

# EtherLab's Open-Source EtherCAT Master

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## Why EtherCAT?

### Master Implementation

EtherLab

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## Advantages

- ▶ Ethernet-based
- ▶ High bandwidth (10 kHz with 100 servo axes)
- ▶ Less overhead (summing frame, single master)
- ▶ Flexible topologies (physical)
- ▶ Logical ring structure (realtime capable)
- ▶ Open standards (ETG, IEC 61158 type 12, IEEE 802.3, etc.)
- ▶ Cheap hardware (at least master and cabling)

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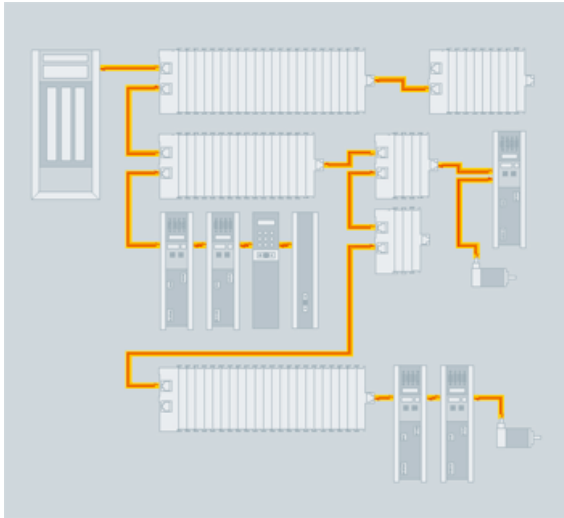
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# Frame processing “on the fly”



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- ▶ Synchronisation via Distributed Clocks (DC)
- ▶ Redundancy via multiple Ethernet links
- ▶ Mailbox protocols (... over EtherCAT)
  - ▶ CANopen protocol (CoE)
  - ▶ Sercos profile (SoE)
  - ▶ Ethernet (EoE)
  - ▶ File-access (FoE)
  - ▶ Vendor-specific (VoE)
- ▶ Functional safety over EtherCAT (FSoE)
- ▶ Diagnosis via standard tools

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## Disadvantages

- ▶ Special (intelligent) slave hardware required
- ▶ Complex technology
- ▶ Interfering features
- ▶ Redundancy not foolproof
- ▶ “Wrong” endianness

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Ether**CAT**

EtherLab (<http://ethercat.org>) is an open-source automation toolkit covering several components:

- ▶ EtherCAT master
- ▶ MATLAB/Simulink blocks for EtherCAT
- ▶ Process data access and visualisation libraries
- ▶ Data-logging services

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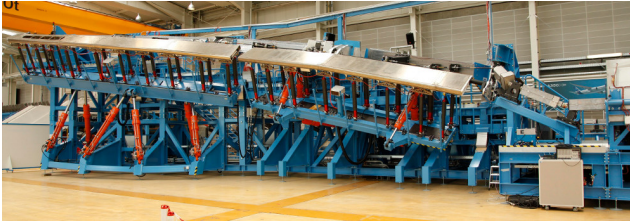
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## Airbus High-Lift Testtrigs



## Neumayer Station, Antarctica



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- ▶ Mercurial-Repository

<https://sourceforge.net/projects/etherlabmaster>

Branches:

default Development (unstable)  
stable-1.5 Current stable version

- ▶ Tarballs and Documentation

<http://etherlab.org>

⇒ “Software components” ⇒ “EtherCAT master”

- ▶ Mailing lists

- ▶ [etherlab-users@etherlab.org](mailto:etherlab-users@etherlab.org)
- ▶ [etherlab-dev@etherlab.org](mailto:etherlab-dev@etherlab.org)

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- ▶ Reference implementation for Windows supplied by Beckhoff
- ▶ Alternative: Linux
  - ▶ Complete control over OS kernel
  - ▶ Open source
  - ▶ Full-featured operating system
  - ▶ No license costs
  - ▶ Realtime extensions

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- ▶ Implementation from scratch acc. to IEC 61158
- ▶ Kernel modules and userspace libraries for Linux 2.6 and later
- ▶ Master licenced under GPLv2; userspace library under LGPLv2
- ▶ Several masters can co-exist on the same host
- ▶ Optimized performance (e. g. no unnecessary copy operations in realtime context) and robustness

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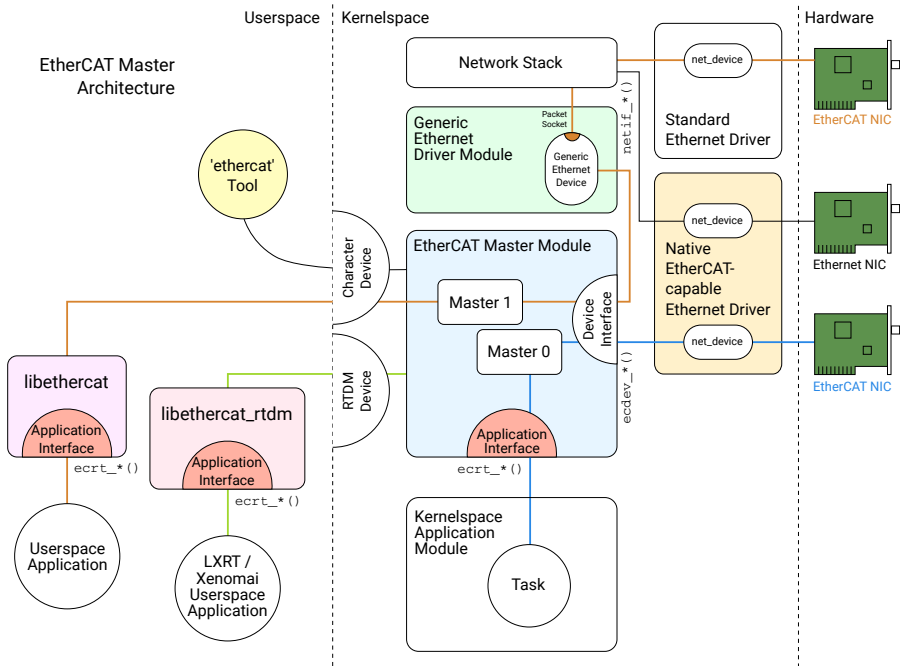
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# EtherCAT Master Architecture



# Master phases

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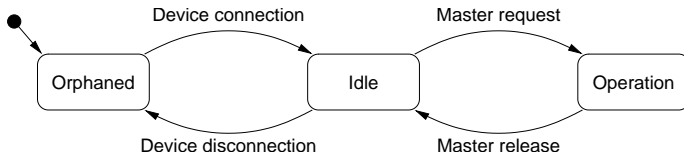
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## EtherCAT-capable versions of standard Linux Ethernet drivers

- ▶ Realtek drivers `8139too` and `r8169`
- ▶ Intel drivers `e100`, `e1000` and `e1000e`
- ▶ Beckhoff CCAT FPGA
- ▶ Interrupt-less operation (deterministic cycle)
- ▶ Porting of further drivers due to common “device interface”

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- ▶ Covers **all** chips supported by the Linux kernel
- ▶ Uses the lower layers of the Linux network stack
- ▶ Not usable with certain realtime extensions (RTAI etc.)

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Supports any Linux realtime extension due to an independent architecture

- ▶ [RTAI](#), [Xenomai](#), [RT-Preempt](#), etc.
- ▶ Operation possible even without realtime

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## Common C/C++ interface for EtherCAT applications

- ▶ Kernel- and userspace (same header `ecrt.h`)
- ▶ Master management (requesting / releasing)
- ▶ Bus information
- ▶ Slave configuration
- ▶ Cyclic operation

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## Partitions of the process data image

- ▶ Handling slaves with different sample times
- ▶ Monitoring of process data exchange
- ▶ Dynamic slave handling

Every master runs a finite state machine in process context, that has the following tasks:

1. Bus scanning – Started after each topology change
2. Slave configuration – Automatic configuration of slaves (after request)
3. Request processing – Handling of external requests
4. Bus monitoring – Slave states are cyclically queried

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The EtherCAT logo, with 'Ether' in black and 'CAT' in bold black, followed by a red arrow pointing to the right.

## Implementation of the “Ethernet over EtherCAT” (EoE) mailbox protocol

- ▶ Tunnelling of Ethernet traffic via the EtherCAT bus
- ▶ Virtual network interfaces for all EoE-capable slaves
- ▶ Both a switched and a routed topology are natively supported (configurable via standard system tools)

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## Command-line tool `ethercat` (this will be your friend)

- ▶ Information about masters, slaves, domains, configurations, process data, etc.
- ▶ E<sup>2</sup>PROM access and alias addressing
- ▶ Parameter and file transfers
- ▶ Physical memory access
- ▶ Controlling application-layer states
- ▶ Generation of slave information in several formats (C-code, XML, MATLAB, DOT language)

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## Seamless integration in arbitrary GNU/Linux distributions

- ▶ “Linux Standard Base” compatible init script / systemd service file for inserting the master as a system service
- ▶ Configuration of master via a sysconfig file / `ethercat.conf`

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- ▶ Improve mailbox handling
- ▶ Improve scanning performance
- ▶ Update of native drivers
- ▶ Version 1.5.3 in 2016

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Tack så mycket



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Thank you very much for your interest!

