

# The use of EtherCAT with EPICS at Diamond

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EPICS Collaboration Meeting, CEA, Saclay, Oct 2014



# Contents

- EtherCAT
- Diamond setup
  - Hardware
  - EPICS driver
- Recent work and work in-progress
  - Screenshots from actual setup

# EtherCAT

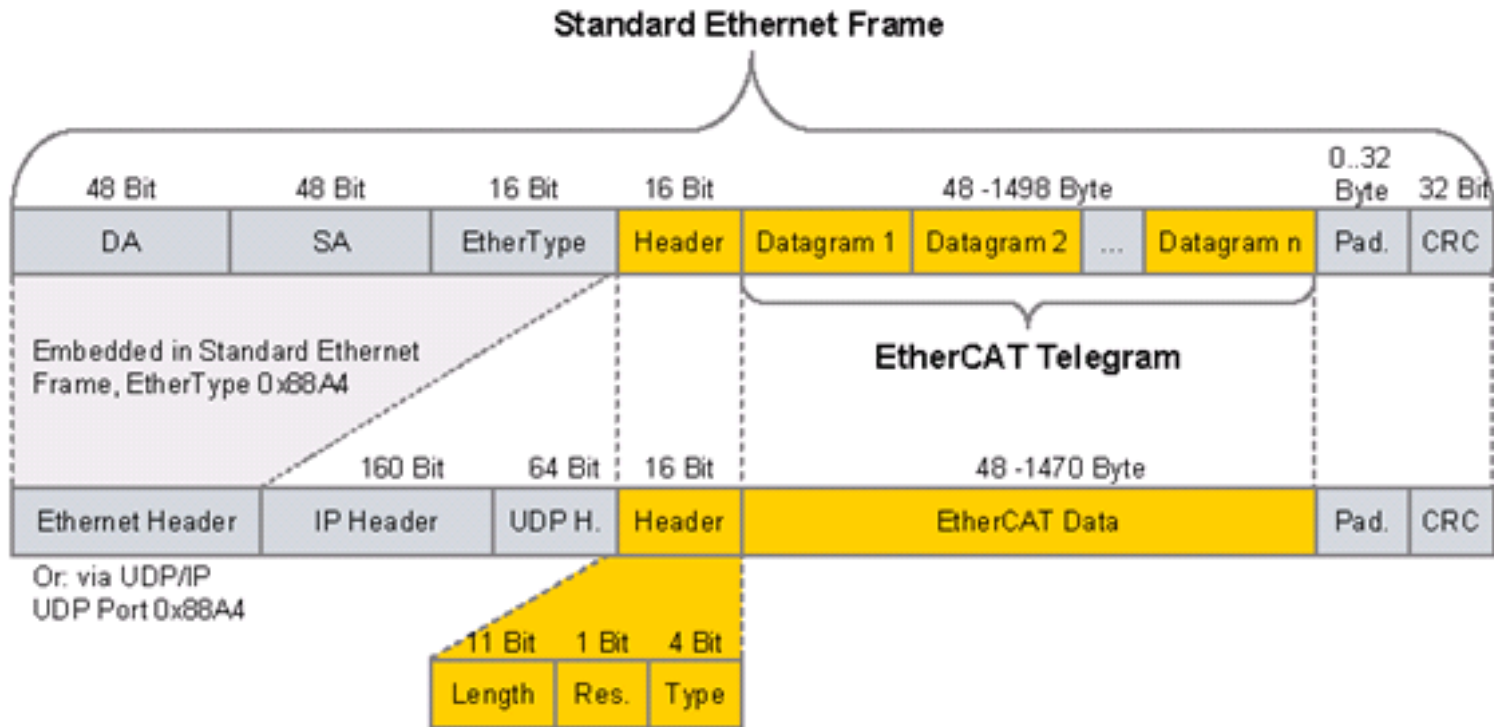
- Why EtherCAT?
- How does it work?
  - EtherCAT master startup of LRW cycle



# Why EtherCAT?

- Open protocol, uses standard Ethernet hardware
- Uses standard Ethernet cable and connectors. Can use standard switches and routers. **DLS uses separate cabling - fieldbus.**
- Available Linux open source master.
- Faster than most other fieldbuses.

# EtherCAT frame structure



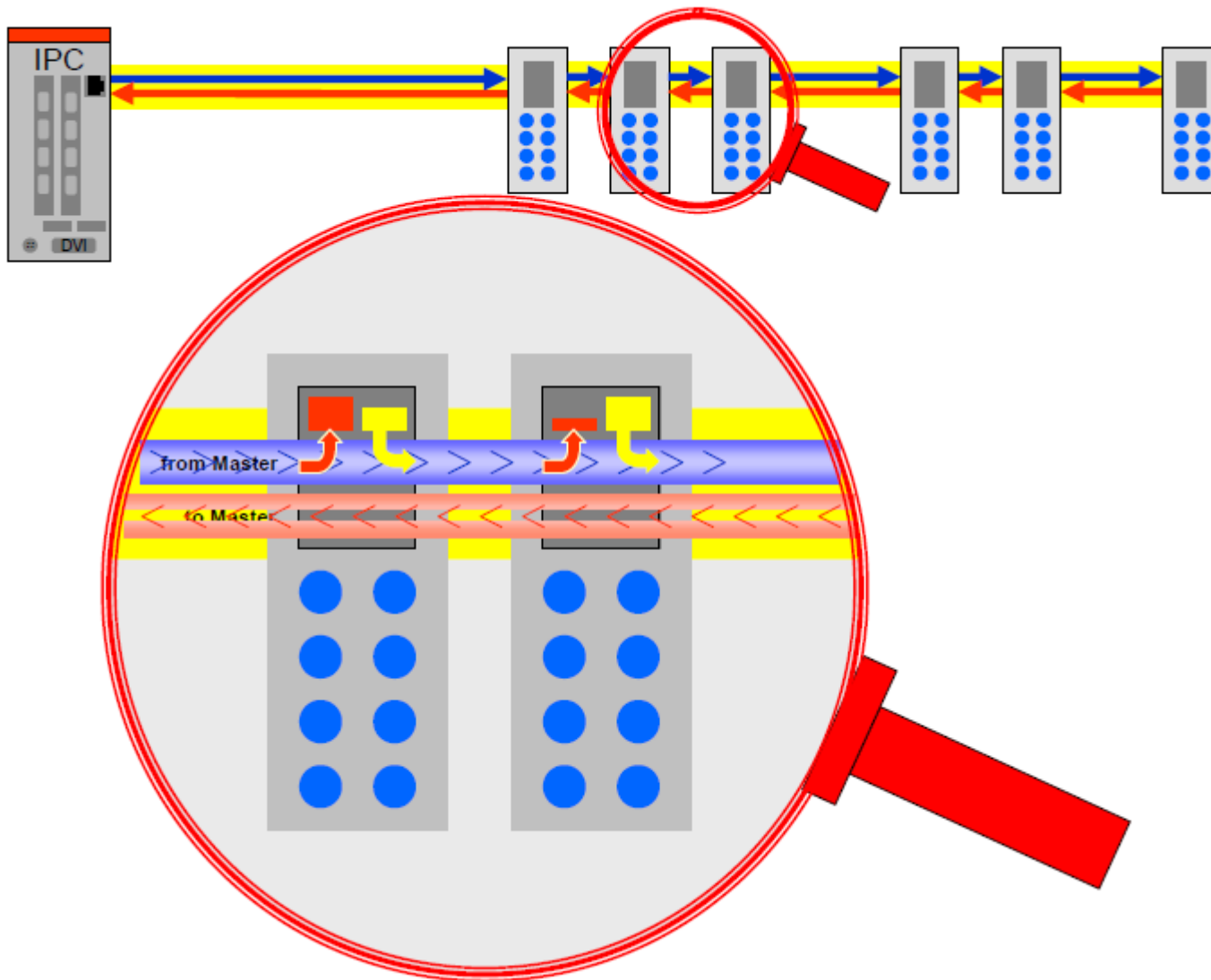
- IEC 61138 (Type 12)

# EtherCAT: Principle of operation

- Master – slave communications with a periodic scan cycle
- All operations in hardware, using an FPGA or an ASIC
- Global addressing
- Messages processed on the fly. One pass on the way out and on return – used for distributed clocks timing..

Master

EtherCAT Segment (Slaves)

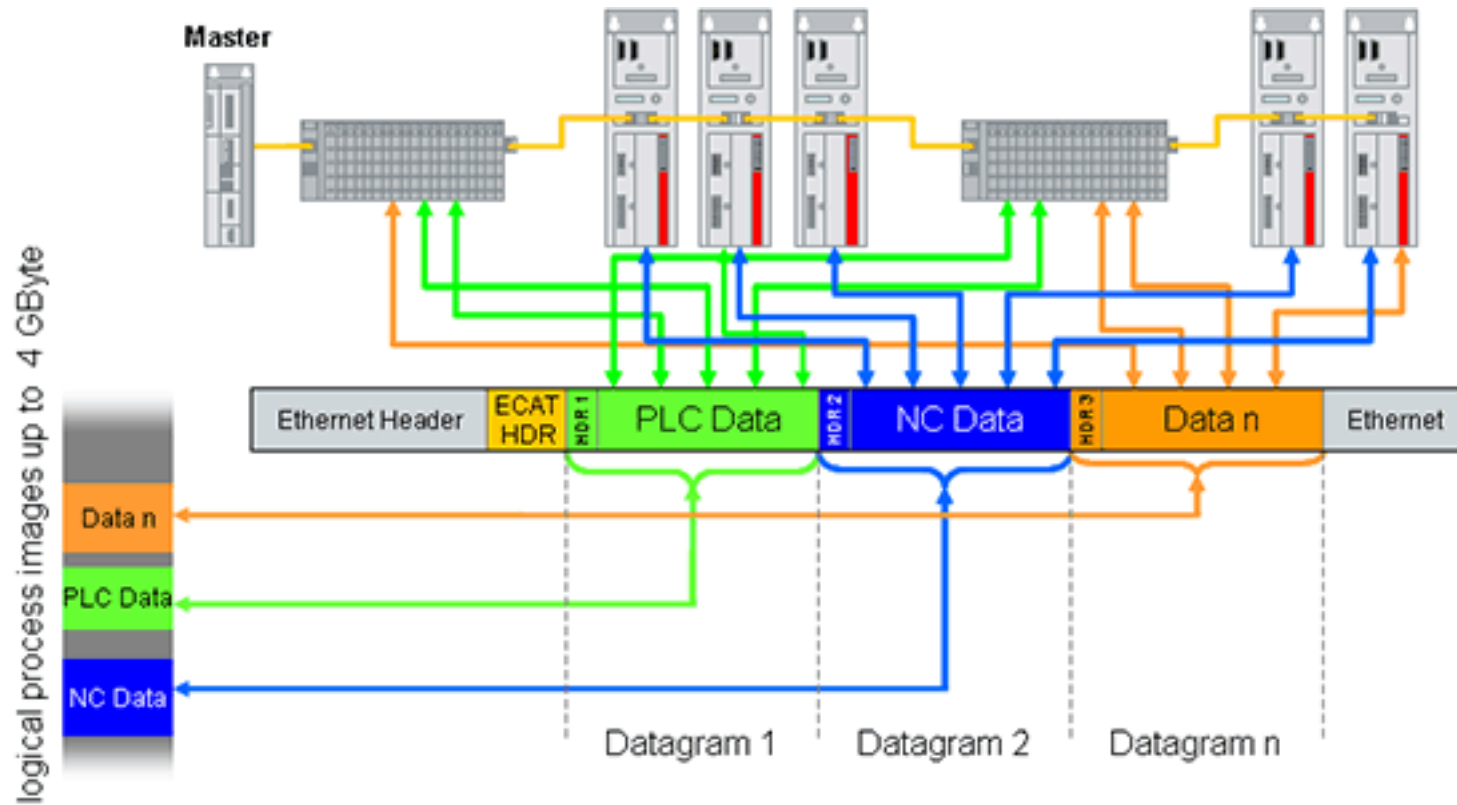


Picture by EtherCAT Technology Group  
EPICS Collaboration Meeting, CEA, Saclay, Oct 2014



# Master startup

- (

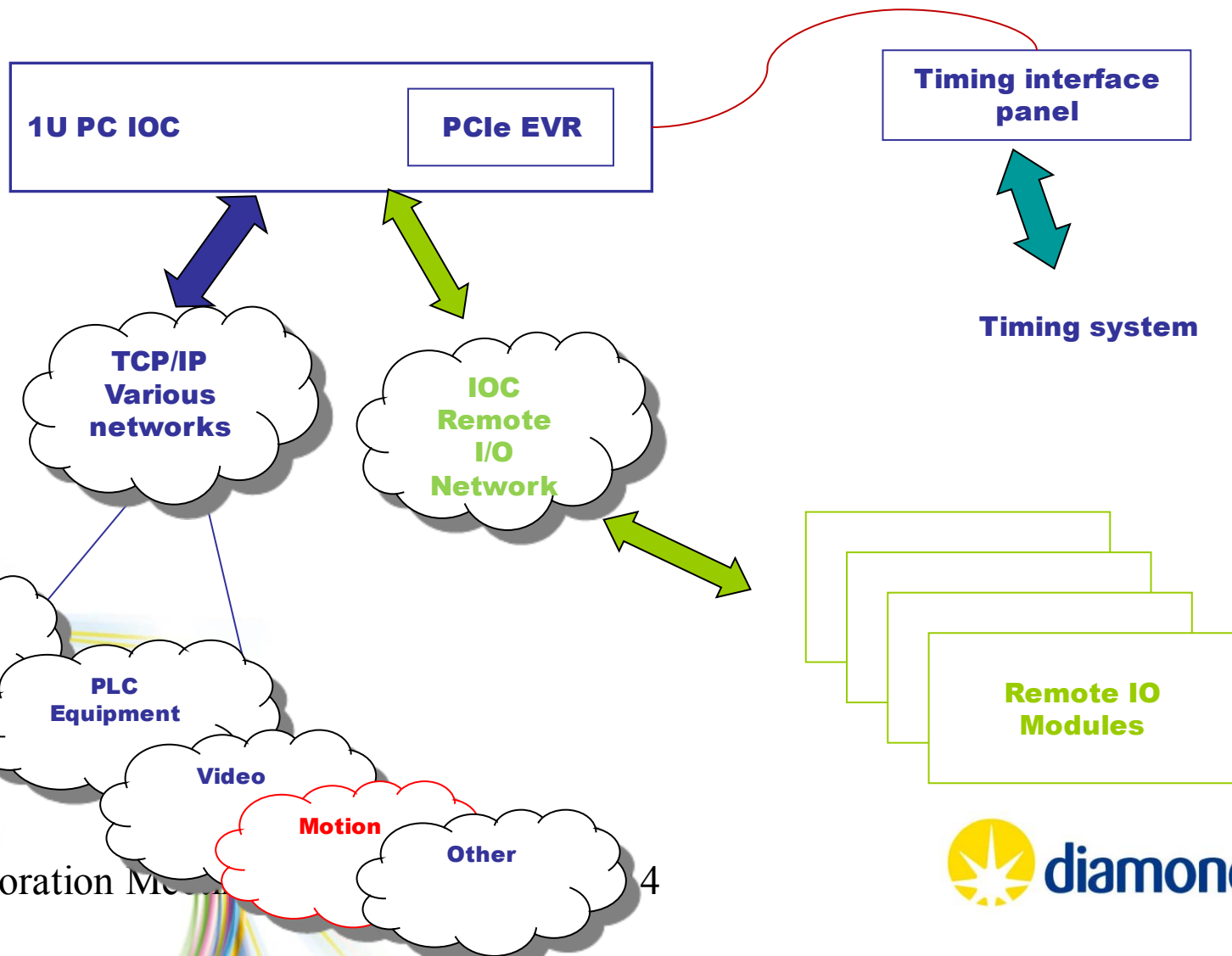




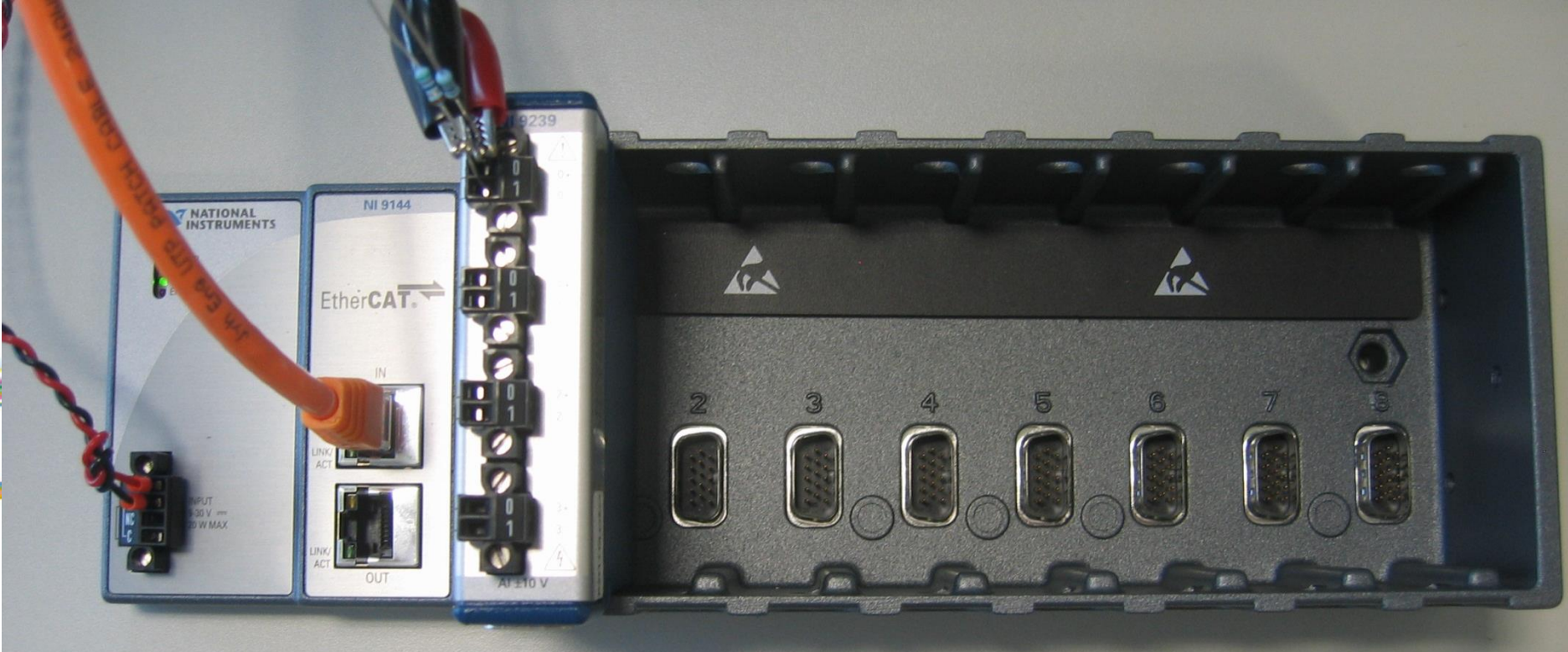
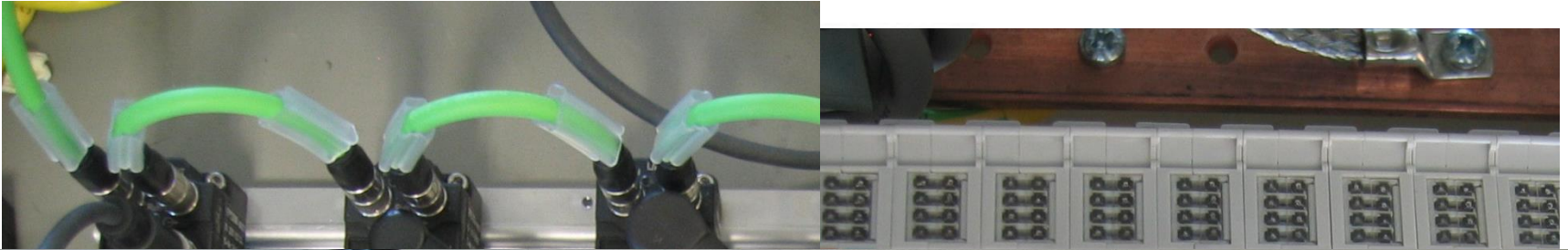
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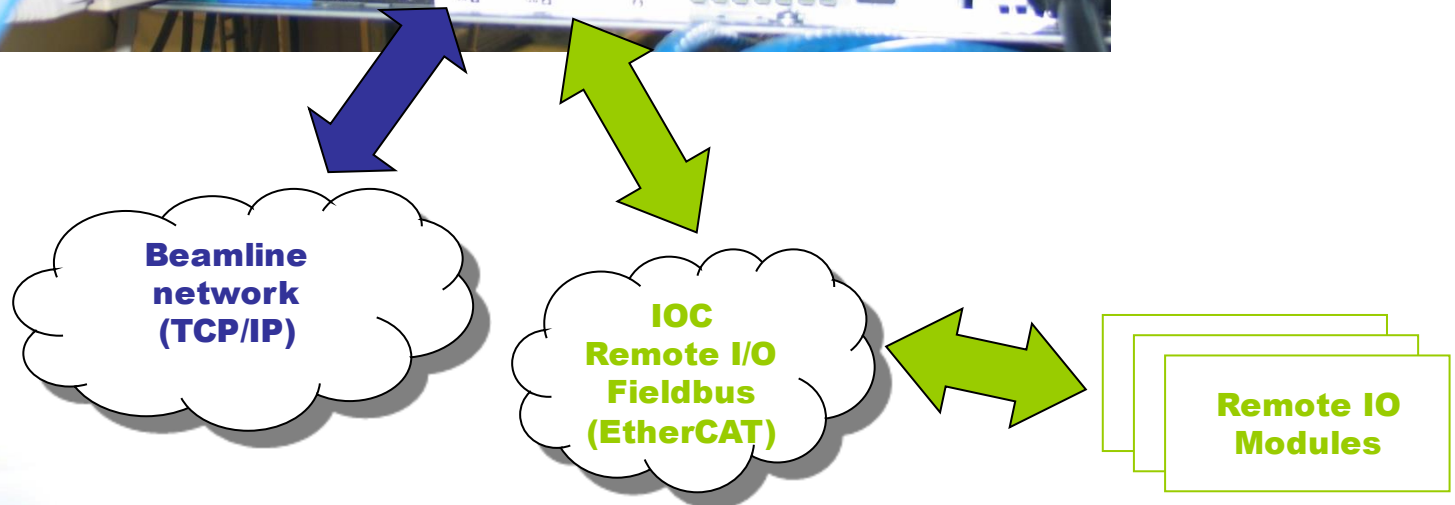
# Experimental Remote I/O



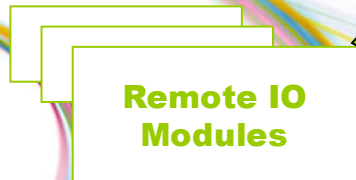
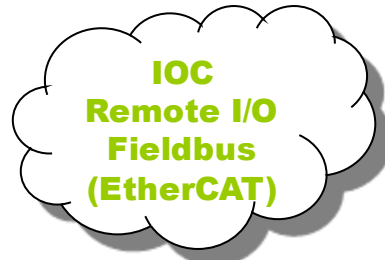
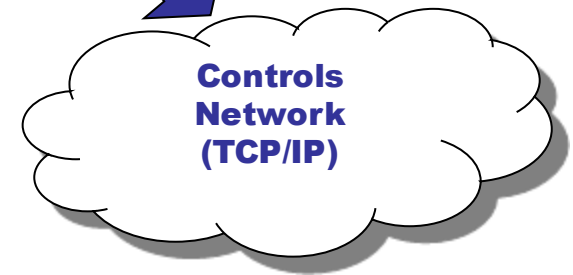
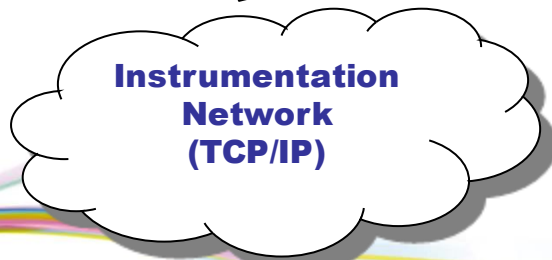
# Hardware: Master and slaves



# View at the back of a server



# View at the back of a Front End server



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# EtherCAT Scanner (Master)

- EtherLab Master
  - [www.etherlab.org](http://www.etherlab.org)
  - Open source, GPLv2
  - Realtime Linux (RTAI, Preempt\_RT and others)
  - Part of Etherlab, marketed by IgH (Germany)

# Ether

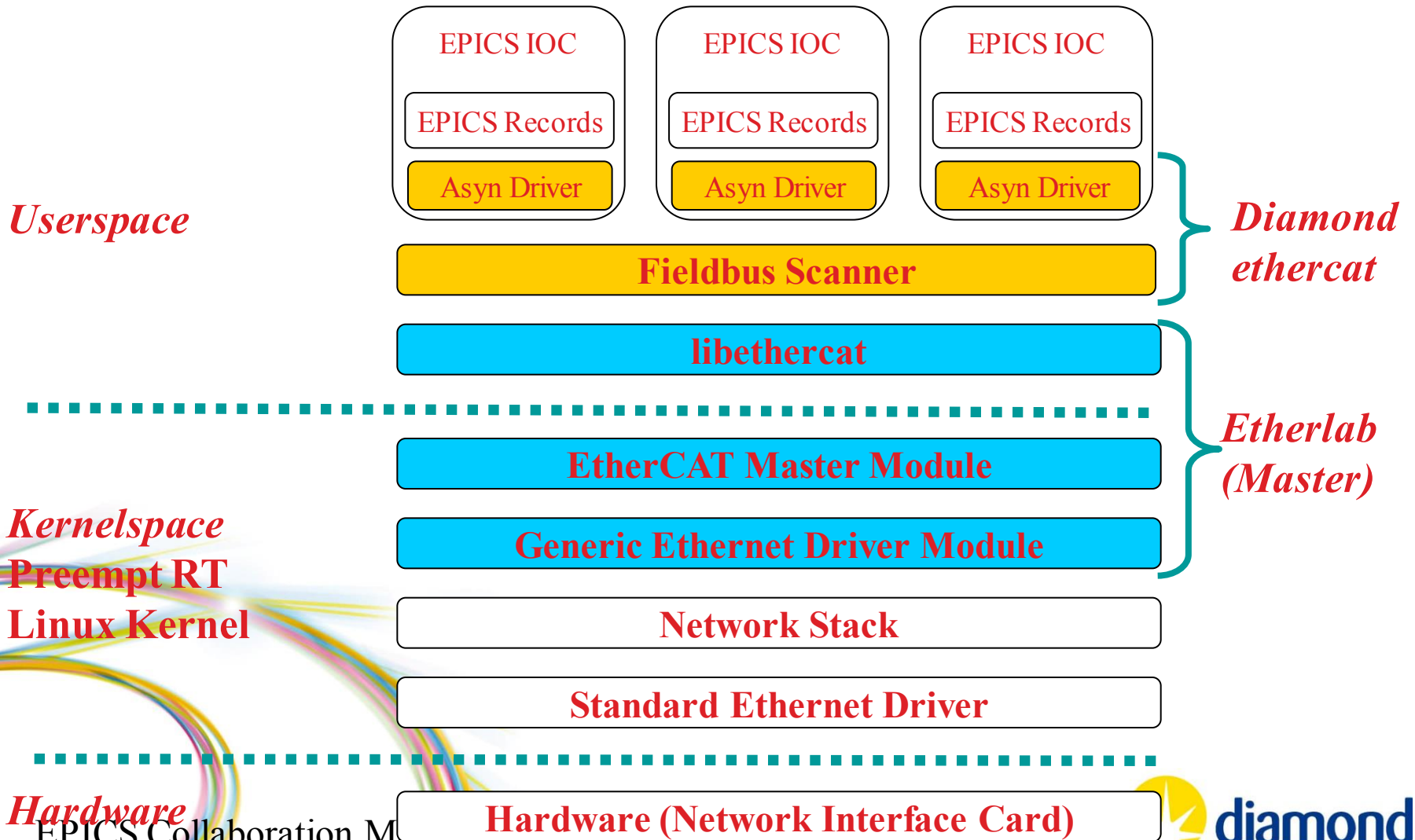
- Kern
- User
- Gene
- FMN
- Scan
- Con

KHz

```
[[local@bt231-di-rserv-01 ~]]$ ethercat slave
0 0:0 OP + EK1100 EtherCAT-Koppler (2A E-Bus)
1 0:1 OP + EK1122 2-Port EtherCAT-Abzweig
2 0:2 OP + EK1100 EtherCAT-Koppler (2A E-Bus)
3 0:3 OP + EL3104 4K. Ana. Eingang +/-10V Diff.
4 0:4 OP + EL3104 4K. Ana. Eingang +/-10V Diff.
5 0:5 OP + EL3104 4K. Ana. Eingang +/-10V Diff.
6 0:6 OP + EL3104 4K. Ana. Eingang +/-10V Diff.
7 0:7 OP + EL3104 4K. Ana. Eingang +/-10V Diff.
8 0:8 OP + EL3104 4K. Ana. Eingang +/-10V Diff.
9 0:9 OP + EL2624 4K. Relais Ausgang, Schließer (125V AC / 30V DC)
10 0:10 OP + EL1014 4K. Dig. Eingang 24V, 100s
11 0:11 OP + NI 9144
12 0:12 OP + EK1100 EtherCAT-Koppler (2A E-Bus)
13 0:13 OP + EL3104 4K. Ana. Eingang +/-10V Diff.
14 0:14 OP + EL3124 4K. Ana. Eingang 4-20mA Diff.
15 0:15 OP + EL4134 4K. Ana. Ausgang -10/+10V. 16bit
16 0:16 OP + EL1014 4K. Dig. Eingang 24V, 100s
17 0:17 OP + EK1122 2-Port EtherCAT-Abzweig
18 0:18 OP + EK1100 EtherCAT-Koppler (2A E-Bus)
19 0:19 OP + EL9512 Netzteilklemme 12V
20 0:20 OP + EL3104 4K. Ana. Eingang +/-10V Diff.
21 0:21 OP + EL3104 4K. Ana. Eingang +/-10V Diff.
22 0:22 OP + EL2024-0010 4K. Dig. Ausgang 12V, 2A
23 0:23 OP + EL2024-0010 4K. Dig. Ausgang 12V, 2A
24 0:24 OP + EL2024-0010 4K. Dig. Ausgang 12V, 2A
25 0:25 OP + EL2024-0010 4K. Dig. Ausgang 12V, 2A
26 0:26 OP + NI 9144
27 0:27 OP + EK1122 2-Port EtherCAT-Abzweig
28 0:28 OP + EK1100 EtherCAT-Koppler (2A E-Bus)
29 0:29 OP + EL9512 Netzteilklemme 12V
30 0:30 OP + EL3104 4K. Ana. Eingang +/-10V Diff.
31 0:31 OP + EL3104 4K. Ana. Eingang +/-10V Diff.
32 0:32 OP + EL2024-0010 4K. Dig. Ausgang 12V, 2A
33 0:33 OP + EL2024-0010 4K. Dig. Ausgang 12V, 2A
34 0:34 OP + EL2024-0010 4K. Dig. Ausgang 12V, 2A
35 0:35 OP + EL2024-0010 4K. Dig. Ausgang 12V, 2A
36 0:36 OP + NI 9144
37 0:37 PREOP + EP4374-0002 2K. Ana. Eingang +/-10V, 0-10V, 0/4-20mA konfigurie
38 0:38 OP + EK1122 2-Port EtherCAT-Abzweig
39 0:39 OP + EK1100 EtherCAT-Koppler (2A E-Bus)
40 0:40 OP + EL3202-0010 2K. Ana. Eingang PT100 (RTD), hochgenau
41 0:41 OP + EL3202-0010 2K. Ana. Eingang PT100 (RTD), hochgenau
```



# Diamond EtherCAT Driver



*Userspace*

*Kernelspace*  
**Preempt RT**  
**Linux Kernel**

*Hardware*

# Diamond EtherCAT Driver

- EtherCAT integrated into EPICS. Uses
  - PREEMPT\_RT Linux
  - Etherlab Ethercat Master for Linux
  - Asyn
- Scanner broadcast bus data to several Soft IOCs for segregation of areas. Automatic Asyn port creation
  - One port per slave
  - One port for master status

# Recent work and work in progress

- PDO assignments
- SDO read/write
- Worst Case Response Time patch
- Interfacing to Beckhoff Embedded PC CX9020

```

<!-- parsed from file /dls_sw/prod/R3.14.12.3/support/ethercat/3-3/etc/xml/Beckhoff EL2xxx.xml -->
<device name="EL2595" vendor="0x00000002" product="0x0a233052" revision="0x00120000">
  <sync index="0" dir="MBoxOut" watchdog="0">
    </sync>
  <sync index="1" dir="MBoxIn" watchdog="0">
    </sync>
  <sync index="2" dir="Outputs" watchdog="0">
    <pdo name="DOX Control" index="0x00001600">
      <entry name="Control_Gap2864" index="0x00001600" bit_length="1" datatype="BOOL" >
      <entry name="Control_Output" index="0x00001601" bit_length="1" datatype="BOOL" >
      <entry name="Control_Gap2865" index="0x00001602" bit_length="1" datatype="BOOL" >
      <entry name="Control_Input trigger" index="0x00001603" bit_length="1" datatype="BOOL" >
      <entry name="Control_Gap2866" index="0x00001604" bit_length="1" datatype="BOOL" >
      <entry name="Control_Reset" index="0x00001605" bit_length="1" datatype="BOOL" >
      <entry name="Control_Gap2867" index="0x00001606" bit_length="1" datatype="BOOL" >
    </pdo>
    <pdo name="DOX Current" index="0x00001607">
      <entry name="Output current" index="0x00001607" bit_length="16" datatype="UINT" >
    </pdo>
  </sync>
  <sync index="3" dir="Inputs" watchdog="0">
    <pdo name="DOX Status" index="0x00001608">
      <entry name="Status_Ready to activate" index="0x00006000" subindex="0x00000001" bit_length="1" datatype="BOOL" >
      <entry name="Status_Output active" index="0x00006000" subindex="0x00000002" bit_length="1" datatype="BOOL" >
      <entry name="Status_Gap2860" index="0x00000000" subindex="0x00000000" bit_length="4" datatype="BOOL" >
      <entry name="Status_Warning" index="0x00006000" subindex="0x00000007" bit_length="1" datatype="BOOL" >
      <entry name="Status_Error" index="0x00006000" subindex="0x00000008" bit_length="1" datatype="BOOL" >
      <entry name="Status_Gap2861" index="0x00000000" subindex="0x00000000" bit_length="3" datatype="BOOL" >
      <entry name="Status_Digital input" index="0x00006000" subindex="0x0000000c" bit_length="1" datatype="BOOL" >
      <entry name="Status_Gap2862" index="0x00000000" subindex="0x00000000" bit_length="3" datatype="BOOL" >
      <entry name="Status_TxPDO Toggle" index="0x00006000" subindex="0x00000010" bit_length="1" datatype="BOOL" >
    </pdo>
  </sync>
</device>

```

**LED - BL23I-EA-LED-01**

LED Backlight LED

Desired Value 0 29

Readback Value 29

0 save rest 50

Current 29 29

Power control OFF ON

Output Active Warning Error

# CoE-Einstellungen und Diagnosedaten

- EL3632 - 2 C
- Foreword
- Product c
- Basics cr
- Mounting
- Commissi
- Twin
- Gene
- Basic
- Objek
- Appli
- Error han
- Appendix

Add Grafik\_Vorlage Online Data Module OD (AoE Port): 0

Index	Name	Flags	Value	Unit
+ 6000:0	DOX Inputs Ch.1	RO	> 18 <	

<entry name="Status Digital input" index="0x00006000" subindex="0x0000000c" bit length="1" datatype="boolean">

Device - cTop (on pc0074.cs.diamond.ac.uk)

cTop

SDO-voltage

Readback: 675

Read

SDO-warnlvl src

Readback: 5

Read

SDO-errovlvl out

Readback: 22

Read

SDO-holdcurrent

Readback: 100

Read

SDO-errlvl src

Readback: 22

Read

LED1 OFF ON

ADC

SDO-supvoltage

Readback: 2400

Read

SDO-warnlvl out

Readback: 5

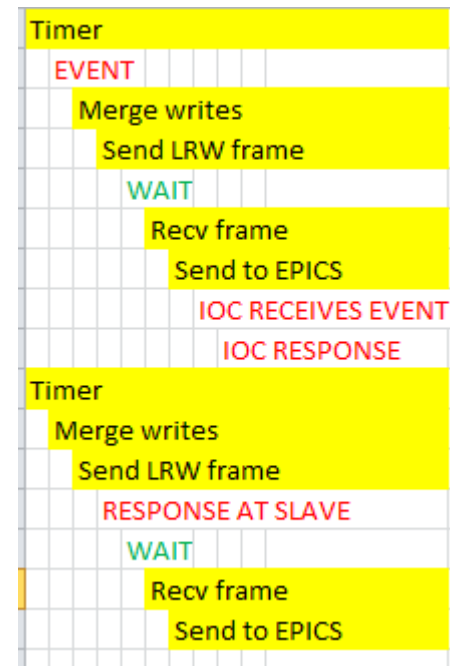
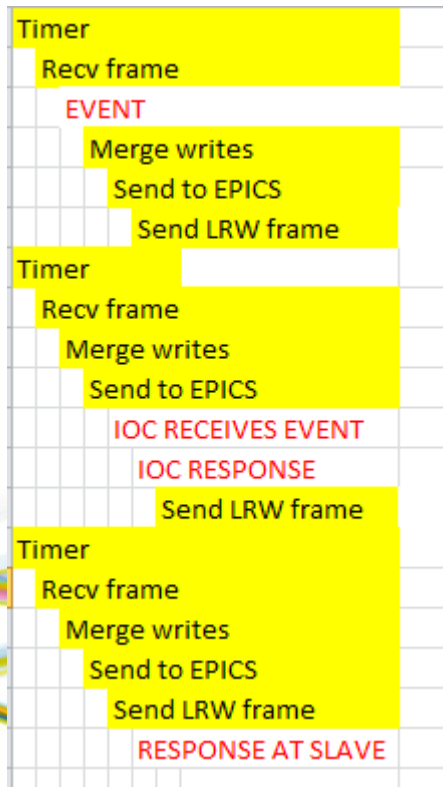
Read

EXIT

8002:06	Enable automatic saving of counter	RW	TRUE
8002:11	Select info data 1	RW	Output voltage (7)

# Worst Case Response Time

- Reduce WCRT from 3 to 2 (Damien Lynch, ANSTO)



# Interfacing to CX9020

- Work by Damien Lynch at ANSTO
- Adds Float64 data type



# Thank you for listening!

<http://controls.diamond.ac.uk/downloads/support/ethercat/>

Thanks to:

James Rowland

Linda Pratt

Peter Leicester

Tom Cobb

Ian Gillingham

Andy Foster

Damien Lynch (Ansto)

Kevin Wilkinson

Armin Wagner