Integration of IEC 61131-3 and IEC 61499 control logic using FORTE and ProConOS

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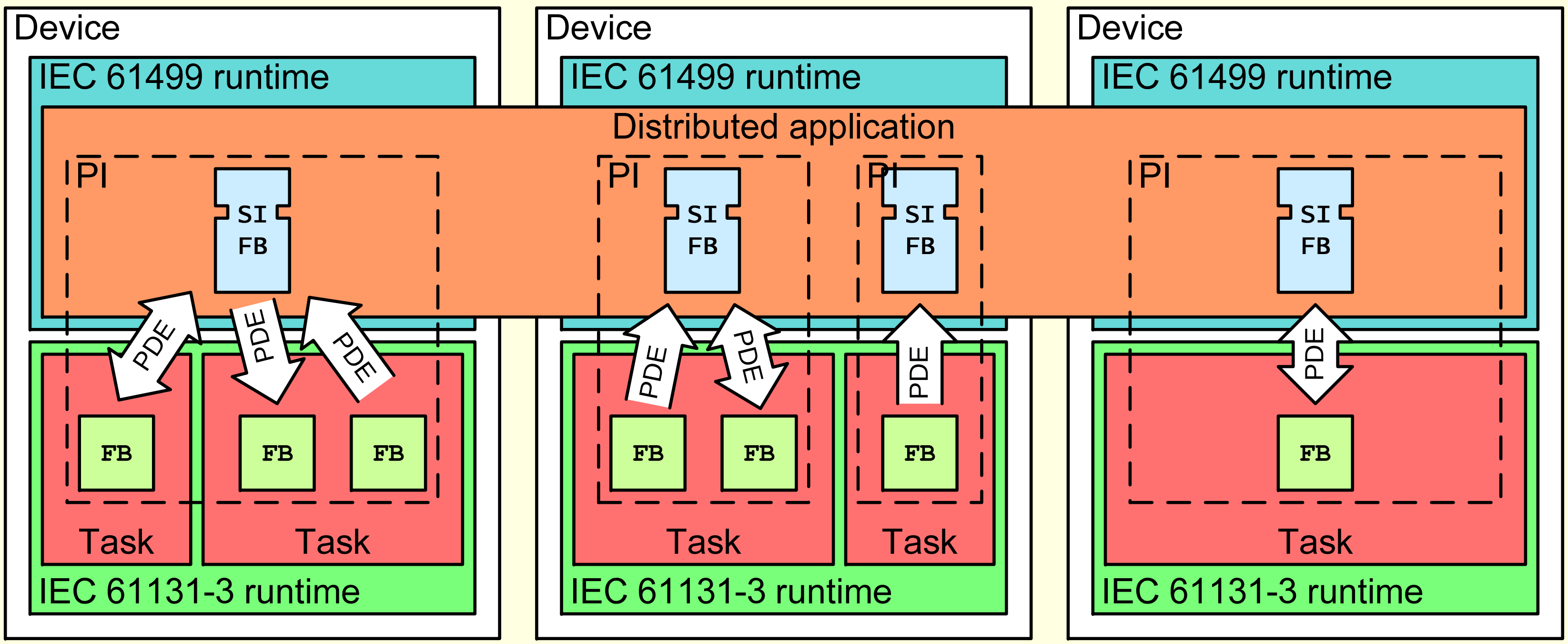
Introduction

- IEC 61131-3 widely adopted by PLC producers
  - Used in many existing control systems
  - Large base of software libraries, know-how and personnel competences
- IEC 61131-3 has very little support for distributed control
  - IEC 61131-5 communication function blocks
  - Engineering approach device centered
  - No support for distribution of control logic
- IEC 61499 is more suitable for designing distributed control applications

Proposed Architecture (1/2)

- Problems
  - realization of distributed control between existing IEC 61131-3 systems
  - reuse of existing IEC 61131-3 software in an IEC 61499 system
  - reuse of existing know-how and personnel competences about IEC 61131-3
- Proposed approach: Coexistence
  - IEC 61131-3 and IEC 61499 are complementary standards
  - Each device has both IEC 61131-3 and IEC 61499 execution environments
  - A communication interface is provided in order to allow data exchanges between the two standards

Proposed Architecture (2/2)

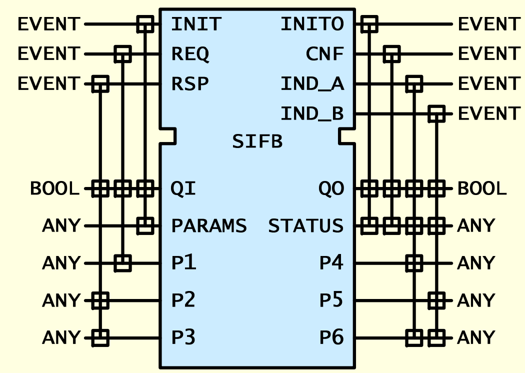


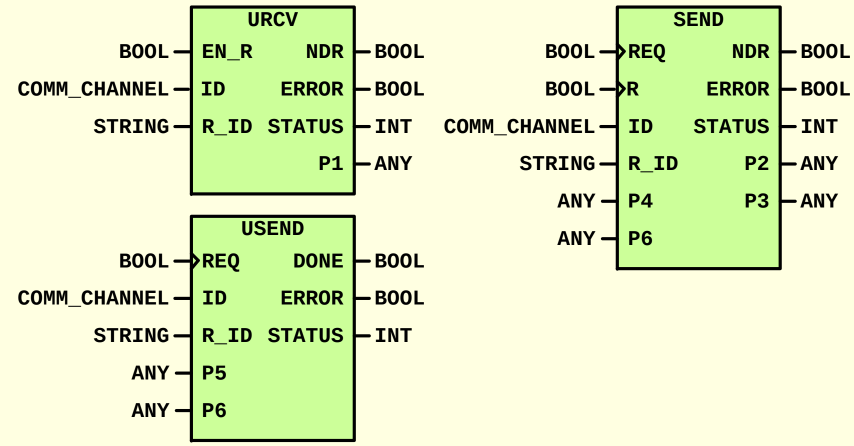
PI: PLC Interface

PDE: PLC Data Exchange

PLC Interfaces

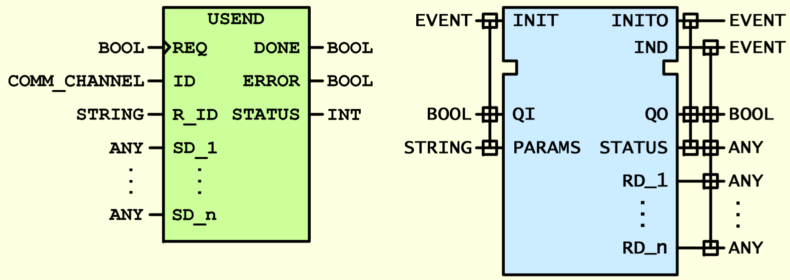
- PLC Data Exchange
  - Data Transfer PDE
  - Procedure Call PDE
- PLC Interface
  - A group of PDEs
- IEC 61499
  - PI as a SIFB
  - Each PDE has its own events and data in/outs
- IEC 61131-3
  - Each PDE as an IEC 61131-5 FB

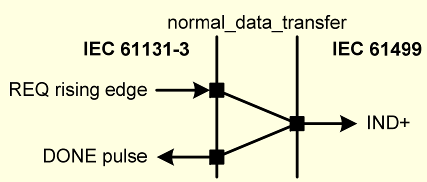




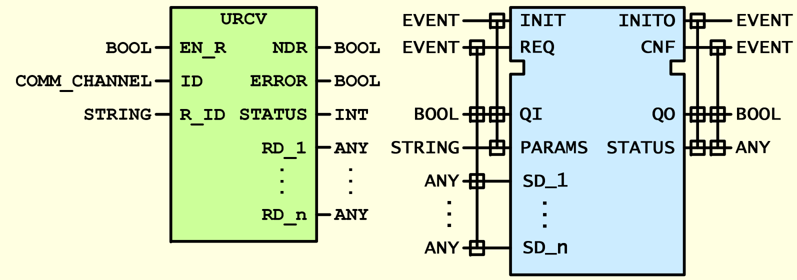
Data Transfer PDEs

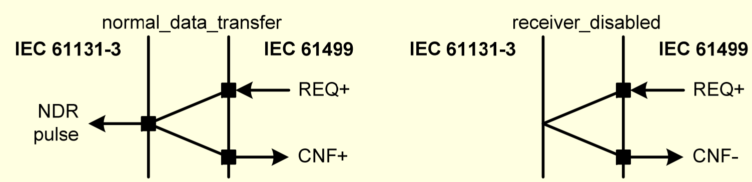
Data Transfer from IEC 61131-3 to IEC 61499





Data Transfer from IEC 61499 to IEC 61131-3





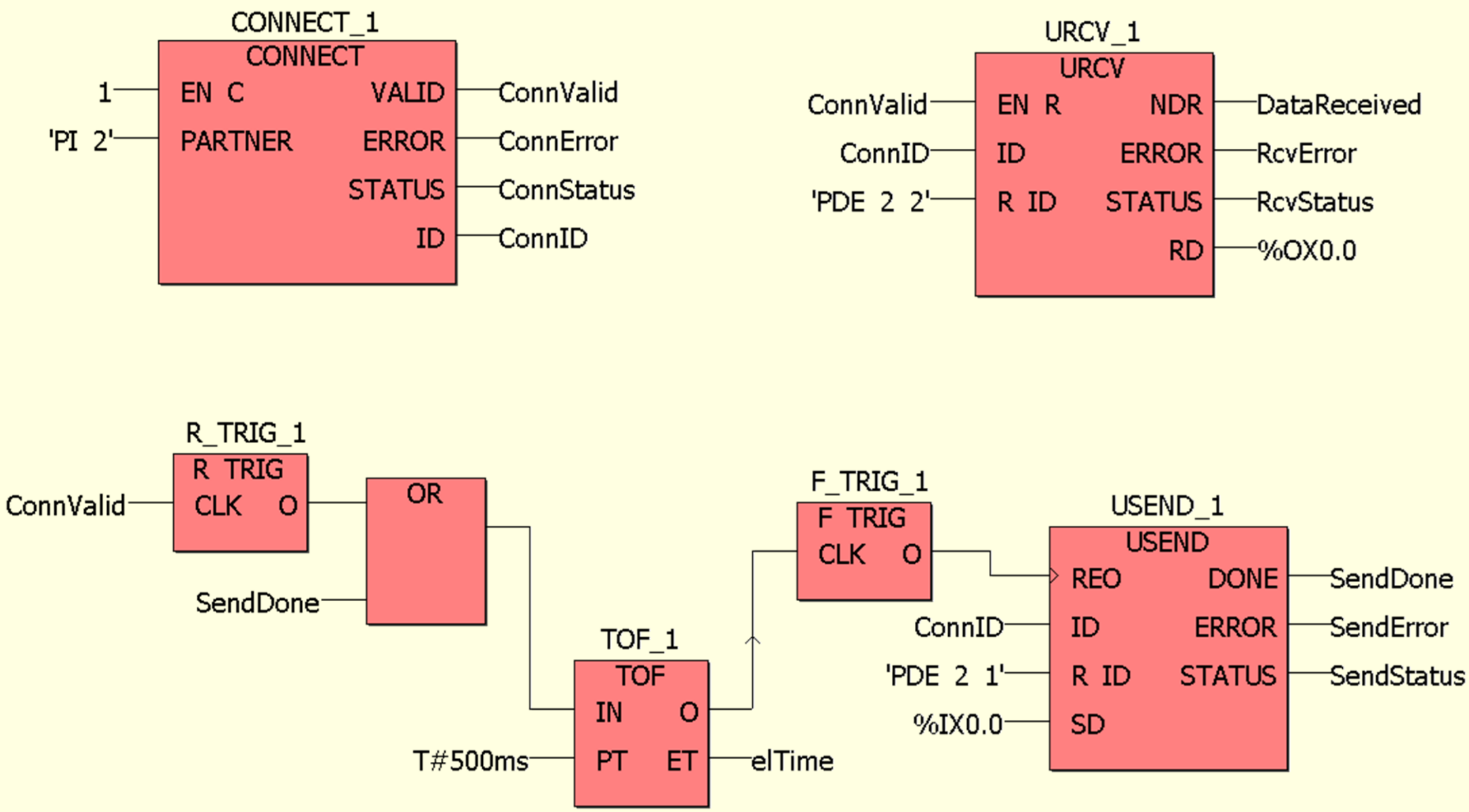
Tools Used for Implementation

- Operating System
  - Microsoft Windows
- IEC 61499
  - 4DIAC IDE 1.0
  - FORTE 1.0
    - Custom SIFBs implemented as a C++ class
- IEC 61131-3
  - KW-Software MULTIPROG 4.8
  - ProConOS 4.0
    - Custom FBs implemented as a C function

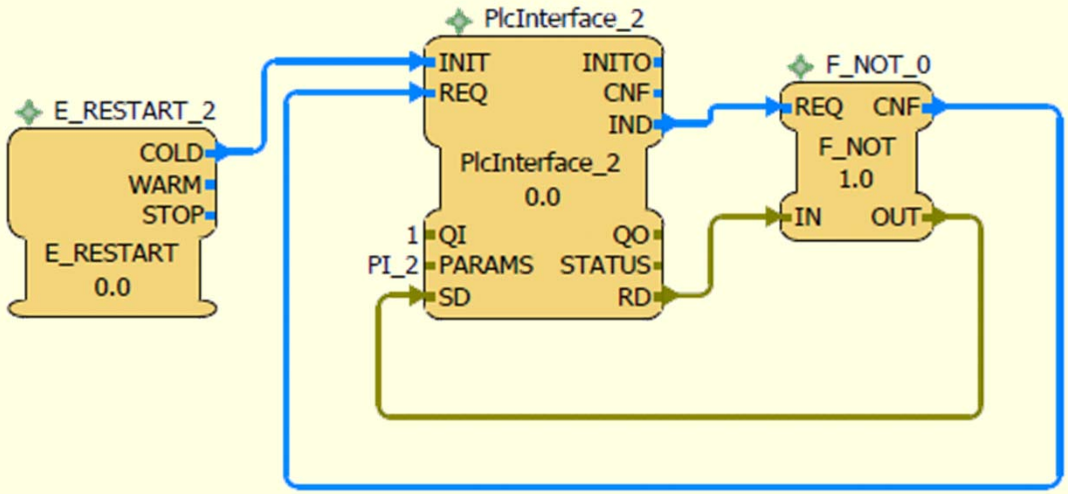
A Simple Application (1/3)

- Sample application:
  - Periodically reads a digital input
  - Applies a logical not operation on the read value
  - Updates a digital output with the new value
- The IEC 61131-3 program reads the input value and updates the output value
- The IEC 61499 application implements the not logic
- Definition of the PLC interface:
  - 1 Data Transfer PDE from IEC 61131-3 to IEC 61499 to send the input boolean value
  - 1 Data Transfer PDE from IEC 61499 to IEC 61131-3 to send the output boolean value

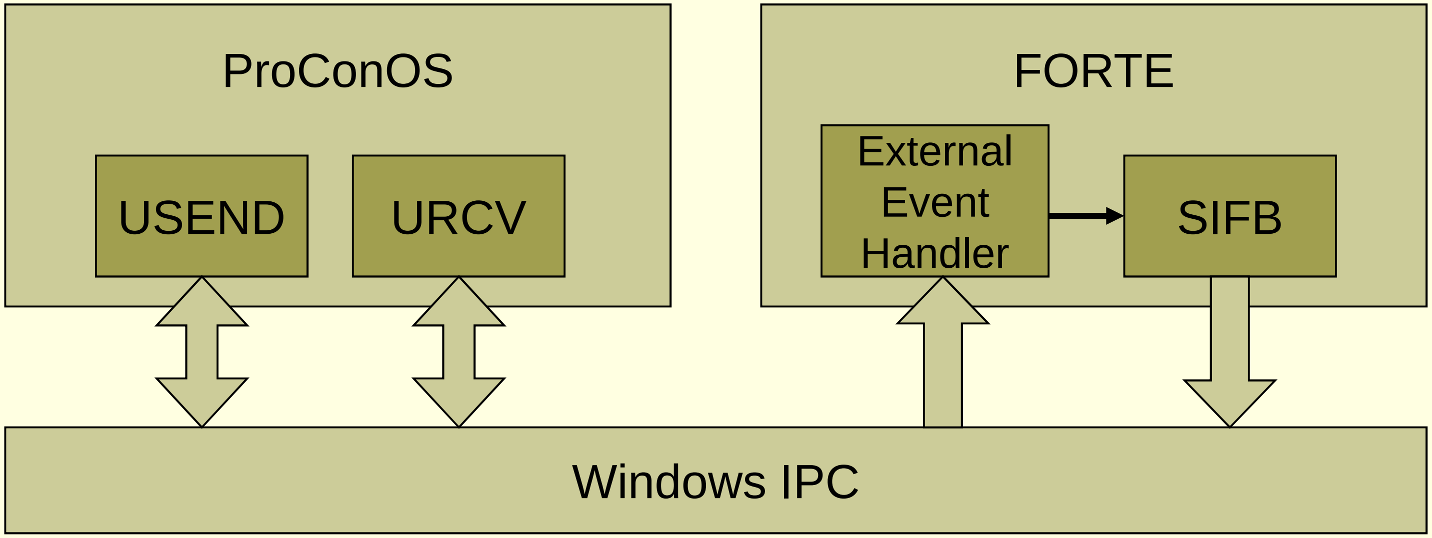
A Simple Application (2/3)



A Simple Application (3/3)

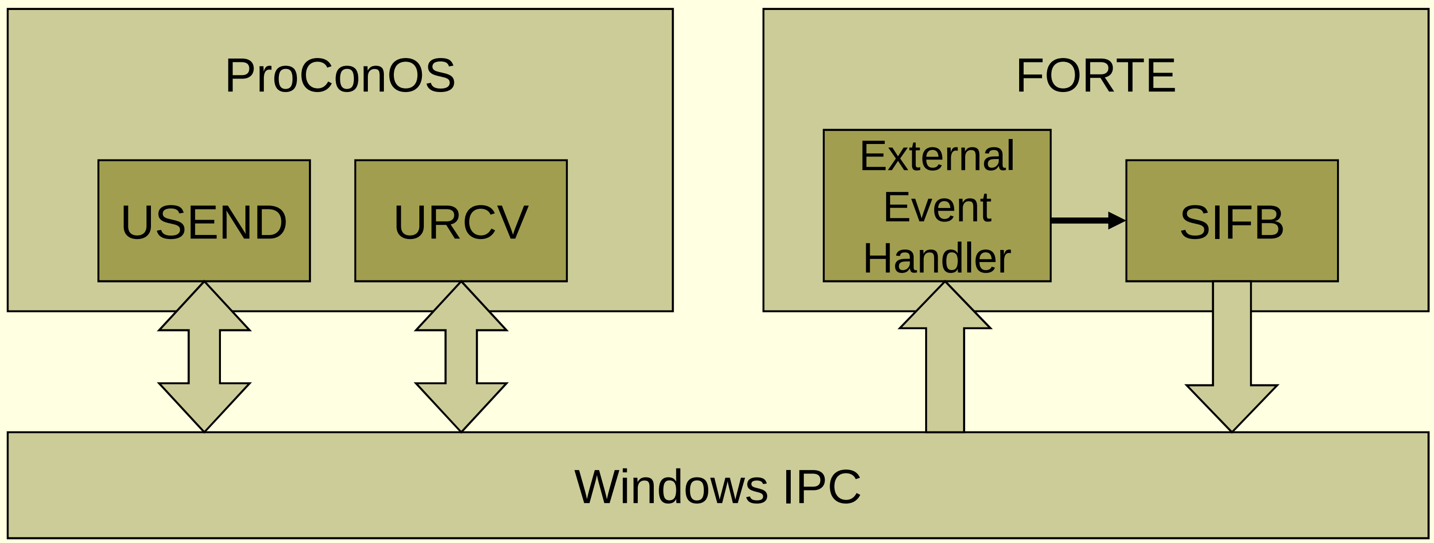


Implementation of the PI (1/3)



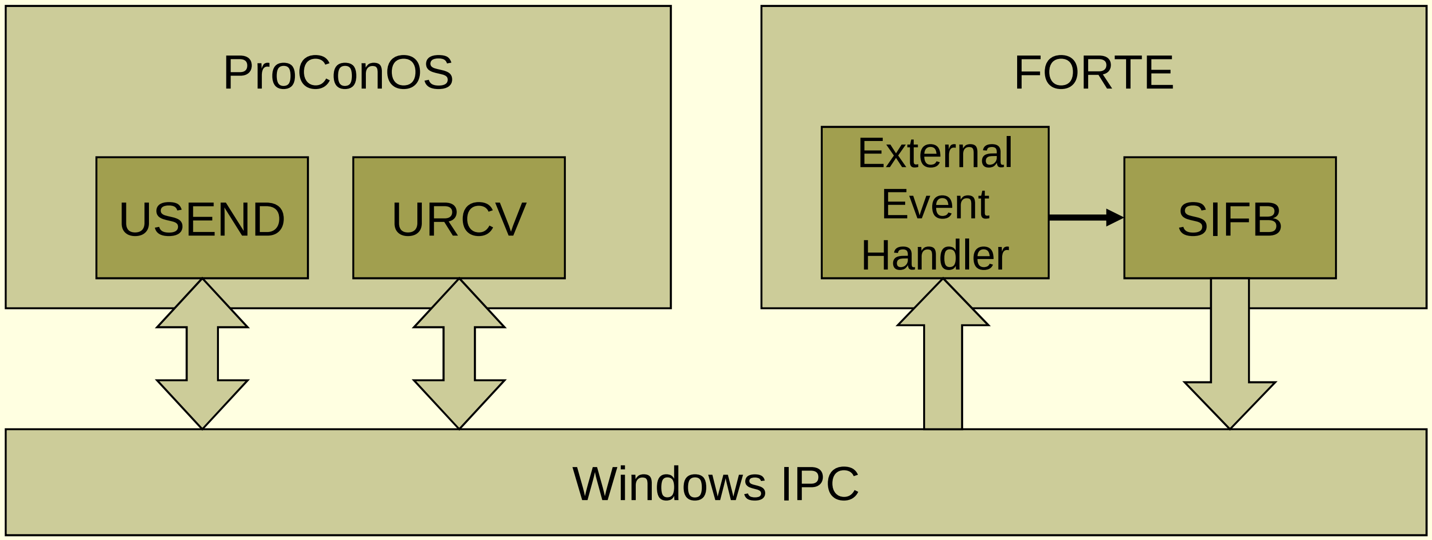
- Communication via IPC
  - Shared memory
  - Semaphores

Implementation of the PI (2/3)



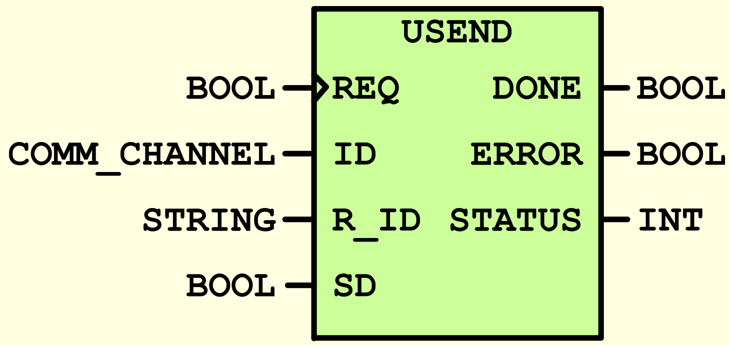
- IEC 61499
  - PI implemented as an Event Source SIFB
    - executeEvent handles input events and the external event
  - External Event Handler Thread
    - Waits on semaphores for events such as data reception
    - Sends the external event to the SIFB

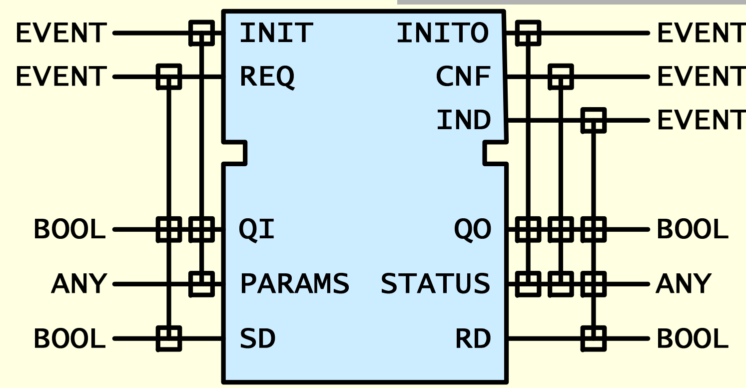
Implementation of the PI (3/3)



- IEC 61131-3
  - IEC 6131-5 FBs implemented as C functions
    - Parameters: input/output variables and internal state
    - Realize state machines
    - Non-blocking waits

Implementation of Data Transfer PDEs
IEC 61131-3 to IEC 61499





- IEC 61131-5 USEND:

LOOP {
    idle_until_req_detected
    copy_SD_to_shared_mem
    release_SendSem1
    wait_RcvSem1
    pulse_done
}

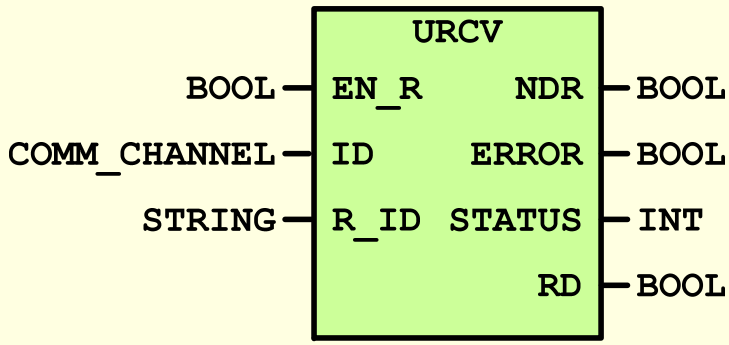
- External Event Handler:

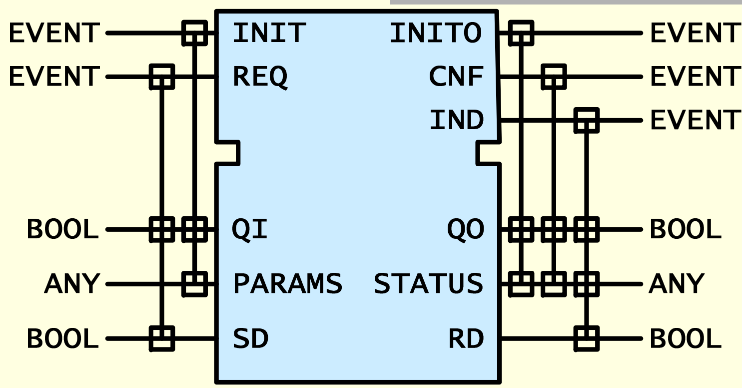
LOOP {
    wait_SendSem1
    startEventChain
}

- executeEvent:

CASE ExternalEvent:
    copy_shared_mem_to_RD
    release_RcvSem1
    send_IND

Implementation of Data Transfer PDEs
IEC 61499 to IEC 61131-3





- IEC 61131-5 URCV:

LOOP {
    wait_SendSem2
    copy_shared_mem_to_RD
    pulse_NDR
    release_RcvSem2
}

- External Event Handler:

LOOP {
    wait_RcvSem2
    startEventChain
}

- executeEvent:

CASE REQ:
    copy_SD_to_shared_mem
    release_SendSem2
CASE ExternalEvent :
    send_CNF

Conclusion

- We proposed an architecture to integrate IEC 61499 and IEC 61131-3 control logic
- Architecture based on coexistence of both standards
- Future works:
  - Test the architecture with a reference case study derived from literature and industrial applications
  - Implement a tool for automatic generation of the PLC Interface code modules.

Thanks for the Attention

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