# AIT Austrian Institute of Technology

## Accessing remote I/Os with Ethernet POWERLINK and 4DIAC

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*W3 Second 4DIAC User's Workshop (4DIAC)*

*16th IEEE International Conference on*
*Emerging Technologies and Factory Automation (ETFA'2011)*
*September 5th-9th, 2011, Toulouse, France*

# Content

- Introduction / Motivation

- Overview Ethernet POWERLINK and openPOWERLINK

- IEC 61499 Integration of Ethernet POWERLINK

- 4DIAC/openPOWERLINK Toolchain

- Configuration of Decentralized I/O Modules

- Implemented Test Case

- Future Activities

# Introduction / Motivation

## 4DIAC and POWERLINK

- New control environment needed for AIT power distribution laboratory

  - Switches and loads

  - Control devices

  - Measurement units

- Based on standardized methods and free/open source

  - IEC 61499 as distributed control system

  - 4DIAC for distributed control

  - openPOWERLINK for decentralized I/O access

- Integration of openPOWERLINK and 4DIAC Framework needed

  - Development of IEC 61499 Ethernet POWERLINK I/O SIFBs

  - Integration of the openPOWERLINK stack into the FORTE (4DIAC-RTE)

# Overview Ethernet POWERLINK

Main Characteristics

- Standard Ethernet

  - Only real-time solution based on standard Ethernet

  - Fully compliant to IEEE 802.3

  - Ready for future evolutions of Ethernet

- High performance

  - 100 Mbits/s

  - 100 ns synchronization

  - 100 µs cycle time

- Simplicity

  - Basic and robust mechanism

  - No complex time synchronization

  - Adequate to industrial automation
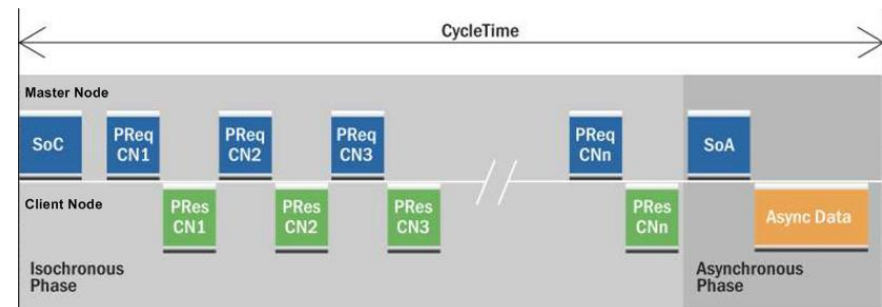
Source: Ethernet POWERLINK Standardisation Group (EPSG)

# Overview openPOWERLINK

Main Characteristics

- openPOWERLINK

    - Open Source POWERLINK stack (MN/CN)

    - Developed by SYS TEC electronic GmbH

    - Released under Open Source BSD license

    - Generic code (multi-platform)

    - Hosted on SourceForge

- Two stack implementations for Linux

    - Linux kernel module (max. performance)

    - Userspace library using libpcap

- Stack implementation on Windows

    - Implementation based on WinPcap library
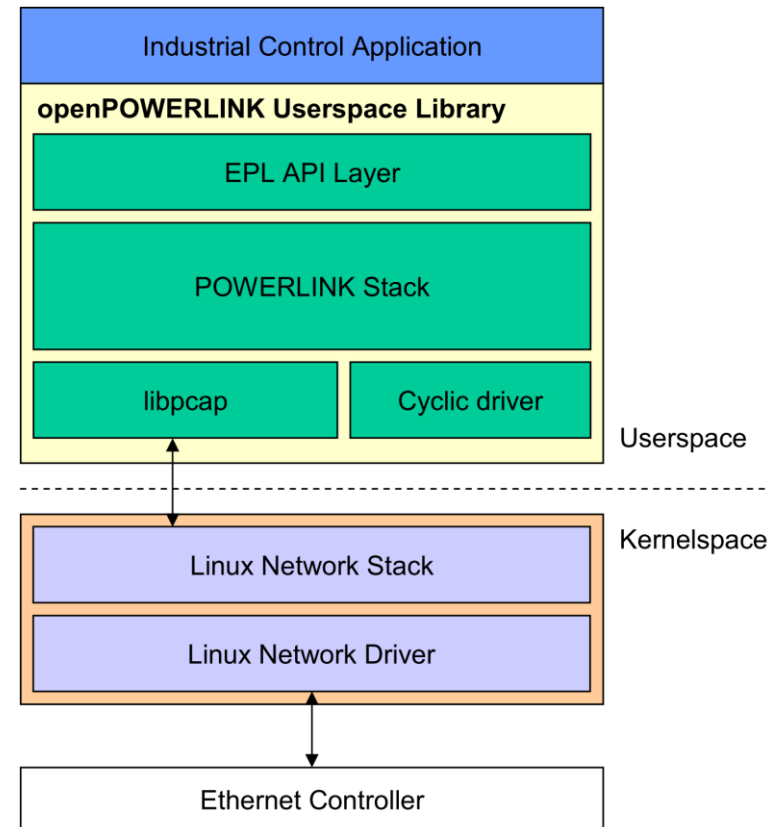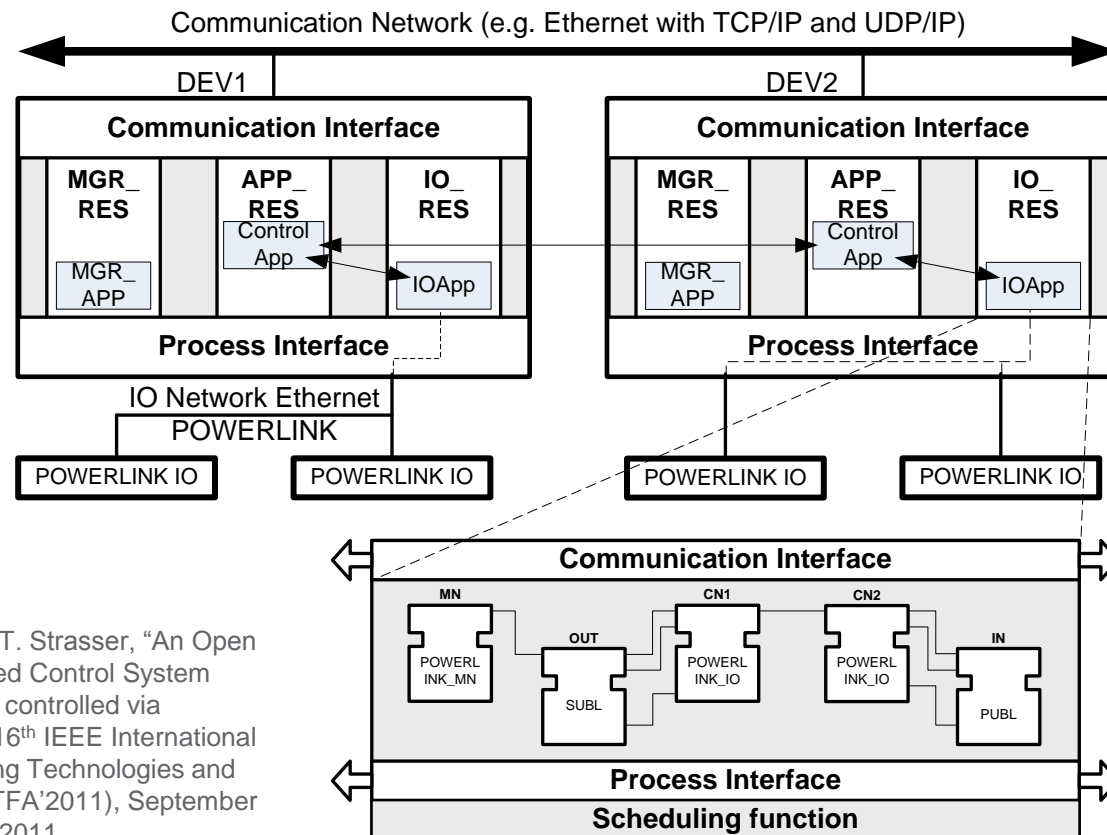


Source: B&R

# IEC 61499 Integration of Ethernet POWERLINK
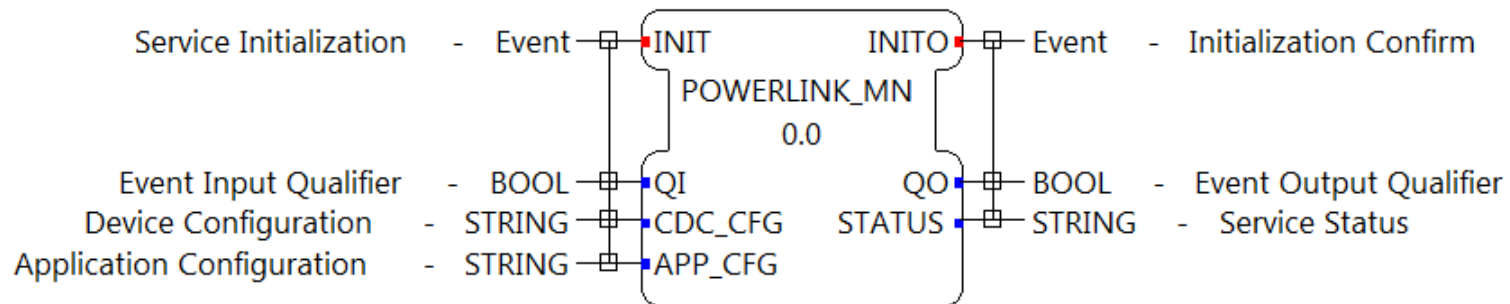
## Concept Overview

- IEC 61499 System Model



Source: F. Andrén and T. Strasser, "An Open Source based Distributed Control System with Decentralized I/Os controlled via Industrial Ethernet," in 16th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA'2011), September 5-9, Toulouse, France, 2011.

# IEC 61499 Integration of Ethernet POWERLINK

Function Block Library

- Master Node FB



```
Service Initialization   -   Event  ── ■INIT          INITO■ ──  Event   -   Initialization Confirm
                                      POWERLINK_MN
                                          0.0
Event Input Qualifier    -   BOOL  ── ■QI              QO■ ──  BOOL   -   Event Output Qualifier
Device Configuration     -   STRING ── ■CDC_CFG     STATUS■ ──  STRING  -   Service Status
Application Configuration -  STRING ── ■APP_CFG
```

# IEC 61499 Integration of Ethernet POWERLINK

Function Block Library

- Client Node FBs – Generic I/O FB



| | | | |
|---|---|---|---|
| Service Initialization | - | Event | INIT |
| Service Request | - | Event | REQ |
| Application Response to IND | - | Event | RSP |

POWERLINK_IO
0.0

| Event Input Qualifier | - | BOOL | QI |
| Client Node ID | - | USINT | CNID |
| Station Number | - | UINT | MODID |
| Output Number of Station | - | USINT | OUTPUTID |
| Input Number of Station | - | USINT | INPUTID |
| Output Value | - | ANY | OUTPUT |

| INITO | Event | - | Initialization Confirm |
| CNF | Event | - | Confirmation of Requested Service |
| IND | Event | - | Indication from Resource |
| QO | BOOL | - | Event Output Qualifier |
| CNIDO | USINT | - | Client Node ID output |
| STATUS | STRING | - | Service Status |
| INPUT | ANY | - | Input Value |

# IEC 61499 Integration of Ethernet POWERLINK

Function Block Library

- Client Node FBs – Analogue I/O FBs

| | | | | | | |
|---|---|---|---|---|---|---|
| Service Initialization | - | Event | INIT | INITO | Event | - Initialization Confirm |
| Service Request | - | Event | REQ | CNF | Event | - Confirmation of Requested Service |
| Application Response to IND | - | Event | RSP | IND | Event | - Indication from Resource |

X20AI4622
0.0

| | | | | | | |
|---|---|---|---|---|---|---|
| Event Input Qualifier | - | BOOL | QI | QO | BOOL | - Event Output Qualifier |
| Client Node ID | - | USINT | CNID | CNIDO | USINT | - Client Node ID out |
| Module ID | - | UINT | MODID | STATUS | STRING | - Network Status |
| | | | | AI01 | INT | - Analogue Input 01 |
| | | | | AI02 | INT | - Analogue Input 02 |
| | | | | AI03 | INT | - Analogue Input 03 |
| | | | | AI04 | INT | - Analogue Input 04 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Service Initialization | - | Event | INIT | INITO | Event | - Initialization Confirm |
| Service Request | - | Event | REQ | CNF | Event | - Confirmation of Requested Service |

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| | | | | | | |
|---|---|---|---|---|---|---|
| Event Input Qualifier | - | BOOL | QI | QO | BOOL | - Event Output Qualifier |
| Client Node ID | - | USINT | CNID | CNIDO | USINT | - Client Node ID out |
| Module ID | - | UINT | MODID | STATUS | STRING | - Network Status |
| Analog Output 01 | - | INT | AO01 | | | |
| Analog Output 02 | - | INT | AO02 | | | |
| Analog Output 03 | - | INT | AO03 | | | |
| Analog Output 04 | - | INT | AO04 | | | |

# IEC 61499 Integration of Ethernet POWERLINK

## Function Block Library

- Client Node FBs – Digital I/O FBs

# IEC 61499 Integration of Ethernet POWERLINK

4DIAC Integration
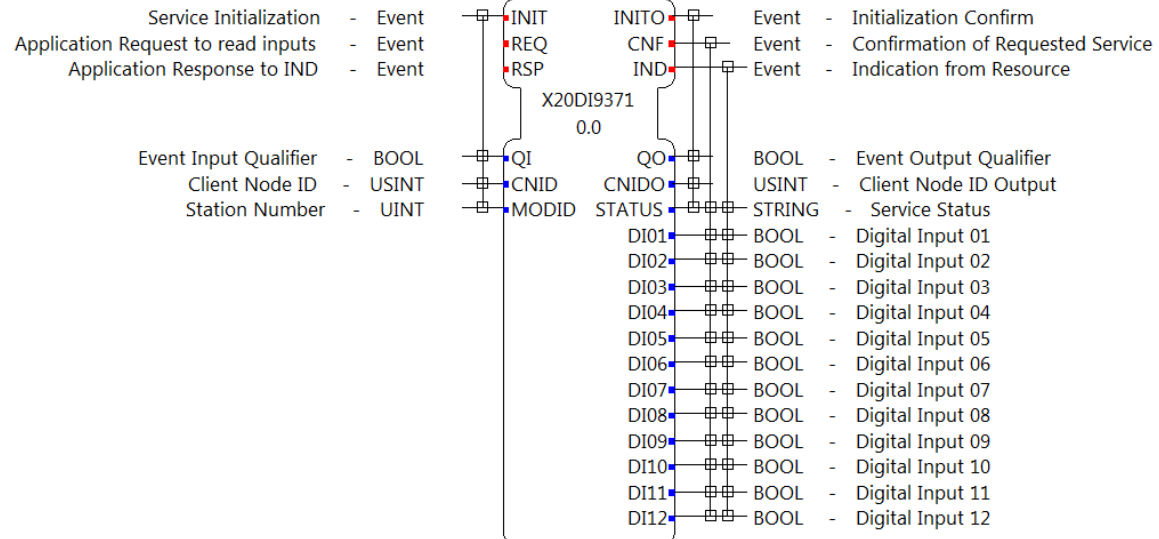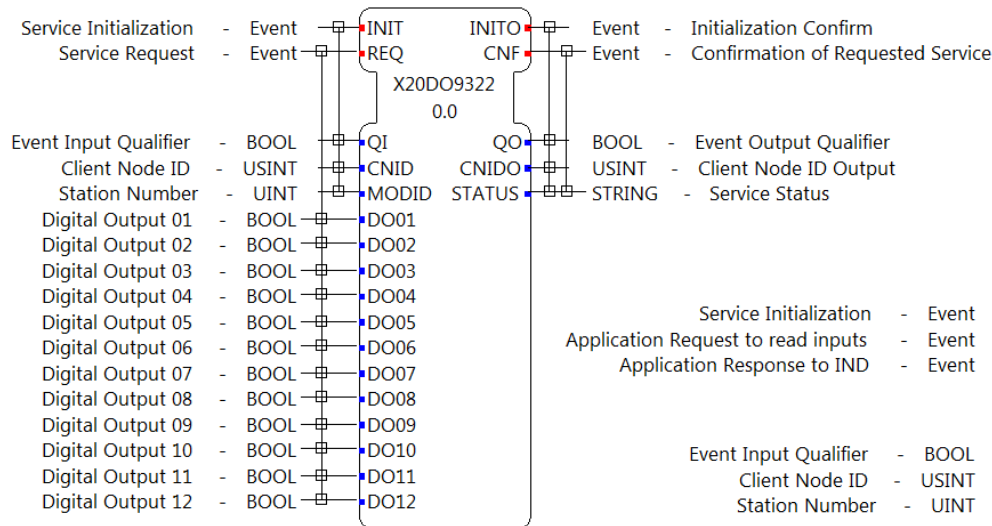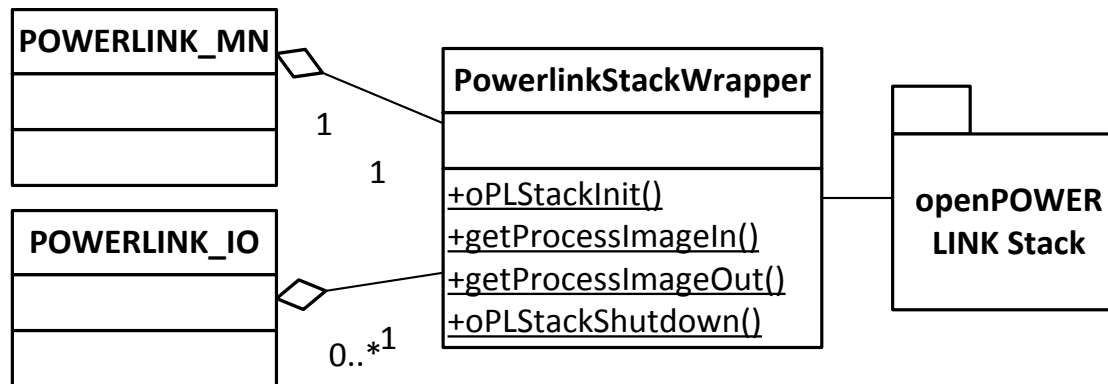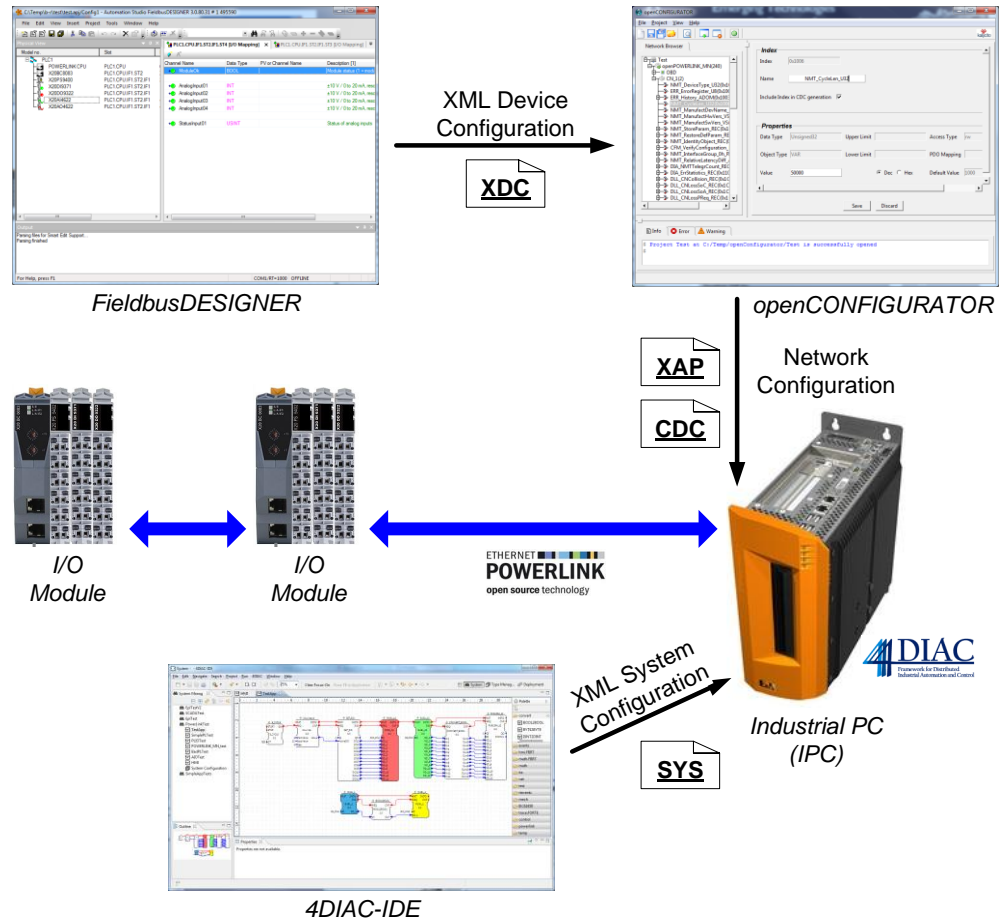
- openPOWERLINK stack access through wrapper class

# 4DIAC/openPOWERLINK Toolchain

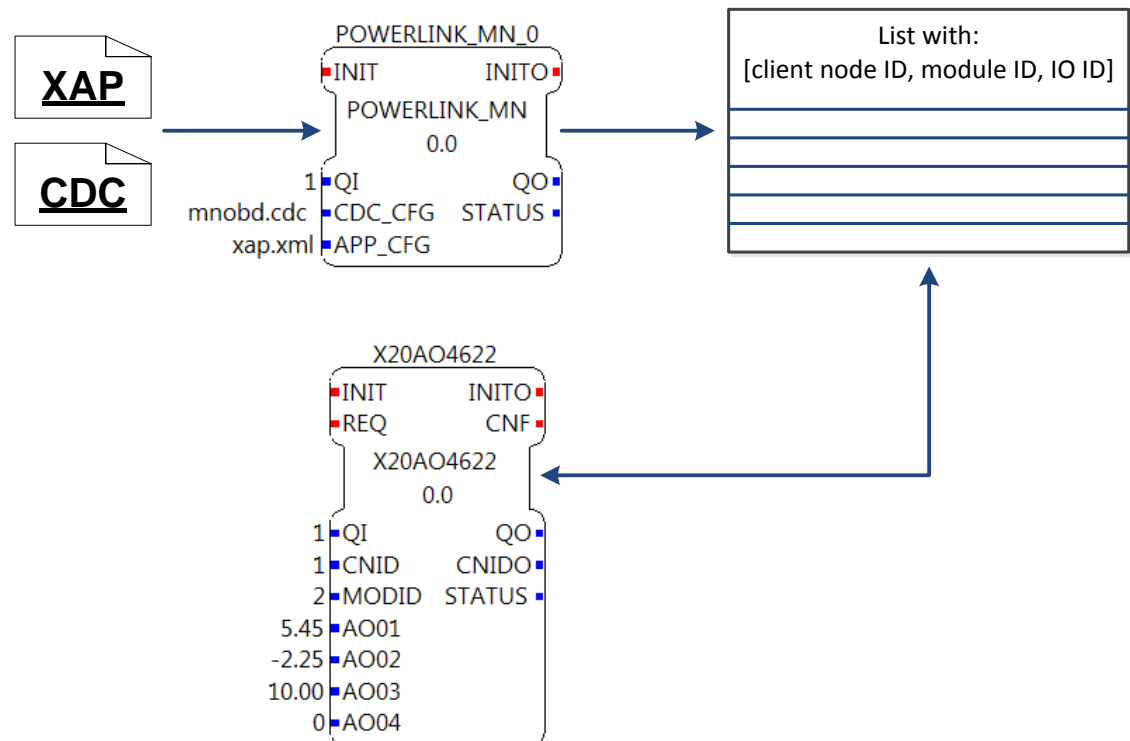## Distributed IEC 61499 System with Decentralized I/O Modules

- Necessary Tools/Software

  - FieldbusDESIGNER

  - openCONFIGURATOR

  - 4DIAC-IDE

  - FORTE

*FieldbusDESIGNER*

*openCONFIGURATOR*

XML Device Configuration

**XDC**

**XAP**

**CDC**

Network Configuration

*I/O Module*

*I/O Module*

ETHERNET **POWERLINK** open source technology

*Industrial PC (IPC)*

XML System Configuration

**SYS**

*4DIAC-IDE*

# IEC 61499 Integration of Ethernet POWERLINK

Configuration of Decentralized I/O Modules

- Two Possibilities

    - Originally with header xap.h → compilation of FORTE necessary

    - Configuration using xap.xml & mnobd.cdc

        → no need to compile FORTE for every new I/O setup
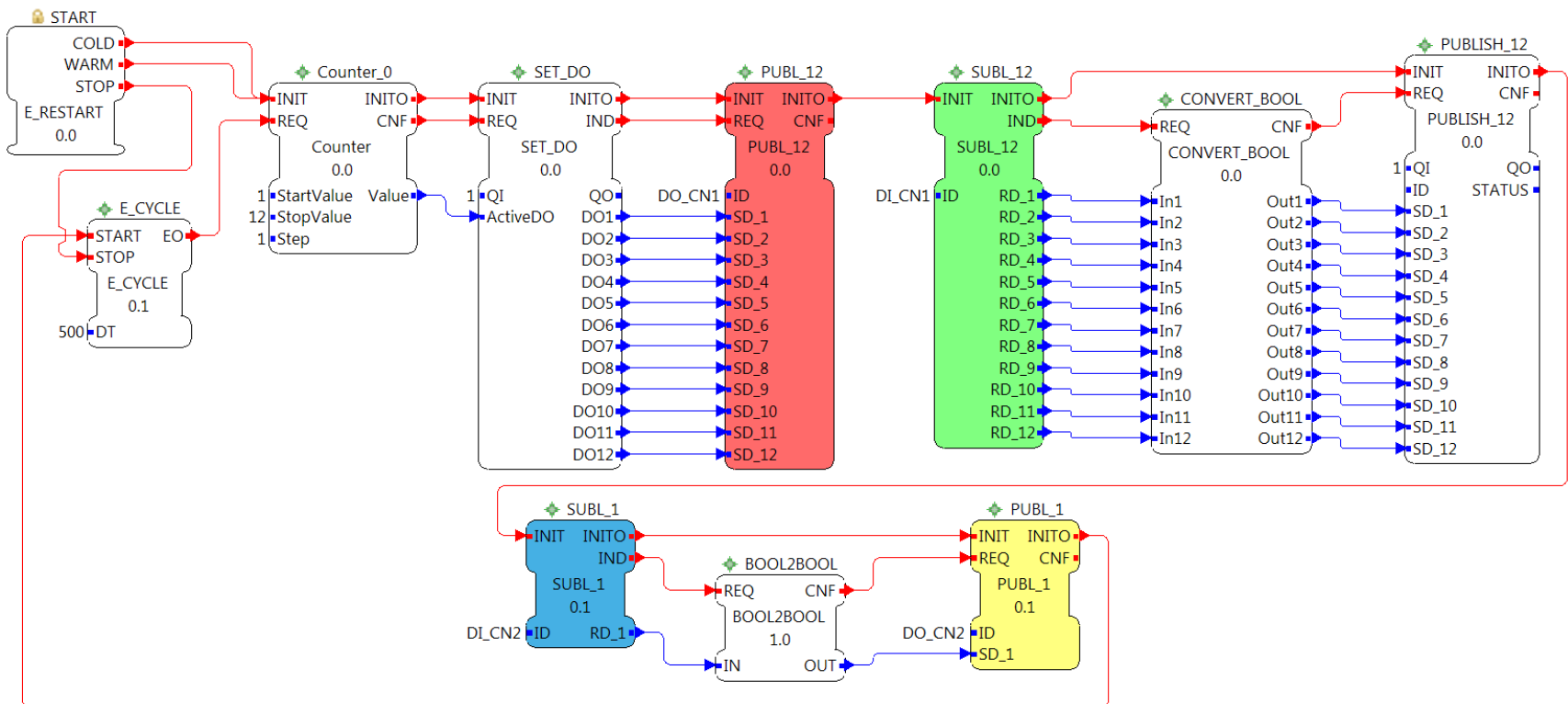
# Implemented Test Case

## Hardware Setup

- Test Application



Control Application Execution with FORTE

Industrial PC (IPC)

Dezentralized I/Os

MN    CN 1    CN 2

Ethernet (POWERLINK Protocol)
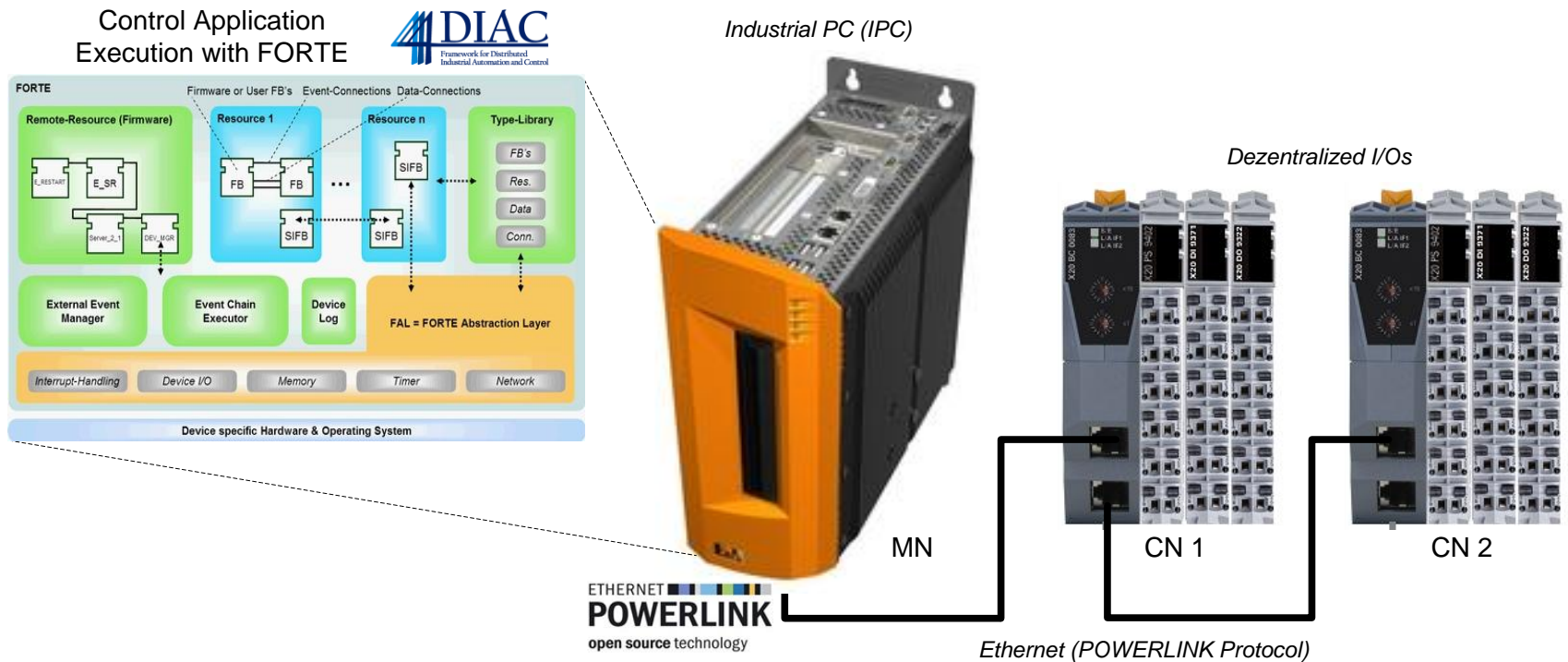
# Implemented Test Case
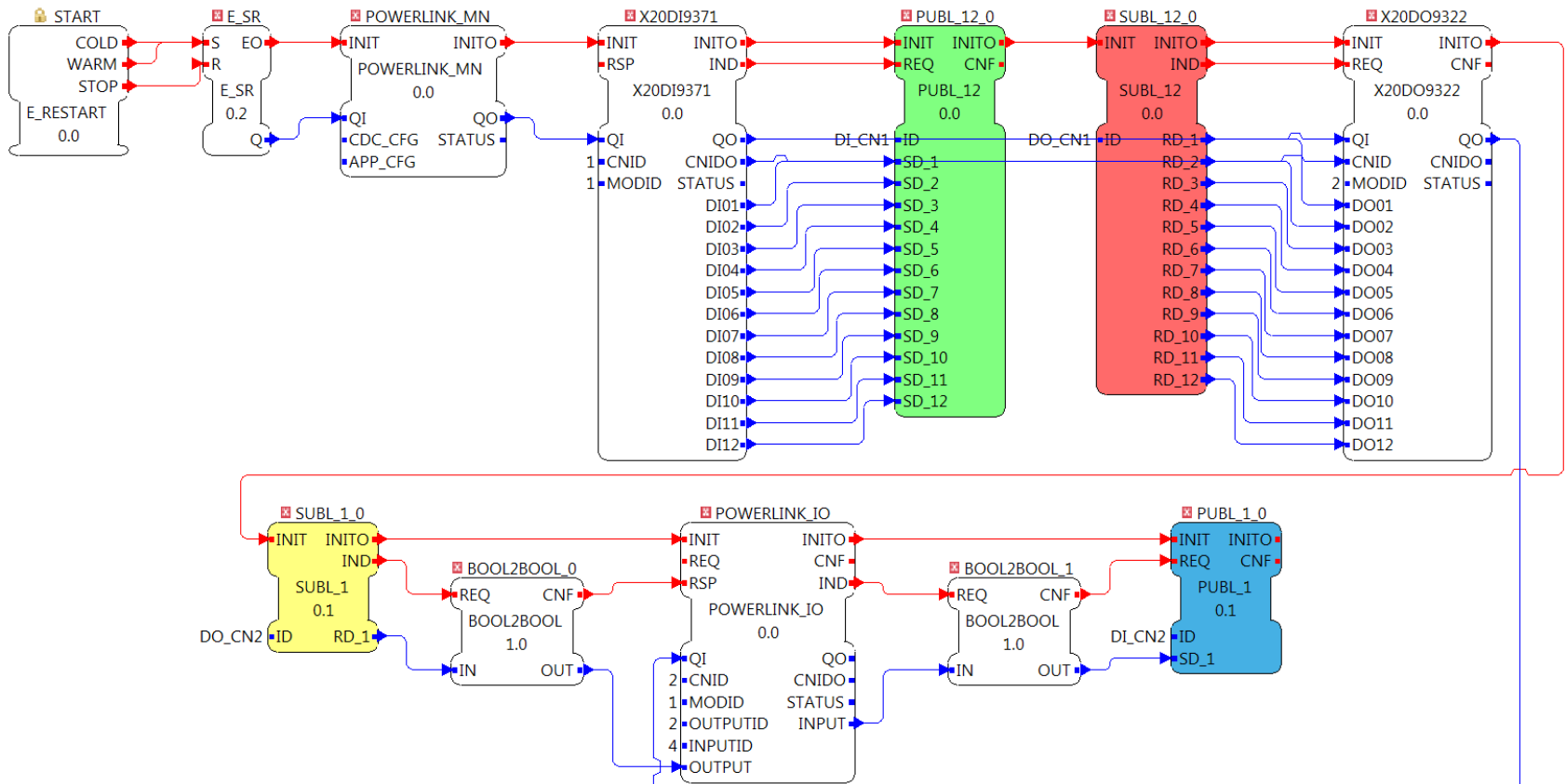
## Control Application

- Control Application Resource

# Implemented Test Case

## Control Application

- **IO Resource Application**

# Future Activities

Plans for the upcoming months

- Implementation of additional I/O modules (e.g. temperature module, etc.)

- Porting to Linux

- Documentation of the source code

- User documentation

- Further tests in the AIT laboratory environment

- Provision as 4DIAC open source module under the EPL

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your ingenious partner

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