Driver Manual

cifX Device Driver

Linux (Kernel 2.6.x / 3.x.x)

V1.1.0.0

Hilscher Gesellschaft für Systemautomation mbH

www.hilscher.com

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1 Introduction

1.1 About this document

This manual describes the Hilscher cifX driver for Linux and its architecture.

The driver offers access to the Hilscher netX-based hardware (e.g. CIFX50) with the same functional API as the cifX Device Driver for Windows®.

1.2 List of revisions

Rev	Date	Name	Chapter	Revision
4	2010-06-01	SD		Updated udev rule to get write access Added compilation with Eclipse Update functions / limitations / little changes for driver version 1.0.0.0 Added cifXGetDriverVersion() Update file storage if rotary switch is used
5	2012-05-11	RM/SD	 3.4.2.2 4.2.3 3.7.1 to 3.7.2 4.1.1	Tested with Linux Kernel 2.6.35 and 3.3.3 Added information to start build process under Eclipse Added toolkit compiler option CIFX_TOOLKIT_TIME Added xDriverRestartDevice() function Added MRAM support Fixed pictures of the directory structure (changed boot loader name and config.nxd instead of warmstart.dat) Update initialization structure CIFX_LINUX_INIT: - Added support of initializing particular card - Added locking mechanism to synchronize access from multiple applications (CIFX_DRIVER_INIT_CARDNUMBER). - Stack size of polling thread is configurable.
6	2013-02-13	RM/SD	1.4 3.4.1.2 3.4.1.2/3.6 3.7.4 -/-	Information about CIFX API manual added. Unnecessary header files removed. Description of compiler flags settings reworked. Section *Creating the directory tree of the configuration file storage* added. DMA support information added.
7	2014-3-10	SD	1.7 3 4 4.6 7	CD layout updated (folder templates added). Reworked (added information of automated build scripts 3.3). Reworked (to be more informative). Information about the Virtual cifX Ethernet Interface added. Chapter for FAQs added.
8	2014-11-03	SD	1.5 1.7 3.4.2 3.6 4 4.1.1 / 4.1.2 4.3 6 6.2	Features updated: Custom Hardware Interface support, Interrupt support for ISA devices. ISA and SPI example added. Compiler options updated. Module arguments added: custom card defintion. Features ‘custom hardware interface support’ updated. Reworked (due to new features). Information about non-PCI device support added, including section 4.3.1 / 4.3.2 / 4.3.2.1 / 4.3.2.2 / 4.3.2.3 / 4.3.2.4) Reworked ISA example code added.

Table 1: List of revisions

1.3 Overview

The cifX Linux driver runs as a library in userspace and accesses the card via a UIO kernel module (Userspace I/O).

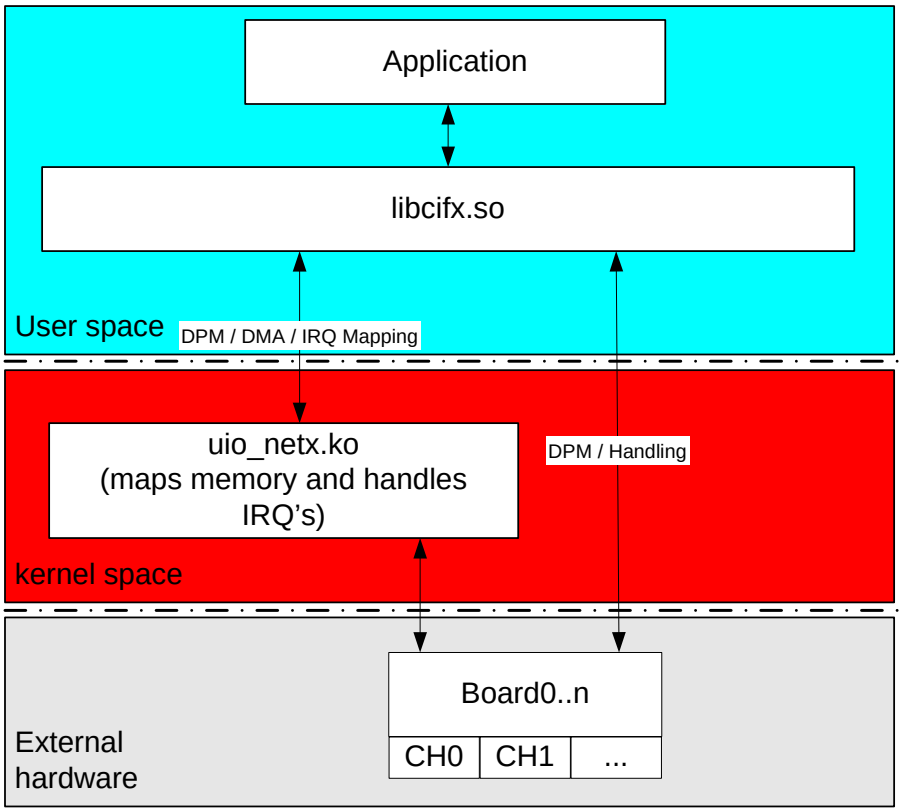

Figure 1: Linux cifX driver architecture

1.4 Requirements

Mandatory

- Linux Source (tested under 2.6 / 3.3.3 / 3.13.5)
- libpthread, librt
- cifX board (PCI/PCIe), NXSB-PCA / NXSB100 / netPLC, netJACK / NXHX board or NX-PCA-PCI / NXHX or netX Chip (DPM connections).
- Building with configure:
  - *pkg-config* utility for automatic finding/configuring needed libraries
- Building with *Eclipse*:
  - *Eclipse* environment (tested V3.5.2 / V3.7.2 / V4.4)
  - *Eclipse* CDT-plugin (V6.0.2 or later)

Optional

- Linux standard libraries *libpciaccess* (tested with V0.10.2 / V0.13.1-2)
  - always needed for cifX PCI cards, support can be disabled by defining *CIFX_TOOLKIT_DISABLEPCI*)

1.5 Features

- Based on the netX Toolkit source V1.2.0.0
- Unlimited number of cifX boards supported
- Support for NXSB-PCA or NX-PCA-PCI, netPLC, netJACK boards included
- Interrupt notification for applications
- Support of second Memory Window for PCI-based device (e.g. MRAM)
- Setting the device time during start-up if time handling is supported by the device
- DMA Support
- Support of a Virtual cifX Ethernet Interface (see section *netX-based virtual Ethernet interface* on page 51)
- uio_netx driver supports custom memory mapped devices
  (e.g. DPM, ISA, or other non PCI devices)
- Interrupt support for ISA devices (when using uio_netx with custom device)
- Simple integration of custom hardware interface (e.g. via SPI)

1.6 Limitations

- No Interrupt support for NXSB-PCA and NX-PCA-PCI boards
- On big-endian machines the user is responsible for converting send/receive packets from/to little endian. This is **NOT** automatically done inside the driver / toolkit.
- Interrupt support only available for devices handled through uio_netx kernel module
- Only one application can access a card simultaneously. For multi-application access to a single card, a special application needs to be implemented by user.
- Online diagnostics access via SYCON.net needs a TCP/IP Server functionality integrated into the user application. An example stand alone server is offered with the Linux driver.
- **libcifx (Toolkit) needs to run as 'root' or with a user that has the following rights:**
  - **read/write access to the PCI configuration registers (i.e. '/sys/class/uio/uio<n>/device/config')**
  - **Mapping of DPM to user space (see 'mmap' and 'ulimit -l')**
  - **read/write access to devices '/dev/uio<n>'**
  - **read/write access to /dev/mem (for user added devices)**

1.7 CD contents

Folder		Content
documentation		Driver documentation
driver		
	libcifx	cifX Linux driver source (autoconf project / Eclipse project)
	patches	uio-netx-dma-support.patch - (includes update of the uio_netx kernel module and necessary extension of the Linux kernel Build Environment (DMA support)
	uio_netx	netx uio driver sources
	BSL	boot loader files
	scripts	installation scripts for the uio_netx kernel module
	templates	templates for several device configurations
examples		cifX example application
	basedir	Example card configuration directory (copy to /opt/cifx or to your own base directory)
	cifxsample	Small example application, demonstrating driver initialization and toolkit usage (autoconf project / Eclipse project)
	cifXTCPServer	Example stand alone TCP server for SYCON.net diagnostic access (autoconf project / Eclipse project)
	cifXTestConsole	Demo application for testing toolkit functions (autoconf project / Eclipse project)
	LoadModules	Example application, demonstrating firmware module loading. (Eclipse project / Makefile)
	ISASample	Small application, demonstrating the initialization of an ISA device via User Space library libcifx
	SPISample	Small application, demonstrating the initialization of an SPI device via User Space library libcifx
Diagnostic and Remote Access		Documentation, example and sources for the netX diagnostic and remote access

Table 2: CD contents

1.8 Terms, abbreviations and definitions

Term	Description
cifX	**C**ommunication **I**nter**f**ace based on netX
comX	**Co**mmunication **M**odule based on netX
PCI	**P**eripheral **C**omponent **I**nterconnect
UIO	**U**serspace **I/O**
API	**A**pplication **P**rogramming **I**nterface
DPM	**D**ual-**P**ort **M**emory Physical interface to all communication board **Note:** DPM is also sometimes used for PROFIBUS-**DP M**aster

Table 3: Terms, abbreviations and definitions

1.9 References to documents

This document refers to the following documents:

[1] Hilscher Gesellschaft für Systemautomation mbH:
CIFX API - Application Programming Interface Revision 2, english, 2013.

[2] Hilscher Gesellschaft für Systemautomation mbH: Driver Manual cifX Device Driver - Windows 2000/XP/Vista/7/8 V1.1.x.x, revision 22, english, 2013

[3] Hilscher Gesellschaft für Systemautomation mbH: Protocol API, PROFINET IO-Device, Revision 14, English, 2013.

[4] Hilscher Gesellschaft für Systemautomation mbH: cifX netX Toolkit - DPM TK, revision 7, english, 2014

Table 4: References to documents

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1.10.1 Copyright

1.10.2 Important notes

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2 Licensing terms

The Hilscher cifX Linux driver consists of several modules.

- **uio_netx** Offered by Hilscher Gesellschaft für Systemautomation mbH

  The latest version of the *uio_netx* kernel module is located on the CD.

  This module is licensed under GPL V2 and can be used under these terms.

- **libcifx** Offered by Hilscher Gesellschaft für Systemautomation mbH

  This library is a userspace library and an intellectual property of the *Hilscher Gesellschaft für Systemautomation mbH*.

  The source code and library can be used for internal development, modification and debugging purpose.

  Distribution of the original **libcifx** source code, parts of the **libcifx** source code or modifications based on it is prohibited.

  Binary distribution for use in products is allowed.

3 Installation

This chapter describes the installation procedure consisting of the compile and installation process of the user space library *libcifx* and the kernel module *uio_netx* including the cifX example programs.

The cifX driver can be installed in two ways

- Using the installation script located on the CD, building automatically all required components and installing all required files
- Installing all components separately

For the standard use case the automatic installation should be sufficient (see section *Installation of the driver in one step* on page 14). In case of custom needs (e.g. update of only a single component, building the driver for another target system or any installation trouble) the single step installation is the preferred way (see section *Single step installation process* on page 14).

The following steps are required to run a demo application

- Plug in the cifX hardware and start the system
- Extract the driver sources (see section *Preparation* on page 13)
- Install all required driver components (see sections *Installation of the driver in one step* / *Single step installation process* on page 14)
- Load the kernel driver (optional depends on the chosen installation method, see section *Loading netX UIO driver module* on page 26)
- Build the demo application (see section *Compiling the example programs* on page 23)

In case of any installation trouble please refer to the chapter *Question and answers* on page 59.

3.1 Prerequisites

- Kernel header (version of the kernel, the modules should be build for / tested with 3.13.5)
- GCC 4.x.x (tested with version 4.6.3)

For PCI card support

- Library and development package of **libpciaccess** (tested with V0.10.3 / V0.13.1-2)

3.2 Preparation

The following steps explain how to copy the driver source from the CD and extract them in a working directory.

Note: Some files of the driver package provide special functions, e.g. scripts are marked as executable. Not to loose such attributes and permissions, it is required to unpack the driver archive under Linux operating systems. Unpacking the archive under another operating systems may clear all attributes. In this case it is not possible to run the scripts without restoring all attributes and permissions.

- Change to your working directory (e.g. /home/project/)

  cd /home/project/

Note: Do not use any whitespaces within your project path since the provided scripts can not handle these.

- Extract/copy the sources from the cdrom (choose the archive because of the file attributes, see note above)

  tar xvjf /mnt/cdrom/driver.tar.bz
- Change into the extracted folder

  cd ./driver
- Most of the work, explained in this document will start from this point. If not especially noted, '***project folder***' refers to this folder.

Note: Since several installation instructions rely on the *'**project folder**'*, in the following the document estimates the folder as extracted.

If not especially noted, *'**project folder**'* refers to the folder of the extracted driver source.

3.3 Installation of the driver in one step

The following guide requires extracting the sources from the CD (see section *Preparation* on page 13).

Build process

- Change to the driver directory

  cd driver/
- Run the installation script (root rights requested during installation)

  ./build_install_driver
- Follow the installation instructions
- In case of successful installation the driver is ready to use. For any restrictions see the following note.

Note: In case of a successful installation, note the following restrictions

Running an example program, every accessed device will appear with only the boot loader being flashed. For device specific configuration (e.g. download of device specific firmware) see section *Firmware and configuration file storage* on page 27.

In case of a system reboot the kernel driver needs to be reloaded (for an automated load see section *Loading netX UIO driver module* on page 26).

3.4 Single step installation process

The single step installation process comprises the installation of the following components

- **Boot loader and Firmware**

  Install the firmware and the boot loader (see section *Firmware and configuration file storage* on page 27 and *Creating the directory tree of the configuration file storage* on page 31).
- **Kernel Module**

  Build the kernel module netanalyzer.ko and install it (see section *Compiling the netX UIO kernel module* on page 15).
- **User Space library**

  Build the libcifx user space library and install it (see section *Compiling the cifX userspace library* on page 19).

3.4.1 Compiling the netX UIO kernel module

Building the uio_netx kernel module can be done in two ways

- Building the uio_netx kernel module during the kernel build procedure
- Building the uio_netx kernel module only

The way, which should be chosen, depends on, if the kernel of the target system is already built.

In case, the kernel is already built, there is no need to rebuild the whole kernel. It is possible to build the uio_netx module as an external module and install it afterwards.

3.4.1.1 Compiling the UIO kernel module during kernel build process

The following steps describe how to build the whole kernel including the uio_netx module. This generic kernel build procedure may differ from your kernel build mechanism.

Note: If the kernel is already built, it is not necessary to recompile the whole kernel. In this case, skip this step and continue with section *Compiling the UIO kernel module* on page 17.

- Change to your working directory (e.g. /usr/src)

  cd /usr/src
- Extract the kernel sources

  tar xjf linux-source-x.x.x.tar.bz2
- Change into the uio driver folder within the extracted kernel source

  cd linux-source-x.x.x/drivers/uio
- Apply the patch of uio_netx driver

  patch -p0 <[path to project folder]/patches/uio_netx_update.patch

  (e.g. patch -p0 </usr/src/driver/patches/uio_netx_update.patch)

  The patch includes:
  - update of the uio_netx kernel module uio_netx.c
  - extension of the Kernel configuration scripts (Kconfig,Makefile) for DMA support

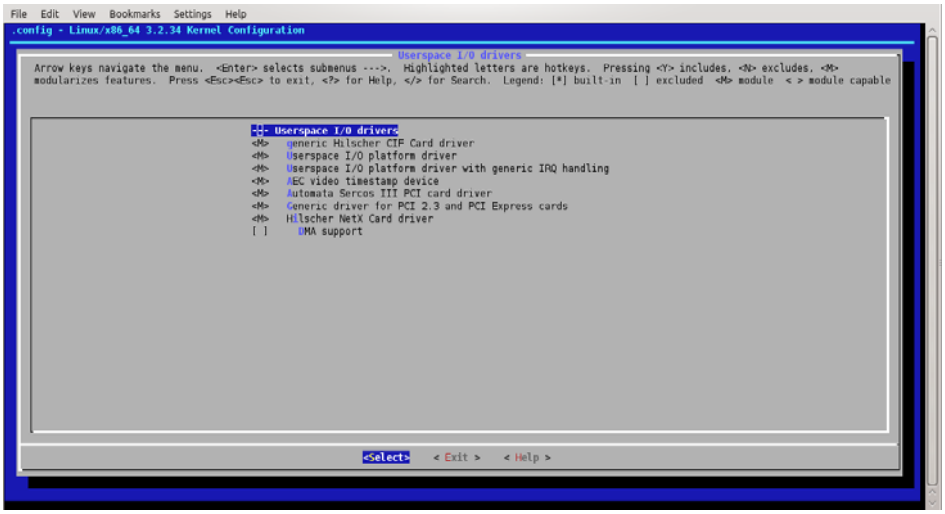
  Note: Patching is only guaranteed to work for the latest tested kernel version (see *Mandatory*, Requirements on page 6).
- Load your old kernel configuration via command line or inside 'make menuconfig'

  make oldconfig
- Configure your kernel to include UIO ('Userpace I/O drivers') and uio_netx ('Hilscher NetX Card driver')

  make menuconfig

  Enable 'Device Drivers / Userspace I/O Drivers / Hilscher netX Card Driver'

  On demand enable DMA support



- Optional: Rebuild the kernel (necessary only if Hilscher netX Card driver should be a built-in driver, not a module)

  make all install

- Build and install the modules

  make modules modules_install

3.4.1.2 Compiling the UIO kernel module only

The following text describes how to build the kernel module for an kernel already built. The build and installation process can be done manually or by script. If the target machine is the same machine as the build machine and the module should be built for the current running kernel the automatic installation process is the preferable way because of its easy usage. In contrast, the manual way is more flexible. In case of building the modules for another system choose the manual method.

Any further step depends on the preferred installation method, script-based or manually.

Automatic Installation Process using the Scripts:

- Change into the *project driver folder* (see section *Preparation* on page 13)

  (e.g.) cd /home/projects/driver
- Change into 'scripts'

  cd ./scripts
- Build the kernel module (during the build process it is possible to enable or disable DMA support)

  ./install_uio_netx build
- Install the module to the current kernel installation path (see /lib/modules/$(uname -r)/)

  ./install_uio_netx install
- Update the kernel's module dependencies

  ./install_uio_netx update

At this point the module is installed only. Module loading is described in chapter *Loading netX UIO driver module* on page 26.

Manual installation process

- Change to your *project driver folder* (see section *Preparation* on page 13)

  (e.g.) cd /home/project/driver
- Change into 'uio_netx'

  cd uio_netx
- Run the makefile

  Note: By default the makefile will generate a module for the active kernel (-> see ***uname -r***) and DMA support enabled.

  To generate a module for a specific kernel set the argument 'KDIR' to the kernel header directory the module should be build for. To disable DMA set the argument 'DMA_DISABLE' to '1'.

  Example: Disabled DMA support and kernel header files located under /home/project/my_kernel/:

  make DMA_DISABLE=1 KDIR=/home/project/my_kernel/
- Copy the uio_netx module in the target directory of the system the module is built for

  cp uio_netx.ko /lib/modules/[kernel-version]/kernel/drivers/uio/

  (Example: cp uio_netx.ko /lib/modules/$(uname -r)/kernel/drivers/uio/)
- Update the list of the module dependencies

  depmod

At this point the module is installed only. Module loading is described in chapter *Loading netX UIO driver module* on page 26.

3.4.2 Compiling the cifX userspace library

The userspace library contains the cifX Toolkit with all necessary Linux adaptions. This library needs to be build for the system the library should run on. The library can be build via the console or the Eclipse IDE.

3.4.2.1 Using the console

Installation procedure

- Change to your *project driver folder* (see section *Preparation* on page 13)
  (e.g.) cd /home/project/driver
- Change to the libcifx build directory (the correct name depends on the version)
  cd libcifx_1.0.x.0
- Run the configure script
  ./configure

Option	Parameter	Description
--prefix	Installation path	Sets the path where the library (subdirectory lib) and include files (subdirectory include/cifx) will be installed. Default: /usr/local
--enable-debug	none	Enables debug symbols for the generated library
--disable-pci	none	Disable PCI support. This will remove all links to libpciaccess. **Note:** When compiling without PCI support, the driver cannot handle cifX PCI cards any more
--enable-verbose	none	Enable verbose outputs to console (outputs debug information before the log file is created)
--enable-single-directory	none	Use subdirectory *'deviceconfig/FW/channelx'* beneath base directory for firmware/configuration file storage. **Note:** This will force all handled devices to use the same firmware/configuration
--enable-time-setup	none	Enables toolkit function, setting the device time during device start-up.
--enable-dma	none	Enables DMA support
PCIACCESS_CFLAGS PCIACCESS_LIBS	compiler parameters	Force the usage of the given parameters for the libpciaccess and don't use pkg-config
--enable-cifxethernet	none	Enables support for the netX based virtual ethernet interface **Note:** This feature requires dedicated hardware and firmware (for more information see section *netX-based virtual Ethernet interface* on page 51).
--enable-hwif	none	Enables support for custom hardware interface (e.g. SPI) (for more information see section *Support for non-PCI device* on page 41)
CFLAGS	Compiler flags	Custom compiler flags (e.g. 32-bit on 64-bit platform CFLAGS=-m32)

Table 5: Additional libcifx configuration options

- Build all source modules

  make all

- Install the library and include files (root required)

  make install

Example for compilation without using pkg-config

```
./configure PCIACCESS_CFLAGS="-I/opt/pciaccess/include -L/opt/pciaccess/lib"
    PCIACCESS_LIBS="-lpciaccess"
make all
```

3.4.2.2 Using the Eclipse IDE

Get the Eclipse environment from http://www.eclipse.org/downloads/. Depending on the download, you will need additionally the CDT-plugins (http://www.eclipse.org/cdt/downloads.php). They are required to build and debug C/C++ projects. For more information see http://www.eclipse.org/cdt/. There is also information about how to start and develop under the Eclipse environment.

When Eclipse is installed and the workspace path is set, you can load the predefined cifX library project as follows:

- Start Eclipse.
- Select **File > Import** and choose in the folder **General**, **Existing Projects into Workspace**.
- Select the path to the extracted sources (['*project folder*']*/libcifx,* see section *Preparation* on page 13) and load the shown pre-selected project.

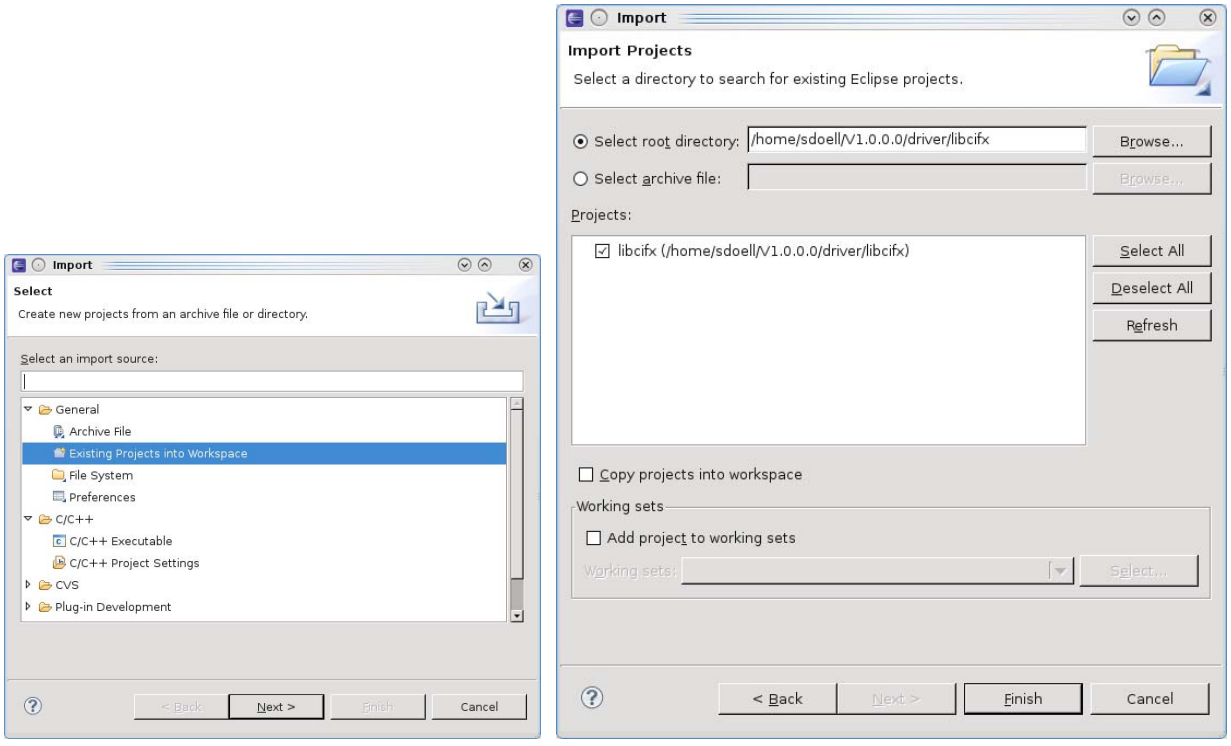


Figure 2: Eclipse IDE – Import project

Note: Figure 2 shows a project import of the cifX library V1.0.0.0. The project name depends on the cifX library version.

After importing the project, right click on libcifx, which is shown in the project explorer, to open the extended settings.

- Right click on the project **libcifx**.
- Select **Properties > C/C++ Build > Settings**.
- Under the tab **Tool Settings > Symbols** you can define or undefine special compiler flags.

The default setting is a debug version (g3) without any optimization. The following compiler flags can be set additionally.

Option	Parameter	Description
DEBUG	compiler parameters	Enables debug symbols for the generated library
CIFX_TOOLKIT_ DISABLEPCI	compiler parameters	Disable PCI support. This will remove all links to libpciaccess. **Note:** When compiling without PCI support, the driver cannot handle cifX PCI cards any more
VERBOSE	compiler parameters	Enable verbose outputs to console
CIFX_TOOLKIT_ USESINGLE_DIRECTORY	compiler parameters	Use subdirectory *'deviceconfig/FW/channelx'* beneath base directory for firmware/configuration file storage. **Note:** This will force all handled devices to use the same firmware/configuration
CIFX_TOOLKIT_TIME	compiler parameters	Enables toolkit function, setting the device time during device start-up.
CIFX_TOOLKIT_DMA	compiler parameters	Enables DMA support
CIFXETHERNET	compiler parameters	Enables support for the netX based virtual Ethernet interface **Note:** This feature requires dedicated hardware and firmware (for more information see section *netX-based virtual Ethernet interface* on page 51).
CIFX_DRV_HWIF	compiler parameters	Enables support for custom hardware interface (e.g. SPI) (for more information see section *Support for non-PCI device* on page 41)

Table 6: Additional libcifx configuration options

Build the project

Use either the menu entry **Project->Build All** or right click the libcifx project entry in the 'Project Explorer' view and chose **Build Configurations->Build->All**.

Install the library

Now the library (located under '~/libcifx/Release/' or '~/libcifx/Debug/') needs to be copied to the installation path (/usr/local/lib/). The correct library file is in the format libcifx.so.[Major].[Minor].[Release].

Note: The name of the library depends on the version (e.g. library libcifx.so.1.0.4)

Finally run the next three steps:

- Change into the installation directory (cd /usr/local/lib/).
- Run ldconfig to register library and create a link

  ldconfig
- Create a symbolic link '*libcifx.so*' to the cifx library libcifx.so.[Maj].[Min].[Rel]

  Example for libcifx library V1.0.4

  ln –s libcifx.so.1.0.4 libcifx.so

Note: The required include files must also be copied to the installation path (/usr/local/include/cifx/).
- ./src/cifxlinux.h
- ./src/Toolkit/cifXUser.h
- ./src/Toolkit/cifXErrors.h
- ./src/Toolkit/cifXEndianess.h
- ./src/Toolkit/rcX_Public.h
- ./src/Toolkit/TLR_Types.h
- ./src/Toolkit/rcX_User.h

3.5 Compiling the example programs

All example applications listed in section *CD contents* on page 7, rely on the same two ways to be build.

- **Via Console (autoconf / Makefile)**
- **Via IDE (Eclispe)**

The following chapter explains how to build an application using the *cifxsample* test program.

Note: Before using the test applications make sure you have compiled and installed the cifX library which is described in section *Compiling the cifX userspace library* on page 19.

3.5.1 Compiling the cifX example program via console

Installation procedure

- Change into your working directory (e.g. cd ~)
- Extract/copy the ex*ample* sources from the CD-ROM

  In case of an archive use:

  tar xvjf /mnt/cdrom/example.tar.bz2

  If it is already extracted use:

  cp -R /mnt/cdrom/example/ .
- Change to *cifxsample* build directory

  cd example/cifxsample
- Run the configure script

  ./configure

Option	Parameter	Description
--prefix	Installation path	Sets the path where the program will be installed. Default: /usr/local
--enable-debug	None	Enables debug symbols for the generated library
--with-cifx-lib	Path to cifX library	Needs to be set if your installation target of the cifX library is not in your default library search path
--with-cifx-include	Path to cifXUser.h, etc.	Needs to be set if the cifX includes are not in your default include path
CFLAGS / CXXFLAGS	Compiler flags	Custom compiler flags (e.g. 32bit on 64bit platform CFLAGS=-m32)

Table 7: Additional cifxsample configuration options

- Build all source modules

  make all
- Optional: Install the program

  make install

Example for compiling without using pkg-config

```
./configure libcifx_CFLAGS="-I/usr/local/include/cifx -L/usr/local/lib"
  libcifx_LIBS="-lcifx -lpthread -lrt" PCIACCESS_CFLAGS="-I/opt/pciaccess/include
  -L/opt/pciaccess/lib" PCIACCESS_LIBS="-lpciaccess"
make all
```

3.5.2 Compiling the cifX example program via IDE

As mentioned before, you must copy the entire *example* folder in your local workspace to open the example project.

- Change into the working directory (e.g. cd /home/~/workspace/).
- Extract/copy the *example* sources from the CD-ROM

  In case of an archive use:

  tar xvjf /mnt/cdrom/example.tar.bz2

  If it is already extracted use:

  cp -R /mnt/cdrom/example/ .
- Start Eclipse and import the project as noted in section *Using the Eclipse IDE* on page 20.

Note: Before compiling the example, the library libcifx must be installed (see section *Compiling the cifX userspace library* on page 19).

The default search path for the header is '/usr/local/include/cifx'. If another path is used, set the include path to the specified one.

- Right click the project **cifxsample**
- Select **Properties > C/C++ Build > Settings**.
- Under the tab **Tool Settings > Directories** you can set a new or additional include path.

Debug information output from the example program can be activated by defining the compiler flag *DEBUG* (set compiler flags, see section *Using the Eclipse IDE* on page 20).

Option	Parameter	Description
DEBUG	compiler parameters	Enables debug information output. (Disabled by default)

Table 8: Additional cifxsample configuration options

Build the project

- Use either the menu entry **Project->Build All** or a right click to the example project entry in the ‘Project Explorer' view and chose **Build Configurations->Build->All**.

The Eclipse debug environment can be used after compiling the project. When the library libcifx is built in debug version, it is also possible to step into the driver functions.

3.6 Loading netX UIO driver module

Module loading / unloading

To load the UIO driver module, you will need to login as ***root*** and enter the following command:

modprobe uio_netx

Note: To automatically load the UIO driver module at system startup, check the manual of your Linux distribution. Usually kernel modules loaded at startup are placed in /etc/modules.

To unload the module run

modprobe –r uio_netx

Optional arguments

The uio_netx driver provides mapping of non-PCI devices by passing the appropriate arguments (user_dpm_addr, user_dpm_len and user_irq). For more information refer to section *Support for non-PCI devices* on page 41. The module arguments are arrays, so it is possible to pass a comma separated list of parameters.

Option	Parameter	Description
user_dpm_addr	ULONG Array	Physical start address of the DPM (system dependent)
user_dpm_len	ULONG Array	Length of the DPM (depends on the device)
user_irq	int Array	Number of the interrupt line (0 = not connected)

Table 9: uio-netx optional arguments

Example parameter usage

The following command loads the kernel module and maps two cards, with a DPM memory location at 0xD0000 (16kB, IRQ5) and 0xFECC0000 (64kB, no IRQ).

modprobe uio_netx user_dpm_start=0xD0000,0xFECC0000 user_dpm_len=0x4000,0x10000 user_irq=5,0

Using netX UIO Driver as user (non-root)

If you want to access the UIO driver with user privileges you will need to make sure the user has read / write access to the following device nodes and files:

- /dev/uio<n>
- /sys/class/uio/uio<n>/device/config

  This can automatically be done by writing an *udev* rule (see example below):

```
/etc/udev/netx.rules
SUBSYSTEMS=="pci",ATTRS{vendor}=="0x15cf",ATTRS{device}=="0x0000",MODE="0666",PROGRAM="/b
in/bash –c ’chmod 0666 /sys/class/uio/uio%n/device/config’"
```

An example of an udev rule (*80-udev-netx.rules*) is located on the CD under /driver/templates/udev/ (see section *CD contents* on page 7). For standard use case (the rule file will match all Hilscher cards) copy the rule file ‘*80-udev-netx.rules’* to *‘/etc/udev/rules.d/’*. To make the changes take effect restart the udev system via ‘***sudo udevadm trigger***’ or unload and then reload the kernel module *uio_netx*.

3.7 Firmware and configuration file storage

cifX cards are not using any flash memory to store a firmware or configuration on the card. Every time the card is powered-up all files (boot loader, firmware and configuration) must be loaded into the hardware.

This chapter describes where to store these files depending on the way the cards should be identified. Identification of a card can be done in three different ways (single directory / device and serial number / *Slotnumber*) described below.

When the appropriate storage method is chosen, the folder structure can be easily created with the provided helper scripts (see section *Creating the directory tree of the configuration file storage* on page 31).

Note: Firmware and configurations are not stored on the hardware and must be loaded into the hardware each time the card is powered-up.

It is the task of the driver to initialize the card and therefore the driver has to know which files have to be loaded into the hardware.

To allow device-specific configuration, every file that needs to be downloaded must be stored in a unique way. This relation (device <-> device firmware, configuration) is done via a specific folder structure. These folders reside under a global base folder (default: '/opt/cifx', can be changed during driver initialization).

- **(1) Use a single directory**

  If only **ONE** cifX device needs to be supported, a predefined directory can be used by setting the define CIFX_TOOLKIT_USESINGLE_DIRECTORY accordingly (see compiler flag USESINGLE_DIRECTORY (Eclipse) or *enable-single-directory* (autoconf)). The firmware and configuration file must reside in the subdirectory named *FW*.

  For detailed information of the folder structure layout, see section *Device identification via single directory* on page 28.

- **(2) Use the *Slotnumber* (hardware rotary switch)**

  The *Slotnumber* serves to distinguish between multiple cifX cards installed in one PC. The *Slotnumber* must be set at the cifX card using the "Rotary switch". While *Slotnumber* 0 means, that the cifX card is identified via its device and serial number, values from 1 to 9 corresponds to the *Slotnumber* 1 to 9. The firmware and configuration file must reside in the subdirectory *Slot_<1..9>*.

  For detailed information of the folder structure layout see section *Device identification via slotnumber (Rotary switch)* on page 29.

- **(3) Use the device and serial number (default)**

  If the cifX device is not equipped with a rotary switch to set the slotnumber or the slotnumber mechanism should not be used, the device is identified by its device and serial number. The firmware and configuration file must reside in the subdirectory /*<Device Number>/<Serial Number>/*.

  For detailed information of the folder structure layout see section *Device identification via device and serial number* on page 30.

Note: How to setup the basic directory tree of the configuration file storage is described in section *Creating the directory tree of the configuration file storage* on page 31.

Note: When creating directories or files remember Linux is case sensitive.

3.7.1 Device identification via single directory

The following table describes the different subdirectory levels, using a s*ingle directory* which should hold the firmware and configuration files.

Note: This method requires to compile the user space library libcifx with single directory support enabled (for more information see section *Compiling the cifX userspace library* on page 19).

Subdirectory	Description
<BASEDIR>	Base directory **Default:** '**/opt/cifx**' Can be changed during userspace library initialization. This directory must contain the second stage PCI boot loader (e.g. NETX100-BSL.BIN).
deviceconfig	Device specific configuration files
FW	If s*ingle directory* is used, the search path is set to <**BASEDIR**>/**deviceconfig/FW** Contains the *device.conf* which holds the device specific settings **Note:** This directory must contain the rcX base firmware if loadable modules are used.
channel<#>	Channel specific files - firmware file (*.nxf - e.g. cifxdpm.nxf) - fieldbus configuration file (*.nxd - e.g. config.nxd) - firmware loadable module file (*.nxo) **Note:** Currently only channel 0 is supported

Table 10: Firmware and configuration file storage - Single directory

Sample directory structure for *single directory* usage

```
+ <BASEDIR>/
|
|-- NETX100-BSL.BIN (bootloader)
|
|--+ deviceconfig
   |
   |--+ FW
      |
      |-- device.conf (configuration file)
      |
      |--+ channel0
      |  |
      |  |-- cifXdps.nxf (firmware)
      |  |-- config.nxd (fieldbus database or warmstart.dat)
      |
      |--+ channel1
      |--+ channel2
      |--+ channel3
      |--+ channel4
      |--+ channel5
```

Note: *Single directory* usage is intended to be used if only one cifX device is supported by the hardware and application. Because all requests to a firmware and/or configuration file downloads are routed to the same "single" directory.
The base directory structure (including the second stage boot loader) can easily be created using the provided script, see section *Creating the directory tree of the configuration file storage* on page 31.

3.7.2 Device identification via slotnumber (Rotary switch)

The following table describes the different subdirectory levels, if the device provides a "*Rotary switch*" which is used as the Slotnumber identification.

Subdirectory	Description
<BASEDIR>	Base directory **Default:** '**/opt/cifx**' Can be changed during userspace library initialization. This directory must contain the second stage PCI boot loader (e.g. NETX100-BSL.BIN)
deviceconfig	Device specific configuration files
Slot_<1..9>	If device provides a rotary switch, the files will be stored under: **Slot**_<**rotary switch set**>. (Only if the rotary switch is not 0) Contains the *device.conf* which holds the device specific settings **Note:** This directory must contain the rcX base firmware if loadable modules are used.
channel<#>	Channel specific files - firmware file (*.nxf - e.g. cifxdpm.nxf) - fieldbus configuration file (*.nxd - e.g. config.nxd) - firmware loadable module file (*.nxo) **Note:** Currently only channel 0 is supported

Table 11: Firmware and configuration file storage - Rotary switch

Sample directory structure for a cifX device identified by *Slotnumber* 2

```
+ <BASEDIR>/
|
|-- NETX100-BSL.BIN (bootloader)
|
|--+ deviceconfig
   |
   |--+ Slot_1
...|
   |--+ Slot_2
   |  |
   |  |-- device.conf (configuration file)
   |  |
   |  |--+ channel0
   |  |  |
   |  |  |-- cifxdpm.nxf
   |  |  |-- config.nxd (fieldbus database or warmstart.dat)
   |  |
   |  |--+ channel1
   |  |--+ channel2
   |  |--+ channel3
   |  |--+ channel4
   |  |--+ channel5
...|
   |--+ Slot_3
   |--+ Slot_4
   |--+ Slot_5
   |--+ Slot_6
   |--+ Slot_7
   |--+ Slot_8
   |--+ Slot_9
```

Note: The base directory structure (including the second stage boot loader) can easily be created using the provided script, see section *Creating the directory tree of the configuration file storage* on page 31.

3.7.3 Device identification via device and serial number

Device identification via the device and serial number are the default way to distinguish between multiple cifX devices in one PC.

Note: *<Device Number>/<Serial Number>* are shown on the device hardware label.
Example:
Hardware Label Entry: **1250.100 / 20217**
Directory Entry: '**/1250100/20217'**

The following table describes the different subdirectory levels, without using the rotary switch:

Subdirectory	Description
<BASEDIR>	Base directory **Default:** '**/opt/cifx**' Can be changed during userspace library initialization. This directory must contain the second stage PCI boot loader (e.g. NETX100-BSL.BIN)
deviceconfig	Device specific configuration files
<Device Number>	Device number of the device (e.g. 1250100)
<Serial Number>	Serial number of the device (e.g. 20217) Contains *device.conf* storing device specific settings **NOTE:** This directory must contain the rcX base firmware if loadable modules are used.
channel<#>	Channel specific files - firmware file (*.nxf - e.g. cifxdpm.nxf) - fieldbus configuration file (*.nxd - e.g. config.nxd) - firmware loadable module file (*.nxo) **NOTE:** Currently only channel 0 is supported

Table 12: Firmware and configuration file storage - Device and serial number

Sample directory structure for a cifX device with device number 1250100 and serial number 20217

```
+ <BASEDIR>/
|
|-- NETX100-BSL.BIN (bootloader)
|
|--+ deviceconfig
   |
   |--+ 1250100
      |
      |--+ 20217
      |  |
      |  |-- device.conf (configuration file)
      |  |
      |  |--+ channel0
      |  |  |
      |  |  |-- cifXdps.nxf (firmware)
      |  |  |-- config.nxd (fieldbus database or warmstart.dat)
      |  |
      |  |--+ channel1
      |  |--+ channel2
      |  |--+ channel3
      |  |--+ channel4
      |  |--+ channel5
      |
```

Note: The base directory structure (including the second stage boot loader) can easily be created using the provided script, see section *Creating the directory tree of the configuration file storage* on page 31.

3.7.4 Creating the directory tree of the configuration file storage

An easy way to setup the configuration file storage is to use the provided installation script 'install_firmware' located on the CD under **/driver/scripts/**.

The following steps show how to create the directory tree needed by the different configuration file storage methods noted in sections *Device identification via single directory* to *Device identification via device and serial number* starting on page 28.

- Change to your *project folder* (see section *Preparation* on page 13)

  (e.g.) cd /usr/src/driver.
- Change into 'script'

  cd ./script
- First install the second stage boot loader by calling (**root** privileges are required)

  ./install_firmware install

  This creates the folder '**/opt/cifx/deviceconfig'** and copies the second stage boot loader to '**/opt/cifx/'**
- Depending on the chosen configuration file storage method, execute one of the following commands (**root** privileges are required)

  Device identification via device and serial number:

  ./install_firmware add_device [device no] [serial no]

  Device identification via slotnumber:

  ./install_firmware add_slot_dir [slot no]

  Device identification via single directory:

  Note: This method requires to compile the user space library libcifx with single directory support enabled (for more information see section *Compiling the cifX userspace library* on page 19).

  ./install_firmware create_single_dir

Note: This installation procedure only creates the directory structure, installs the boot loader and adds a default configuration file.

To install an application specific firmware refer to section *Device identification via single directory* on page 28 to section *Device identification via slotnumber (Rotary switch)* on page 29.

For further device configuration see section *Device configuration (device.conf)* on page 49.

Remember to adapt the permissions, in case of normal users should be able to access files located in the configuration storage.

4 Linux driver specific information

The Linux driver needs some special initialization compared to the standard Windows driver, because it is not executed by the kernel at system startup.

The driver (libcifx) is linked to an application and needs to be configured correctly to work.

To enable the use of the cifX driver by an application, some special functions are provided. These functions are described in the following chapters. Further the Linux driver supports also access to devices via different hardware interfaces (e.g. SPI, ISA), for more information refer to *Support for non-PCI device* on page 41.

Chapter *Driver/Library start-up procedure* on page 47 describes the correct usage and sequence of the functions.

Features

The user space driver libcifX provides debug output feature. The tracing can be enabled during the driver's initialization (see *Trace Level*, *Structure CIFX_LINUX_INIT* on page 33).

Depending on the trace level the following messages will be logged:

- Trace Level = 0x00 – Tracing disabled
- Trace Level = 0x01 – Debug messages will be logged
- Trace Level = 0x02 – Information messages will be logged
- Trace Level = 0x04 – Warning messages will be logged
- Trace Level = 0x08 – Errors messages will be logged
- Trace Level = 0xFF – All messages will be logged

For debugging purposes it is sometimes useful to enable all debug messages.

By default the driver creates a log file in the driver's ***'base directory'*** (see *Firmware and configuration file storage* on page 27). If the log file creation fails (e.g. no permissions to create or write to a file in the configuration directory) the debug messages will be printed to the console output.

Note: By default root can create and write to a log file only. To be able to log debug messages created by an application started by a normal user, remember to change the permissions of the driver's configuration base directory (see section *Firmware and configuration file storage* on page 27).

Restrictions

By default only root can access a cifX device

Note: libcifx (netX/cifX Toolkit) needs to be run as 'root' or with a user that has the following rights:
=> read/write access to the PCI configuration registers (i.e.'/sys/class/uio/uio<n>/device/config')
=> read/write access to devices '/dev/uio<n>'
=> Mapping of DPM to user space (see 'mmap' and 'ulimit -l')
=> read/write access to /dev/mem (for user added devices)

To be able to access a device as 'normal user' see section *Loading netX UIO driver module* on page 26.

4.1 Additional structures

Some of the Linux specific functions need parameters provided through structures. The structures and the meaning of the internal data are described in the following chapter.

4.1.1 Structure CIFX_LINUX_INIT

This structure is used to initialize the cifX driver.

Element	Data type	Description
init_options	int	Driver Initialization options: **0 = CIFX_DRIVER_INIT_NOSCAN** Driver does not scan for available cards detected by the UIO driver (driver handles only the user defined cards, see element *user_cards*) **1 = CIFX_DRIVER_INIT_AUTOSCAN** Driver scans for all available cards, which are detected by the UIO driver initializes and adds them to the application. **2 = CIFX_DRIVER_INIT_CARDNUMBER** Driver scans for only one card (UIO device) specified by iCardNumber. Independently of the number the Device name is set to 'cifX0'.
iCardNumber	int	Index of card to initialize when init_option is set to **CIFX_DRIVER_INIT_CARDNUMBER**
fEnableCardLocking	int	Locking multiple application access to a specific cifX card. **fEnableCardLocking = 0** User application has to synchronize access from multiple applications. **fEnableCardLocking <>0** Ignore access to cards already used by another application. It is not possible to open a second instance of a locked cifX device. (Useful option in mode **CIFX_DRIVER_INIT_CARDNUMBER)**
base_dir	const char*	Set the base directory of the driver, Set to NULL to use the default directory (*'**/opt/cifx**'*)
poll_interval	unsigned long	Polling interval in milliseconds [ms] for non-interrupt cards. Used for *Change of State* (COS) detection **0 = default of 500ms** **CIFX_POLLINTERVAL_DISABLETHREAD** can be used to completely disable COS polling
poll_priority	int	Priority of the polling thread (for possible values see man page of pthread_setschedparam) **0 = default (priority of the calling thread)**
poll_schedpolicy	int	Scheduling policy, need to be set when poll_priority is set 0 = SCHED_NORMAL (poll_priority 0) 1 = SCHED_FIFO (poll_priority 1..99) 2 = SCHED_RR (poll_priority 1..99)
poll_StackSize	int	Stack size of the polling thread. *poll_StackSize* specifies the number additional bytes to add to PTHREAD_STACK_MIN (= 0x4000Bytes). If *poll_StackSize* is set to 0 the default size +0x1000 byte is used. **Default Stack-Size: PTHREAD_STACK_MIN + 0x1000**
trace_level	unsigned long	Set the trace level of the driver. **0x0000 = no trace information is created** **0xFFFF = maximum trace information is created**
user_card_cnt	int	Number of user cards to be manually added to the driver. Devices are specified by the CIFX_DEVICE_T structure.

Element	Data type	Description
user_cards	struct CIFX_DEVICE_T*	Pointer to an optional array of additional user card structures. Number of card structures in the array must be given in ***user_card_cnt***. For more information see section *Structure CIFX_DEVICE_T* on page 34.

Table 13: Structure CIFX_LINUX_INIT definition

4.1.2 Structure CIFX_DEVICE_T

This structure contains all information describing a cifX device. The structure needs to be filled in the following cases:

- **Handling non-UIO devices**

  In case of a netX device, which is not detectable by the UIO driver, should be added to the driver's control (for more information see section *Support for non-PCI devices* on page 41).

- **Controlling more than one UIO device, but not all that exists in the system**

  In this case neither the *CIFX_DRIVER_INIT_CARDNUMBER* nor the *CIFX_DRIVER_INIT_AUTOSCAN* option can be used. Instead an array of the required cards needs to be passed to the driver.

Thereby the requested cards, so called '*User Cards*', are differentiated by the following two groups

- ***UIO-Devices***

  Detected by the UIO driver (cifX PCI cards)

- ***Non-UIO devices***

  Not detectable by the UIO driver

In case of a ***UIO-Device*** the information for the CIFX_DEVICE_T structure can be easily retrieved by calling *cifXFindDevice(). cifXFindDevice()* fills the CIFX_DEVICE_T structure for the requested device and returns. In case of a ***non-UIO device*** the structure needs to be filled by the user and passed to the driver. In this case UIO-specific fields need to be invalidated by setting the values to '-1'.

CIFX_DEVICE_T data content

Element	Data type	Description	
		UIO device	**None UIO device**
dpm	unsigned char*	**Virtual pointer to card DPM**	
		Filled by *cifXFindDevice()*	Must be provided by the user (e.g. via mmap()).For more information refer to Support for non-PCI devices on page 41
dpmaddr	unsigned long	**Virtual pointer to card DPM**	
		Filled by *cifXFindDevice()*	Must be provided by the user. For more information refer to Support for non-PCI devices on page 41
dpmlen	unsigned long	**Size of the DPM in bytes**	
		Filled by *cifXFindDevice()*	Must be provided by the user. For more information refer to Support for non-PCI devices on page 41
uio_num	int	**UIO number of the device**	
		Filled by *cifXFindDevice()*	Not used set to '-1'

Element	Data type	Description	
		UIO device	**None UIO device**
uio_fd	int	**File handle to UIO device**	
		Filled by *cifXFindDevice()*	Not used set to '-1'
pci_card	int	**PCI card handling** 0 = Card is a non-PCI card with firmware in FLASH memory (no reset during start-up required) 1 = Card is a PCI card, needs to be reset on every start	
		- Filled by *cifXFindDevice()* - *Can be overwritten by user*	Not used set to '-1'
force_ram	int	**Force card storage behavior** 0 = Auto-detect card storage (PCI = RAM, DPM = Flash) 1 = Force usage of RAM only on this card. (This will execute a HW reset and download boot loader / Firmware on every start of the card)	
		- Filled by *cifXFindDevice()* - *Can be overwritten by user*	Must be provided by the user
notify	PFN_CIFX_NOTIFY_EVENT	**Optional user initialization function** Callback that is made at several stages when initializing a device. This allows the user to setup DPM and timings if they are different from the netX ROM Loader settings. **NULL = suppress callback**	
		User provided	User provided
userparam	void*	**User definable information per device**	
		User provided	User provided
Optional (requires the compiler flag CIFX_DRV_HWIF set, when compiling the user space library libcifx, see section Compiling the cifX userspace library on page 19**)**			
hwif_init		**Optional: User definable function.** Initializes the hardware interface (may be NULL). For more information refer to Custom specific hardware interface (e.g. SPI) on page 43.	
		Not used set to NULL	User provided
hwif_deinit		**Optional: User definable function.** De-initializes the hardware interface (may be NULL). For more information refer to Custom specific hardware interface (e.g. SPI) on page 43	
		Not used set to NULL	User provided
hwif_read		**User definable function. Implements the read access to the netX device.** Function implementation highly depends on the hardware interface. For more information refer to Custom specific hardware interface (e.g. SPI) on page 43	
		Not used set to NULL	User provided
hwif_write		**User definable function. Implements the write access to the netX device.** Function implementation highly depends on the hardware interface. For more information refer to Custom specific hardware interface (e.g. SPI) on page 43	
		Not used set to NULL	User provided

Table 14: CIFX_DEVICE_T data content

4.2 Additional functions

This chapter describes functions which are available for the Linux version of the driver only. These functions need to be used to initialize the driver to be usable inside an application.

Linux driver specific functions:

Function	Description
cifXDriverInit()	Driver initialization function, see *cifXDriverInit()*) on page 37.
cifXDriverDeinit()	De-initialization of the driver, see *cifXDriverDeinit()* on page 38,
xDriverRestartDevice()	Restarts the specified device, see *xDriverRestartDevice()* on page 38,
cifXGetDriverVersion()	Returns the driver and toolkit version, see *cifXGetDriverVersion()* on page 39,
cifXGetDeviceCount()	Returns the number of the detected UIO devices, see *cifXGetDeviceCount()* on page 39,
cifXFindDevice()	Returns the information structure (CIFX_DEVICE_T) of the requested UIO device, see *cifXFindDevice()* on page 40.
cifXDeleteDevice()	Deletes a previously via cifXFindDevice() acquired device. see *cifXDeleteDevice()* on page 40.

Table 15: Linux cifX Driver: Linux specific driver functions

4.2.1 cifXDriverInit()

This function must be called before accessing any driver function. It initializes the driver and adds the needed devices to the control of the libcifx shared library.

Function call

```
int32_t cifXDriverInit(struct CIFX_LINUX_INIT* init_params)
```

Arguments

Argument	Data type	Description
init_params	struct CIFX_LINUX_INIT_T*	Initialization parameters (see section *Structure CIFX_LINUX_INIT* on page 33 for details)

Return Values

CIFX_NO_ERROR (0) if the driver was successfully initialized.

Remarks

The driver initialization provides three different types, see element '***init_options***' in *Structure CIFX_LINUX_INIT* on page 33.

Note: The given initialization option belongs only to UIO devices. In general user defined Non-UIO devices (see *Structure CIFX_DEVICE_T* on page 34) given in '*user_cards*' are not effected and will be always added to the driver's control.

- **CIFX_DRIVER_INIT_NOSCAN**

  The driver ignores all devices which are detected by the UIO driver.

  The driver handles only the given ***User Cards*** (see element '***user_cards***' in section *Structure CIFX_LINUX_INIT* on page 33).

  Use case: The application should not acquire every device found, instead specified ones only.

- **CIFX_DRIVER_INIT_AUTOSCAN**

  The driver scans for all devices, which are detected by the UIO driver and adds them to the driver's control.

  Use case: The application should have access to all cards, found in the PC.

- **CIFX_DRIVER_INIT_CARDNUMBER**

  The driver scans for the requested device (UIO device) and adds it to the driver's control.

  Use case: The application should have access to only one specific card (UIO device).

4.2.2 cifXDriverDeinit()

Un-initialize the driver and remove all devices from the control of the *libcifx* shared library. After calling this function the application must not access any cifX Driver API function any more.

Function call

```
void cifXDriverDeinit(void)
```

Arguments

None

4.2.3 xDriverRestartDevice()

The function can be used to restart a netX board. The driver processes the same functions as on a power-on reset (reset the hardware and download the second stage boot loader, firmware and configuration files etc.).

A restart is necessary on PCI-based-netX boards, if a running firmware should be updated or changed. Because on such boards the firmware is not stored in a FLASH file system and updating the firmware while it is running in RAM is not possible.

Note: A restart is only performed, if no application has an open handle to the board or one of its communication channels.

Function call

```
int32 t APIENTRY xDriverRestartDevice(    CIFXHANDLE hDriver,
                                          char*      szBoardName,
                                          void*      pvData);
```

Arguments

Argument	Data type	Description
hDriver	CIFXHANDLE	Handle to the driver (returned by *xDriverOpen*)
szBuffer	String	Identifier for the board. (e.g. 'cifX<BoardNumber>')
pvData	void*	For further extensions can be NULL

Return Values

CIFX_NO_ERROR if the function succeeds.

4.2.4 cifXGetDriverVersion()

This function returns the version of the cifX driver for Linux.

Function call

```
int32_t cifXGetDriverVersion ( uint32_t ulSize, char* szVersion);
```

Arguments

Argument	Data type	Description
ulSize	unsigned long	Size of buffer referenced by parameter *szVersion*
szVersion	char*	Buffer to return driver version string

Return values

Return values	
CIFX_NO_ERROR	Memory mapping successful
CIFX_INVALID_BUFFERSIZE	Size of supplied buffer is too small

4.2.5 cifXGetDeviceCount()

Query the number of available UIO devices. Device detection only works through the netX UIO driver.

Function call

```
int cifXGetDeviceCount(void)
```

Arguments

None

Return values

Number of detected devices.

4.2.6 cifXFindDevice()

Build a CIFX_DEVICE_T structure for a given device.

The structure can be used by an application if only some specific cards should be used. Therefore the application has to add them manually to the driver as a user card, see section *Structure CIFX_LINUX_INIT* on page 33.

This can be done by calling the function *cifXDriverInit()* with the '***CIFX_DRIVER_INIT_NOSCAN***' option and passing the card information in the *user_cards* parameter.

Function call

```
struct CIFX_DEVICE_T* cifXFindDevice(int num, int fCheckAccess)
```

Arguments

Argument	Data type	Description
num	int	Device number of the chosen device. Range: 0..cifXGetDeviceCount()
int	fCheckAccess	Check if device is already used by another application fCheckAccess = 0, do not check if already accessed fCheckAccess = 1, check if device is already accessed

Return values

Pointer to the device information structure of the given device.

NULL, if the device number is invalid or not available or if *fCheckAccess* = 1 and the device is already used by another application.

4.2.7 cifXDeleteDevice()

Delete a CIFX_DEVICE_T structure that was returned by *cifXFindDevice()*. This needs to be done **after** the driver un-initialization to clean up all internally used administration data and allocated memory areas.

Function call

```
void cifXDeleteDevice(stuct CIFX_DEVICE_T* device)
```

Arguments

Argument	Data type	Description
device	struct CIFX_DEVICE_T*	Pointer to a device returned by *cifXFindDevice()*

4.3 Support for non-PCI devices

The *Linux cifX Driver* provides the ability to access devices connected via several hardware interfaces. In general, the supported devices can be grouped into so called memory-mapped devices and non-memory-mapped devices. Since the driver is capable to detect PCI devices autonomously only, other devices need to be published by the customer.

Depending on the type of the device (memory-mapped or non-memory-mapped) the driver provides the following integration possibilities:

Device type	Integration interface	Features / limitations / description
Memory-mapped DPM	Kernel Mode Driver uio-netx	Features - No difference between custom and standard uio device - Interrupt support - No additional initialization in user space (skips adding user defined card) Limitations - Parameter need to be passed during driver startup Memory mapped devices can easily passed to the driver without any driver preparation. For more information see section *ISA or other memory-mapped devices* on page 42.
	User Space Driver libcifx	Features - Independent of the uio_netx kernel module Limitations - No interrupt support Memory mapped devices can easily passed to the driver without any driver preparation. For more information see section *ISA or other memory-mapped devices* on page 42.
Non-Memory Mapped DPM	User Space Driver libcifx	Features - Depends on the customer's implementation Limitations - Depends on the customer's implementation This method requires the implementation of dedicated hardware read/write functions. For more information see section *Custom specific hardware interface (e.g. SPI)* on page 43. **Note: To be able to handle a non memory mapped device the driver need to be build with the compiler flag CIFX_DRV_HWIF set (see section *Compiling the cifX userspace library* on page 19).**

Table 16: Overview supported device types

4.3.1 ISA or other memory-mapped devices (DPM)

The netx-uio kernel mode driver is capable to detect PCI devices autonomously only. Other memory-mapped devices like ISA or DPM devices do not provide any detection methods and need to be published by the customer. The device can easily be integrated by passing the device-specific-memory parameter to the driver. Memory-mapped devices can be passed to the uio-netx kernel module or the *User Space Driver* libcifx. For the differences of both methods see section *Overview supported device types* on page 41.

- ***Memory-mapped device via kernel module uio_netx***

  The device-specific information can be passed via command line parameter during module loading:
  modprobe user_dpm_addr=0xD0000 user_dpm_len=0x4000 user_irq=4

  The above example adds a device with the DPM located at the physical address 0xD0000, DPM length of 16 KB and interrupt connected to IRQ line 4. For more information of the parameter see section *Loading netX UIO driver module* on page 26.

  In case the mapping succeeds, the driver creates a new uio_netx device which is accessible via the user space library libcifx **as common uio device**.

  For an example refer to Using UIO driver on page 57.

- ***Memory-mapped device via user space library libcifx***

  Integration of a memory mapped device via a user space library requires the device specification via *Structure CIFX_DEVICE_T* (page 34). The filled structure need to be passed to the drivers initialization routine *cifXDriverInit()* via *Structure CIFX_LINUX_INIT* (page 33).

  The following table shows the important parameter of the CIFX_DEVICE_T structure. For other parameter or general information refer to *Structure CIFX_DEVICE_T* on page 34.

Name	Type	Description
dpm	unsigned char*	Virtual Pointer to the card's DPM. The driver provides a helper function (*cifx_ISA_map_dpm()*), mapping the physical address to the application's specific virtual memory. For more information refer to the Example: Driver initialization for ISA device on page 56.
dpmaddr	unsigned long	Physical address to the card's DPM (this parameter depends on the system and the hardware configuration, for more information refer to the appropriate hardware documentation).
dpmlen	unsigned long	Size of the DPM in bytes (depends on the device, for more information refer to the appropriate hardware documentation).

Table 17: Initialization parameter: Custom memory mapped device

  For an example refer to *Not using UIO driver* on page 56.

4.3.2 Custom specific hardware interface (e.g. SPI)

Note: To enable the following feature, the user space library needs to be build with the compiler flag CIFX_DRV_HWIF (set), see section *Compiling the cifX userspace library* on page 19.

Additional to *Memory-mapped devices*, the cifX Toolkit is capable to access netX-based hardware via the *cifXToolkit Hardware Function Interface.* For more information refer to Hilscher Gesellschaft für Systemautomation mbH: cifX netX Toolkit - DPM TK, revision 7, english, 2014.

Similar to a '*non-UIO-memory-mapped Device*', the custom device needs to be specified via the *Structure CIFX_DEVICE_T* (on page 34). Though, the custom hardware interface feature requires an additional implementation of interface-specific read/write functions.

The hardware-specific read/write functions need to be specified per device, during driver initialization (see *hwif_read, hwif_write*, *Structure CIFX_DEVICE_T*).

The following table shows the important parameter of the CIFX_DEVICE_T structure. For other parameter or general information refer to *Structure CIFX_DEVICE_T* on page *Structure CIFX_DEVICE_T* on page 34.

Name	Type	Description
dpm	unsigned char*	set to 0 (since no physical address exists)
dpmaddr	unsigned long	set to 0 (since the driver cannot access the device's DPM directly)
dpmlen	unsigned long	Size of DPM in Bytes (depends on the device, refer to the hardware documentation)
userparam	void*	Optional: User parameter (may point to information required for the hardware interface). If not used set to NULL
hwif_init	PFN_DRV_HWIF_INIT	Optional: Initializes the custom hardware interface **Note: Need to be implemented by customer** (see section *Hardware initialization via* hwif_init on page 44). If not used set to NULL
hwif_deinit	PFN_DRV_HWIF_DEINIT	Optional: De-initializes the custom hardware interface **Note: Need to be implemented by customer** (see section *Hardware de-initialization via hwif_deinit* on page 44). If not used set to NULL
hwif_read	PFN_DRV_HWIF_MEMCPY	Reads a given number of bytes from the netX DPM via the custom hardware interface. **Note: Need to be implemented by customer** (see section *Hardware read access via hwif_read* on page 45).
hwif_write	PFN_DRV_HWIF_MEMCPY	Writes a given number of bytes to the netX DPM via the custom hardware interface. **Note: Need to be implemented by customer** (see section *Hardware write access via hwif_write* on page 46).

Table 18: Initialization parameter: Custom hardware interface

In case of registered hardware functions (*hwif_read*, *hwif_write*), the toolkit replaces the common memory access (e.g. via memcpy()) by the appropriate access function.

The initialized structure need to be passed to the drivers initialization routine *cifXDriverInit()* via *Structure CIFX_LINUX_INIT*.

For an SPI example application see SPISample, *CD contents* on page 7).

4.3.2.1 Hardware initialization via hwif_init

This function needs to be implemented by the customer. The function needs to provide a complete initialization of the specific hardware interface. If the function returns success (*CIFX_NO_ERROR*) it must be guaranteed that is is possible to read from and write to the interface. Further, the function implementation must be aware of its initialization state, since it may be called during application runtime (e.g. in case of a reset via *xDriverRestartDevice()*). The passed device-specific structure *Structure CIFX_DEVICE_T*, provides a tag called *userparam*, which enables passing of interface-specific information and states.

This function is optional. In case initialization is not required set the *hwif_init* in *Structure CIFX_DEVICE_T* to NULL.

Function call

```
int32_t hwif_init (stuct CIFX_DEVICE_T* device)
```

Arguments

Argument	Data type	Description
device	struct CIFX_DEVICE_T*	Pointer to the device

Return values

CIFX_NO_ERROR on success

For all possible error values refer to the header file *cifXErrors.h* located in the *cifX Driver Toolkit*, see Toolkit, *CD contents* on page 7.

4.3.2.2 Hardware de-initialization via hwif_deinit

This function needs to be implemented by the customer. The function needs to provide a complete de-initialization of the specific-hardware interface. Further, the function implementation must be aware of its initialization state, since it may be called during application runtime (e.g. in case of a reset *xDriverRestartDevice()*). The passed device specific structure *Structure CIFX_DEVICE_T* provides a tag called *userparam*, which enables passing of interface-specific information and states.

This function is optional. In case de-initialization is not required, set the *hwif_deinit* in the Structure CIFX_DEVICE_T to NULL.

Function call

```
void hwif_deinit (stuct CIFX_DEVICE_T* device)
```

Arguments

Argument	Data type	Description
device	struct CIFX_DEVICE_T*	Pointer to the device

4.3.2.3 Hardware read access via hwif_read

This functions need to be implemented by the customer. The function needs to provide reading the number of bytes given by ulLen from the DPM. pvAddr contains the offset where to start reading from the DPM.

The passed device specific structure *Structure CIFX_DEVICE_T* provides a tag called *userparam*, which enables passing of interface-specific information and states.

Function call

```
void* hwif_read ( stuct CIFX_DEVICE_T* device,
                  void* pvAddr,
                  void* pvData,
                  uint32_t ulLen)
```

Arguments

Argument	Data type	Description
device	struct CIFX_DEVICE_T*	Pointer to the device
pvAddr	void*	Offset in DPM where to read from **Note: This is a pointer to the DPM location where to read from. This can be handled as an offset (unsigned long) from the beginning of the DPM, if the parameter *dpmaddr* is set to NULL (see *Structure CIFX_DEVICE_T* on page 34). Otherwise *dpmaddr* need to subtracted to get the offset.**
pvData	void*	Pointer to memory where to store read data
ulLen	uint32_t	Length of data to read

Return values

Pointer to the read buffer passed into the function call (pvData).

4.3.2.4 Hardware write access via hwif_write

This function needs to be implemented by the customer and has to write the number of bytes, given by ulLen to the DPM start offset contained in pvAddr.

The passed device specific structure *Structure CIFX_DEVICE_T* provides a tag called *userparam*, which enables passing of interface specific information and states.

Function call

```
void* hwif_write ( stuct CIFX_DEVICE_T* device,
                   void* pvAddr,
                   void* pvData,
                   uint32_t ulLen)
```

Arguments

Argument	Data type	Description
device	struct CIFX_DEVICE_T*	Pointer to the device
pvAddr	void*	Offset in DPM where to write to **Note: This is a pointer to the DPM location where to write to and it can be handled as an offset (unsigned long) from the beginning of the DPM, if the parameter *dpmaddr* is set to NULL (see *Structure CIFX_DEVICE_T* on page 34). Otherwise *dpmaddr* need to subtracted to get the offset.**
pvData	void*	Pointer to a buffer containing the write data
ulLen	uint32_t	Length of data to write

Return values

Pointer holding the write address passed into the function (pvAddr).

4.4 Driver/Library start-up procedure

The driver start-up procedure can be controlled by the user, setting the appropriate initialization flag (*Structure CIFX_LINUX_INIT (init_options)* on page 33).

The following three use cases are available:

- **CIFX_DRIVER_INIT_AUTOSCAN**

  Automatically add all found uio_netx-based devices and add user specified devices.
- **CIFX_DRIVER_INIT_CARDNUMBER**

  Add only one specific uio_netx-based device and add user specified devices.
- **CIFX_DRIVER_INIT_NOSCAN**

  Skip uio_netx device scan and add only user specified devices.

4.4.1 Startup via AUTOSCAN or CARD number

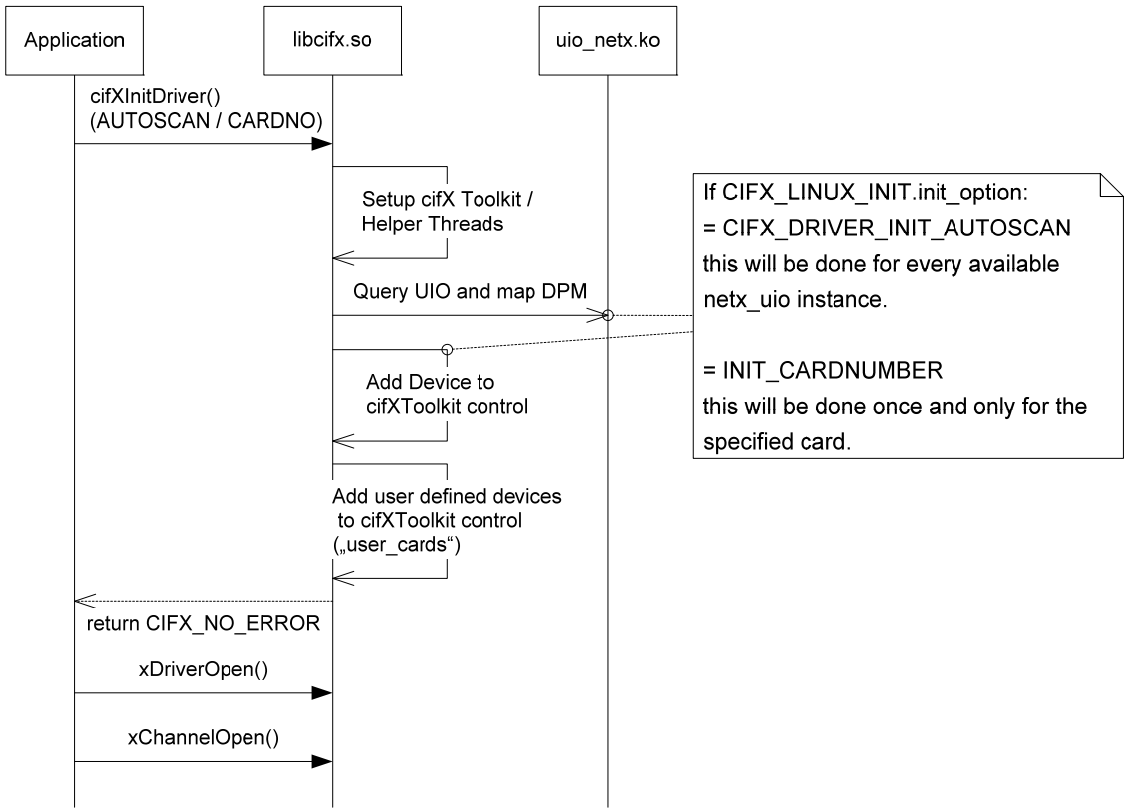


Figure 3: Initialization of libcifx using CIFX_DRIVER_INIT_AUTOSCAN / CIFX_DRIVER_INIT_CARDNUMBER

4.4.2 Startup via CIFX_DRIVER_INIT_NOSCAN

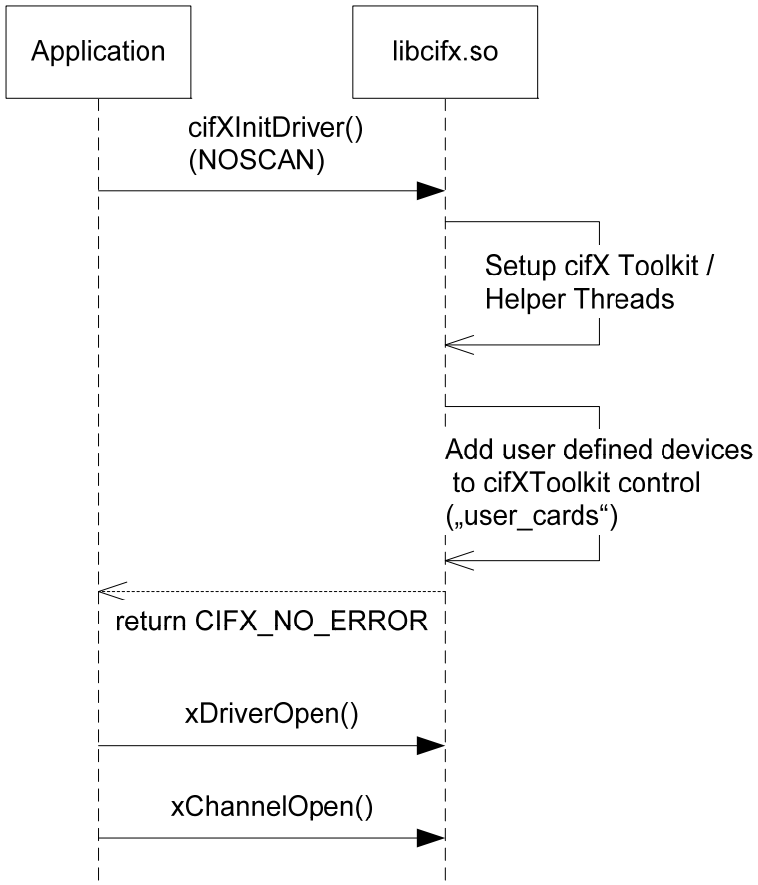


Figure 4: Initialization of libcifx using CIFX_DRIVER_INIT_NOSCAN

4.5 Device configuration (device.conf)

Parameters like a unique alias name and interrupt support can be configured per device. The configuration file must be named *'device.conf'.* Where to place the configuration file, depends on the chosen configuration file storage method, see sections *Device identification via single directory* to *Device identification via device and serial number* starting on page 28:

Device identification via device and serial number

- *'/opt/cifx/deviceconfig/[device no]/[serial no]/device.conf'*
  e.g. device no: 1250100 / serial no: 20217
  '/opt/cifx/deviceconfig/1250100/20217/*device.conf*'

Device identification via slotnumber

- '*/opt/cifx/deviceconfig/Slot_[no]/device.conf*'
  e.g. slot number 1
  '/opt/cifx/deviceconfig/Slot_1/*device.conf* '

Device identification via single directory

- '*/opt/cifx/deviceconfig/FW/device.conf*'

The file may contain the following keys:

Key	Datatype	Description
alias	char[16]	Alias name for the device. Must be less than 16 characters
irq	string	Enable/Disable IRQ on the device **'no' = IRQ disabled** **'yes' = IRQ enabled**
irqprio	int	Priority of the ISR handler thread (0 = default (priority of the calling thread) see Linux man pages pthread_attr_setschedparam
irqsched	string	Setup alternate ISR scheduling algorithm See Linux man pages pthread_attr_setschedpolicy **'fifo' = FIFO scheduling (see SCHED_FIFO -> irqprio 1..99)** **'rr' = Real-Time Scheduling (see SCHED_RR -> irqprio 1..99)**
dma	string	Enable/Disable DMA support of the device **'no' = DMA disabled** **'yes' = DMA enabled** **Note:** DMA support needs also to be enabled in the *uio_netx* kernel module, for more information see sections *Compiling the UIO kernel module during kernel build* (page 15) and Compiling the UIO kernel module (page 17).
eth	string	Enable/Disable Virtual Ethernet Interface support of the device **'no' = Ethernet Interface disabled** **'yes' = Ethernet Interface enabled** **Note:** This feature requires a firmware running on the PC card cifX that provides an extra channel supporting a dedicated stack to transport Raw-Ethernet data (for more information see section *netX-based virtual Ethernet interface* on page 51)

Table 19: device.conf parameters

Sample device.conf

```
#Sample device configuration file
alias=PROFIBUS
irq=no
irqprio=1
irqsched=fifo
dma=no
```

4.6 netX-based virtual Ethernet interface

Note: This feature requires a firmware running on the PC card cifX that provides an extra channel supporting a dedicated stack to transport Raw-Ethernet data.

The libcifx user space library provides an extension to create and serve a virtual Ethernet device for common network application usage.

The virtual network adapter is based on the TUN/TAP driver.

4.6.1 Features

- Polling Mode
- Simultaneous access of the PC card cifX from cifX driver and the corresponding Ethernet device

4.6.2 Requirements

- cifX Device Driver V1.0.3.0 or later
- Firmware with appropriate Ethernet Interface

  Tested fimware:

  - PROFINET I/O IRT Slave V3.4.144.1

    For more information see reference [3] section *1.5.2 Technical Data – Ethernet Interface*.
- Hardware: cifX PCI/PCIe

4.6.3 Limitations

- **Performance:**

  Max. TCP/IP throughput (send/receive): 42-49 MBit/s / 11-17 MBit/s.

  Note: The throughput highly depends on the running firmware and the fieldbus configuration.
- **Network packets:**

  Network packet type indication is not configurable. Since the libcifx driver does no packet filtering (Multicast, Broadcast, …) the types of delivered packets depends on the firmware. For detailed information about the set of provided network packets refer to the documentation of the firmware which will be installed.
- **MAC Address:**

  The device MAC address is not configurable and therefore bind to a fixed MAC address. For more information refer to documentation of the firmware which will be installed. The fieldbus stack running on the netX will hold its own MAC address.
- The application/user must have CAP_NET_ADMIN privileges
- The Ethernet device lifetime is bind to applications lifetime, which initializes the driver
- Ethernet device will disappear if a device reset is executed
- Application must not access the communication channel used for raw Ethernet access

4.6.4 Overview

The following figure shows an example application and all the required components and how they are layered and interact.

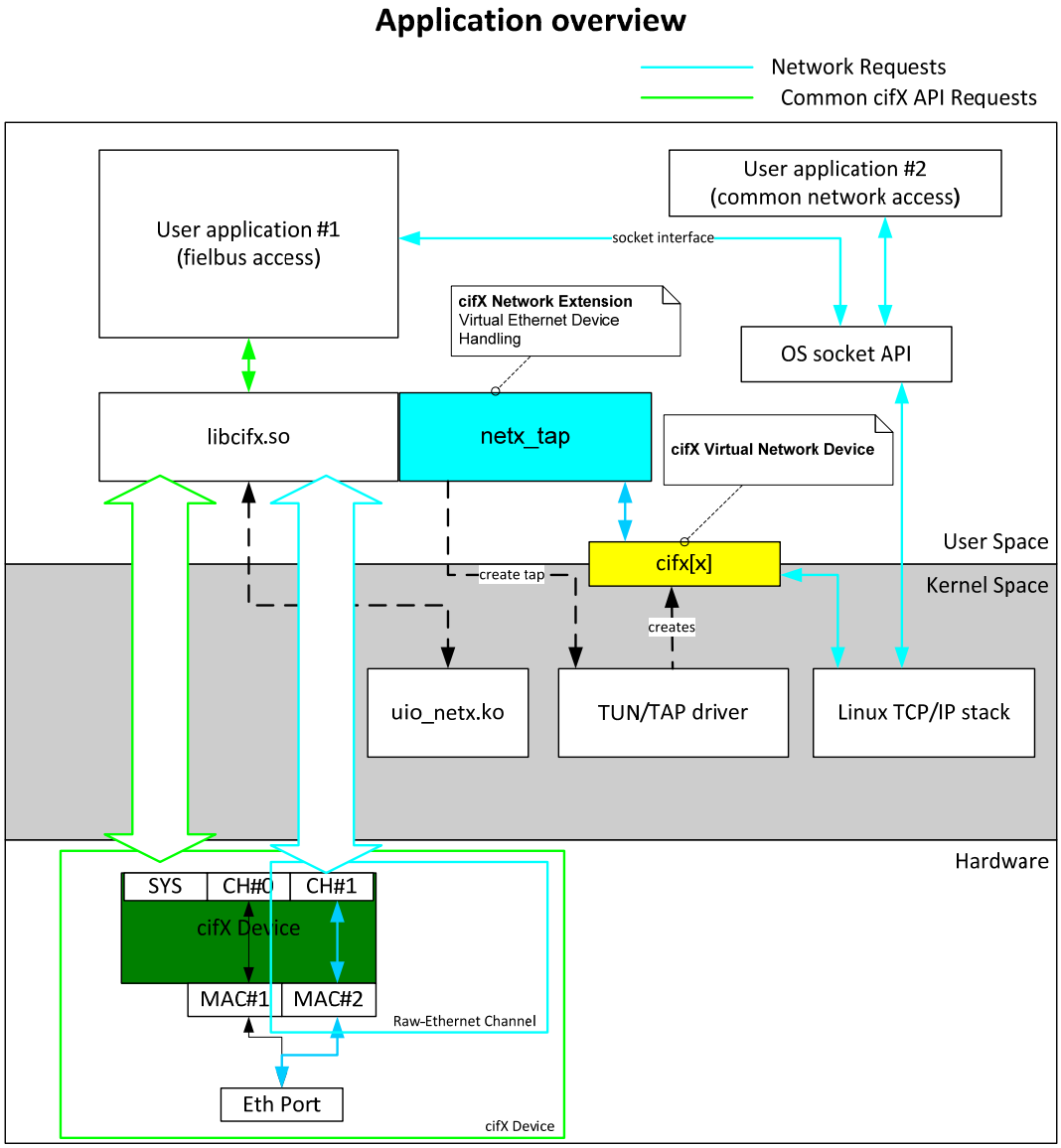


Figure 5: Virtual cifX network interface – Application overview

The *netx_tap* module is an extension of the user space library *libcifx* and manages the virtual Ethernet iterface handling. In case of cifX-Ethernet support is enabled, see section *Virtual cifX Ethernet interface setup* on page 53, the driver searches for an appropriate channel providing Raw-Ethernet support. If a channel is detected the *netx_tap* extension attaches via the cifX API (libcifx) and creates a virtual network interface *'netx_tap device'*.

The creation of the virtual network interface and all of its required initialization is done by the TUN/TAP driver. During runtime the *netx_tap* module transfers the network data from the cifx device to the netx_tap device and vice versa.

From the application point of view network requests are routed through the Linux network API through the TUN/TAP driver over the libcifX to the device.

It is also possible to access the device via the common cifX API in parallel.

4.6.5 Virtual cifX Ethernet interface setup

Prerequisites

Make sure to configure at least one card to run a firmware providing the Raw-Ethernet support, see section *Firmware and configuration file storage* on page 27.

Setup

- **Build the user space library libcifx providing the cifX Ethernet extension**
  - Build and install the user space library libcifx with Ethernet support enabled, see section *Compiling the cifX userspace library* on page 19.

    ./configure –enable-cifxethernet
  - Enable Ethernet support for the device providing the firmware with an extra communication channel for Raw-Ethernet Support, see section *Device configuration (device.conf)* on page 49.

    eth=yes
- **Start an application which initializes the driver**

Note:	The initialization options (see *cifXDriverInit()* on page 37) must not skip the device providing the Raw-Ethernet interface.

- **Start network application accessing the cifx Ethernet interface**

  After driver initialization the virtual cifX Ethernet device should be present (see *ifconfig -a*). The device is named as its parent device (e.g. parent device cifx3 -> Ethernet interface cifx3)

Optional

- **Allow non-root users to start the application**

Note:	By default root can create a virtual ethernet interface only.

  - By default root can create a cifX Ethernet interface only. To be able to run the application as non-root user, add the CAP_NET_ADMIN capability to your application

    ***setcap cap_net_admin+pe* [name of the application] (root required)**
- **Automatic interface startup and configuration**

Note:	By default the network interface will not appear until it is configured and enabled by the administrator (root) e.g. via *ifconfig*. This interface setup can be skipped by adding an *udev* rule which automatically configures the interface.

  - Add *udev* rule, which automatically configures the Ethernet interface. A template is located on the CD (/driver/templates/udev/80-udev-cifxeth.rules, see section *CD contents* on page 7).

    cp 80-udev-cifxeth.rules /etc/udev/rules.d/
  - The previously installed rule file refers to a script named ***cifxeth***, which provides the device start and configuration. The template *udev* rule estimates the configuration script to be located under /etc/init.d/.

    cp cifxeth /etc/init.d
  - Customize the start and configuration script to your own needs. The provided template (cifxeth) will enable DHCP for every cifX Ethernet interface.

5 Using SYCON.net to configure the fieldbus system

The Hilscher fieldbus hardware has to be configured by a Windows application called SYCON.net. SYCON.net is based on the FDT/DTM concept and generates the configuration files for the hardware. It is also able to update the firmware for a specific card.

Please use the following steps to create a configuration:

- Install SYCON.net
- Open SYCON.net and create a configuration
- Store the SYCON.net configuration project and export the configuration from SYCON.net into a so called database file (NXD).
- Copy the database and the firmware files to the device configuration directory (see section *Firmware and configuration file storage* on page 27).
- Now start/restart the cifX Linux driver. This will load the firmware and configuration into the cifX card.

5.1 Remote access via TCP/IP-Server

SYCON.net is also able to connect to a remote device supporting the Hilscher 'cifX Diagnostics and Remote Access' functions.

The driver CD also includes a standalone TCP/IP server example (cifXTCPServer), offering access to a remote system with an installed CIFX hardware.

The example can be found in the examples directory of the Linux driver CD.

Note: The TCP/IP server example exclusively accesses the remote CIFX hardware without a running user application on the Linux (remote) system.
It can be used to test fieldbus configurations and running fieldbus diagnostics from SYCON.net.

6 Programming with the cifX Linux Driver

6.1 Example: Generic driver initialization

The cifX Linux driver offers the same interface described in the CIFX API. Therefore the *CIFX API - Application Programming Interface* manual (see reference [1]) can be used. This manual describes the driver functions, error codes and shows some program examples.

Note: As the driver is contained in the library linked to your application, you will need to initialize the driver by a calling the function '*cifXDriverInit*' and '*cifXDriverDeInit*'.

Initialization example

```
struct CIFX_LINUX_INIT init =
{
  .init_options        = CIFX_DRIVER_INIT_AUTOSCAN, // Find all UIO devices automatically
  .iCardNumber         = 0,       // not used when init_options set to AUTOSCAN
  .fEnableCardLocking  = 0,       // do not lock card
  .base_dir            = NULL,    // use default (/opt/cifx/)
  .poll_interval       = 0,       // use default poll interval (500ms)
  .poll_StackSize      = 0,       // used default size (0x5000 Byte)
  .trace_level         = 255,     // Enable all debugging outputs to log file
  .user_card_cnt       = 0,       // no user defined cards
  .user_cards          = NULL,    // not used
};
  /* First of all initialize toolkit */
  long lRet = cifXDriverInit(&init);

  /* TODO: Insert your application here */

  cifXDriverDeinit();
```

The installation CD includes an 'Example' directory with Linux-specific examples.

6.2 Example: Driver initialization for ISA device

6.2.1 Not using UIO driver

The following example shows how to initialize the driver to map an ISA device passed via user space liberary libcifx.

```
struct CIFX_DEVICE_T   tISADevice  = {0};
struct CIFX_LINUX_INIT tDriverInit = {0};

tISADevice.dpmaddr = 0xD0000; /* physical address to DPM of the ISA device, need to  */
                              /* be set according to the jumper settings             */
                              /* NOTE: for more information of the address setup     */
                              /* (jumper settings) refer to hardware's documentation */
tISADevice.dpmlen  = 0x4000;  /*!< length of DPM in bytes, depends on the device     */

/* since device is not a uio device and no pci card invalidate the following parameter */
tISADevice.uio_num   = -1; /*!< uio number, -1 for non-uio devices      */
tISADevice.uio_fd    = -1; /*!< uio file handle, -1 for non-uio devices */

/* Open the system memory file (/dev/mem)        */
/* Required to map the memory of the ISA device. */
if ((iISAfd = cifx_ISA_open())<0) {
  printf("Error opening the system memory (%s)
  return -1;
}
printf("Try to map the physical dpm address to a virtual memory\n");
if ((fSucess = cifx_ISA_map_dpm( iISAfd,
                                 (void**)&tISADevice.dpm,
                                 tISADevice.dpmaddr,
                                 tISADevice.dpmlen))<0) {
  printf("Error mapping dpm (%s)!\n", strerror(errno));
  cifx_ISA_close( iISAfd);
  return -1;
} else {
{
  /* setup the standard driver initializaion structure */
  tDriverInit.init_options  = CIFX_DRIVER_INIT_NOSCAN; /* NOSCAN since we are not   */
                                                       /* interested in other cards */
  tDriverInit.user_card_cnt = 1; /* set user card count to 1 since we pass one */
                                 /* user card */
  tDriverInit.user_cards    = &tISADevice; /* the previously prepared ISA device */

  /* initialize driver */
  lRet = cifXDriverInit(&tDriverInit);

  if (CIFX_NO_ERROR == lRet) {

    /* TODO: Insert your application here */

    cifXDriverDeinit();
  }
  cifx_ISA_unmap_dpm(tISADevice.dpm, tISADevice.dpmlen);
}
cifx_ISA_close(fd_isa);
```

For an ISA example application see ISASample, CD contents on page 7.

Note: Using this method does not allow using interrupt mode on ISA devices.

6.2.2 Using UIO driver

The following example shows how to initialize the driver to map an ISA device passed via the uio_netx kernel mode driver.

1. Pass ISA card to uio driver:

```
modprobe uio_netx user_dpm_start=0xD0000 user_dpm_len=0x4000 user_irq=5
```

2. Initialize driver as required (e.g. AUTOSCAN for devices)

```
struct CIFX_LINUX_INIT init =
{
  .init_options        = CIFX_DRIVER_INIT_AUTOSCAN, // Find all UIO devices automatically
  .iCardNumber         = 0,       // not used when init_options set to AUTOSCAN
  .fEnableCardLocking  = 0,       // do not lock card
  .base_dir            = NULL,    // use default (/opt/cifx/)
  .poll_interval       = 0,       // use default poll interval (500ms)
  .poll_StackSize      = 0,       // used default size (0x5000 Byte)
  .trace_level         = 255,     // Enable all debugging outputs to log file
  .user_card_cnt       = 0,       // no user defined cards
  .user_cards          = NULL,    // not used
};
  /* First of all initialize toolkit */
  long lRet = cifXDriverInit(&init);

  /* TODO: Insert your application here */

  cifXDriverDeinit();
```

Note: This method does allow using interrupt mode on ISA devices.

6.3 Example: Driver initialization for custom hardware interface

The following example shows how to initialize the driver to be able to communicate via custom hardware interface. For an SPI example application see SPISample, CD contents on page 7.

```
void* CustomHwIFRead(struct CIFX_DEVICE_T* ptDev, void* pvaddr,
                     void* pvdata, uint32_t ulLen)
{
  //TODO: Need to be implemented by the customer
  /* read the given number of bytes from the DPM */

  return pvdata; /* return destination address */
}

void* CustomHwIFWrite(struct CIFX_DEVICE_T* ptDev, void* pvaddr,
                     void* pvdata, uint32_t ulLen)
{
  //TODO: Need to be implemented by the customer
  /* write the given number of bytes to the DPM */

  return pvaddr; /* return destination address */
}


int main()
{
  struct CIFX_DEVICE_T   tCustomDev  = {0};
  struct CIFX_LINUX_INIT tDriverInit = {0};

  tCustomDev.dpmaddr = 0x00;    /* not used since address is not memory mapped */
  tCustomDev.dpmlen  = 0x10000; /*!< length of DPM in bytes, depends on the device */

  /* since device is no uio device and no pci card invalidate the following parameter */
  tCustomDev.uio_num   = -1; /*!< uio number, -1 for non-uio devices      */
  tCustomDev.uio_fd    = -1; /*!< uio file handle, -1 for non-uio devices */

  /* custom hardware interface initialization */
  tCustomDev.hwif_init     = NULL; /* we need no initialization of the interface */
  tCustomDev.hwif_deinit = NULL; /* we need no initialization of the interface */
  tCustomDev.hwif_read   = CustomHwIFRead; /* custom read function */
  tCustomDev.hwif_write  = CustomHwIFWrite; /* custom read function */

  /* setup the standard driver initializaion structure */
  tDriverInit.init_options  = CIFX_DRIVER_INIT_NOSCAN; /* NOSCAN since we are not   */
                                                       /* interested in other cards */
  tDriverInit.user_card_cnt = 1; /* set user card count to 1 since we pass 1 user card */
  tDriverInit.user_cards    = & tCustomDev; /* the previously prepared device */

  /* initialize driver */
  lRet = cifXDriverInit(&tDriverInit);
  if (CIFX_NO_ERROR == lRet) {
    /* TODO: Insert your application here */

    cifXDriverDeinit();
  }
  return 0;
}
```

7 Question and answers

Troubleshooting Instruction

Try to solve the problem in the order of the noted solutions following below.

7.1 cifX Device Driver

7.1.1 Failed to install driver via build script

Make sure that the path to your project folder does not contain any whitespaces.

In case the path does not contain any whitespaces refer to the console output and analyze the given error message. In case of an imprecise error message try to install the driver manually. This might give a more detailed description.

- How to build the user space library manually - *Compiling the cifX userspace library* on page 19
- How to build the kernel modul uio_netx - *Compiling the netX UIO kernel module* on page 15

7.1.2 It is not possible to run any script located on the CD

Some files of the driver package provide special functions. E.g. the scripts are marked as executable. Extracting the sources under another operating system than Linux may clear such attributes and permissions. Therefore make sure to choose the '.tar.bz' archive of the driver, located on the CD and extract it under Linux, see section *Preparation* on page 13.

7.1.3 Failed to load the uio_netx kernel module

Note: To be able to load the kernel module root privileges are required.

- Refer to the error message returned when loading the module.
- Make sure the required uio module is already loaded (dump the list of the currently loaded modules)

  Run the ***lsmod*** command.
- Refer to information kept in the kernel log.

  Print the kernel log message (e.g. via ***dmesg***).

7.1.4 Unable to access or find a device

- Refer to the log file of the driver

  How to enable the drivers log file – see section *Linux driver specific information* on page 32.
- Verify to have the correct permissions to access a device.

  Refer to the restrictions listed in section *Linux driver specific information* on page 32.
- Failed to map the DPM

  Go to section *Failed to map the DPM of a device* on page 60.
- Make sure the no other application is running and already accessing the device.

7.1.5 Failed to map the DPM of a device

To allow mapping of the DPM to a user application, make sure the application is allowed to *mmap* enough memory (at least 64 Kbyte). You can check the current memory lock limit using the following command, which returns the maximum possible mapped memory in kB: ***ulimit -l***

7.1.6 cifX device is not correctly configured

The device appears without or with the wrong firmware/configuration being flashed

- Make sure the device configuration is correctly setup.

  Refer to the cifX log (cifX[x].log) file located in the driver's configuration directory.
- Refer to the driver's log file and make sure according to the chosen configuration method, the appropriate folder structure is created. For more information see section *Firmware and configuration file storage* on page 27.
- If no driver log file can be found – see section *No log file of the user space driver is created* on page 60.

7.1.7 No log file of the user space driver is created

If the driver's tracing feature is enabled, by default the driver tries to create a log file in the driver's configuration directory. If this fails the driver will print the debug messages to the console. Error messages, which appear before log file creation, will be printed to '*stderr*'.

- How to enable the drivers log file – see section *Linux driver* specific *information* on page 32.
- Make sure to have to correct access rights to the driver's configuration directory (read+write!)

7.1.8 Failed request DMA state or to exchange IO-data via DMA

DMA support needs to be enabled during build of both driver components

- Make sure to enable DMA support during built of the kernel module uio_netx

  Compiling the netX UIO kernel module on page 15
- Make sure to enable DMA support during built user space driver libcifx

  Compiling the cifX userspace library on page 19

7.2 netX-based virtual Ethernet interface

7.2.1 Failed to create a virtual Ethernet interface

Note: A virtual Ethernet interface will be created during the driver's initialization and its lifetime is bind to the applications lifetime, which initializes the driver.

- Refer to the error message printed to *stderr* or the cifX log file.
- Make sure to enable the Ethernet extension when building the user space library libcifx.

  How to build the user space library manually - *Compiling the cifX userspace library* on page 19.
- Ethernet support needs to be enabled per device. Make sure to enable Ethernet support on the device with the firmware providing the Raw-Ethernet channel.

  Refer to Device configuration (device.conf) on page 49.
- Make sure to have the correct permissions to be able to create a Virtual Ethernet interface.

  see CAP_NET_ADMIN – section *Virtual cifX Ethernet interface setup* on page 53.
- If the previous steps does not solve the problem, go on with section *No cifX Ethernet device appears* on page 61.

7.2.2 No cifX Ethernet device appears

The device may already be created but still not active. An Ethernet interface still needs to be enabled by the administrator.

- Make sure the application which initializes the driver is running without any errors.

  Go to section *Failed to create a virtual Ethernet interface* on page 61.
- Verify if the interface is already created by running the command ***ifconfig –a***
  - If device is not present go on with *Failed to create a virtual Ethernet interface* on page 61.
  - If device is present verify the automated setup and configuration - *Virtual cifX Ethernet interface setup* on page 53.

7.2.3 No network access although device successfully created

- On some distributions, configuring more than one network adapter to the very same subnet may lead into communication errors

  Make sure to configure only one adapter per subnet

7.2.4 Network adapter disappears during device reset

When resetting a device or the system channel all of its channels will be re-initialized. Therefore a reset of a device, offering a virtual *cifX Ethernet Interface,* as a consequence, also restarts the *cifX Ethernet interface* and all connections using the Ethernet interface get interrupted.

8 Appendix

8.1 List of tables

8.2 List of figures

8.3 Contacts

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