



Programmers Guide
cifX/netX Application Programmers Guide

V0.0

Hilscher Gesellschaft für Systemautomation mbH

www.hilscher.com

DOC13xxxxPGxxEN | Revision 0 | English | 2014-02 | development | Public

Table of Contents

1	Introduction.....	4
1.1	About this Document.....	4
1.2	List of Revisions	5
1.3	Terms, Abbreviations and Definitions	6
2	Programming Resources.....	7
2.1	Manuals and Documents	7
2.2	Product CDs/DVDs and Content.....	8
2.3	Choose a Programming Level.....	9
2.3.1	Hardware Level	11
2.3.2	Low Level	11
2.3.3	Intermediate Level.....	12
2.3.4	Driver Level	12
3	Fundamentals - DPM Layout and Content.....	13
3.1	The DPM Layout	14
3.1.1	DPM Area Definition.....	14
3.1.2	DPM Definitions, Structures and Header Files	15
3.2	System Channel Structure	16
3.2.1	System Information.....	17
3.2.2	System Status	17
3.3	Handshake Channel.....	18
3.3.1	Handshake Register Functionality.....	19
3.4	Communication Channel Structure	20
3.4.1	Channel Information	21
3.4.2	Channel State.....	21
3.5	Data Transfer Methods and Areas	22
3.5.1	Packet Definition and Transfer via a Mailbox System.....	22
3.5.2	I/O Data Transfer.....	25
3.6	Communication Mechanism and Synchronization.....	26
3.6.1	System Channel Handshake Register.....	26
3.6.2	Communication Channel Handshake Register.....	27
3.6.3	Working with Handshake Registers and Flags.....	28
3.6.3.1	Simple State and Command Handshake Flags	28
3.6.3.2	Synchronization Handshake Flags	28
3.6.3.3	Packet Data Transfer - Handshake Flag Synchronisation	29
3.6.3.4	I/O Data Transfer - Handshake Flag Synchronisation	32
3.6.3.5	Change of State Mechanism (COS)	36
3.7	Programming Interface - CIFS-API	40
4	Examples.....	41
4.1	System Identification and Start-Up Handling	41
4.2	Channel Identification and Start-Up Handling.....	42
4.3	Packet Transfer	43
4.3.1	Send a Packet to the Device	43
4.3.2	Read a Packet from the Device.....	44
4.4	I/O Data Transfer	45
4.4.1	Write Output data to the Device	45
4.4.2	Read Input data from Device.....	46
4.5	Change of State (COS) Information and Handling.....	47
4.5.1	Host COS Handling	47
4.5.2	Communication COS Handling.....	48
4.6	Hardware and Protocol Stack Identification	49
4.7	Additional Functions.....	49
4.8	Hardware and Driver Installation Guides	50
4.9	Load a Firmware to a CIFS Card	50
4.10	Start with an Example Program	50
4.11	Protocol Stack handling via CIFS API.....	51
5	Additional Resources	51
5.1	Protocol API Manuals.....	51
6	Appendix	52

Introduction

3/53

6.1

List of Tables

52

6.2

List of Figures.....

52

6.3

Contacts

53

1 Introduction

1.1 About this Document

This guide is an introduction to the programming of Hilscher netX based device. It explains the fundamentals necessary to understand the functions and the handling of Hilscher netX hardware and will show the programming principals needed for correct device handling.

It should also help to choose the level where to start with developments, describes where to find the necessary information.

Furthermore it explains the available information in regards to the programming level, describes necessary synchronisation mechanism for the data transfer between a host and the netX firmware and covers all aspects from a simple memory connection to a netX (dual-port-memory access), the use of pre-created low level hardware functions, the netX C toolkit, the implementation of own drivers based the toolkit until the use of Hilscher device drivers for different operating systems.

1.2 List of Revisions

Rev	Date	Name	Chapter	Revision
1	2013-07-26	RM	1	created

Table 1: List of Revisions

1.3 Terms, Abbreviations and Definitions

Term	Description
cifX	C ommunication I nterface based on netX
comX	C ommunication M odule based on netX
PCI	P eripheral C omponent I nterconnect
DPM	D ual- P ort M emory Physical interface to all communication board (DPM is also used for PROFIBUS- DP Master).
API	A pplication P rogramming I nterface

Table 2: Terms, Abbreviations and Definitions

2 Programming Resources

Hilscher offers several resources for the programming. The following list contains the most important manuals necessary.

- Hilscher Website: <http://www.hilscher.com>

2.1 Manuals and Documents

- ***netX Dual-Port Memory Interface DPM xx.EN.pdf*** manual
This manual describes the memory layout of the DPM and explains the information which can be found inside the DPM. This is the basis of a host to netX device communication.
- ***cifX netX Toolkit -DPM TK xx EN.pdf*** manual
The toolkit manual describes the C toolkit, the usage, implementation and the adaptation to own target systems.
- ***CIFX API PR xx EN.pdf*** manual
The CIFX API manual describes the Hilscher standard application programming interface. This API offers all necessary functions and information needed to handle netX based device. With the knowledge from the DPM layout, a correlation between the information in the DPM and the functions the API functions can be seen (e.g. what is a channel and how to exchange asynchronous command and cyclic I/O data).
- ***cifX Device Driver - <operating system> DRV xx EN.pdf*** manuals
Each operating system specific Hilscher device driver comes with an own manual, describing the specific information and behaviour.
- ***PC Cards CIFX <card type> UM xx EN.pdf*** manual
and
PC Cards cifX Software Installation UM xx EN.pdf guide
Hilscher offers netX devices in different form factor (PC boards, PCI104, Compact PCI, etc.) for the most common hardware connections (DPM, ISA, PC104/PC104+, PCI/PCIe, serial interface, USB, Ethernet).
Each device (card type) comes with a specific hardware installation, operation, and description manual, including technical data, connector details, jumper settings, LED state definitions etc. And a software installation and configuration guide.

2.2 Product CDs/DVDs and Content

- **Communication Solutions DVD**
 - Device Driver CD for Windows (NXDRV-WIN)
 - Driver Toolkit CD (NXDRV-TKIT)

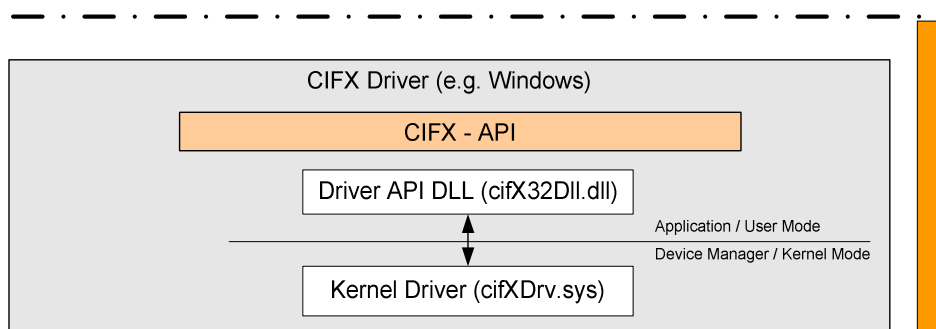
- **Device Driver CDs** (NXDRV-WIN)
 - . (NXDRV-CE)
 - . (NXDRV-Linux)
 - . (NXDRV-QNX)
 - . (NXDRV-VxWorks)
 - . (NXDRV-INtime)
 - . (NXDRV-RTX)
 - Driver documentation and installation (operating system dependent)
 - C development resources (header and libraries) (operating system dependent)
 - Sources and Examples (operating system dependent)
 - Additional manual: *CIFX API* manual
 - Additional manual: *netX Dual-Port Memory Interface DPM* manual

- **cifX netX Toolkit CD** (NXDRV-TKIT)
 - Toolkit documentation and source code
 - Toolkit example implementation (Win32 / nonOS / MQX / rcX)
 - Toolkit hardware functions example implementation (Win32 / WinCE / nonOS)
 - Additional manual: *CIFX API* manual
 - Additional manual: *netX Dual-Port Memory Interface DPM* manual
 - Additional manual: *Serial DPM Interface with netX* manual
 - Additional manual: *SPI Slave DPM netX 100 500 HAL* manual
 - Additional manual: *Second Stage Bootloader netX* manual

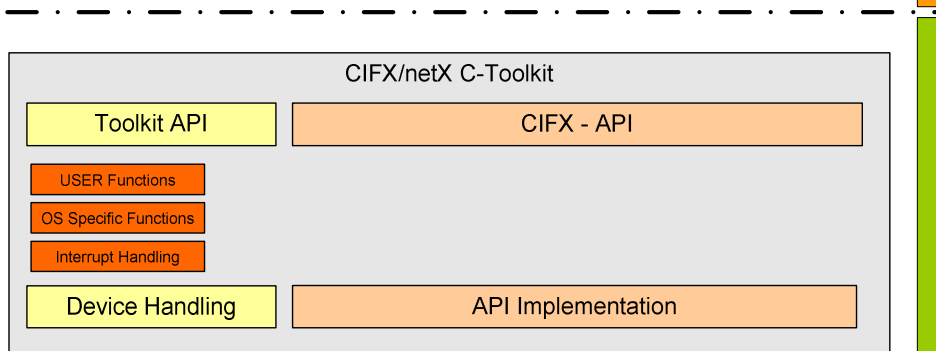
2.3 Choose a Programming Level

Hilscher offers support to different programming levels. Programming levels are starting at the plain dual-ported memory until up to the device driver level for the most common operating systems.

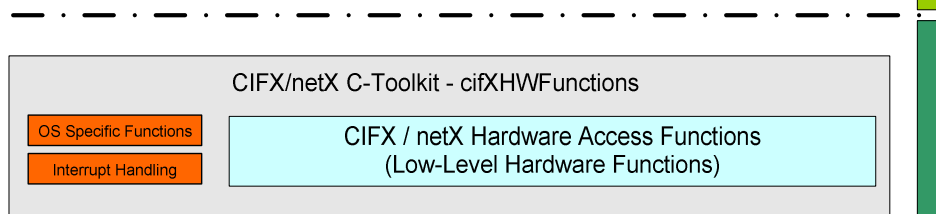
Driver Level



Intermediate Level



Low Level



Hardware Level

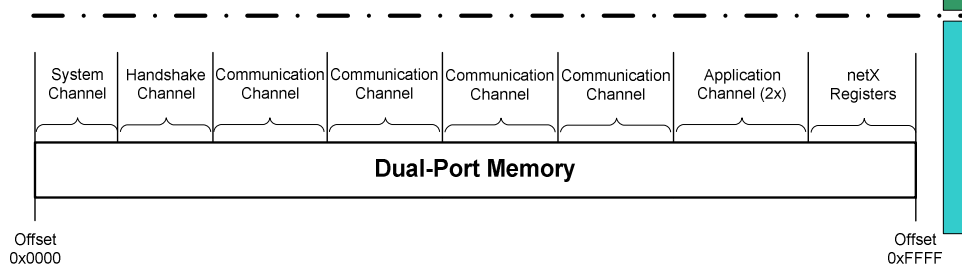


Figure 1: Overview - Programming Levels

The following picture gives an overview of the possible development environments and the migration to embedded systems. This should help to choose a programming level fit best to the application needs.

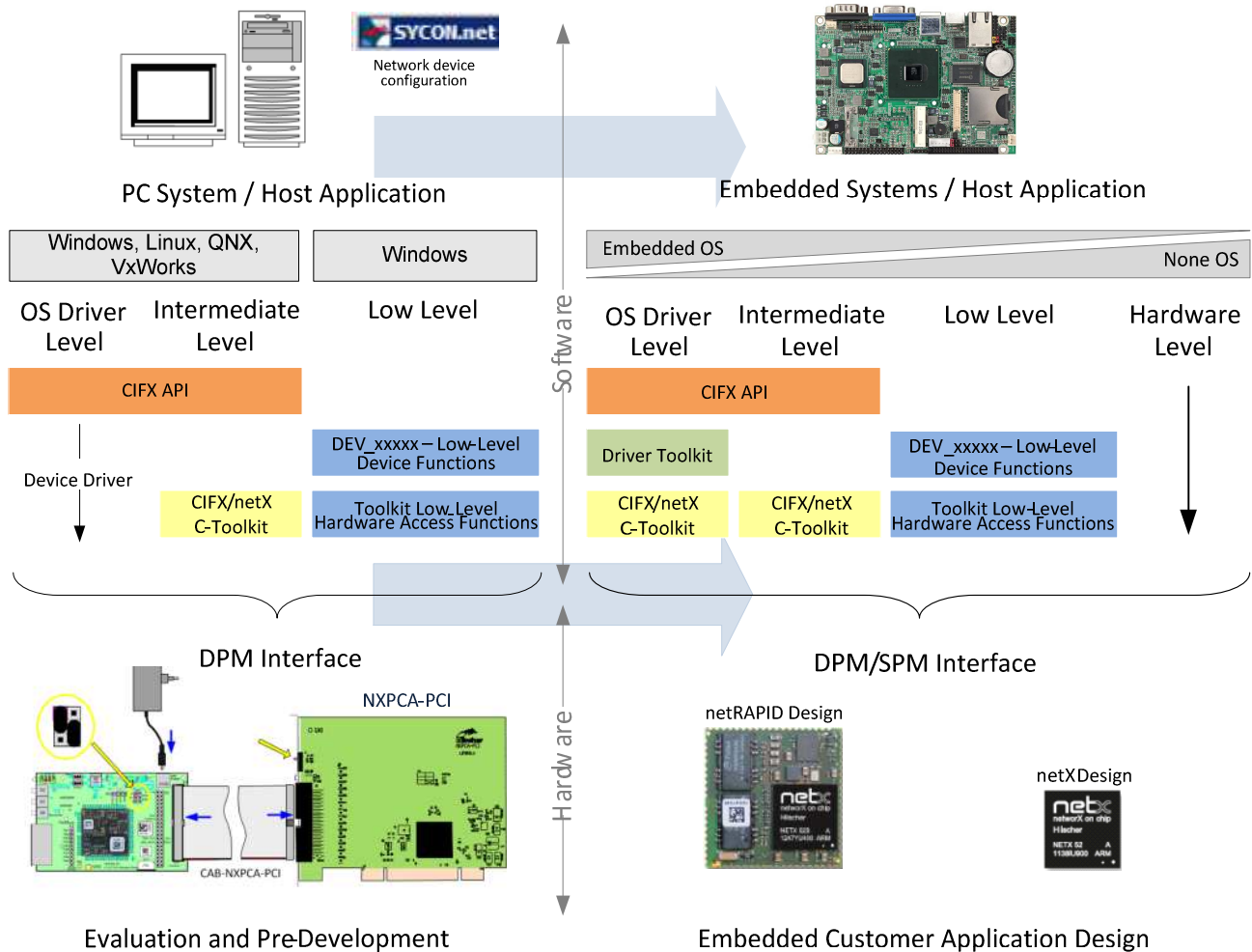


Figure 2: Choose a Programming Level

2.3.1 Hardware Level

The hardware level is the direct access to the physical DPM of a netX device. Programming is supported by offering C header files describing the DPM structures, content, states, flags, bit masks etc.

Usage: One or more netX Chip(s) or COMX modules connected to microcontrollers

- Very limited system resources
- Highly optimized hardware access
- Dedicated function to access the hardware
- None C based development environment

Manuals: *netX Dual-Port Memory Interface DPM xx EN.pdf*
(Dual Port Memory layout, structures and functionalities)

CD / DVD: NXDRV-TKIT or Communication Solution DVD

Header Files: rcX_User.h Dual Port Memory structures
rcX_Public.h Asynchronous packet definitions

2.3.2 Low Level

Access to the DPM via pre-created hardware functions which are part of the "*cifX netX Toolkit*" (see "*Toolkit Low-Level Hardware Access Functions*").

Usage: One or more netX Chip(s), COMX modules or CIFX cards connected to microcontrollers

- DPM or ISA connection to the netX hardware
- with or without an operating system
- limited system resources (RAM/FLASH)

Programming Resources:

Manuals: *netX Dual-Port Memory Interface DPM xx EN.pdf*
(Dual Port Memory layout, structures and functionalities)

CIFX netX Toolkit DPM TK xx EN.pdf

CD /DVD NXDRV-TKIT or Communication Solution DVD

Source Files: Toolkit .\Examples\cifXTKitHWFunctions directory
cifXUser.h
cifXErrors.h
netX_RegDefs.h
cifXHWFunctions.h.c / cifXHWFunctions.h
cifXEndianness.c / cifXEndianness.h
cifXInterrupt.c / cifXInterrupt.h

2.3.3 Intermediate Level

Using the "*cifX netX Toolkit*" and CIFX API functions offered by the toolkit. Porting the toolkit to own hardware platforms or write own device drivers.

Usage: One or more netX chip(s), COMX modules, CIFX cards connected to a host PC system

- Support for standard Hilscher devices (complete function support)
- C / C++ development environment
- With or without an operating system
- Writing own drivers

Programming Resources:

Manuals: *CIFX netX Toolkit DPM TK xx EN.pdf*
CIFX API PR xx EN.pdf

CD /DVD NXDRV-TKIT or Communication Solution DVD

Source Files: Toolkit .\cifXToolkit directory

2.3.4 Driver Level

Using the CIFX API offered by a operating system drivers created by Hilscher to write own user applications on top of a Hilscher netX based communication device.

Usage: Host PC system with an operating system or real time extension supported by Hilscher

- COMX modules, CIFX cards connected to a host PC
- ISA / PC104 / PCI or PCIeexpress bus system
- Support for standard Hilscher devices (complete function support)
- Creation own high level user applications

Programming Resources:

Manuals: CIFX API PR xx EN.pdf

CD /DVD NXDRV-xxx or Communication Solution DVD

Source Files: Comming with the driver
cifXUser.h
cifXErrors.h

3 Fundamentals - DPM Layout and Content

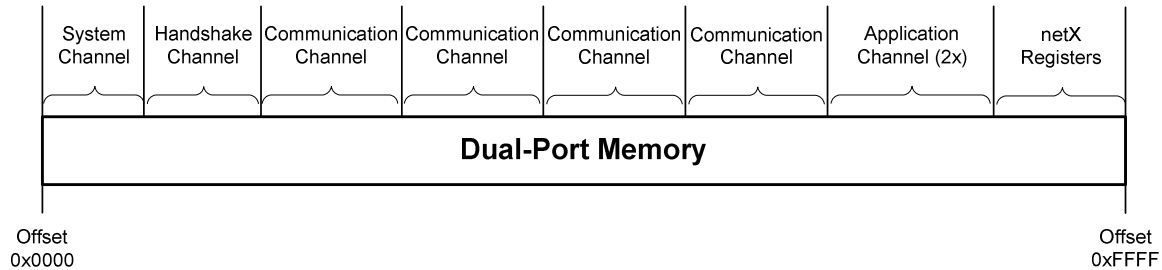
The fundamental of the netX hardware is the so call dual-ported memory (DPM) of netX based hardware. Hilscher has defined a memory structure (netX DPM Interface structure) and corresponding definitions suitable for the handling of communication devices, offering all information needed by applications to manage the hardware and the underlying Hilscher communication firmware.

It covers also system state information, the functionalities to exchange data with netX based hardware and to synchronize data access between a host and the asynchronous working netX firmware.

All Hilscher netX based devices processing a Hilscher standard firmware performing in the same way.

3.1 The DPM Layout

The DPM structure is a representation of the hardware functions and places the functions and corresponding information into separate, independent, areas.



- Maximum DPM size = 64Kbyte
- COMX modules can have a different size (e.g. 8 KByte)

3.1.1 DPM Area Definition

System Channel / System Device:

- Global system information and system services like firmware download and hardware reset etc.
- Global system state information
- General channel information

Handshake Channel:

- Special hardware registers containing synchronization flags and channel states
- Independent registers pairs for each channel
- Register pairs consists of a host dedicated and netX dedicated register
- Registers are able to create interrupts on the corresponding (host register on netX, netX register on host side)

Communication Channel (max. 4 times):

- Dedicated channel to access a protocol stack
- Dedicated handshake registers in the "*Handshake-Channel*"
- Independent from other channels on the hardware
- General communication control and state information
- Protocol specific control, state and data areas
- Default layout, default size 15616 Byte

Application Channel:

- Dedicated channel to access a customer application running on netX
- Optional and not defined yet

netX Global Register Block:

- Direct access to netX chip registers
- Defined in the "netX Program Reference Guide"
- Functions like netX chip state / Reset / Interrupt / DMA etc.
- Needed for RAM based devices, not needed for FLASH based devices

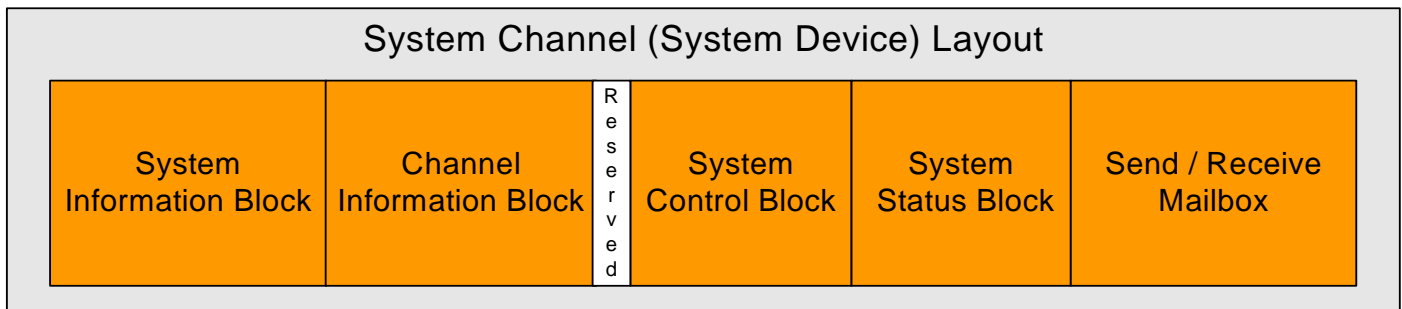
3.1.2 DPM Definitions, Structures and Header Files

The whole DPM structures and definitions are provided by two C header files.

- rcx_User.h
Definition of the DPM structure, data blocks and all global definitions offered by the DPM. The C-header file contains all parts necessary to work with the DPM by using symbolic names.
- rcx_Public.h
Definition of "*rcX Public Packet*" functions.
Packets are asynchronous commands which can be sent to the hardware. A packet is the combination of a "*Packet-Header*", containing global command, routing and handling information for the packet, and a following "*User-Data Area*" containing command specific data.

NOTE: All structures and definition used in the following chapters can be found in these two header files

3.2 System Channel Structure



System Channel Structure Definition:

```

/*****
/! Structure of the whole system channel (DPM) (Size 512 Byte)
/*****
typedef __RCX_PACKED_PRE struct NETX_SYSTEM_CHANNELtag
{
    NETX_SYSTEM_INFO_BLOCK      tSystemInfo;                /*!< 0x000:0x02F System information block */
    NETX_CHANNEL_INFO_BLOCK     atChannelInfo[NETX_MAX_SUPPORTED_CHANNELS]; /*!< 0x030:0x0AF Channel information block */
    NETX_HANDSHAKE_CELL         tSysHandshake;              /*!< 0x0B0:0x0B3 Handshake cells used, if not
in Handshake block */
    uint8_t                     abReserved[4];               /*!< 0x0B4:0x0B7 unused/reserved */
    NETX_SYSTEM_CONTROL_BLOCK    tSystemControl;             /*!< 0x0B8:0x0BF System control block */
    NETX_SYSTEM_STATUS_BLOCK     tSystemState;               /*!< 0x0C0:0x0FF System state block */
    NETX_SYSTEM_SEND_MAILBOX     tSystemSendMailbox;         /*!< 0x100:0x17F Send mailbox */
    NETX_SYSTEM_RECV_MAILBOX     tSystemRecvMailbox;         /*!< 0x180:0x1FF Receive mailbox */
} __RCX_PACKED_POST NETX_SYSTEM_CHANNEL;

```

System Information Block: (NETX_SYSTEM_INFO_BLOCK)

General system information for the complete device

Channel Information Block: (NETX_CHANNEL_INFO_BLOCK)

Information about available communication channels, general channel information and channel layout.

System Control Block: (NETX_SYSTEM_CONTROL_BLOCK)

General system control functions, currently not used

System Status Block: (NETX_SYSTEM_STATUS_BLOCK)

General system and device information

System Send/Receive Mailbox: (NETX_SYSTEM_SEND /RECEIVE_MAILBOX)

System channel mailbox for asynchronous packet based commands

3.2.1 System Information

General system information can be obtained from the system information block NETX_SYSTEM_INFO_BLOCK (see below).

```

/*****
 *! System information block (Size = 48 Byte)
 *****/
/*****
typedef __RCX_PACKED_PRE struct NETX_SYSTEM_INFO_BLOCKtag
{
    uint8_t    abCookie[4];                /*!< 0x00 "netX" cookie */
    uint32_t    ulDpmTotalSize;            /*!< 0x04 Total Size of the whole dual-port
memory in bytes */
    uint32_t    ulDeviceNumber;            /*!< 0x08 Device number */
    uint32_t    ulSerialNumber;            /*!< 0x0C Serial number */
    uint16_t    ausHwOptions[4];           /*!< 0x10 Hardware options, xC port 0..3 */
    uint16_t    usManufacturer;            /*!< 0x18 Manufacturer Location */
    uint16_t    usProductionDate;          /*!< 0x1A Date of production */
    uint32_t    ulLicenseFlags1;           /*!< 0x1C License code flags 1 */
    uint32_t    ulLicenseFlags2;          /*!< 0x20 License code flags 2 */
    uint16_t    usNetxLicenseID;            /*!< 0x24 netX license identification */
    uint16_t    usNetxLicenseFlags;        /*!< 0x26 netX license flags */
    uint16_t    usDeviceClass;             /*!< 0x28 netX device class */
    uint8_t     bHwRevision;               /*!< 0x2A Hardware revision index */
    uint8_t     bHwCompatibility;          /*!< 0x2B Hardware compatibility index */
    uint8_t     bDevIdNumber;              /*!< 0x2C Device identification number (rotary
switch) */
    uint8_t     bReserved;                 /*!< 0x2D Reserved byte */
    uint16_t    usReserved;                /*!< 0x2E:0x2F Reserved */
} __RCX_PACKED_POST NETX_SYSTEM_INFO_BLOCK;

```

3.2.2 System Status

The system status block contains global system information and the corresponding data structure is defined as NETX_SYSTEM_STATUS_BLOCK.

```

/*****
 *! System status block (Size = 64 Byte)
 *****/
/*****
typedef __RCX_PACKED_PRE struct NETX_SYSTEM_STATUS_BLOCKtag
{
    uint32_t    ulSystemCOS;               /*!< 0x00 System channel change of state
acknowledge */
    uint32_t    ulSystemStatus;            /*!< 0x04 Actual system state */
    uint32_t    ulSystemError;             /*!< 0x08 Actual system error */
    uint32_t    ulBootError;               /*!< 0x0C Bootup error (only set by 2nd Stage
Bootloader) */
    uint32_t    ulTimeSinceStart;          /*!< 0x10 time since start in seconds */
    uint16_t    usCpuLoad;                 /*!< 0x14 cpu load in 0,01% units (10000 => 100%)
*/
    uint16_t    usReserved;                /*!< 0x16 Reserved */
    uint32_t    ulHWFeatures;              /*!< 0x18 Hardware features */
    uint8_t     abReserved[36];            /*!< 0x1C:3F Reserved */
} __RCX_PACKED_POST NETX_SYSTEM_STATUS_BLOCK;

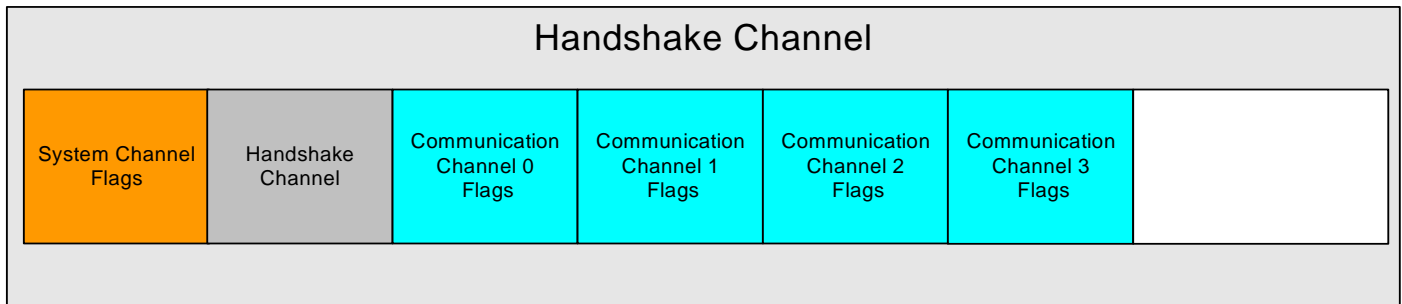
```

3.3 Handshake Channel

The *Handshake-Channel* contains the "*Channel Handshake Registers*" with their channel state and synchronization flags.

Synchronized access to data areas is always necessary if data consistency must be assured between the host and the netX firmware, especially if a data area consists of more than one byte.

Byte consistency is guaranteed by the DPM hardware preventing concurrent access to a single byte while multi byte areas requiring other mechanism realized by the handshake flags (software) and by defining access rules (read only / write only areas).



Handshake Channel Structure Definition:

```

/*****
/*! Handshake channel definition */
/*****
typedef struct NETX_HANDSHAKE_CHANNELtag
{
    NETX_HANDSHAKE_CELL tSysFlags;           /*!< 0x00 System handshake flags */
    NETX_HANDSHAKE_CELL tHskFlags;          /*!< 0x04 not used */
    NETX_HANDSHAKE_CELL tCommFlags0;        /*!< 0x08 channel 0 handshake flags */
    NETX_HANDSHAKE_CELL tCommFlags1;        /*!< 0x0C channel 1 handshake flags */
    NETX_HANDSHAKE_CELL tCommFlags2;        /*!< 0x10 channel 2 handshake flags */
    NETX_HANDSHAKE_CELL tCommFlags3;        /*!< 0x14 channel 3 handshake flags */
    NETX_HANDSHAKE_CELL tAppFlags0;         /*!< 0x18 not supported yet */
    NETX_HANDSHAKE_CELL tAppFlags1;         /*!< 0x1C not supported yet */
    uint32_t aulReserved[ 56 ];             /*!< 0x20 - 0xFF */
} NETX_HANDSHAKE_CHANNEL;

```

Note: *Handshake Registers* are able to generate interrupts.
On the host side, if the firmware writes to the *netX flags* and on the firmware side if the host writes to the *host flags*.

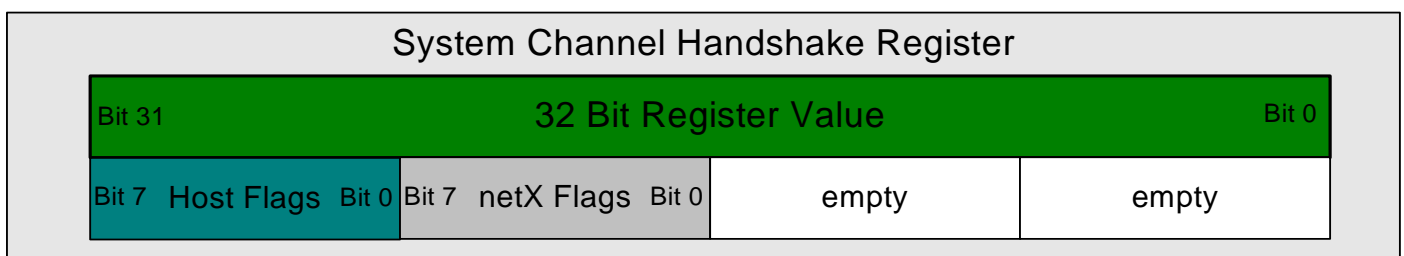
3.3.1 Handshake Register Functionality

Each channel has an own handshaking register, except the *Handshake Channel* itself which does not need a synchronization mechanism.

A handshake register is defined as a 32 bit value, divided into two parts. The "*NETX Flags*" and the "*HOST Flags*" and a definition where only the owner of a register is allowed to read and write it, while the opposite user is only allowed to read the register. And handshake registers are able to generate interrupt requests.

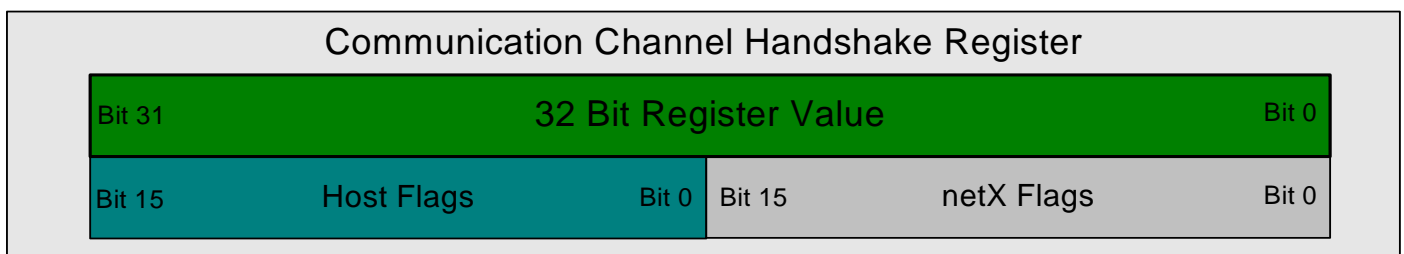
System Channel Handshake Register Structure:

The system channel handshake register defines 8 bits for the netX firmware (netX Flags = bNetxFlags) and 8 bits for the host application (Host Flags = bHostFlags), because it need less synchronization flags than a communication channel (see t8Bit structure below).



Communication Channel Handshake Register Structure:

The communication channel handshake register defines 16 bits for the netX firmware (netX Flags = usNetxFlags) and 16 bits for the host application (Host Flags = usHostFlags) (see t16Bit structure below).



Handshake register pairs are defined by the structure NETX_HANDSHAKE_CELL.

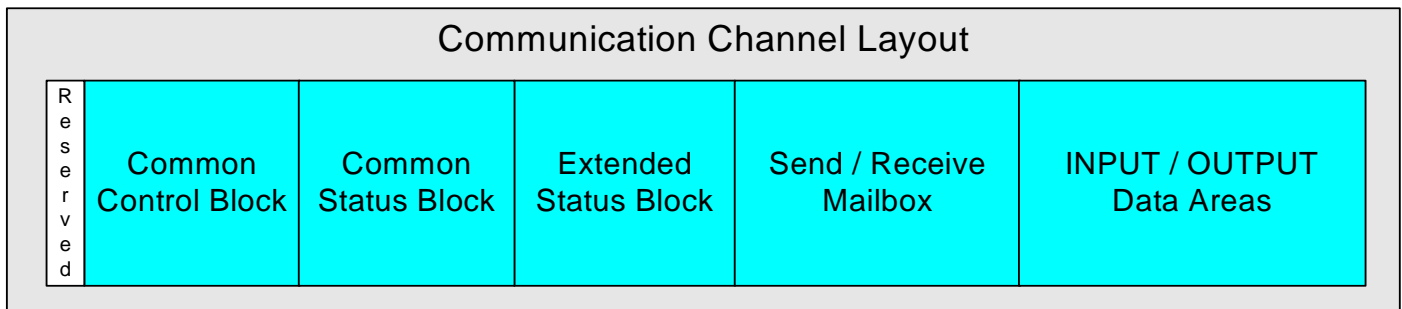
```

/*****
 *! Handshake cell definition
 *****/
typedef __RCX_PACKED_PRE union NETX_HANDSHAKE_CELLtag
{
    __RCX_PACKED_PRE struct
    {
        volatile uint8_t abData[2];          /*!< Data value, not belonging to handshake */
        volatile uint8_t bNetxFlags;        /*!< Device status flags (8Bit Mode) */
        volatile uint8_t bHostFlags;        /*!< Device command flags (8Bit Mode) */
    } __RCX_PACKED_POST t8Bit;

    __RCX_PACKED_PRE struct
    {
        volatile uint16_t usNetxFlags;       /*!< Device status flags (16Bit Mode) */
        volatile uint16_t usHostFlags;      /*!< Device command flags (16Bit Mode) */
    } __RCX_PACKED_POST t16Bit;
    volatile uint32_t ulValue;              /*!< Handshake cell value */
} __RCX_PACKED_POST NETX_HANDSHAKE_CELL;

```

3.4 Communication Channel Structure



Communication Channel Structure Definition (NETX_DEFAULT_COMM_CHANNEL):

```

/*****
/! Structure of the DEFAULT communication channel (Size 15616 Byte)
/*****
typedef __RCX_PACKED_PRE struct NETX_DEFAULT_COMM_CHANNELtag
{
    NETX_HANDSHAKE_BLOCK      tReserved;                /*!< 0x000:0x007 Reserved for later use */
    NETX_CONTROL_BLOCK        tControl;                  /*!< 0x008:0x00F Control block */
    NETX_COMMON_STATUS_BLOCK  tCommonStatus;             /*!< 0x010:0x04F Common status block */
    NETX_EXTENDED_STATUS_BLOCK tExtendedStatus;          /*!< 0x050:0x1FF Extended status block */
    NETX_SEND_MAILBOX_BLOCK   tSendMbx;                  /*!< 0x200:0x83F Send mailbox block */
    NETX_RECV_MAILBOX_BLOCK   tRecvMbx;                  /*!< 0x840:0xE7F Recveice mailbox block */
    uint8_t                   abPd1Output[NETX_HP_IO_DATA_SIZE]; /*!< 0xE80:0xEBF Process data 1 output area */
    uint8_t                   abPd1Input[NETX_HP_IO_DATA_SIZE]; /*!< 0xEC0:0xEFF Process data 1 input area */
    uint8_t                   abReserved1[256];           /*!< 0xF00:0xFFFF Reserved */
    uint8_t                   abPd0Output[NETX_IO_DATA_SIZE]; /*!< 0x1000:0x267F Process data 0 output area */
    uint8_t                   abPd0Input[NETX_IO_DATA_SIZE]; /*!< 0x2680:0x3CFF Process data 0 input area */
} __RCX_PACKED_POST NETX_DEFAULT_COMM_CHANNEL;

```

Common Control Block: (NETX_CONTROL_BLOCK)

Common communication channel and protocol stack control functions

Common Status Block: (NETX_COMMON_STATUS_BLOCK)

Common communication channel and protocol stack status information

Extended Status Block: (NETX_EXTENDED_STATUS_BLOCK)

Protocol stack specific state information

Send/Receive Mailbox: (NETX_SEND_MAILBOX_BLOCK / NETX_RECEIVE_MAILBOX_BLOCK)

Communication channel mailbox system for asynchronous packet based commands.

INPUT/OUTPUT Areas: (abPd(x)Output / abPd(x)Input)

Communication channel cyclic process data images (Input / Output data areas)

Note: An 8 kbyte *Communication Channel Structure* is also available (see NETX_8K_DPM_COMM_CHANNEL).

3.4.1 Channel Information

General communication channel information about all available channels is located in the "*System Channel -> Channel Information Block*".

3.4.2 Channel State

Communication channel general state and protocol stack specific states are offered by the following structures:

- Common Status Block => NETX_COMMON_STATUS_BLOCK
General communication channel information.
- Extended Status Block => NETX_EXTENDED_STATUS_BLOCK
Protocol stack specific channel information.

3.5 Data Transfer Methods and Areas

The netX firmware offers two general methods to exchange data with it.

■ Non-Cyclic data via *Packets* and a *Mailbox System*

Non-cyclic data are binary data streams named "*Packets*". A packet is a structure which consists of a header with general administration information (command / length / source / destination etc) and a data area. The mailbox system contains two memory areas used to exchange packets between the host and the netX device.

■ Cyclic data via Input/Output *Data Areas*

Cyclic data are the field bus protocol stack input and output data which are cyclical exchanged between members of a field bus network.

3.5.1 Packet Definition and Transfer via a Mailbox System

A packet is a memory area including command and data areas which should be transferred to and back from the hardware.

Packets are exchanged with the firmware by using a "*Mailbox System*".

A "*Mailbox System*" defines one memory area to send packets to the firmware and one area to receive packets from the firmware.

Access synchronisation to these areas is done by "*Handshake-Register-Flags*" (see *Handshake Registers*), signalling the state of the "*Mailbox Memory Area*" (empty or full).

To simplify the send and receive handling the mailbox system and their state flags are divided into a send direction and receive direction with separate handshake flags.

General Packet Definition:

Packet Header -> tHeader			
Variable	Data Type	Description	
ulDest	UINT32	Destination Queue Handle	
ulSrc	UINT32	Source Queue Handle	
ulDestId	UINT32	Destination Queue Reference	
ulSrcId	UINT32	Source Queue Reference	
ulLen	UINT32	Packet Data Length (in Bytes)	
ulId	UINT32	Packet Identification As Unique Number	
ulState	UINT32	Status / Error Code	
ulCmd	UINT32	Command / Response	
ulExt	UINT32	Reserved	
ulRout	UINT32	Routing Information	
Packet Data -> tData			
Variable	Data Type	Description	
...	...	User Data => Specific to ulCmd	

Table 3: General Packet Structure

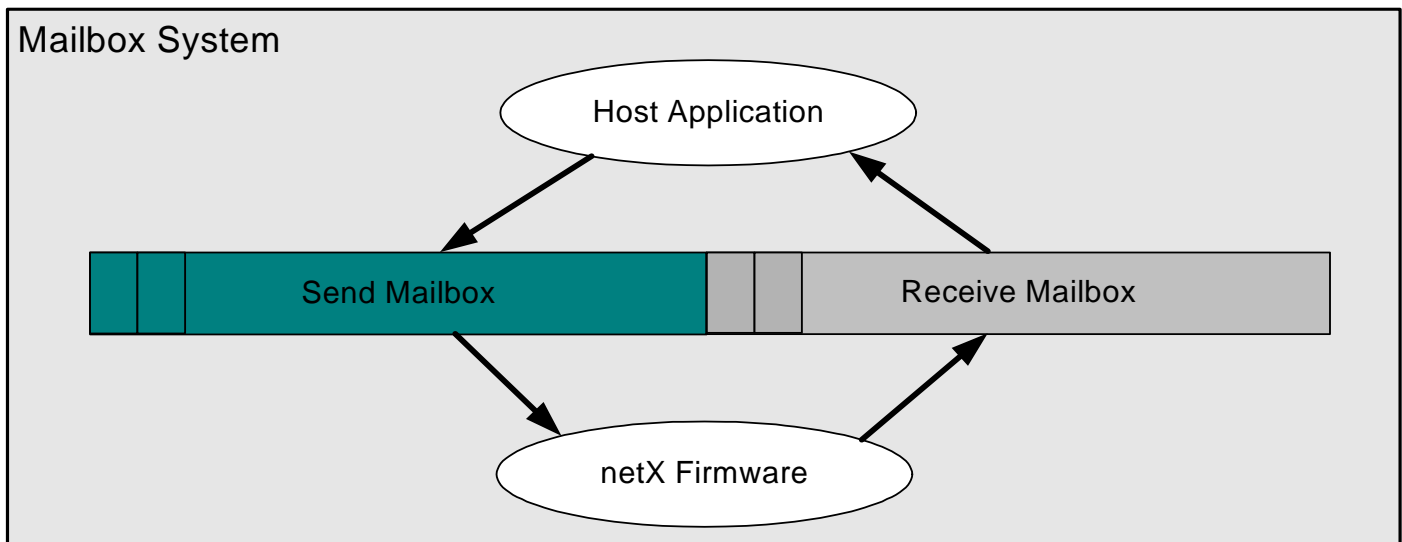
Default Packet Structure from rcX_User.h

```

/*****
 *! Default RCX packet header structure
 *****/
typedef __RCX_PACKED_PRE struct RCX_PACKET_HEADERtag
{
    uint32_t    ulDest;                /*!< 00:04, Destination of packet, process queue */
    uint32_t    ulSrc;                 /*!< 04:04, Source of packet, process queue */
    uint32_t    ulDestId;              /*!< 08:04, Destination reference of packet*/
    uint32_t    ulSrcId;               /*!< 12:04, Source reference of packet */
    uint32_t    ulLen;                 /*!< 16:04, Length of packet data without header */
    uint32_t    ulId;                  /*!< 20:04, Identification handle of sender */
    uint32_t    ulState;                /*!< 24:04, Status code of operation */
    uint32_t    ulCmd;                 /*!< 28:04, Packet command */
    uint32_t    ulExt;                 /*!< 32:04, Extension */
    uint32_t    ulRout;                /*!< 36:04, Router (internal use only) */
} __RCX_PACKED_POST RCX_PACKET_HEADER;

/*****
 *! Default RCX packet structure, including user data
 *****/
typedef __RCX_PACKED_PRE struct RCX_PACKETtag
{
    RCX_PACKET_HEADER tHeader;          /*!< Packet header */
    uint8_t            abData[RCX_MAX_DATA_SIZE]; /*!< Packet data */
} __RCX_PACKED_POST RCX_PACKET;

```

Mailbox System:

The netX firmware defines 2 mailbox structures:

- System Channel Mailbox
NETX_SYSTEM_SEND_MAILBOX / NETX_SYSTEM_RECEIVE_MAILBOX
- Communication Channel Mailbox
NETX_SEND_MAILBOX_BLOCK / NETX_RECV_MAILBOX_BLOCK

Example: System Channel Mailbox Structure

```

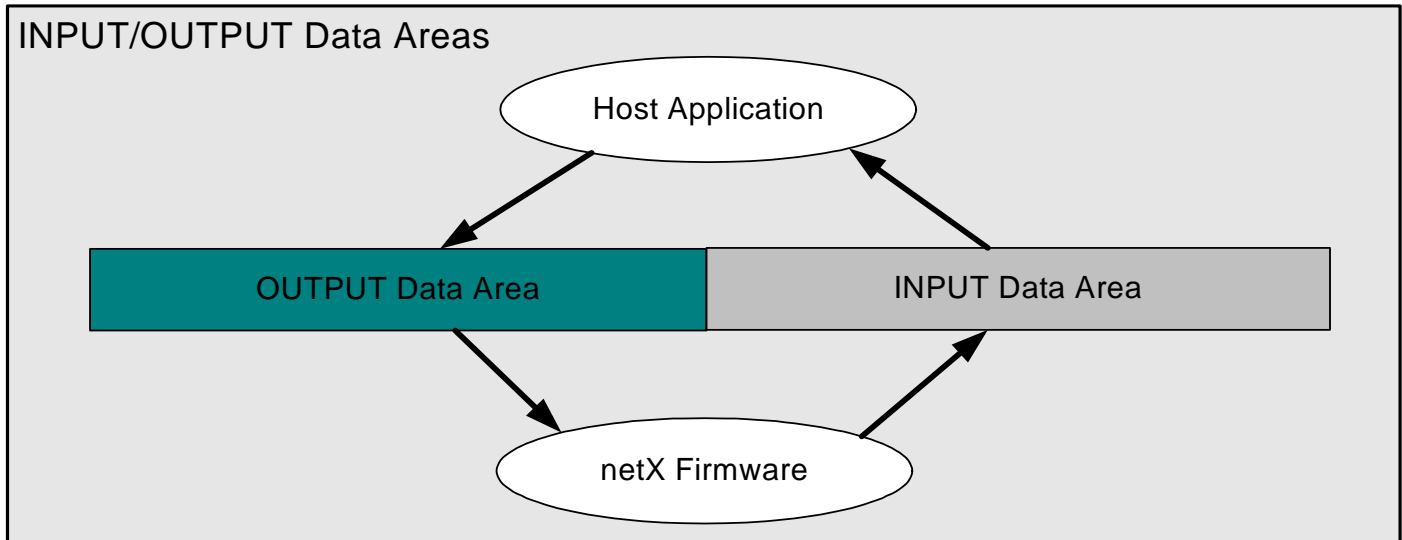
/*****
/! System send packet mailbox (Size 128 Byte)
/*****
typedef __RCX_PACKED_PRE struct NETX_SYSTEM_SEND_MAILBOXtag
{
    uint16_t  usPackagesAccepted;           /*!< Number of packages that can be accepted */
    uint16_t  usReserved;                   /*!< Reserved */
    uint8_t   abSendMbx[NETX_SYSTEM_MAILBOX_MIN_SIZE]; /*!< Send mailbox packet buffer */
} __RCX_PACKED_POST NETX_SYSTEM_SEND_MAILBOX;

/*****
/! System receive packet mailbox (Size 128 Byte)
/*****
typedef __RCX_PACKED_PRE struct NETX_SYSTEM_RECV_MAILBOXtag
{
    uint16_t  usWaitingPackages;           /*!< Number of packages waiting to be processed */
    uint16_t  usReserved;                   /*!< Reserved */
    uint8_t   abRecvMbx[NETX_SYSTEM_MAILBOX_MIN_SIZE]; /*!< Receive mailbox packet buffer */
} __RCX_PACKED_POST NETX_SYSTEM_RECV_MAILBOX;

```


3.5.2 I/O Data Transfer

I/O data areas containing the cyclic process data of a fieldbus protocol stack. These areas are also divided into output and input areas with dedicated synchronisation flags for each area and transfer direction.



3.6 Communication Mechanism and Synchronization

Handshake registers are used to signal general channel information, activate commands and for synchronised data access to the mailbox system, I/O data areas and to handle change of state information (COS).

3.6.1 System Channel Handshake Register

netX System Flags (NSF)

=> read and written by the netX firmware, host is only allowed to read

Host System Flags (HSF)

=> read and written by the host, netX firmware is only allowed to read

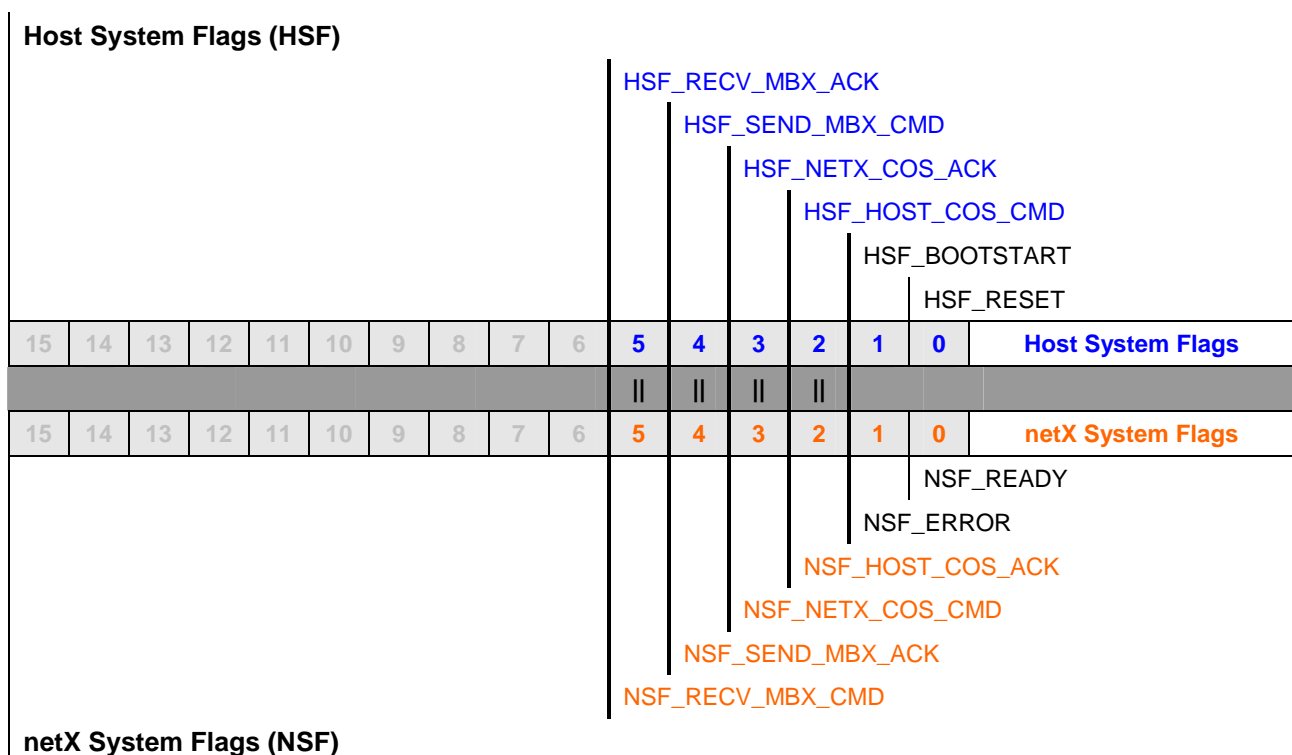


Table 4: Host System Flags / netX System Flags

3.6.3 Working with Handshake Registers and Flags

Handshake flags are located in the handshake registers and either used to signal a specific state, activate a specific command or, in conjunction with another flag, to create a synchronised data access.

3.6.3.1 Simple State and Command Handshake Flags

These flags just having two states (signaled = 1 / none signaled = 0).

0	State / Command is inactive
1	State / Command is active

System Channel State / Command Flags:

HSF_RESET	1 = Activate a RESET on the device / 0 = do nothing
HSF_BOOTSTART	1 = Activate the Bootloader of the device / 0 = do nothing
NSF_READY	1 = System Channel is READY / 0 = System Channel is not READY
NSF_ERROR	1 = System Channel error / 0 = no error

Communication Channel State / Command Flags:

NCF_COMMUNICATING	1 = Communicating / 0 = not Communicating
NCF_ERROR	1 = Error / 0 = no error

3.6.3.2 Synchronization Handshake Flags

A netX system defines 3 different synchronization mechanisms realized by handshake flags. Therefore pairs of handshake bits are defined. One bit from the host handshake flags and one bit from the netX handshake flags. Both together are used to handle the synchronisation.

Following functions are synchronized:

- Packet Data Transfer via the mailbox system
- I/O data transfer mechanism
- COS - Change Of State mechanism

3.6.3.3 Packet Data Transfer - Handshake Flag Synchronisation

The following flags pairs are used for packet data transfer (mailbox handling). The flags are found in the system channel handshake register and the communication channel handshake register (ulNetxFlags / ulHostFlags):

- System Channel Flags
 - HSF_SEND_MBX_CMD / NSF_SEND_MBX_ACK
 - NSF_RECV_MBX_CMD / HSF_RECV_MBX_ACK
- Communication Channel Flags
 - HCF_SEND_MBX_CMD / NCF_SEND_MBX_ACK
 - NCF_RECV_MBX_CMD / HCF_RECV_MBX_ACK

General Mailbox Definition:

Handshake Flag	Status		Handshake Flag	Mailbox State
SYSTEM CHANNEL - Send Mailbox				
HSF_SEND_MBX_CMD	0	0	NSF_SEND_MBX_ACK	EMPTY
	1	1		EMPTY
	1	0		FULL
	0	1		FULL
SYSTEM CHANNEL - Receive Mailbox				
NSF_RECV_MBX_CMD	0	0	HSF_RECV_MBX_ACK	EMPTY
	1	1		EMPTY
	1	0		FULL
	0	1		FULL

COMMUNICATION CHANNEL - Send Mailbox				
Handshake Flag	Status		Handshake Flag	Mailbox State
HCF_SEND_MBX_CMD	0	0	NCF_SEND_MBX_ACK	EMPTY
	1	1		EMPTY
	1	0		FULL
	0	1		FULL
COMMUNICATION CHANNEL - Receive Mailbox				
NCF_RECV_MBX_CMD	0	0	HCF_RECV_MBX_ACK	EMPTY
	1	1		EMPTY
	1	0		FULL
	0	1		FULL

Evaluation of the actual mailbox state can be done by an easy XOR relation between the involved flags:

```
if (0 == ((usHostFlags ^ usNetxFlags) & HCF_SEND_MAILBOX))
    /* Mailbox empty */
else
    /* Mailbox full */
```

Example: Host sending a packet to the device (HCF_SEND / send mailbox)

Stage	Flags		Mailbox State	Description
1	Mailbox is inactive / no packet sent to device			
	HCF_SEND_MBX_CMD	NCF_SEND_MBX_ACK	EMPTY	Access allowed by host
	1	1		
	0	0		
2	Host sends a packet to the device - Checking for state 1 - Copy packet data to send mailbox - Toggle HCF_SEND_MBX_CMD (1->0 or 0->1)			
	0	1	FULL	Access switched to netX
	1	0		
	3	netX firmware gets an interrupt and processes following functions - Checking the handshake flags pairs(send mailbox flags not equal => Packet in mailbox available) - Access to mailbox is allowed - Firmware copies the packet from the mailbox to internal RAM - Firmware frees the mailbox by toggle NCF_SEND_MBX_ACK (0->1 or 1->0)		
HCF_SEND_MBX_CMD		NCF_SEND_MBX_ACK	EMPTY	netX has freed the mailbox and access is switched back to host
0		0		
1		1		
Back to step 1				

Example: netX device sending a packet to the host (NCF_RECV / receive mailbox)

Stap	Flags		Mailbox State	Description
1	Mailbox is inactive / no packet sent to device			
	NCF_RECV_MBX_CMD	HCF_RECV_MBX_ACK	EMPTY	Access allowed by netX
	1	1		
	0	0		
2	netX sends a packet to the device - Checking for state 1 - Copy packet data to receive mailbox - Toggle NCF_RECV_MBX_CMD (1->0 or 0->1)			
	0	1	FULL	Access switched to host
	1	0		
3	Host polls the flags and processes following functions - Checking the handshake flags pairs(receive mailbox flags not equal => Packet in mailbox available) - Access to mailbox is allowed - Host copies the packet from the mailbox to internal RAM - Host frees the mailbox by toggle HCF_RECEIVE_MBX_ACK (0->1 or 1->0)			
	NCF_RECV_MBX_CMD	HCF_RECV_MBX_ACK	EMPTY	Host has freed the mailbox and access is switched back to netX
	0	0		
	1	1		
Back to step 1				

NOTE: The system mailbox works in the same way, just the flags are named different and are located in a different handshake register

HSF_SEND_MBX_CMD / **NSF_SEND_MBX_ACK**
NSF_RECV_MBX_CMD / **HSF_RECV_MBX_ACK**

3.6.3.4 I/O Data Transfer - Handshake Flag Synchronisation

The following flags pairs are used for I/O data transfer synchronization, the flags are found in the communication channel handshake register (ulNetxFlags / ulHostFlags):

- I/O Data Exchange

HCF_PDO_OUT_CMD	/	NCF_PD0_OUT_ACK
HCF_PDO_IN_CMD	/	NCF_PD0_IN_ACK

The I/O data transfer uses an additional definition (*Handshake Mode*) which defines the initiator of a data transfer.

Handshake Mode Definition:

- Buffered Host Controlled Mode Host initiates the INPUT/OUTPUT data update
- Buffered Device Controlled Mode Device initiates the INPUT/OUTPUT data update

The combination of the flag state and the handshake mode is used to handle the I/O data transfer.

Example: Read INPUT data by the host in "*Buffered Host Controlled Mode*"

Step	Flags		INPUT State	Description
1	Read INPUT process data by the host			
	HCF_PDO_IN_CMD	NCF_PDO_IN_ACK	FREE	Access allowed by host
	1	1		
	0	0		
2	Host reads INPUT data in "Buffered Host Controlled Mode" - Checking for state 1 - Copy INPUT data from the device to a local buffer - Signal device to update INPUT data - Toggle HCF_PDO_IN_CMD (1->0 or 0->1)			
	0	1	BUSY	Access switched to device which should update the data
	1	0		
	3	Device updates the INPUT data area with local buffer holding the latest data received by the fieldbus connection. - Device getting an interrupt signalling changes in the host flags - Checks the state of HCF_PDO_IN_CMD and NCF_PDO_IN_ACK - Copies the actual local input data into the input process data area in the DPM - Toggle NCF_PDO_IN_CMD (1->0 or 0->1)		
HCF_PDO_IN_CMD		NCF_PDO_IN_ACK	DONE	Device has updated the INPUT data, access is switched back to host
0		0		
1		1		
Host polls flags or waits on an I/O read event and processes following functions - Copy the data from the DPM to a local buffer - Processes the input data				
Back to step 1				

Example: Write OUTPUT data by the host in "Buffered Host Controlled Mode"

Step	Flags		OUTPUT State	Description
1	Write OUTPUT data to the output process data area			
	HCF_PDO_OUT_CMD	NCF_PDO_OUT_ACK	FREE	Access allowed by host
	1	1		
	0	0		
2	Host writes OUTPUT data in "Buffered Host Controlled Mode" - Checking for state 1 - Copy local OUTPUT data to the output process data area - Signal device to take the OUTPUT data - Toggle HCF_PDO_OUT_CMD (1->0 or 0->1)			
	0	1	DATA available	Access switched to device which should take the data
	1	0		
	3	Device takes the OUTPUT data and copies the data to a local output buffer and sending the data with the next bus cycle. - Device getting an interrupt signalling changes in the host flags - Checks the state of HCF_PDO_OUT_CMD and NCF_PDO_OUT_ACK - Copies the actual OUTPUT data from the DPM to a local output buffer - Toggle NCF_PDO_OUT_ACK (1->0 or 0->1)		
HCF_PDO_OUT_CMD		NCF_PDO_OUT_ACK	DONE	Device has taken the OUTPUT data, access is switched back to host
0		0		
1		1		
Back to step 1				

ATTENTION: In "*Device Controlled Mode*" the initiator of the transfer changes from HOST to netX and therefore also the flag meanings are changing (_CMD flags becoming _ACK flags and _ACK flags becoming _CMD flags).

Example: Read INPUT data by the host in "*Buffered Device Controlled Mode*"

Step	Flags		OUTPUT State	Description
1	Read INPUT data by the host			
	NCF_PDO_IN_ACK	HCF_PDO_IN_CMD	FREE	Access allowed by device
	1	1		
	0	0		
2	Device gets new INPUT data from the field bus connection and signals them to the host "Buffered Device Controlled Mode" - Checking for state 1 - Copy local INPUT data to the input process data area in the DPM - Signal host to take the INPUT data - Toggle NCF_PDO_IN_ACK (1->0 or 0->1)			
	0	1	DATA available	Access switched to the host, which should take the data
	1	0		
	3	Host polls the handshake flags or waits on an INPUT event.. - Checks the state of NCF_PDO_IN_ACK and HCF_PDO_IN_CMD - Copies the actual INPUT data from the DPM to a local input buffer - Toggle HCF_PDO_IN_CMD (1->0 or 0->1)		
NCF_PDO_IN_ACK		HCF_PDO_IN_CMD	DONE	Host has taken the INPUT data, access is switched back to device
0		0		
1		1		
Back to step 1				

Example: Write OUTPUT data by the host in "Buffered Device Controlled Mode"

Step	Flags		OUTPUT State	Description
1	Write OUTPUT data by the host			
	NCF_PDO_IN_ACK	HCF_PDO_IN_CMD	FREE	Access allowed by device
	1	1		
	0	0		
2	Device gets new OUTPUT data from the DPM and copies them to the local output data buffer "Buffered Device Controlled Mode" - Checking for state 1 - Copy OUTPUT data from the DPM to the local output process data - Signal host, data taken from the OUTPUT process data area - Toggle NCF_PDO_OUT_ACK (1->0 or 0->1)			
	0	1	DATA available	Access switched to the host, which could place new OUTPUT into the DPM
	1	0		
3	Host polls the handshake flags or waits on OUTPUT event - Checks the state of NCF_PDO_OUT_ACK and HCF_PDO_OUT_CMD - Copies the actual OUTPUT data from a local buffer to the DPM output process data area - Toggle HCF_PDO_OUT_CMD (1->0 or 0->1)			
	NCF_PDO_OUT_ACK	HCF_PDO_OUT_CMD	DONE	Host has placed new OUTPUT data into the DPM, access is switched back to device
	0	0		
	1	1		
Back to step 1				

3.6.3.5 Change of State Mechanism (COS)

A communication channel has more options and commands than bits in the handshake flag register.

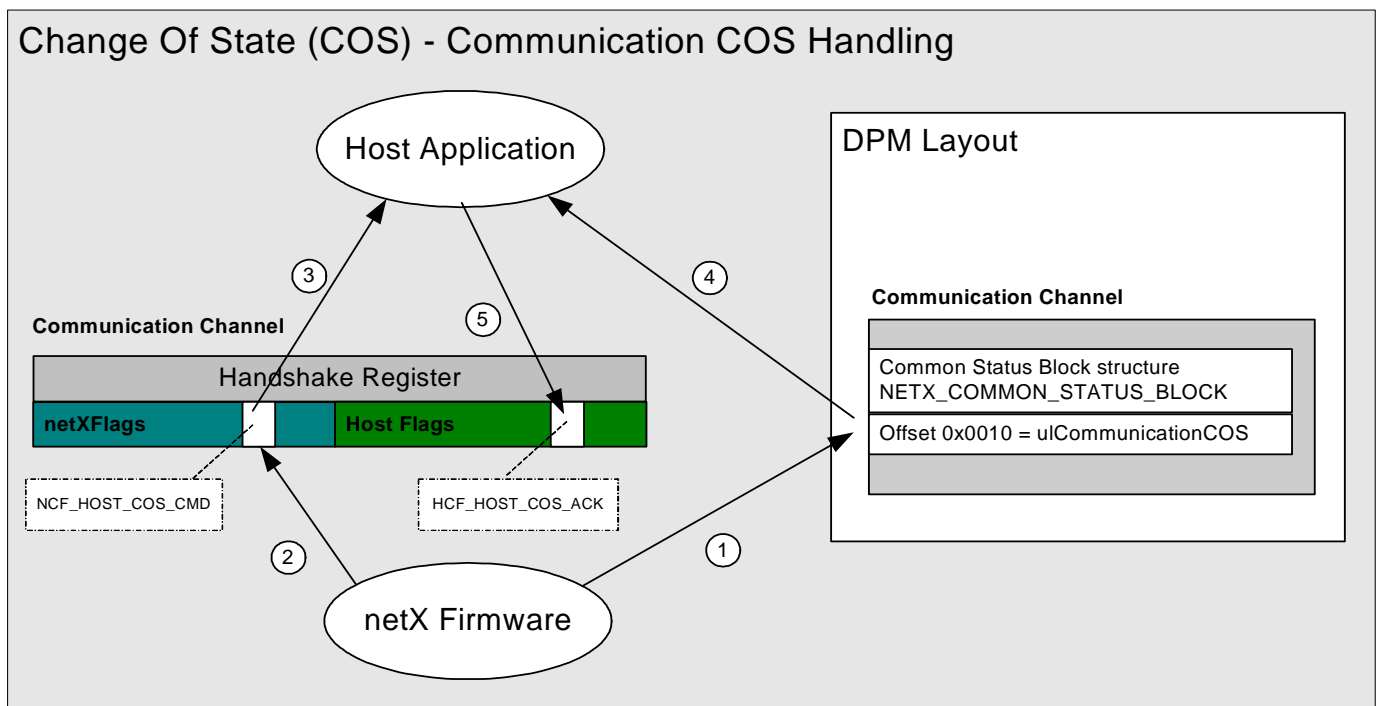
Therefore a so called "*Change of State (COS)*" mechanism is defined which extends the direct usable handshake flags by another 32 Bit value with additional states.

Furthermore the COS mechanism expects an acknowledgement if a state change was signalled, before another state change will be signalled.

This mechanism is direction oriented and distinguishes between state changes from the host application and from the device:

- Device state changes are named "*Communication COS Handling*"
- Application state changes are named "*Application COS Handling*"

Communication COS Handling:



The netX device "COS" flags are located in the "Common Status Block" structure NETX_COMMON_STATUS_BLOCK of a communication channel.

Common Status Block Structure

```
typedef struct NETX_COMMON_STATUS_BLOCKtag
{
    UINT32    ulCommunicationCOS;
    UINT32    ulCommunicationState;
    UINT32    ulCommunicationError;
    UINT16    usVersion;
    UINT16    usWatchdogTime;
    UINT8     bPDInHskMode;
    UINT8     bPDInSource;
    UINT8     bPDOutHskMode;
    UINT8     bPDOutSource;
    UINT32    ulHostWatchdog;
    UINT32    ulErrorCount;
}
```

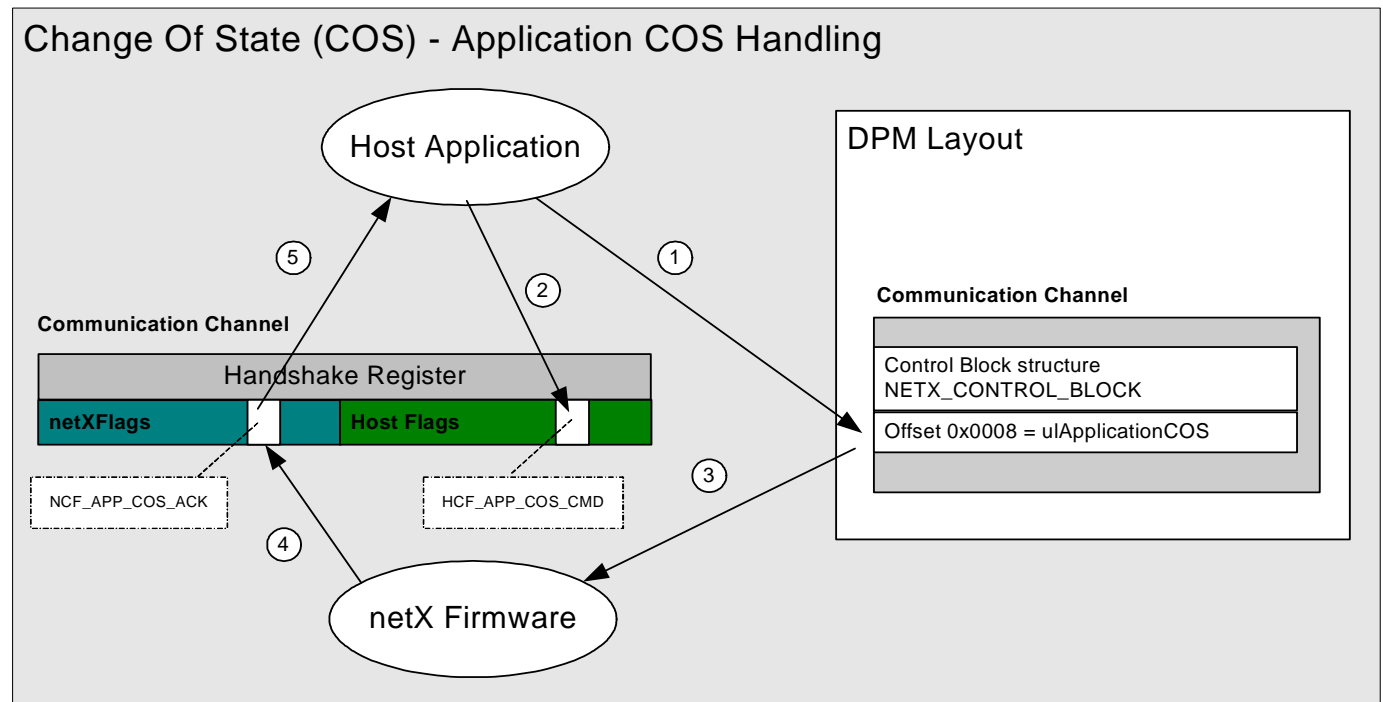
```

UINT8      bErrorLogInd;
UINT8      bErrorPDInCnt;
UINT8      bErrorPDOutCnt;
UINT8      bErrorSyncCnt;
UINT8      bSyncHskMode;
UINT8      bSyncSource;
UINT16     ausReserved[3];
union
{
    {
        NETX_MASTER_STATUS      tMasterStatusBlock;    /* for master implementation */
        UINT32                   aulReserved[6];        /* otherwise reserved */
    } uStackDepended;
} NETX_COMMON_STATUS_BLOCK;

```

Example: Communication COS handling initiated by the device

Step	Flags		COS State	Description
1	Device updates COS state information			
	NCF_NETX_COS_CMD	HCF_NETX_COS_ACK	FREE	Access to COS flags allowed by the device
	1	1		
	0	0		
2	Device updates COS information and signals new COS state - Checking for state 1 - Copy new COS state to ulCommunicationCOS - Signal host, new COS information - Toggle NCF_NETX_COS_CMD (1->0 or 0->1)			
	0	1	new COS information available	Access switched to the host, which could read COS information
	1	0		
3	Host polls the handshake flags - Checks the state of NCF_NETX_COS_CMD and HCF_NETX_COS_ACK - Copies the COS information from ulCommunicationCOS to a local buffer - Toggle HCF_NETX_COS_ACK (1->0 or 0->1)			
	NCF_NETX_COS_CMD	HCF_NETX_COS_ACK	DONE	Host has the new COS information, access is switched back to device
	0	0		
	1	1		
Back to step 1				

Application COS Handling:

The application "COS" flags are located in the "Control Block" structure `NETX_CONTROL_BLOCK` of a communication channel.

Control Block Structure

```
typedef struct NETX_CONTROL_BLOCKtag
{
    UINT32    ulApplicationCOS;
    UINT32    ulDeviceWatchdog;
} NETX_CONTROL_BLOCK;
```

Example: Application COS handling initiated by the host

Step	Flags		COS State	Description
1	Application updates state information			Access to COS flags allowed by the host
	HCF_APP_COS_CMD	HCF_NETX_COS_ACK	FREE	
	1	1		
	0	0		
2	Host updates COS information and signals new COS state			Access switched to device, which could read COS information
	- Checking for state 1			
	- Copy new COS state to ulApplicationCOS			
	- Signal device, new COS information			
	- Toggle HCF_APP_COS_CMD (1->0 or 0->1)			new COS information available
	0	1		
	1	0		
3	Device gets an interrupt			
	- Checks the state of HCF_APP_COS_CMD and NCF_APP_COS_ACK			
	- Copies the COS information from ulApplicationCOS to a local buffer			

	- Toggle NCF_APP_COS_ACK (1->0 or 0->1)			
	HCF_APP_COS_CMD	NCF_APP_COS_ACK	DONE	Device has the new COS information, access is switched back to host
	0	0		
	1	1		
Back to step 1				

3.7 Programming Interface - CIFX-API

The CIFX API is the general application programming interface (API) which offers all necessary function to handle a netX device.

The API offers general handling functions and functions corresponding to the DPM components described above.

Example API functions:

Asynchronous Services (Packets)	
API Function	Description
xChannelGetMBXState	Retrieve the channels mailbox state
xChannelGetPacket	Read a packet from the channel receive mailbox
xChannelPutPacket	Send a packet via the channel send mailbox
.....	

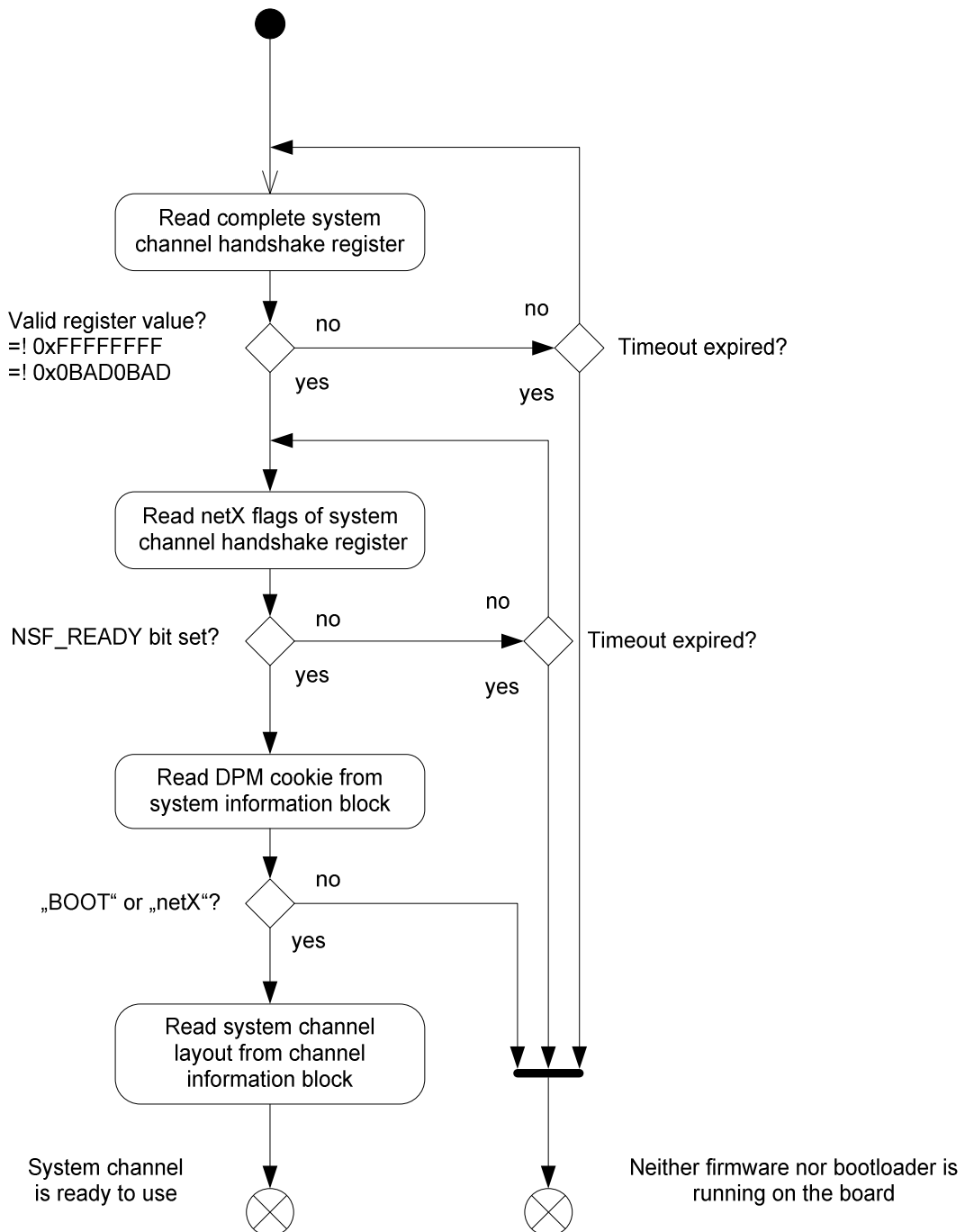
Cyclic Data Services (I/O's)	
API Function	Description
xChannelIORead	Instructs the device to place the latest data into the DPM input data area and passes them to the user
xChannelIOWrite	Copies the data to the DPM send data area and waits for the firmware to retrieve them
.....	

The complete API is described can be found in the "*cifX API PR xx EN.pdf*" manual.

4 Examples

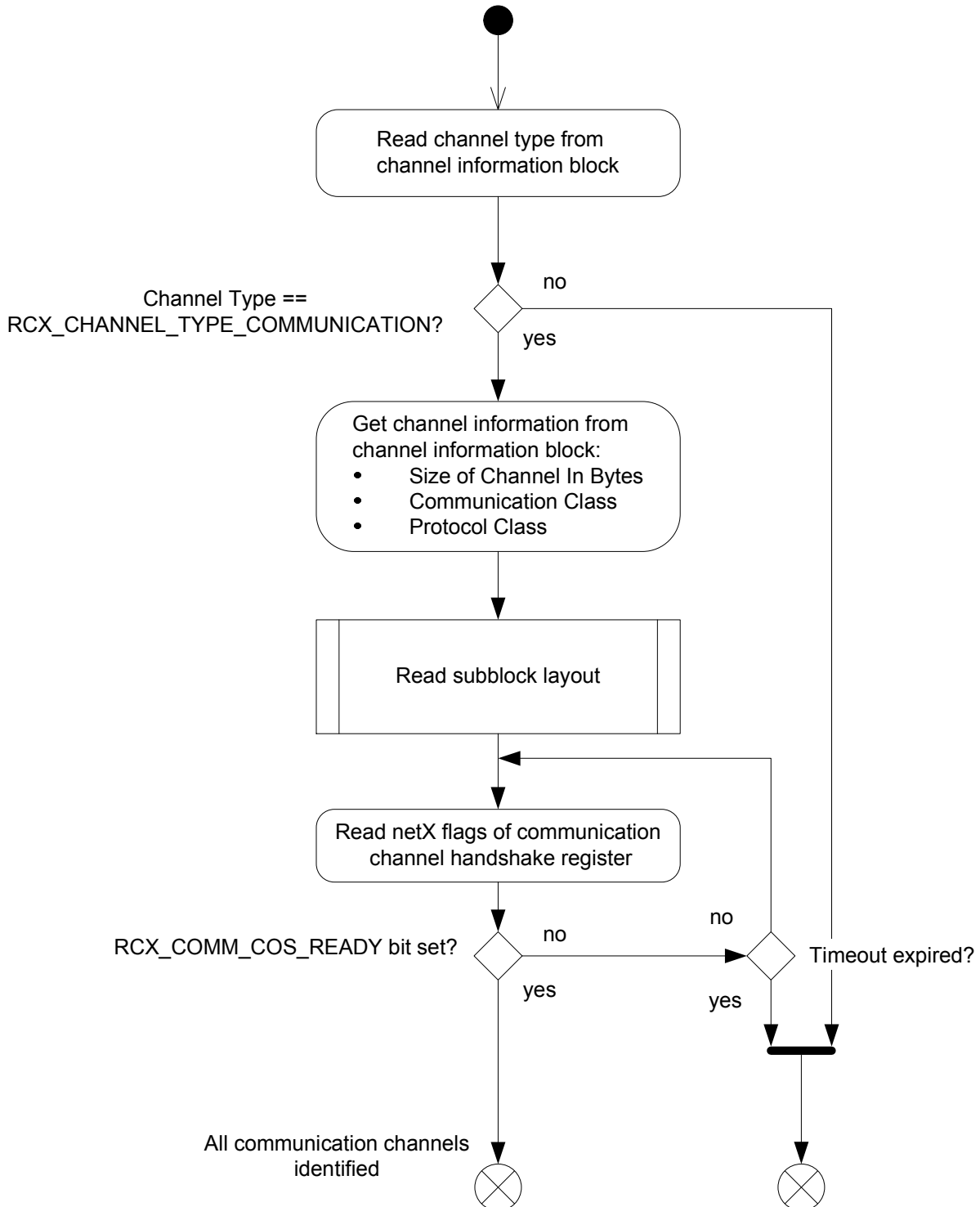
4.1 System Identification and Start-Up Handling

This flow chart describes the necessary start-up handling to identify a running netX boot loader or firmware.



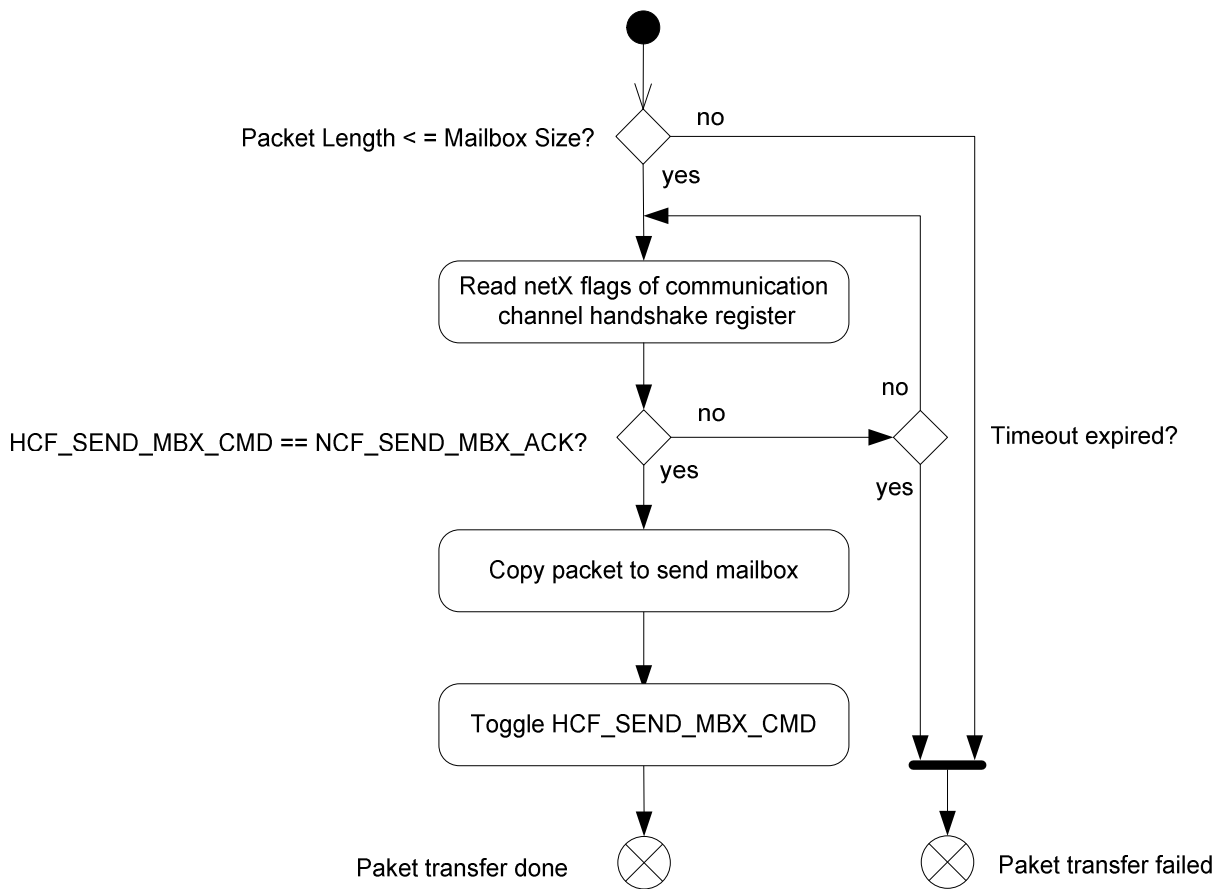
4.2 Channel Identification and Start-Up Handling

After successful identified a system start-up, the following need to be done to verify a running communication stacks.



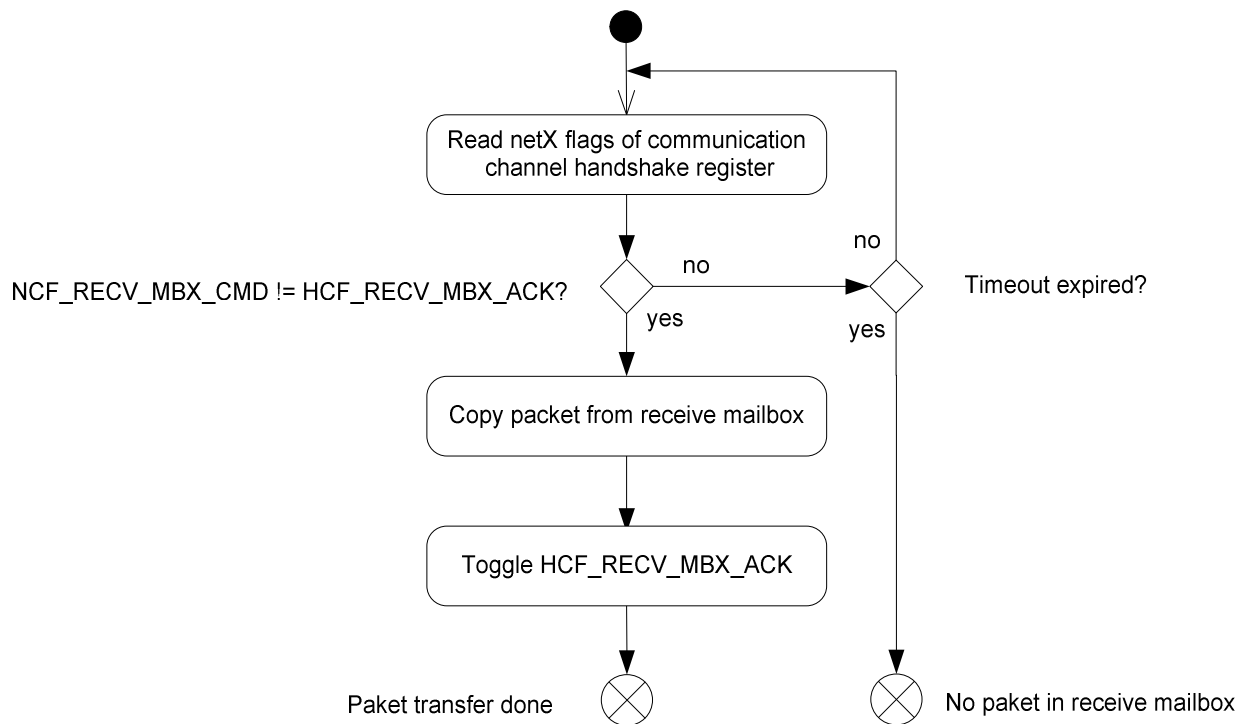
4.3 Packet Transfer

4.3.1 Send a Packet to the Device



CIFX-API Function: xChannelPutPacket()

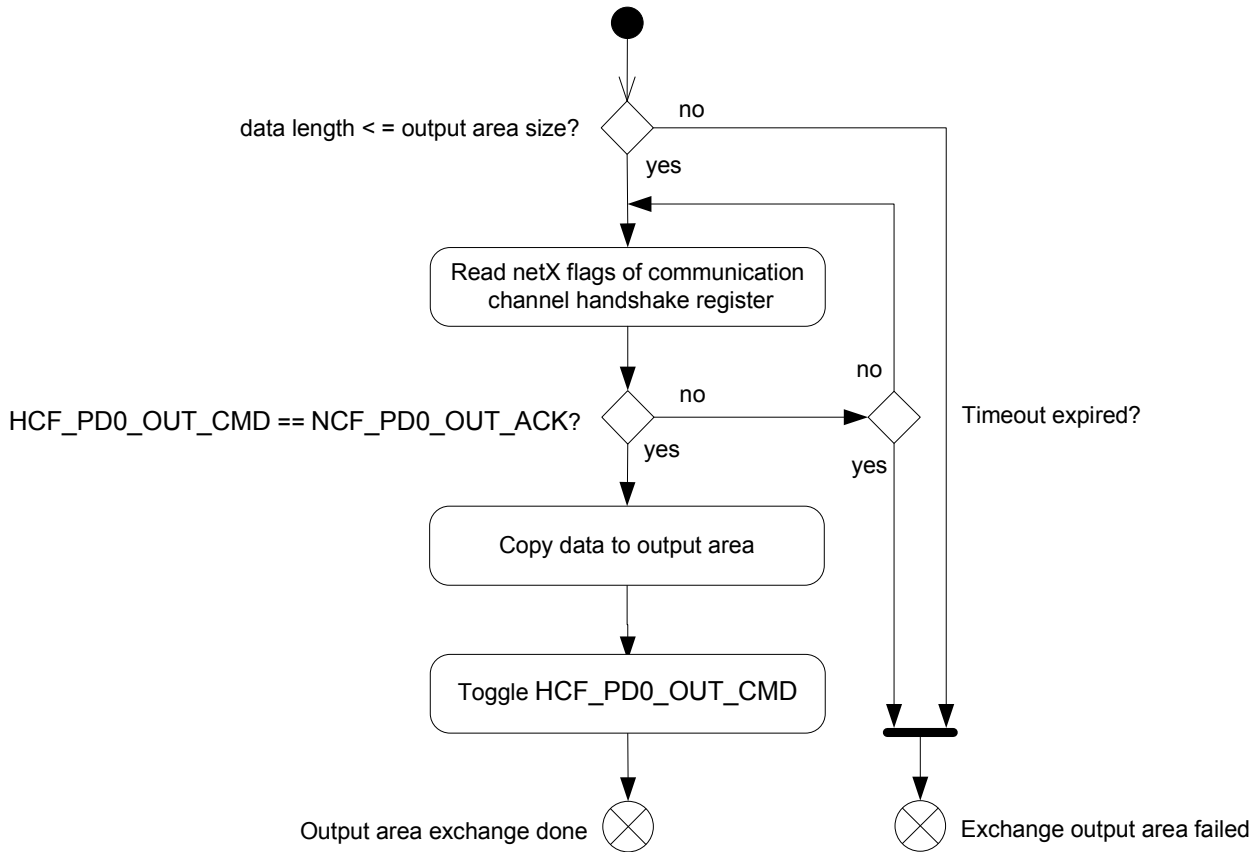
4.3.2 Read a Packet form the Device



CIFX-API Function: xChannelGetPacket()

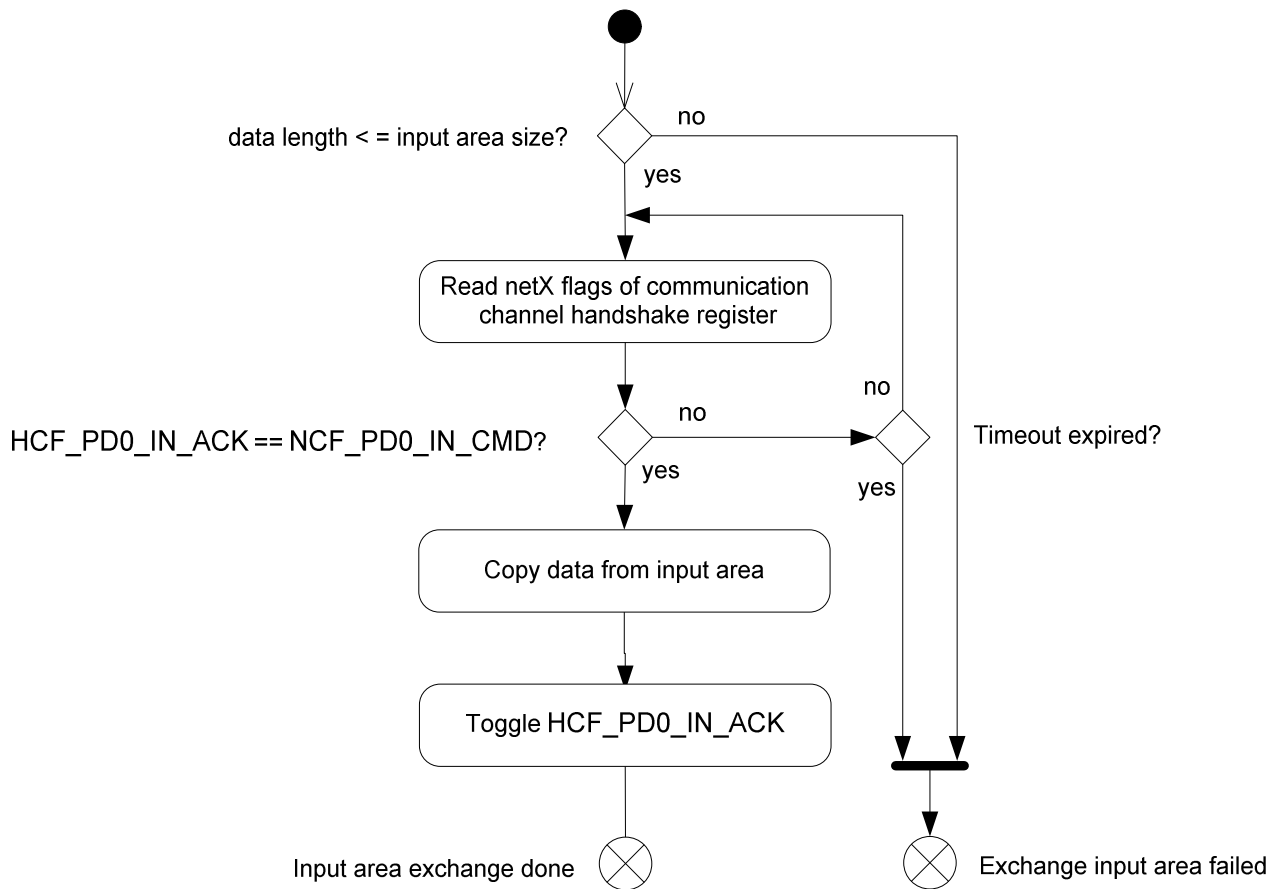
4.4 I/O Data Transfer

4.4.1 Write Output data to the Device



CIFX-API Function: xChannelIOWrite()

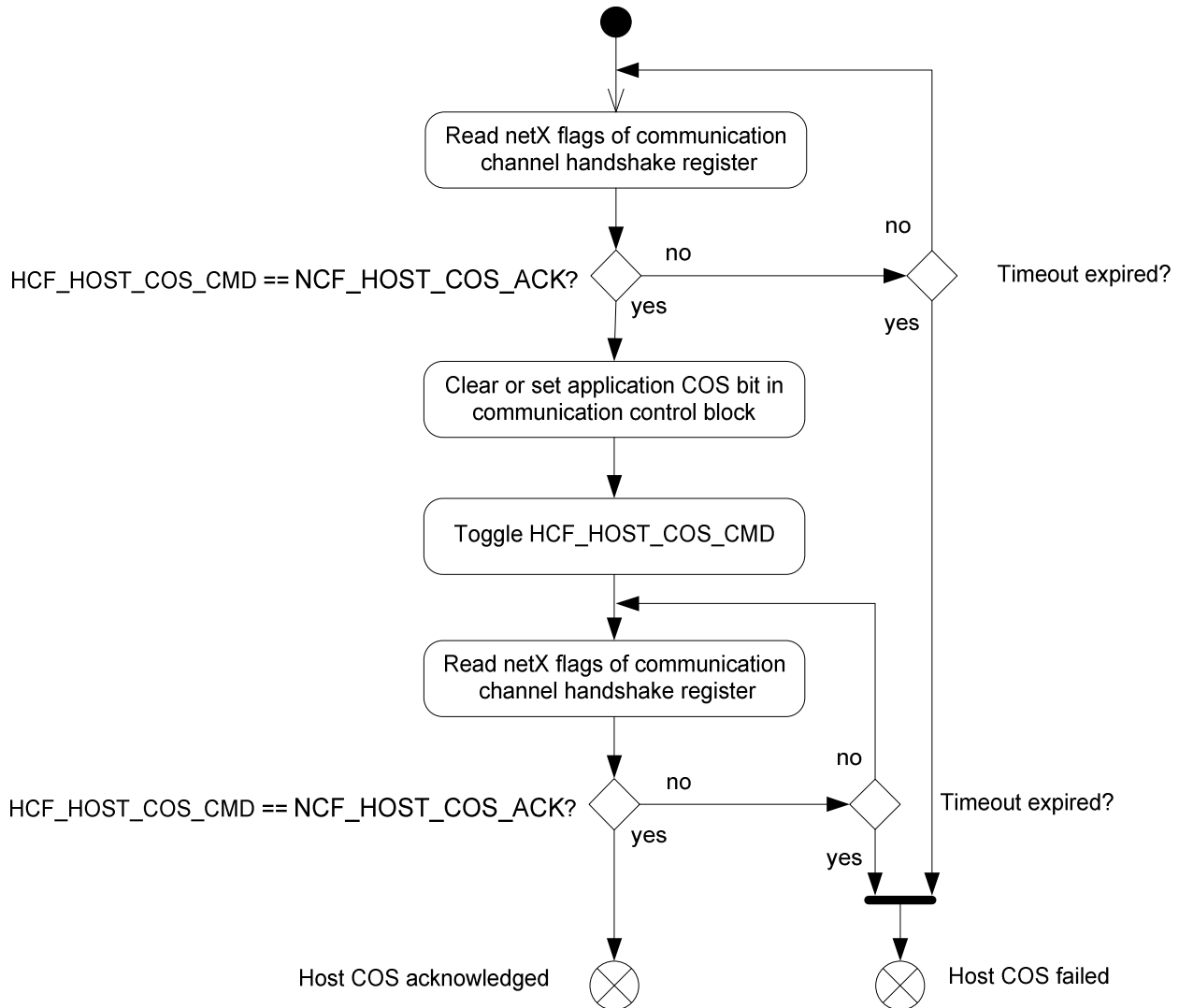
4.4.2 Read Input data from Device



CIFX-API Function: xChannelIORead()

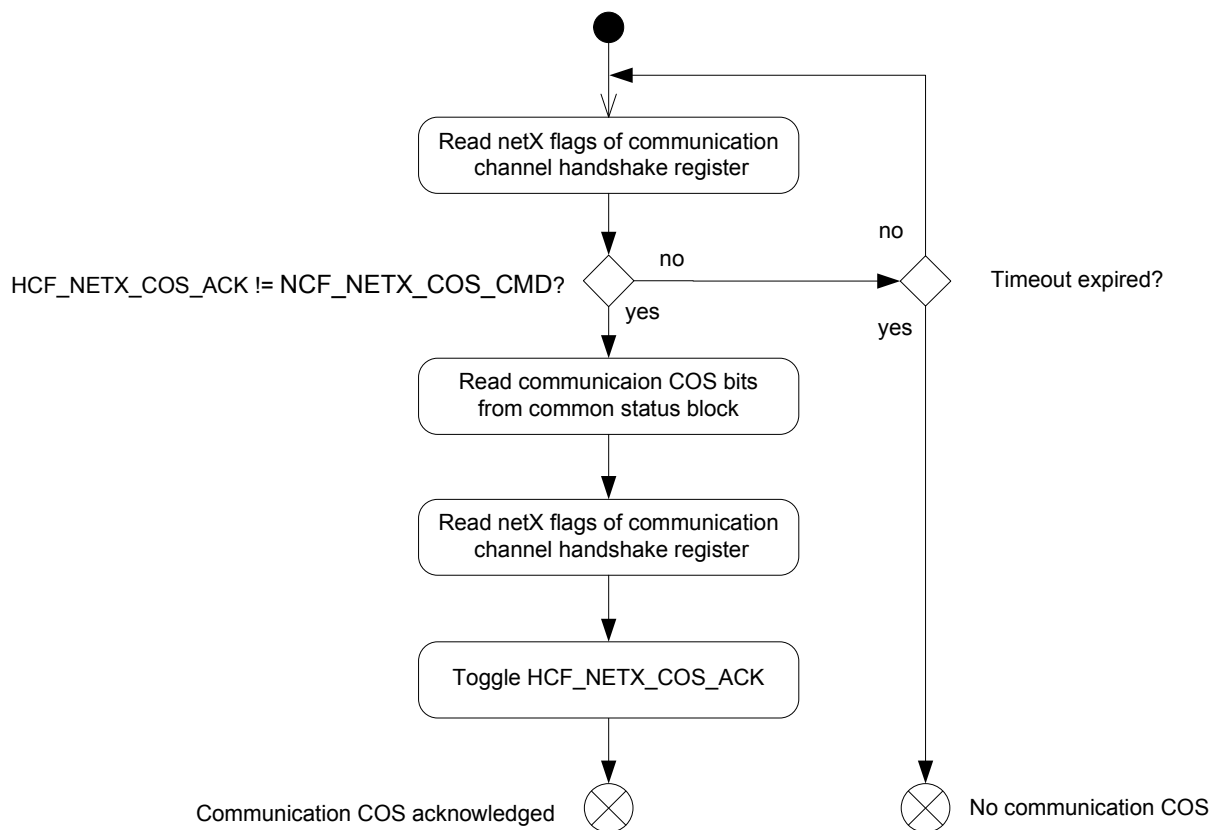
4.5 Change of State (COS) Information and Handling

4.5.1 Host COS Handling



CIFX-API Function: `xChanneltHostState()`
`xChannelBusState()`
`xChannelConfigLog()`

4.5.2 Communication COS Handling



4.6 Hardware and Protocol Stack Identification

The DPM contains information to determine the hardware type and the protocol stack type. And if the protocol is a master or slave stack.

- **Hardware Identification**
This information can be found in the "**System Information Block**"
Device Class => DPM Offset 0x0028 usDeviceClass
- **Hardware Assembly Option**
Defines which communication hardware is offered by the device
This information can be found in the "**System Information Block**"
Hardware Option => DPM Offset 0x0010 ausHwOptions
- **Protocol Stack Identification**
The protocol stack identification per communication channel can be found in the Channel I
"**Channel Information Block**"
Therefore evaluate the channel type (bChannelType = COMMUNICATION) and read the communication class (usCommunicationClass) and protocol class (usProtocolClass).

This information can be found in the "**netX Dual Port Memory Interface DPM...pdf**" manual.

4.7 Additional Functions

- **System and Channel Information**
Can be read via *xSysdeviceInfo()*
- **Handshake States**
Can be read via a *xChannelInfo()* function
- **Transfer Packet**
If a synchronous packet transfer must be realized, where the user function has to wait until the answer to the previously command packet is received, a transfer packet functions must be implemented by using *xChannelPutPacket()* and *xChannelGetPacket()*.
- **Interrupt mode / Event handling**
Event handling can be used if the hardware is handled in interrupt mode. Than the toolkit / drivers are able to create events for an application to signal state changes of the hardware. The user application can use the *xChannelRegisterEvent()* function to use hardware events.
- **Watchdog**
The CIFX API offers a watchdog function per channel, where the protocol stack is able to supervise an user application and if the user application failes, the bus communication can be stopped. See *xChannelWatchdog()* function in the CIFX API.
- **DMA**
PCI bus based netX hardware is able to work as a bus master DMA device. This means the hardware can active read and write data form the memory of a host system.
The netX DMA mode is limited to the Input/Output data from the netX hardware.
The CIFX API offers a *xChannelDMAState()* functions to switch the I/O data exchange with

the hardware to DMA mode assumed, the hardware is PCI bus based and runs in interrupt mode.

4.8 Hardware and Driver Installation Guides

Hilscher devices are delivered with a hardware and driver installation guide describing the step by step handling to get a working netX device into a PC based host system

A description on how to install and pre-configure the hardware you will found under:

.\\documentation\\Installation - "cifX Device Driver Installation for Windows"

4.9 Load a Firmware to a CIFX Card

Hilscher offers different communication devices. PC based CIFX cards like CIFX50 / CIFX70 / CIFX90 devices, which are PCI bus based so not store the firmware and configuration file on the hardware.

Such devices must be pre-loaded with a firmware to be usable by a configuration tool or by any application which want a field bus protocol firmware.

Actual firmware can be taken from the "Communication Solution DVD" (either shipped with the device or downloadable Hilscher web site the following link:

http://de.hilscher.com/hcde/files_software/Communication_Solutions_DVD_20xx-xx-1.....

Go to the "Firmware" sub-directory and choose the appropriate firmware for your hardware (like described in the "**cifX Device Driver Installation for Windows**" manual.

On COMX module the firmware is stored on the hardware and a firmware download during start-up is not necessary.

4.10 Start with an Example Program

After loading the hardware with the necessary firmware (in case of PCI based devices) it is possible to use it and to start with example programs (e.g. "cifXTest_console example" from the CIFX Driver CD, see **.\\examples\\cifXTest_console**)

.

This example contains most of the CIFX API functions in separate source modules an mostly contains a corresponding project file (e.g. Microsoft Visual Studio project under Windows) which can be used to compile and run the example.

The main function of the example can be found in the source module cifXTest_console.cpp which than calls the function RunCifXConsoleTest() in the source module cifXConsole_Main.cpp for further processing.

4.11 Protocol Stack handling via CIFS API

An overview of the minimal necessary API functions and the order how they should be called can be found in the CIFS-API manual Chapter 5 and 6.

5 Additional Resources

5.1 Protocol API Manuals

Each fieldbus protocol stack has its own documentation, describing the protocol specific functions and commands.

Protocol API manuals can be found on the "**Communication Solution DVD**" in the **.\\Documentation\\Programming Manuals** directory and the manual file names are containing the protocol stack name, e.g. "*PROFIBUS Master Protocol API....pdf*"

6 Appendix

6.1 List of Tables

Table 1: List of Revisions 5

Table 2: Terms, Abbreviations and Definitions..... 6

Table 3: General Packet Structure 22

Table 4: Host System Flags / netX System Flags 26

Table 5: Host Communication Flags / netX Communication Channel Flags 27

6.2 List of Figures

Figure 1: Overview - Programming Levels 9

Figure 2: Choose a Programming Levels 10

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