for transmission, or 0 for transmission all bytes from serial line controller TX buffer. So CHAPI serial line understand that CHAPI serial line controller has data for transmission and must call CHAPI serial line controller's method **get_tx_char(...)** via wrapper **ctrl_get_tx_char(...)** to obtain data for transmission.

Return :

0 - No errors

```
virtual int set_tx_enable() = 0;
```
Enable transmission.

Return:

0 - No errors

```
virtual int set_tx_disable() = 0;
```
Disable transmission.

Return:

0 - No errors

```
virtual int set_rx_enable() = 0;
```
Enable receive.

Return:

0 - No errors

```
virtual int set_rx_disable() = 0;
```
Disable receive.

Return:

0 - No errors

```
virtual int set_extra_command(void * extra_command, int arg) = 0;
```
Set serial line’s extra features.

extra - void pointer

arg - integer argument

Return:

0 - No errors

```
virtual int get_rx_char(unsigned char & from_buf) = 0;
```
Get received data from serial line RX buffer, ***CHAPI serial line must provide RX buffer***.

from_buf - place to put received char

Return: note

1 - No errors, you have got 1 received char

-1 - No received char, serial line RX buffer is empty

```
int ctrl_rx_done(unsigned int len);
```
Wrapper for calling CHAPI serial line controller’s callback function, serial line must call function **ctrl_rx_done(...)** to notify controller about received data.

len - number of received data

Return:

0 - No errors

```
int ctrl_tx_done(unsigned int len);
```
Wrapper for calling CHAPI serial line controller’s callback function, serial line must call function **ctrl_tx_done(...)** to notify controller about completion of send operation.

len - number of sent data

Return :

0 - No errors

```
int ctrl_get_tx_char(unsigned char & from_buf);
```
Wrapper for calling CHAPI serial line controller’s callback function, serial line must call function **ctrl_get_tx_char(...)** to get data for transmission from serial line controller’s TX buffer.
Note: *CHAPI serial line controller must provide TX buffer.*

from_buf - place to put char for transmission

Return:

1 - No errors, you have got 1 char for transmission

-1 - No char for transmission, serial line controller's TX buffer is empty

```
int ctrl_input_signal(unsigned char in_signal);
```
Wrapper for calling CHAPI serial line controller's callback function, serial line must call function **ctrl_input_signal(...)** to notify controller about new input signals (modem).

in_signal - input signals

Return:

0 - No errors

```
int ctrl_error_tx(unsigned char error);
```
Wrapper for calling CHAPI serial line controller's callback function, serial line must call function **ctrl_error_tx(...)** to notify controller about transmission errors.

error - transmission error

Return:

0 - No errors

```
int ctrl_error_rx(unsigned char error);
```
Wrapper for calling CHAPI serial line controller's callback function, serial line must call function **ctrl_error_rx(...)** to notify controller about receive errors.

error - receive error

Return:

0 - No errors

```
int ctrl_extra(void * extra, int arg);
```
Wrapper for calling CHAPI serial line controller's callback function, serial line must call function **ctrl_extra(...)** for serial line controller's extra features.

***extra** - void pointer

arg - integer argument

Return:

0 - No errors

```
void log_msg(log_message_type_t msg_type, const char *fmt, ...);
```
Message logging.

msg_type - type of message

***fmt** - message

```
void debug_trace(unsigned char debug_level, const char *fmt, ...);
```
Trace logging.

debug_level - debug level

***fmt** - trace message

```
void get_sys_err( unsigned long err );
```
System error logging.

err - system error number

NOTE about implemented CHAPI serial line controllers and CHAPI serial lines.

Three CHAPI serial lines were implemented:

- CHAPI serial line mapped to MOXA NPort 5210;
- CHAPI serial line mapped to COM port;
- CHAPI serial line mapped to TCP/IP protocol;

To load implemented CHAPI serial line at run-time you should:

1) Load dll by calling :

   ```
   hinst=::LoadLibrary(TEXT("chapi_serial.dll"));
   ```

2) Find initiating function in loaded dll:

   ```
   pf_init_line_t init_line = (pf_init_line_t)::GetProcAddress(hinst,
   init_name);
   ```
   init_name – can be:
   - "init_moxa_line"
   - "init_tcpip_line"
   - "init_com_line"

   Type of initiating function defined as:

   ```
   typedef bool (*pf_init_line_t)(void * ctrl, chapi_serial_line_interface **
   p_serial_l_i, unsigned char line_id);
   ```

   Where:

ctrl - pointer to CHAPI serial line controller instance
p_serial_l_i - place to put created CHAPI serial line instance
line_id - CHAPI serial line instance number

In implemented CHAPI serial line controllers and CHAPI serial lines used predefined options.

Modem signals definitions:

```
#define R_T_S (0x01 << 0)
#define D_T_R (0x01 << 1)
#define D_C_D (0x01 << 2)
#define C_T_S (0x01 << 3)
#define D_S_R (0x01 << 4)
#define R_I_N_G (0x01 << 5)
```

RX errors definitions:

```
#define LINE_ERROR_BREAK (0x01 << 0)
#define LINE_ERROR_OVER (0x01 << 1)
#define LINE_ERROR_FRAMING (0x01 << 2)
#define LINE_ERROR_PARITY (0x01 << 3)
```

Break controls definitions:

```
#define START_BREAK   1
#define STOP_BREAK    0
```

Flow control definitions:

```
#define NONE_FLOW_CONTROL 0x00
#define XON_XOFF_FLOW_CONTROL (0x01 << 0)
#define DTR_DSR_FLOW_CONTROL (0x01 << 1)
#define RTS_CTS_FLOW_CONTROL (0x01 << 2)
```

Parity control definitions:

```
#define PARITY_CONTROL_NONE 0x00
#define PARITY_CONTROL_EVEN (0x01 << 0)
#define PARITY_CONTROL_ODD (0x01 << 1)
#define PARITY_CONTROL_MARK (0x01 << 2)
#define PARITY_CONTROL_SPACE (0x01 << 3)
```

Extra features definition:

```
#define EXTRA_LINE_SETUP (0x01 << 0)
```

Setup parameters pass to the CHAPI serial line via

```
set_extra_command(void * extra_command, int arg)
```

as a **NULL TERMINATED** string and **arg** must be **EXTRA_LINE_SETUP**.

For example:

- to pass setup option to CHAPI serial line mapped to COM port we must call:

```
 line[0]->set_extra_command(“com=1”, EXTRA_LINE_SETUP);
```

- to pass setup option to CHAPI serial line mapped to NPort5210 we must call:

```
 line[7]->set_extra_command(“ip=192.168.127.254 port=1”, EXTRA_LINE_SETUP);
```

- to pass setup option to CHAPI serial line mapped to TCP/IP protocol we must call:

```
 line[3]->set_extra_command(“port=10020 application=txa0.ht”, EXTRA_LINE_SETUP);
```

Note about implemented CHAPI serial lines:

- should avoid calling **line[x]->do_tx(...)** before line calls **tx_done(...)** from the previous calling **line[x]->do_tx(...)**
- it is recommended to transmit characters to the line one by one, because it is closer to the behaviour of the real serial line controllers
- if CHAPI serial line XON/XOFF flow control enable and CHAPI serial line controller sends XOFF (via TX buffer or as control character) , **line[x]->get_rx_char(...)** will return (**-1**), until XON will be sent or XON/XOFF flow control disable
- **line[x]->set_tx_disable(...)** and **line[x]->set_tx_enable(...)** means nothing

5.2.3 Library usage examples

Library usage example can be found in CHAPI_DLV11 source C++ code.

5.3 Storage I/O CHAPI support library

5.3.1 Library files

Storage I/O CHAPI support library consists of:

1) Header file which contains base class **chapi_tape_device_iface** for all CHAPI tape controllers (also chapi_tsv05.dll) that can work with CHAPI tape transports based on class **chapi_tape_transport_iface** - **chapi_tape_device_iface.h;**

2) Header file which contains base class **chapi_disk_device_iface** for all CHAPI disk drive controllers (also chapi_rlv12.dll) that can work with CHAPI disk drive based on class **chapi_disk_drive_iface** - **chapi_disk_device_iface.h;**

3) Header file which contains base class **chapi_tape_transport_iface** for all CHAPI tape transports (also chapi_storage.dll) that can work with CHAPI tape controllers based on class **chapi_tape_device_iface** - **chapi_tape_transport_iface.h**;

4) Header file which contains base class **chapi_disk_drive_iface** for all CHAPI disk drives (also chapi_storage.dll) that can work with CHAPI disk controllers based on class **chapi_disk_device_iface** - **chapi_disk_drive_iface.h**;

5) Library file to link with in order to create new CHAPI tape transport library or disk drive library – release **chapi_storage.lib,** debug **chapi_storaged.lib**;

6) Dynamically linked library, containing all implementation of CHAPI tape transports and disk drives – release **chapi_storage.dll,** debug **chapi_storaged.dll**;

7) Dynamically linked library, containing implementation of CHAPI TSV05 – **chapi_tsv05.dll;**

8) Dynamically linked library, containing implementation of CHAPI RLV12 – **chapi_rlv12.dll;**

Library source codes aren't provided.

5.3.2 Library description

The main goal for tape I/O is to describe methods for CHAPI tape controllers and CHAPI tape transports, so all CHAPI tape controllers can work with all CHAPI tape transports. Also, the main goal for disk I/O is to describe methods for CHAPI disk controllers and CHAPI disk drives, so all CHAPI disk controllers can work with all CHAPI disk drives.

Definitions of standard CHAPI interface (like **read(...)**, **write(...)** …) will be skipped.

CHAPI tape controller's methods

CHAPI tape controller's methods described in class **chapi_tape_device_iface**, so all CHAPI tape controllers' classes must be derived from the class **chapi_tape_device_iface.**

chapi_tape_transport_iface * tape[_MAX_TAPE_NUMBER_];

Array of CHAPI tape transport pointers, instances of CHAPI tape transports.

virtual int cmd_done(int transport_number, int cmd, unsigned int status, unsigned int n_of_data)

The only callback function, CHAPI tape transport must calls controller's callback **cmd_done(...)** to notify CHAPI tape controller about requested command completion, initiated by calling CHAPI tape transport's method **do_command(...)**).

transport_number - tape transport instance number

cmd - requested command;

status - tape transport status after requested command completion (can be mixed);

n_of_data - depends on operation:

a. number of bytes **ACTUALLY** transferred by READ/WRITE operations;
b. number of items **NOT** skipped by SKIP operations;

virtual void get_sys_err(unsigned long err)

System error logging, also callback function, tape transport must calls tape controller's callback **get_sys_err(...)** for system error logging;

err - system error number;

void log_msg(log_message_type_t msg_type, const char *str)

Message logging, also callback function, tape transport must calls tape controller's callback **log_msg(...)** for message logging;

msg_type - type of message;

***str** - message;

void debug_trace(unsigned char debug_level, const char *str)

Trace logging, also callback function, tape transport must calls tape controller's callback **debug_trace(...)** for trace logging;

debug_level - debug level;

***str** - trace message;

CHAPI tape transport methods

CHAPI tape transport's methods described in class **chapi_tape_transport_iface**, so all CHAPI tape transport classes must be derived from the class **chapi_tape_transport_iface**.

chapi_tape_transport_iface(void * ctrl, unsigned char transport_number)

Constructor of CHAPI tape transport instance.

ctrl - tape controller instance (pointer);

transport_number - current tape transport instance number;

virtual void start()

Start tape transport.

virtual void stop()

Stop tape transport.

virtual void setup(void * param, int arg)

Setup parameters for tape transport, **MUST** be called before **start()**.

param - pointer to parameter;

arg - integer parameter;

virtual bool is_online()

Check if tape transport is online.

Returns:

true - tape transport is online;

false - tape transport is offline;

virtual bool is_write_prot()

Check if tape is write protected.

Returns:

true - tape is write protected;

false - tape is not write protected;

virtual void do_command(unsigned int cmd, char * io_buf_p, unsigned int n_of_data)

Initiate tape transport operation.

cmd - tape transport operation, see operation definition;

io_buf_p - IO buffer for **READ/WRITE** operations;

n_of_data - depends on operation:

c. number of bytes to write for **WRITE** operations;
d. size of IO buffer for **READ** operations
e. number of skip items for **SKIP** operations;

void log_msg(log_message_type_t msg_type, const char *fmt, ...)

Message logging.

msg_type - type of message

***fmt** - message

void debug_trace(unsigned char debug_level, const char *fmt, ...)

Trace logging.

debug_level - debug level

***fmt** - trace message

void get_sys_err(unsigned long err)

System error logging.

err - system error number

chapi_tape_device_iface * ctrl

Instance of tape transport controller (pointer).

unsigned int transport_number

Tape transport instance number.

NOTE about implemented CHAPI tape controller and CHAPI tape transports.

It was implemented 3 CHAPI tape transports:

- CHAPI tape transport mapped to ***.mtd** file;
- CHAPI tape transport mapped to **SCSI** port;
- CHAPI tape transport mapped to **tape driver** ;

To load implemented CHAPI tape transport at run-time you should:

1) Load dll by calling :
   hinst=::LoadLibrary(TEXT("chapi_storage.dll"));
2) Find initiating function in loaded dll :
   pf_init_tape_t init_tape = (pf_init_tape_t)::GetProcAddress(hinst[i], init_name);

   init_name – can be:

   - "init_mtd_tape"
   - "init_scsi_tape"
   - "init_driver_tape"

   Type of initiating function defined as:

   typedef bool (*pf_init_tape_t)(void * ctrl, chapi_tape_transport_iface ** p_tape_i, unsigned char transport_number)

Where:

ctrl - pointer to CHAPI tape controller instance

p_tape_i – place to put created CHAPI tape transport instance

transport_number – CHAPI tape transport instance number

Setup parameters pass to the CHAPI tape transport via **setup(void * param, int arg)** as a **NULL TERMINATED** string**.**

For example:

- to pass setup option to CHAPI tape transport mapped to ***.mtd** file we must call:

tape[0]->setup("somefile.mtd", 0);

- to pass setup option to CHAPI tape transport mapped to **SCSI** we must call:

tape[7]->seup("\\.\SCSI4:0:1", 0);

- to pass setup option to CHAPI tape transport mapped to **tape driver** we must call:

tape[3]->setup("\\.\Tape0", 0);

<u>In implemented CHAPI tape controller and CHAPI tape transports used predefined options.</u>

<u>Tape transport commands:</u>

```
enum
{
   // Erase tape
   TAPE_CMD_ERASE,

   // Write tape mark
   TAPE_CMD_WRITE_MARK,

   // Rewrite tape mark
   TAPE_CMD_REWRITE_MARK,

   // Rewind tape
   TAPE_CMD_REWIND,

   // Skip some tape records in forward direction
   TAPE_CMD_SKIP_RECORD,

   // Skip some tape marks in forward direction
   TAPE_CMD_SKIP_MARK,
   // Skip some tape records in backward direction
   TAPE_CMD_SKIP_RECORD_REV,

   // Skip some tape marks in backward direction
   TAPE_CMD_SKIP_MARK_REV,

   // Read one tape record in forward direction
   TAPE_CMD_READ,

   // Read one tape record in backward direction
   TAPE_CMD_READ_REV,

   // Reread one next tape record
   TAPE_CMD_REREAD_NEXT,

   // Reread one previous tape record
   TAPE_CMD_REREAD_PREV,

   // Write one tape record
   TAPE_CMD_WRITE,

   // Rewrite one tape record
   TAPE_CMD_REWRITE,

   // Set tape transport offline
   // Depends on implementation
   TAPE_CMD_OFFLINE,

   // Set tape transport online
   // Depends on implementation
   TAPE_CMD_ONLINE,

   // Obtain tape transport status
   // Depends on implementation
   TAPE_CMD_STATUS
};
```

Tape transport status after command completion:

```
enum
{
    // Good status
    TAPE_STS_OK     =  0x0001 << 0,

    // Bad/fatal tape error, position lost
    TAPE_STS_BTE    =  0x0001 << 1,

    // Tape mark detected
    TAPE_STS_MARK   =  0x0001 << 2,

    // Physical end of tape detected
    TAPE_STS_PEOT   =  0x0001 << 3,

    // Logical end of tape detected
    // Usually double tape mark, position between marks
    TAPE_STS_LEOT   =  0x0001 << 4,
    //Beginning of tape detected
    TAPE_STS_BOT     =  0x0001 << 5,

    //End of recorded data detected, position lost
    TAPE_STS_EOD     =  0x0001 << 6,
};
```

Note:

- it is recommended to check write protected status and online status by tape controller before command initiation and after command completion;
- **TAPE_CMD_STATUS** command refreshes write protected status and online status in tape transport and returns **TAPE_STS_OK**, but they automatically refreshed in case of **TAPE_STS_BTE** respond to another commands;
- **TAPE_CMD_ONLINE** means nothing;
- **TAPE_CMD_OFFLINE** just doing rewind;
- CHAPI TSV05 under unload condition issue **TAPE_CMD_OFFLINE** command;
- **DO NOT** initiate **NEXT** tape transport command before **PREVIOUS** tape transport command completion;
- In implemented tape transports library value “-20” for second parameter in void setup(void * param, int arg) is reserved for internal use;

CHAPI disk controller’s methods

CHAPI disk controller’s methods described in class **chapi_disk_device_iface**, so all CHAPI disk controllers’ classes must be derived from the class **chapi_disk_device_iface.**

```
struct CHAPI_DISK_DRIVE_GEOM {
   unsigned long cylinders_per_disk;
   unsigned long tracks_per_cylinder;
   unsigned long sectors_per_track;
   unsigned long bytes_per_sector;
};
```

Structure definition to containing disk geometry.

```
struct CHAPI_DISK_DRIVE_POS {
   unsigned long volatile cylinder_num;
   unsigned long volatile track_num;
   unsigned long volatile sector_num;
```

};

Structure definition to containing current head’s position.

chapi_disk_drive_iface * HDD[_MAX_DISK_DRIVE_NUMBER_];

Array of CHAPI disk drive pointers, instances of CHAPI disk drives.

CHAPI_DISK_DRIVE_GEOM disk_geom[_MAX_DISK_DRIVE_NUMBER_];

Array of disk drive geometry.

CHAPI_DISK_DRIVE_POS disk_pos[_MAX_DISK_DRIVE_NUMBER_];

Array of disk drive head's position.

virtual int read_done(int disk_number, unsigned int status, unsigned int n_of_byte)

Callback function, disk drive must calls controller`s callback read_done(...) to notify controller about READ command completion, initiated by calling CHAPI disk drive’s method **do_read(...)**.

disk_number - disk drive instance number;

status - disk drive status after read command completion (can be mixed), see status code definition in disk drive methods description;

n_of_byte - number of bytes **ACTUALLY** transferred by READ operations;

Rerurns:

0 – Success;

virtual int write_done(int disk_number, unsigned int status, unsigned int n_of_byte)

Callback function, disk drive must calls controller’s callback write_**done(...)** to notify controller about **WRITE** command completion, initiated by calling CHAPI disk drive’s method **do_write(...)**.

disk_number - disk drive instance number;

status - disk drive status after read command completion (can be mixed), see status code definition in disk drive methods description;

n_of_byte - number of bytes **ACTUALLY** transferred by READ operations;

Rerurns:

0 – Success;

virtual void get_sys_err(unsigned long err)

System error logging, also callback function, disk drive must calls disk controller's callback **get_sys_err(...)** for system error logging;

err - system error number;

void log_msg(log_message_type_t msg_type, const char *str)

Message logging, also callback function, disk drive must calls disk controller's callback **log_msg(...)** for message logging;

msg_type - type of message;

***str** - message;

void debug_trace(unsigned char debug_level, const char *str)

Trace logging, also callback function, disk drive must calls disk controller's callback **debug_trace(...)** for trace logging;

debug_level - debug level;

***str** - trace message;

CHAPI disk drive methods

CHAPI disk drive's methods described in class **chapi_disk_drive_iface**, so all CHAPI disk drive classes must be derived from the class **chapi_disk_drive_iface**.

chapi_disk_drive_iface(void * ctrl, unsigned char disk_number)

Constructor of CHAPI disk drive instance.

***ctrl** - disk drive controller instance (pointer);

disk_number - current disk drive instance number;

virtual void start()

Start disk drive MUST be called after any setup functions.

virtual void stop()

Stop disk drive.

virtual void setup(void * param, int arg)

Setup parameters for disk drive, **<u>MUST</u>** be called before **start()**.

***param** - pointer to parameter;

arg - integer parameter;

virtual void setup_geometry(CHAPI_DISK_DRIVE_GEOM geom)

Setup disk drive geometry, MUST be called before **start().**

geom - disk drive geometry;

virtual bool is_online()

Check if disk drive is online.

Returns:

true - disk drive is online;

false - disk drive is offline;

virtual bool is_write_prot()

Check if disk drive is write protected.

Returns:

true - disk drive is write protected;

false - disk drive is not write protected;

virtual unsigned _int64 capacity()

Obtain disk drive capacity, return value valid after at once **setup(...)** calling only.

Returns:

Disk drive capacity in bytes.

virtual void do_read(CHAPI_DISK_DRIVE_POS disk_pos, char * io_buf_p, unsigned int n_of_byte)

Initiate READ operation on disk drive.

disk_pos - disk drive head's position t start read from;

***io_buf_p** - buffer to read to (pointer);

n_of_byte - number of bytes to read;

virtual void do_write(CHAPI_DISK_DRIVE_POS disk_pos, char * io_buf_p, unsigned int n_of_byte)

Initiate WRITE operation on disk drive

disk_pos - disk drive head's position to tart write from;

***io_buf_p** - buffer to write from (pointer);

n_of_byte - number of bytes to write;

void log_msg(log_message_type_t msg_type, const char *fmt, ...)

Message logging.

msg_type - type of message

***fmt** - message

void debug_trace(unsigned char debug_level, const char *fmt, ...)

Trace logging.

debug_level - debug level

***fmt** - trace message

void get_sys_err(unsigned long err)

System error logging.

err - system error number

chapi_disk_device_iface * ctrl

Instance of disk drive controller (pointer).

unsigned int disk_number

Disk drive instance number.

CHAPI_DISK_DRIVE_GEOM disk_geom;

Current disk drive geometry.

CHAPI_DISK_DRIVE_POS head_pos;

Current head's position.

NOTE about implemented CHAPI disk drive controllers and CHAPI disk drives.

It were implemented two CHAPI disk drives:

- CHAPI disk drive mapped to file of disk drive image;

- CHAPI disk drive mapped to raw physical disk;

To load implemented CHAPI disk drives at run-time you should:

1) Load dll by calling :
   hinst=::LoadLibrary(TEXT(“chapi_storage.dll”));
2) Find initiating function in loaded dll :
   pf_init_disk_t init_disk = (pf_init_disk_t)::GetProcAddress(hinst[i], init_name);

   init_name – can be:

   - “**init_file_disk**”
   - “**init_phys_disk**”

   Type of initiating function defined as:

   typedef bool (*pf_init_disk_t)(void * ctrl, chapi_disk_drive_iface ** p_disk_i, unsigned char disk_number);

   Where:

   ctrl - pointer to CHAPI disk controller instance

   ****p_disk_i –** place to put created CHAPI disk drive instance

   transport_number – CHAPI disk drive instance number

Setup parameters pass to the CHAPI disk drive via **setup(void * param, int arg)** as a **NULL TERMINATED** string**.**

For example:

to pass setup option to CHAPI disk drive mapped to disk image file we must call:

HDD[0]->setup(“somefile.mtd”, 0);

to pass setup option to CHAPI disk drive mapped to raw physical disk we must call:

HDD[0]->setup(“\\.\PhysicalDrive0”, 0);

Disk drive geometry (of disk is being emulated) pass to the CHAPI disk drive via **setup_geometry(CHAPI_DISK_DRIVE_GEOM geom)** as the preset structure.

For example:

to pass geometry to CHAPI disk drive we must do:

```
...
CHAPI_DISK_DRIVE_GEOM disk_geom;
...
disk_geom.cylinders_per_disk = 256*2;
disk_geom.tracks_per_cylinder = 2;
disk_geom.sectors_per_track = 40;
disk_geom.bytes_per_sector = 256;
HDD[1]->setup_geometry(disk_geom);
...
```

In implemented CHAPI disk controller and CHAPI disk drive used predefined options.

Disk drive status after READ / WRITE command completion

```
enum
{
  // Good status
  DRIVE_STS_OK     =  0x0001 << 0,

  // Bad/fatal disk drive error
  DRIVE_STS_BDE    =  0x0001 << 1,

  // Disk drive SEEK error
  DRIVE_STS_SE     =  0x0001 << 2,

  // Disk drive READ error
  DRIVE_STS_RE     =  0x0001 << 3,

  // Disk drive WRITE error
  DRIVE_STS_WE     =  0x0001 << 4,

  // Disk drive HEAD POSITION error
  DRIVE_STS_HPE    =  0x0001 << 5,
  // Disk drive READ/WRITE length error
  DRIVE_STS_LE      =  0x0001 << 6
};
```

Note:

- **DO NOT** initiate **NEXT** disk drive command before **PREVIOUS** disk drive command completion;

- When using raw physical drive and sector size of disk drive is being emulated is less than sector size on real physical drive, any READ or WRITE operations can be performed with number of bytes to read or write less or equal 32768.

- **Be careful while using mapping to raw physical drive, it is ease to corrupt all data on it!**

6.CHAPI design examples

Two CHAPI examples are provided with source code for the moment – LPV11 printer port and DLV11 serial line controller. More devices will be provided in the future release.

6.1 LPV11

Full functional QBUS LPV11 / UNIBUS LP11 printer port with ability to send printed data to the TCP/IP connection or local file on the disk. This device is supplied with HOSTprint utility which maybe used to print data to the default host machine printer. HOSTprint utility maybe started on any host running Windows and visible from the host running CHARON. LPV11 itself maybe easily configured to print data to the printer using HOSTprint utility on the local or remote host system. It is also possible to configure LP11/LPV11 printing to locally attached printer (LPTn: port).

LP(V)11 implementation has been tested with MicroVAX 3600 /VMS and PDP-11/93(4) / RSX-11M-PLUS in configuration with HOSTprint utility.

Provided LPV11 binary will print installed CHARON license key number each 25 lines. In order to remove this functionality just comment out the line "`#define _PRINT_LICENSE_STR`" and rebuild the component.

See document #30-09-06 for source code listing of LPV11 CHAPI device.

6.2 DLV11

Full functional QBUS DLV11 / UNIBUS DL11 serial controller with ability to map its line to three supported ports: 1) Standard host COM port; 2) TCP/IP port; 3) MOXA NPort 5210 port.

DL(V)11 implementation has been tested with PDP-11/RSX-11M-PLUS system.

See document #30-09-06 for source code listing of DLV11 CHAPI device.

6.3 CHAPI device templates

A number of CHAPI device templates have been also supplied. They are intended to be used with CHAPI device creation wizard tool described in this document earlier. All templates use one or more CHAPI support libraries described above with all bonuses like compatibility between different controllers and ports/containers, etc… Below is the list of project templates for different kind of devices with the listing of supplied files and short description:

6.3.1 General CHAPI device

This set of templates represents general structure of CHAPI device w/o any specialization. It is intended to be used as the base for any CHAPI device when there is no specialized template appropriate for the category of implemented device. Use CHAPI device creation wizard to supply parameters for this kind of project and build compilable MS VC++ project. Below is the list of files belongs to this template:

- chapi_general_tmp.cxx – template for implementation file;
- chapi_general_msgid_tmp.h;
- chapi_general_tmp.vcproj – template for the project file.

6.3.2 CHAPI Serial line controller

This set of templates represents proposed structure of serial line multiplexer controller. It is intended to be used as the base for any new CHAPI serial multiplexer implementation. It is not mandatory to use these templates but they can simplify development a lot and allow using already implemented TCPIP, COM and MOXA NPort 5210 serial ports for communication without any additional efforts. Use CHAPI device creation wizard to supply parameters for this kind of project and build compilable MS VC++ project. Below is the list of files belongs to this:

- chapi_serial_ctrl_tmp.cxx – template for implementation file;
- chapi_serial_ctrl_tmp.h – template for header file;
- chapi_serial_ctrl_msgid_tmp.h;
- chapi_serial_ctrl_tmp.vcproj – template for the project file.

6.3.3 CHAPI Serial line port

This set of templates represents proposed structure of serial line port. It is intended to be used as the base for any new CHAPI serial line port implementation. It is not mandatory to use these templates but they can simplify development a lot and allow using newly created port with existing CHAPI serial line multiplexers developed in accordance with mentioned above template. Use CHAPI device creation wizard to supply parameters for this kind of project and build compilable MS VC++ project. Below is the list of files belongs to this template:

- chapi_serial_port_tmp.cxx – template for implementation file;

- chapi_serial_port_tmp.h – template for header file;
- chapi_serial_port_msgid_tmp.h;
- chapi_serial_port_tmp.vcproj – template for the project file.

6.3.4 CHAPI disk controller

This set of templates represents proposed structure of disk controller. It is intended to be used as the base for any new CHAPI disk controller implementation. It is not mandatory to use these templates but they simplify development a lot and allow using already implemented disk container file as storage without any additional efforts (\\.\SCSI and \\.\harddrive containers will be implemented and ready to be used without any additional efforts in the first production release). Use CHAPI device creation wizard to supply parameters for this kind of project and build compilable MS VC++ project. Below is the list of files belongs to this:

- chapi_disk_ctrl_tmp.cxx – template for implementation file;
- chapi_disk_ctrl_tmp.h – template for header file;
- chapi_disk_ctrl_msgid_tmp.h;
- chapi_disk_ctrl_tmp.vcproj – template for the project file.

6.3.5 CHAPI disk container

This set of templates represents proposed structure of disk container. It is intended to be used as the base for any new CHAPI disk container implementation. It is not mandatory to use these templates but they simplify development a lot and allow using newly implemented disk container with existing CHAPI disk controllers developed in accordance with mentioned above template. Use CHAPI device creation wizard to supply parameters for this kind of project and build compilable MS VC++ project. Below is the list of files belongs to this template:

- chapi_disk_drive_tmp.cxx – template for implementation file;
- chapi_disk_drive_tmp.h – template for header file;
- chapi_disk_drive_msgid_tmp.h;
- chapi_disk_drive_tmp.vcproj – template for the project file.

6.3.6 CHAPI tape controller

This set of templates represents proposed structure of tape controller. It is intended to be used as the base for any new CHAPI tape controller implementation. It is not mandatory to use these templates but they simplify development a lot and allow using already implemented tape containers like 1) Tape image file; 2) SCSI tape connected to the host system (\\.\SCSII:m:k); 3) windows driver supported tape connected to the host system (\\.\TapeK) without any additional efforts. Use CHAPI device creation wizard to supply parameters for this kind of project and build compilable MS VC++ project. Below is the list of files belongs to this template:

- chapi_tape_ctrl_tmp.cxx – template for implementation file;
- chapi_tape_ctrl_tmp.h – template for header file;
- chapi_tape_ctrl_msgid_tmp.h;
- chapi_tape_ctrl_tmp.vcproj – template for the project file.

6.3.7 CHAPI tape container

This set of templates represents proposed structure of tape container. It is intended to be used as the base for any new CHAPI tape container implementation. It is not mandatory to use these templates but they simplify development a lot and allow using newly implemented tape container with existing CHAPI tape controllers developed in accordance with mentioned above template. Use CHAPI device creation wizard to supply parameters for this kind of project and build compilable MS VC++ project. Below is the list of files belongs to this template:

- chapi_tape_transport_tmp.cxx – template for implementation file;
- chapi_ tape_transport_tmp.h – template for header file;
- chapi_tape_transport_msgid_tmp.h;
- chapi_ tape_transport_tmp.vcproj – template for the project file.

6.4 CHAPI device testing

There are no special methods to test CHAPI based devices. It has sense to use MDM tests for VAX systems if device is supported by MDM tools; XXDP tests can be used for PDP-11 systems to test newly implemented device. In case when device is supported both on VAX and PDP-11 systems it has a sense to test such kind of device using both MDM and XXDP – these test packages are pretty different and they are using different test algorithms which facilitate bug hunting.

Debug trace facility is described in details in sections (4.21).

7.Source code listings

All CHAPI source code listings and programming examples as referred to in this document are provided in document 30-09-006 CHARON CHAPI source code listing.pdf. This document can be given by the written request.

8.Configuration file samples with CHAPI

8.1 Education configuration file

```
#
# Copyright (C) 1999-2006 Stromasys.
# All rights reserved.
#
# The software contained on this media is proprietary to and
# embodies the confidential technology of Software Resources
# International. Posession, use, duplication, or dissemination
# of the software and media is authorized only pursuant to a
# valid written license from Stromasys.
#

#
# Sample configuration file for CHARON emulators. Should be
# used for education only - your own configurations is better to
# base on most appropriate one from supplied configuration files.
# Their description can be found in CHARON Manual in config
# files Index.
#

#
# Specify hm_model prior to any other commands. This parameter
# informs the emulator what type of PDP-11/VAX it should emulate.
# All the other commands availability and possibility to use depend
# on this specification
#

set session hw_model="MicroVAX_3600"
#set session hw_model="MicroVAX_3600_512"
#set session hw_model="MicroVAX_II"
#set session hw_model="VAXserver_3600"
#set session hw_model="VAXserver_3600_512"
#set session hw_model="PDP1193"
#set session hw_model="PDP1194"

#
# Comment the following line if you do not want the log to be
# saved into file (change name of the file as well if you'd
# like). Default is "overwrite". If "append" is chosen each new
# session of the emulator appends its log to this file,
# therefore it grows bigger with time. Note that the log_method
# should be specified prior to the log parameter - generally it
# is recommended to specify both of them in one line exactly as
# it's shown below.
#

#set session log="mv3k6.log" log_method="append"
set session log="mv3k6.log" log_method="overwrite"

#
# It is possible to reduce the size of the log file using filtering
# possibilities:
#
# 1) Based on message type (info, warning, error)
# 2) Based on repeatetive messages removing.
#
# You can specify which type of messages should be logged using option
# 'log_show_messages' which is a string option containing mentioned above
# message types delimited by comma. Default is "all" which means to log
# all existing message types.
```

```
#
# You can specify that repeatetive messages should be filtered out using
# 'log_repeat_filter' "on"/"off" option. Default value is "off"
#

# The same as default "all"
set session log_show_messages="info, warning, error"

# Show only information and error messages
#set session log_show_messages="info, error"

# Show only error messages
#set session log_show_messages="error"

# Filter repeatetive messages out
#set session log_repeat_filter="on"

#
# Uncomment the following lines if you want to play with exact PDP-11
# instructions timings. See CHARON product documentation for
# detailed description of how to play with this facility. But in
# general, emulator is running at the maximum speed when nothing
# is specified directly; different speed can be achieved when using
# parameters specified below. Note, that this feature is only valid
# for PDP-11 models, VAXes doesn't have such functionality available.
#

#
# Default instruction timings for PDP-11/93 are used.
# It is assumed that emulated CPU frequency is 15Mhz
#

#set cpu_0 frequency=15 instruction_time_table="default"

#
# Instruction timings are taken from the specified file.
# In case if specified file doesn't exists it will be created and
# default timings for PDP-11/93 CPU model will be written there.
# It is assumed that emulated CPU frequency is 15Mhz
#

#set cpu_0 frequency=15 instruction_time_table="file://mypdp.ins"


#
# It is possible to specify autoboot device for PDP11 emulators
# in format <two_letters_device_mnemonics><device_unit_number>.
# In case if specified device is configured in EEPROM boot devices
# list than PDP11 will autoboot from specified device, otherwise
# PDP11 console Video Terminal will be shown and user can select
# boot device manually.
#

# Autoboot from the 0 unit of MSCP controller
#set cpu_0 auto_boot="DU0"

# Autoboot from the 0 unit of TMSCP controller
#set cpu_0 auto_boot="MU0"

#
# The following line tells the emulator where to preserve NVRAM
# content. It will keep the current time of the emulated VAX
# (when you do not run the emulator) and console parameters
# (such as default boot device).
#

set toy container="mv3k6.dat"
```

```
#
# It is possible to load external PDP11 ROM if it is necessary
#
#set rom ext_rom="<external_rom_binary_file>"


#
# Specify the size of RAM . Remember that the license key might
# limit the maximum amount of memory. By the way the following
# memory size settings are valid for different CPU models:
#

# MicroVAX-II (default is 1MB)
#set ram size=1
#set ram size=8
#set ram size=16

# MicroVAX-3600, VAXServer-3600 (default is 16MB)
#set ram size=16
#set ram size=32
set ram size=64

# MicroVAX-3600/VAXServer-3600 512MB memory extension
# (default is 128MB, granularity is 128MB)

#set ram size=128
#set ram size=256
#set ram size=384
#set ram size=512

#
# PDP-11/93, PDP-11/94. Specify the size of RAM in Kb
# Possible RAM size is 2Mb and 4Mb (default). If RAM
# size is less than 2048Kb than it is set to 2048 Kb,
# if RAM size is greater than 4088Kb than it is set to
# 4088 Kb. Warning message is sent to the log file if
# memory size adjustment is done
#

#set ram size=2
#set ram size=4


#
# Now assign console built-in serial line. Currently the
# emulator offers three possible ways using serial lines. First
# of them is connection to COM ports (via physical_serial_line).
# The second is to attach a third party terminal emulator
# (virtual_serial_line). And the third one is to connect to MOXA
# NPort 5210 box ports (via np5210_serial_line).
#
# Once desired way of connection is chosen connect the interface
# to preloaded controller UART
#

# MOXA NPort 5210 box connection
#load np5210_serial_line/chserial OPA0
#set OPA0 ip="xxx.xxx.xxx.xxx" rs_port=n

# Physical COM port connection
#load physical_serial_line/chserial OPA0 line="COM1:"

#
# Virtual serial line connection listening for the TCP/IP port
# number 10003 on the host system. It is possible to connect to
# this port from any appropriate application (standard terminal,
# user written terminal, etc...).
#
```

```
#load virtual_serial_line/chserial OPA0 port=10003

#
# Virtual serial line connection listening for the TCP/IP port
# number 10003 on the host system. Specified program is started
# automatically.
#
load virtual_serial_line/chserial OPA0
set OPA0 port=10003 application="opa0.ht"

set uart line=OPA0

#
# Configure optional RQDX3 storage controller (MSCP/QBUS).
# Handles disk images, disk drives, CD-ROM drives, magneto -
# optical drives, floppy drives.
#
# Note the "/RQDX3" specification which points to specific DLL
# RQDX3.DLL to load the device from. Change this DLL name to
# apropriate name if it's planned to use other implementation of
# RQDX3 disk controller. Once the DLL is loaded by the first
# instance of RQDX3 there is no need to specify "/RQDX3" for
# following instances of RQDX3 controller.
#

load RQDX3/RQDX3 DUA
#set DUA container[0]="..."
#set DUA container[1]="..."
#set DUA container[2]="..."
#set DUA container[3]="..."

#
# Note that for the case of PDP-11/94 UNIBUS system UDA50
# (MSCP/UNIBUS)disk controller should be used instead of RQDX3.
# All configuration details are the same as for RQDX3.
#

#load UDA50/UDA50 DUA
#set DUA container[0]="..."
#set DUA container[1]="..."
#set DUA container[2]="..."
#set DUA container[3]="..."

#
# Configure optional TQK50 tape storage controller (TMSCP/QBUS).
# It can be mapped to physical tape drives attached to the host
#
# Note the "/TQK50" specification which points to specific DLL
# TQK50.DLL to load the device from. Change this DLL name to
# apropriate name if it's planned to use other implementation of
# TQK50 tape controller. Once the DLL is loaded by the first
# instance of TQK50 there is no need to specify "/TQK50" for
# following instances of TQK50 controller
#

load TQK50/TQK50 MUA
#set MUA address=...
#set MUA container[0]="..."
#set MUA container[1]="..."
#set MUA container[2]="..."
#set MUA container[3]="..."

#
# Note that for the case of PDP-11/94 UNIBUS system TUK50
# (TMSCP/UNIBUS) tape controller should be used instead of TQK50.
# All configuration details are the same as for TQK50.
#
```

```
#load TUK50/TUK50 MUA
#set MUA address=...
#set MUA container[0]="..."
#set MUA container[1]="..."
#set MUA container[2]="..."
#set MUA container[3]="..."


#
# Configuring the optional DELQA Ethernet adapters (QBUS).
#.
#
# Load the optional DELQA/DESQA/DEQNA Ethernet adapter then load
# a ndis5 packet port then associate these two devices as shown
# below.
#

load DELQA/DEQNA XQA
#load ndis5_chpack_port/chnetwrk XQA0 interface="..."
#set XQA interface=XQA0


#
# Configuring the optional DELUA Ethernet adapters (UNIBUS).
#
# Load the optional DELUA/DEUNA Ethernet adapter then load
# a ndis5 packet port then associate these two devices as shown
# below.
#

load DELUA/DEUNA XUA
#load ndis5_chpack_port/chnetwrk XUA0 interface="..."
#set XUA interface=XUA0

#
# If specifying multiple Qbus/Unibus devices always take care to follow
# Qbus/Unibus addressing rules.
#

#
# Configure optional DHV11 (DHQ11, CXY08, CXA16, CXB16) serial
# line controller (QBUS). Address and vector must be set as
# required by operating system.
#
# Note "/DHV11" specification to load default dhv11.dll for the
# device to be created. If it's planned to use custom developed
# DLL specify its name after "/" sign
#
# "/DHV11" specification can be omitted in case of DHV11
# controller. Once the DLL is loaded, loading of this DLL can be
# omitted for the following instances.
#
# See comments above for different types of serial line
# connections and their parameters.
#
# Note that UNIBUS DHU11 serial line controller is not implemented yet
# for PDP-11/94 emulator. This will be done later. Don't try to use
# described QBUS models with UNIBUS system!
#

#load DHV11/DHV11 TXA
#load DHQ11/DHV11 TXA
#load CXY08/DHV11 TXA
#load CXA16/DHV11 TXA
#load CXB16/DHV11 TXA
#set TXA address=... vector=...

#load np5210_serial_line/chserial TXA0
```

```
#set TXA0 ip="xxx.xxx.xxx.xxx" rs_port=n

#load physical_serial_line/chserial TXA0 line="COMn:"
#load virtual_serial_line/chserial TXA0 port=10010

#load virtual_serial_line/chserial TXA0
#set TXA0 port=10010 application="txa0.ht"

#set TXA line[0]=TXA0


#load np5210_serial_line/chserial TXA1
#set TXA1 ip="xxx.xxx.xxx.xxx" rs_port=n

#load physical_serial_line/chserial TXA1 line="COMn:"
#load virtual_serial_line/chserial TXA1 port=10011

#load virtual_serial_line/chserial TXA1
#set TXA1 port=10011 application="txa1.ht"

#set TXA line[1]=TXA1


#load np5210_serial_line/chserial TXA2
#set TXA2 ip="xxx.xxx.xxx.xxx" rs_port=n

#load physical_serial_line/chserial TXA2 line="COMn:"
#load virtual_serial_line/chserial TXA2 port=10012

#load virtual_serial_line/chserial TXA2
#set TXA2 port=10012 application="txa2.ht"

#set TXA line[2]=TXA2


#load np5210_serial_line/chserial TXA3
#set TXA3 ip="xxx.xxx.xxx.xxx" rs_port=n

#load physical_serial_line/chserial TXA3 line="COMn:"
#load virtual_serial_line/chserial TXA3 port=10013

#load virtual_serial_line/chserial TXA3
#set TXA3 port=10013 application="txa3.ht"

#set TXA line[3]=TXA3


#load np5210_serial_line/chserial TXA4
#set TXA4 ip="xxx.xxx.xxx.xxx" rs_port=n

#load physical_serial_line/chserial TXA4 line="COMn:"
#load virtual_serial_line/chserial TXA4 port=10014

#load virtual_serial_line/chserial TXA4
#set TXA4 port=10014 application="txa4.ht"

#set TXA line[4]=TXA4


#load np5210_serial_line/chserial TXA5
#set TXA5 ip="xxx.xxx.xxx.xxx" rs_port=n

#load physical_serial_line/chserial TXA5 line="COMn:"
#load virtual_serial_line/chserial TXA5 port=10015

#load virtual_serial_line/chserial TXA5
#set TXA5 port=10015 application="txa5.ht"
```

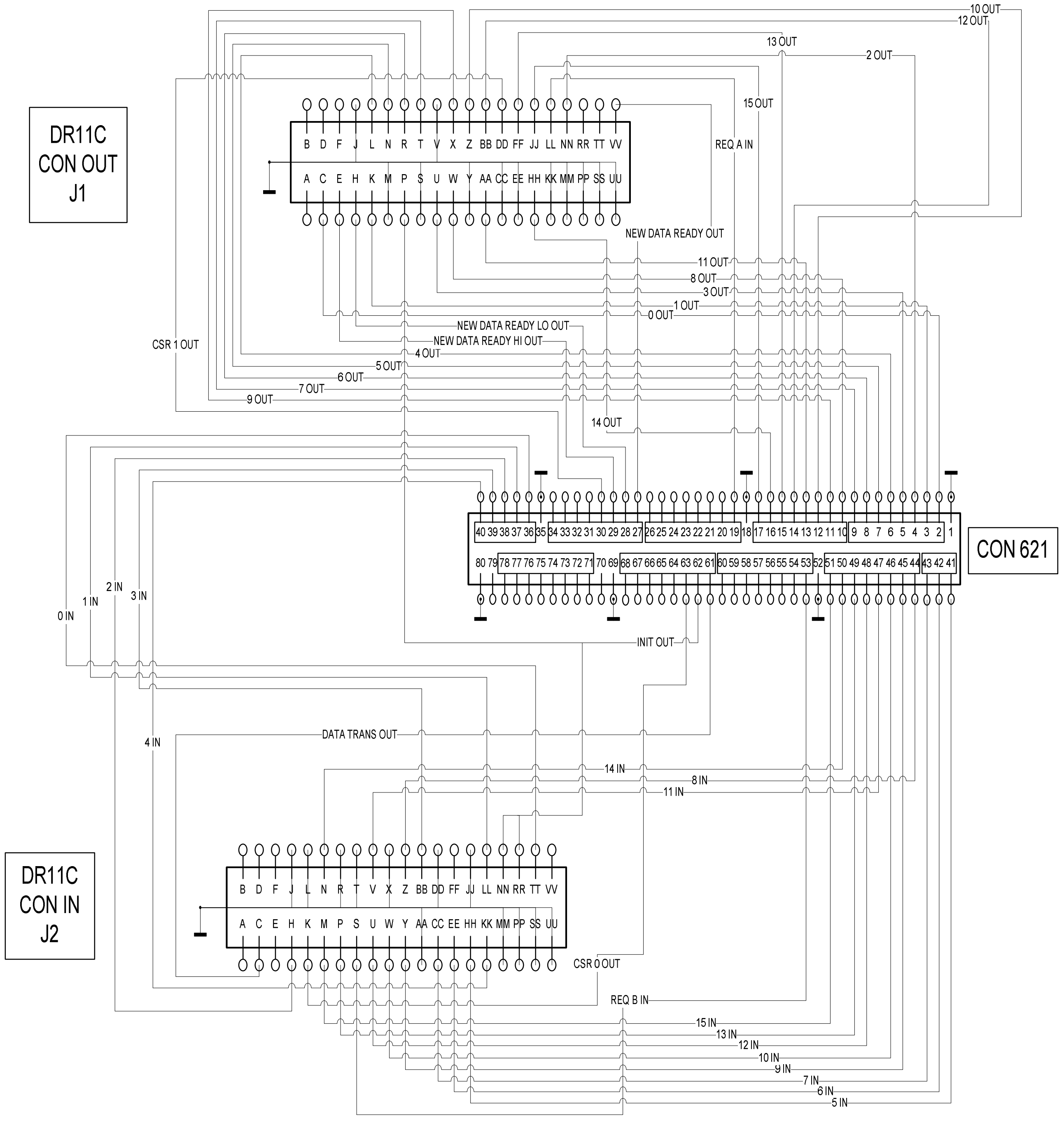
```
#set TXA line[5]=TXA5


#load np5210_serial_line/chserial TXA6
#set TXA6 ip="xxx.xxx.xxx.xxx" rs_port=n

#load physical_serial_line/chserial TXA6 line="COMn:"
#load virtual_serial_line/chserial TXA6 port=10016

#load virtual_serial_line/chserial TXA6
#set TXA6 port=10016 application="txa6.ht"

#set TXA line[6]=TXA6


#load np5210_serial_line/chserial TXA7
#set TXA7 ip="xxx.xxx.xxx.xxx" rs_port=n

#load physical_serial_line/chserial TXA7 line="COMn:"
#load virtual_serial_line/chserial TXA7 port=10017

#load virtual_serial_line/chserial TXA7
#set TXA7 port=10017 application="txa7.ht"

#set TXA line[7]=TXA7


#
# Configure optional DZV11 (DZQ11) serial line controller (QBUS).
# Address and vector must be set as required by operating system.
#
# Note "/DZ11" specification to load default dz11.dll for the
# device to be created. If it's planned to use custom developed
# DLL specify its name after "/" sign
#
# Note that DZ11 should be used for UNIBUS system.
#
# Once the DLL is loaded, loading of this DLL can be omitted for
# the following instances.
#
# See comments above for different types of serial line
# connections and their parameters.
#

#load DZV11/DZ11 TTA
#load DZQ11/DZ11 TTA
#load DZ11/DZ11 TTA
#set TTA address=... vector=...

#load np5210_serial_line/chserial TTA0
#set TTA0 ip="xxx.xxx.xxx.xxx" rs_port=n

#load physical_serial_line/chserial TTA0 line="COMn:"
#load virtual_serial_line/chserial TTA0 port=10110

#load virtual_serial_line/chserial TTA0
#set TTA0 port=10110 application="tta0.ht"

#set TTA line[0]=TTA0


#load np5210_serial_line/chserial TTA1
#set TTA1 ip="xxx.xxx.xxx.xxx" rs_port=n

#load physical_serial_line/chserial TTA1 line="COMn:"
#load virtual_serial_line/chserial TTA1 port=10111

#load virtual_serial_line/chserial TTA1
```

```
#set TTA1 port=10111 application="tta1.ht"

#set TTA line[1]=TTA1


#load np5210_serial_line/chserial TTA2
#set TTA2 ip="xxx.xxx.xxx.xxx" rs_port=n

#load physical_serial_line/chserial TTA2 line="COMn:"
#load virtual_serial_line/chserial TTA2 port=10112

#load virtual_serial_line/chserial TTA2
#set TTA2 port=10112 application="tta2.ht"

#set TTA line[2]=TTA2


#load np5210_serial_line/chserial TXA3
#set TXA3 ip="xxx.xxx.xxx.xxx" rs_port=n

#load physical_serial_line/chserial TTA3 line="COMn:"
#load virtual_serial_line/chserial TTA3 port=10113

#load virtual_serial_line/chserial TTA3
#set TTA3 port=10113 application="tta3.ht"

#set TTA line[3]=TTA3


#
# It is also possible to connect any third-party CHAPI devices
# to the system. Each particular device configuration depends on
# its implementation. Below are number of examples for STROMASYS
# supplied CHAPI devices. Detailed device description can be
# found in CHARON Manual.
#

#-------------------------------------------------------------------
# CHAPI DHV-11 serial line controller. It is possible to map its
# lines to three different kind of ports. Just uncomment appropriate
# lines to test particular type of serial line port.
#
# chapi_serial is default value for line_dll when this option is
# omitted;
# tcpip is default for the line_cfg option when this option is
# omitted.
#
# Note that CHAPI DHU-11 UNIBUS controller has not been implemented yet
# to be used with PDP-11/94 UNIBUS system. Don't try to use CHAPI DHV11
# instead!
#

#load chapi TXA dll=chapi_dhv11.dll
#set TXA address=... vector=...
#set TXA trace_level=0

# LINE[0] IS SERVER
#set TXA line_dll[0]=chapi_serial line_cfg[0]=tcpip
#set TXA line_is_terminal[0]=true line_param[0]="port=10020 application=txa0.ht"

#set TXA line_dll[1]=chapi_serial line_cfg[1]=com
#set TXA line_is_terminal[1]=true line_param[1]="com=1"

#set TXA line_dll[2]=chapi_serial line_cfg[2]=moxa
#set TXA line_is_terminal[2]=true line_param[2]="ip=192.168.127.254 port=1"

#set TXA line_dll[3]=chapi_serial line_cfg[3]=moxa
#set TXA line_param[3]="ip=192.168.127.254 port=2"
```

```
# LINE[4] IS CLIENT
#set TXA line_dll[4]=chapi_serial line_cfg[4]=tcpip
#set TXA line_param[4]="ip=192.168.1.1 port=10055"


#--------------------------------------------------------------------
# CHAPI DLV-11 serial line controller. It is possible to map its
# line to three different kind of ports.
#
# chapi_serial is default value for line_dll when this option is
# omitted;
# tcpip is default for the line_cfg option when this option is
# omitted.
#
# This CHAPI device can be used both with QBUS and UNIBUS systems.
#

#load chapi TT1 dll=chapi_dlv11.dll
#set TT1 address=017760010 vector=0310 trace_level=0
#set TT1 line_dll=chapi_serial line_cfg=com line_is_terminal=true
#set TT1 line_param="com=1" baud_rate=19200
#set TT1 dtr=true rts=true mode="e" breaken=true erroren=true

#load chapi TT2 dll=chapi_dlv11.dll
#set TT2 address=017760020 vector=0320 trace_level=0
#set TT2 line_dll=chapi_serial line_cfg=moxa line_is_terminal=true
#set TT2 line_param="ip=192.168.127.254 port=1" baud_rate=19200
#set TT2 dtr=true rts=true mode="e" breaken=true erroren=true

#load chapi TT3 dll=chapi_dlv11.dll
#set TT3 address=017760030 vector=0330 trace_level=0
#set TT3 line_dll=chapi_serial line_cfg=tcpip line_is_terminal=true
#set TT3 line_param="port=10020 application=txa0.ht" mode="e"


#--------------------------------------------------------------------
# CHAPI LPV11 line printer mapped to the special tool HOSTPrint.
# Just uncomment proper lines to test this kind of CHAPI device.
#
# This CHAPI device can be used both with QBUS and UNIBUS systems.
#

#load chapi LPA dll=lpv11.dll
#set LPA address=...
#set LPA vector=...
#set LPA host ="localhost" port=10004
#set LPA application="HOSTprint -port=10004 -fontsize=10 -font=\Arial Bold\"

# It is also possible to print to the local file...
#set LPA file="printer.txt"

# Or directly to the LPTn connected printer ...
#set LPA file="LPTn:"


#--------------------------------------------------------------------
# CHAPI_QBUS mapped to TLC BCI-2104 bus adapter.
# Just uncomment the lines below to test this kind of CHAPI device.
#
# All options specified for the bus adapter below can be omitted,
# in this case specified values will be used by default.
#
# Options description:
#     adapter_dll - the name of DLL library where to take adapter
#            implementation from (chapi_hw is default);
#     adapter_name - name of the adapter within the DLL library
#            (bci is default);
#     adapter_instance - number of adapter instance to use if more
#           than one adapter is installed in the host system (0 is default);
#     adapter_options - options to  be passed to adapter (no options are
#           defined for the moment - empty string is default).
#
# Note that CHAPI_QBUS can be used both with QBUS and UNIBUS systems.
# In case of QBUS system this is full-functuional BUS adapter, while in
# case of UNIBUS system it works like QBUS<-->UNIBUS converter with the
# only restriction that bus memory locations aren't translated.
#

#load chapi chapi_qbus dll=chapi_qbus.dll trace_level=0
#set chapi_qbus adapter_dll=chapi_hw
#set chapi_qbus adapter_name=bci
#set chapi_qbus adapter_instance=0
#set chapi_qbus adapter_options=""

# ... mentioned above configuration is equal to the following one ...
#load chapi chapi_qbus dll=chapi_qbus.dll trace_level=0


#---------------------------------------------------------------------
# CHAPI_UNIBUS mapped to TLC BCI-2004 bus adapter.
# Just uncomment the lines below to test this kind of CHAPI device.
#
# All options specified for the bus adapter below can be omitted,
# in this case specified values will be used by default.
#
# Options description:
#     adapter_dll - the name of DLL library where to take adapter
#           implementation from (chapi_hw is default);
#     adapter_name - name of the adapter within the DLL library
#           (bci is default);
#     adapter_instance - number of adapter instance to use if more
#           than one adapter is installed in the host system (0 is default);
#     adapter_options - options to  be passed to adapter (no options are
#           defined for the moment - empty string is default).
#
# Note that CHAPI_UNIBUS can be used both with QBUS and UNIBUS systems.
# In case of UNIBUS system this is full-functuional BUS adapter, while in
# case of QBUS system it works like QBUS<-->UNIBUS converter but only
# for non-DMA devices which don't use bus memory locations.
#

#load chapi chapi_unibus dll=chapi_unibus.dll trace_level=0
#set chapi_unibus adapter_dll=chapi_hw
#set chapi_unibus adapter_name=bci
#set chapi_unibus adapter_instance=0
#set chapi_unibus adapter_options=""

# ... mentioned above configuration is equal to the following one ...
#load chapi chapi_unibus dll=chapi_unibus.dll trace_level=0



#---------------------------------------------------------------------
# CHAPI RL01/RL02 disks.
#
# Just uncomment the proper lines below to test this kind of CHAPI
# device with particular configuration.
#
# Options description:
#     disk_dll - the name of DLL library to take disk container implementation
#           from (chapi_storage is default);
#     disk_cfg - the name of disk container implementation within the
#           specified DLL library to use (file is default and only available
#           for the moment);
#     disk_param - the name of container to connect (only disk image is
#           possible for the moment);
#
# When default values for disk_dll/disk_cfg are satisfy user needs -
# just ommit these options and use disk_param only to specify disk image.
#
# This CHAPI device can be used both with QBUS and UNIBUS systems.
#

#load chapi DLA dll=chapi_rlv12.dll address=... vector=... trace_level=0

#set DLA disk_dll[0]=chapi_storage disk_cfg[0]=file
#set DLA disk_param[0]="<image_name1>"

#set DLA disk_dll[1]=chapi_storage disk_cfg[1]=file
#set DLA disk_param[1]=="<image_name2>"

#set DLA disk_dll[2]=chapi_storage disk_cfg[2]=file
#set DLA disk_param[2]=="<image_name3>"

#set DLA disk_dll[3]=chapi_storage disk_cfg[3]=file
#set DLA disk_param[3]=="<image_name4>"


#---------------------------------------------------------------------
# CHAPI TSV05/TS11 tapes.
#
# Just uncomment the proper lines below to test this kind of CHAPI
# device with particular configuration.
#
# Options description:
#     extended_mode - TSV05 emulation if true, TS11 emulation otherwise
#           (default value is true, i.e. TSV05);
#     tape_dll - the name of DLL library where the tape transport
#           implementation is located (chapi_storage is default);
#     tape_cfg - the name of transport within the specified DLL library
#           to use (mtd is default);
#     tape_param - the name of container to connect (disk image name,
#           SCSI device name or windows tape name);
#
# When default values for tape_dll/tape_cfg are satisfy user needs -
# just ommit these options and use tape_param only to specify tape image.
#
# This CHAPI device can be used both with QBUS and UNIBUS systems.
#

#load chapi MSA0 dll=chapi_tsv05.dll address=.. vector=.. trace_level=0
#set MSA0 extended_mode[0]=<false|true>

# It's possible to map tape unit to the tape file as follows...
#set MSA0 tape_dll[0]=chapi_storage tape_cfg[0]=mtd
#set MSA0 tape_param[0]="<tape_image_name>"

# ... or as follows
#set MSA0 tape_param[0]="<tape_image_name>"

# It's also possible to map tape unit to SCSI tape as follows...
#set MSA0 tape_dll[0]=chapi_storage tape_cfg[0]=scsi
#set MSA0 tape_param[0]="\\.\SCSI1:k:j"

# ... or as follows
#set MSA0 tape_cfg[0]=scsi tape_param[0]="\\.\SCSI1:k:j"

# And it's also possible to map tape unit to Windows driver supported
# tape as follows ...
#set MSA0 tape_dll[0]=chapi_storage tape_cfg[0]=driver
#set MSA0 tape_param[0]="\\.\TapeN"

# ... or as follows ...
```

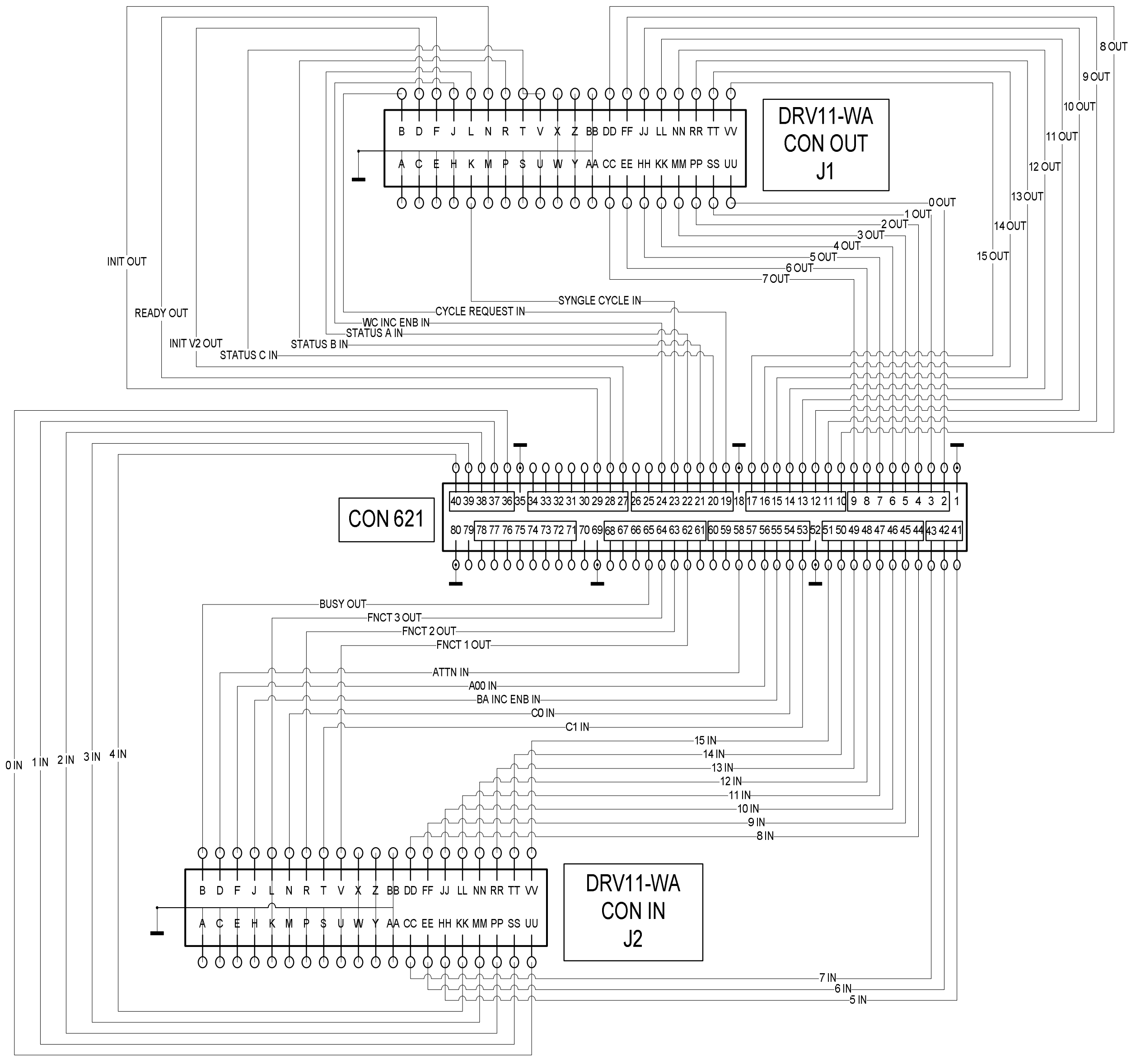
```
#set MSA0 tape_cfg[0]=driver tape_param[0]="\\.\TapeN"


#---------------------------------------------------------------------
# CHAPI DRV11-WA using TLC DCI-1100 board.
#
# Just uncomment the proper lines below to test this kind of CHAPI
# device with particular configuration.
#
# Options description:
#     adapter_dll - the name of DLL library where to take adapter
#           implementation from (chapi_hw is default);
#     adapter_name - name of the adapter within the DLL library
#           (dci1100 is default);
#     adapter_instance - number of adapter instance to use if more
#           than one adapter is installed in the host system (0 is default);
#     adapter_options - options to  be passed to adapter (no options are
#           defined for the moment - empty string is default).
#
# When default values for adapter_* options are satisfy user needs -
# just ommit these options.
#
# This is QBUS device - don't try to use it with UNIBUS systems.
#

#load chapi IXA dll=chapi_drv11wa trace_level=0
#set IXA address=... vector=...
#set IXA adapter_dll=chapi_hw
#set IXA adapter_name=dci1100
#set IXA adapter_instance=0
#set IXA adapter_options=""

# ... mentioned above configuration is equal to the following one ...
#load chapi IXA dll=chapi_drv11wa trace_level=0
#set IXA address=... vector=...

# this is the end of the configuration file #
```

9.The SENSORAY 621 - DR11C/DRV11 adapter.



An 'Eagle' PCB layout for a small connector adapter board can be provided.

10. The SENSORAY 621 - DRV11-WA adapter.



An 'Eagle' PCB layout for a small connector adapter board can be provided.

Reader's Comments

We appreciate your comments, suggestions, criticism and updates of this manual. You can Email us your comments at: info@stromasys.com

Please mention the document reference number: 30-016-040-001

If you found any errors, please list them with their page number.