

# EtherCAT<sup>®</sup> Product Family

**EC** ↔ *Master*

**EC** ↔ *Engineer*   **EC** ↔ *Lyser*

**EC** ↔ *Win*

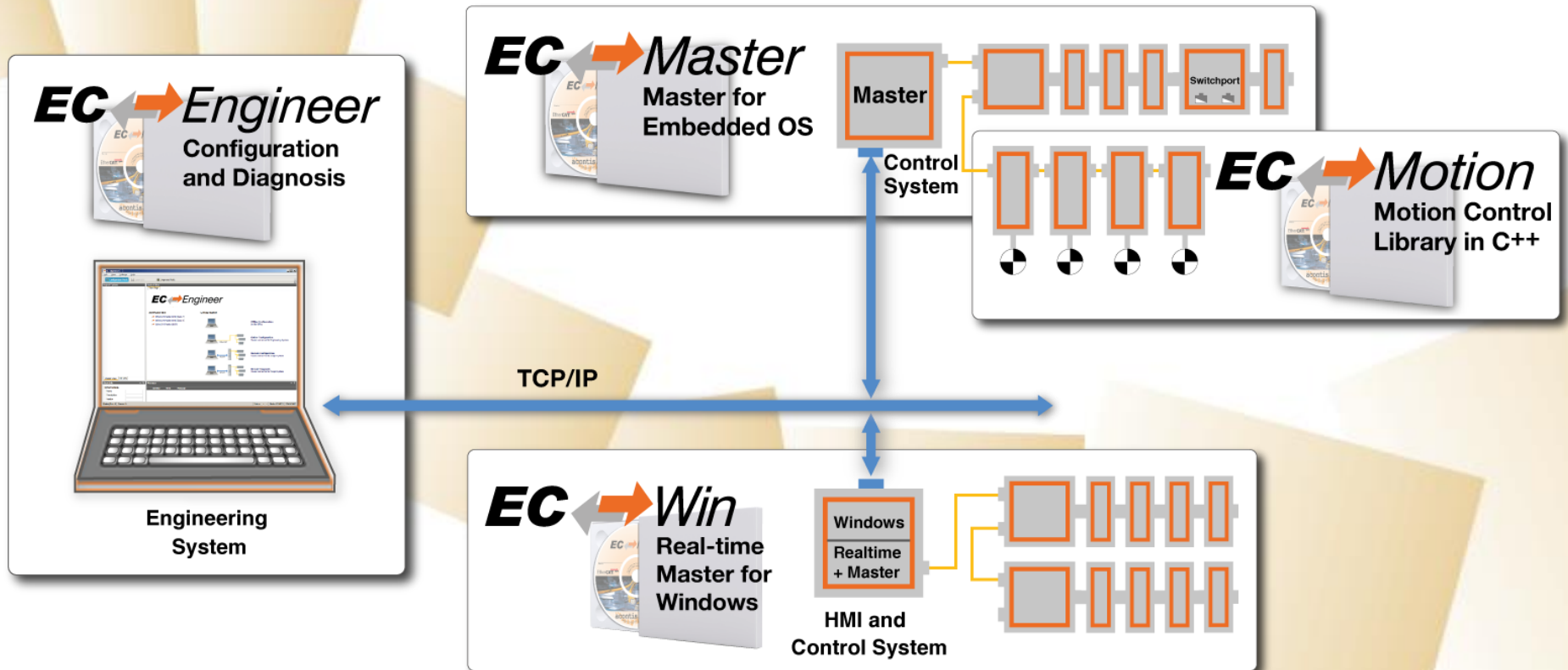
EtherCAT<sup>®</sup> Master Stack

EtherCAT<sup>®</sup> Configuration and Diagnosis Tools

Windows EtherCAT<sup>®</sup> Real-Time Platform

Sales Presentation

# EtherCAT® Product Family



# EtherCAT System Architecture

**EC** ↔ **Engineer**



EtherCAT Slave Information (ESI) Files



EtherCAT Network Information (ENI) File

EtherCAT Application

**EC** ↔ **Master**

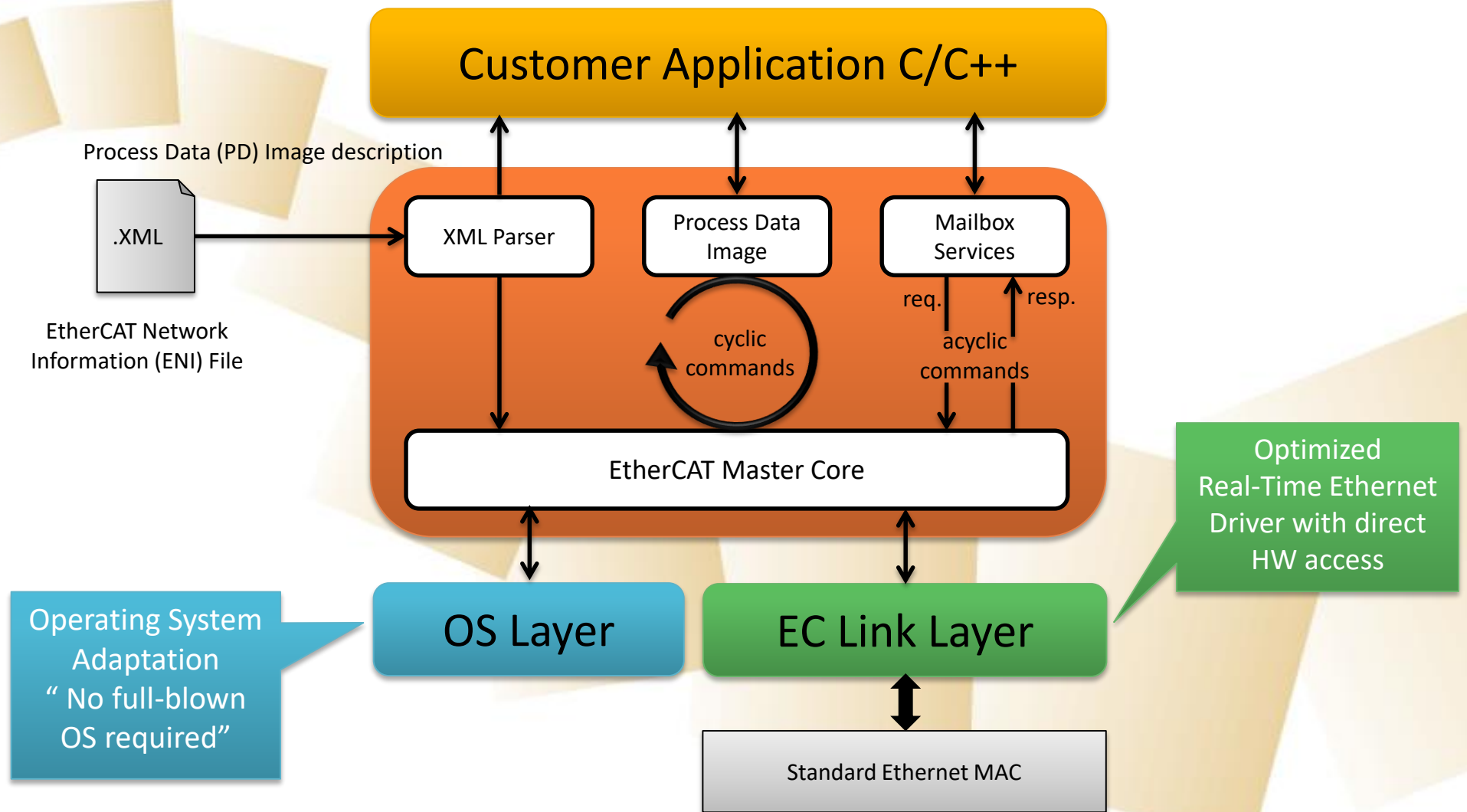
Real-Time Kernel/OS



EtherCAT

EtherCAT

# EC-Master Architecture



# EC-Master SDK – Out of the box for 32-Bit Platforms **EC** ↔ **Master**

## OS Layers



WIND RIVER



Xenomai



x86

ARM

PowerPC

## EC Link Layer

Intel Pro/1000

Xilinx GEM

Realtek Gigabit

Freescale  
FEC, eTSEC

Renesas RZ Family

TI Sitara  
CPSW, ICSS-PRU

Altera Cyclone V

SMSC 9218

Beckhoff CCAT

and more

# EC-Master SDK – Out of the box for 64-Bit Platforms **EC** ↔ **Master**

## OS Layers



x64

## EC Link Layer

Intel Pro/1000

Beckhoff CCAT

Realtek Gigabit

## EC-Master according to ETG.1500 Master Classes Directive

### Class A Core

- Compare network configuration
- Cyclic process data exchange
- All mailbox protocols: CoE, SoE, EoE, FoE, AoE, VoE
- Slave to slave communication
- **Distributed Clocks with master synchronization**

### Class B Core

- Compare network configuration
- Cyclic process data exchange
- Mailbox protocol CoE
- Mailbox protocol SoE
- Mailbox protocol EoE
- Slave to slave communication

Feature Pack  
Cable Redundancy

Feature Pack  
Hot Connect

Feature Pack  
Remote Access

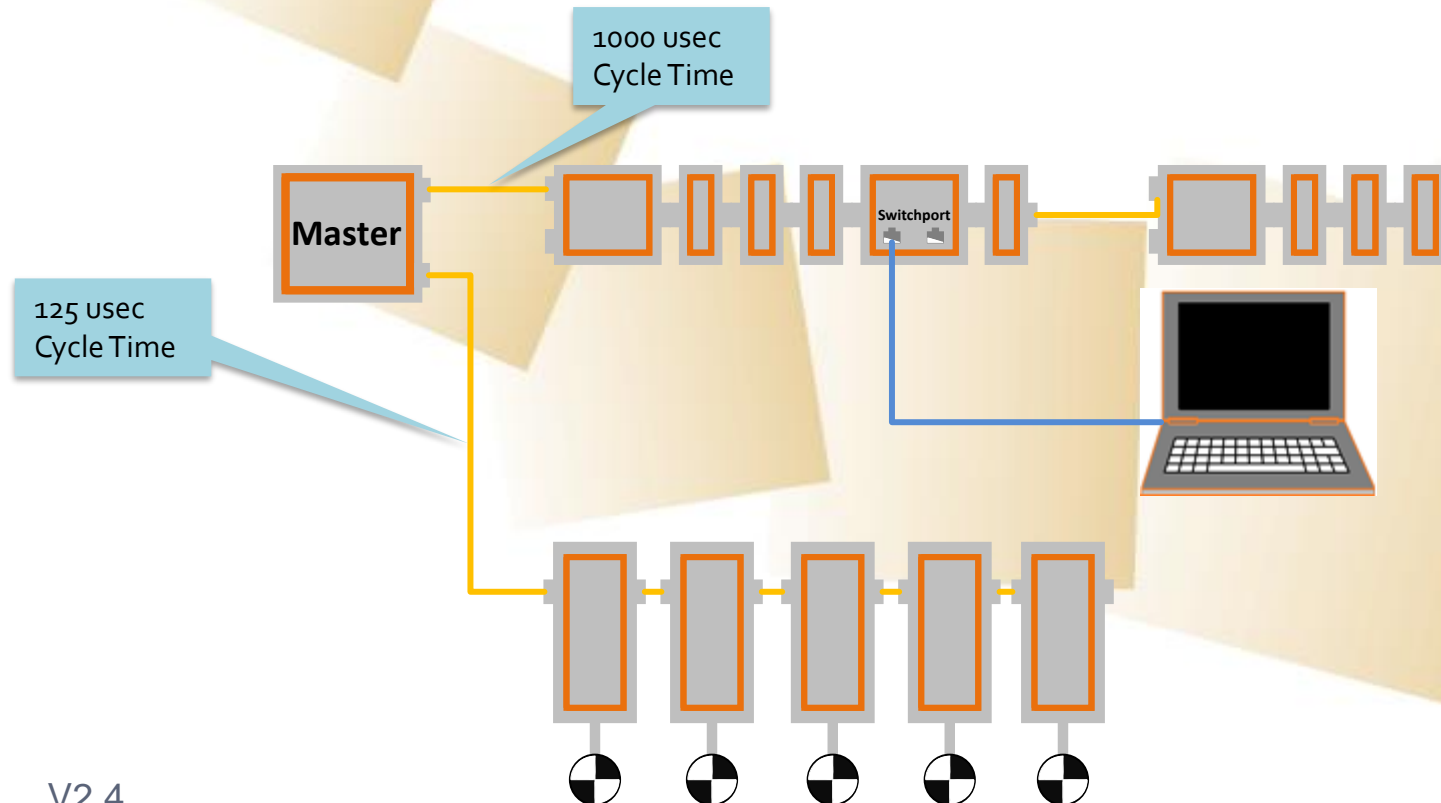
Feature Pack  
Superset ENI

Feature Pack  
EoE Endpoint

Feature Pack  
Master Obj. Dict.

## Multiple Networks (instances)

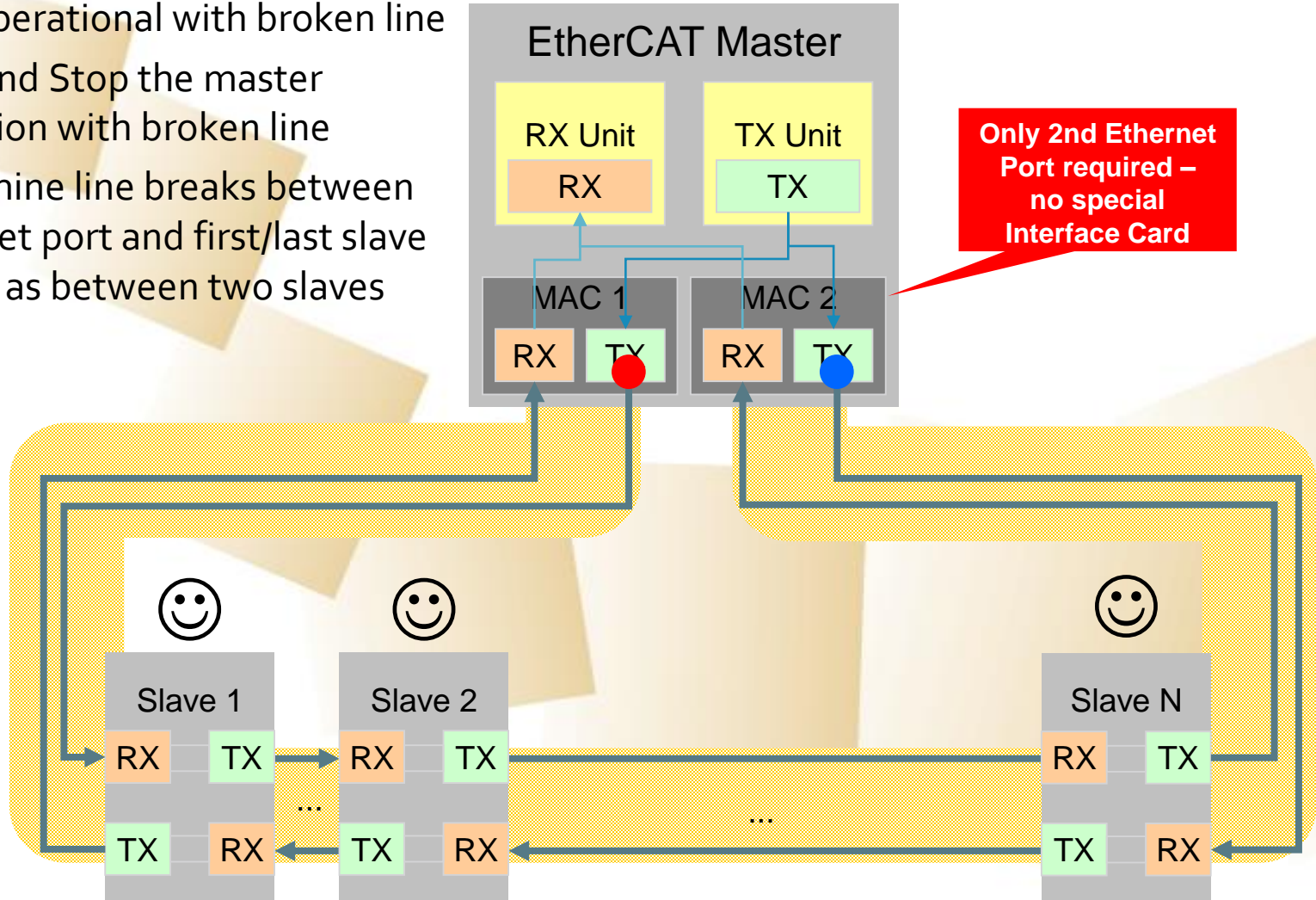
- Use Case: Control more than one EtherCAT network with one system, e. g.,
  - Network 1 (NIC 1) is used for I/O bus system
  - Network 2 (NIC 2) is used for high speed motion (drives)
- Fully independent configuration and operation
- Identical or different link layers, up to 10 networks
- Available for Class A and Class B





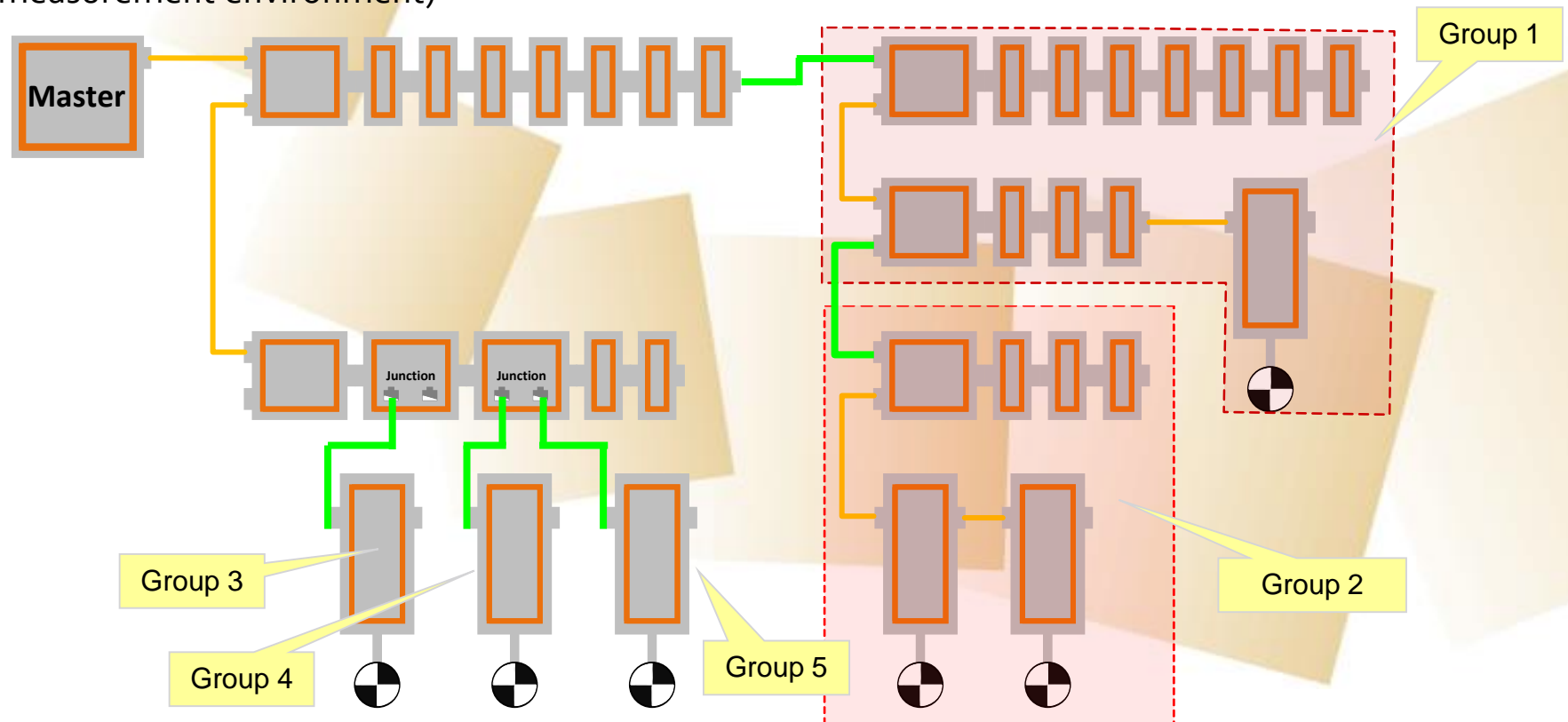
# Feature Pack: Cable Redundancy

- Stay operational with broken line
- Start and Stop the master operation with broken line
- Determine line breaks between Ethernet port and first/last slave as well as between two slaves



# Feature Pack: Hot Connect

- Setting up a complex control system, while parts of the system are not available, powered-off or disconnected.
- Flexibility within the wiring: slaves can be connected to different ports (e.g. analogue to CAN)
- Running a system that consists of mandatory as well as optional devices (e.g. in a test & measurement environment)

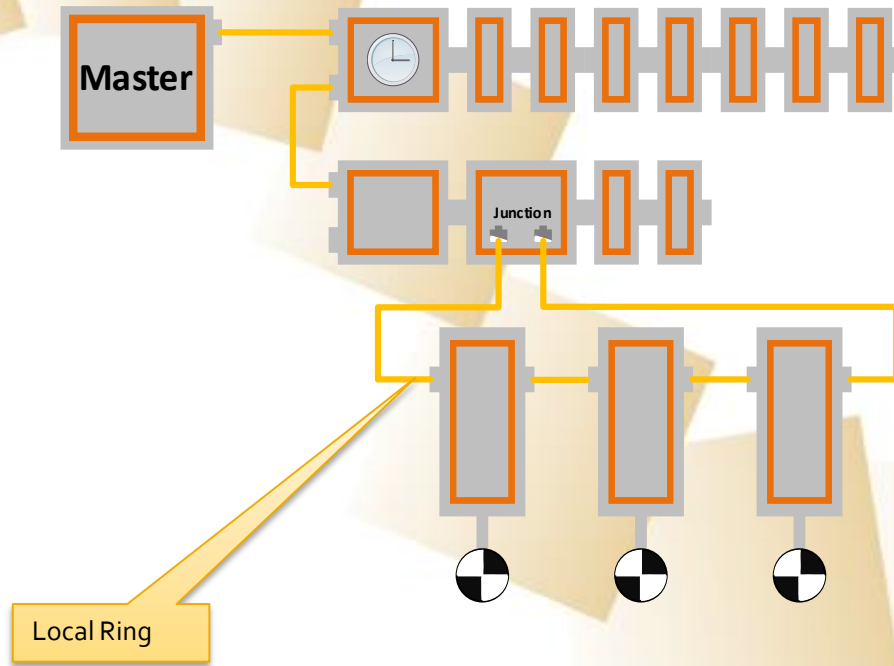


## Functionality:

- Add or remove additional slave devices
- Differentiation of Mandatory and optional slaves
- No wrong slaves must be connected (e.g. wrong address). If a wrong slave is connected, the network stub must be cut-off at this point by the master application.
- Network can be transferred to operational state if slaves are missing which are marked as optional.
- Network may remain operational if an optional slave fails
- The network information file (ENI) contains all slaves. (Optional slave nodes may be marked there.)
- The network has to be configured in a way that all possible slaves are connected simultaneously, even if not all slaves can be connected at once.
- The cyclic commands contain the data for all slaves.

# Junction Redundancy

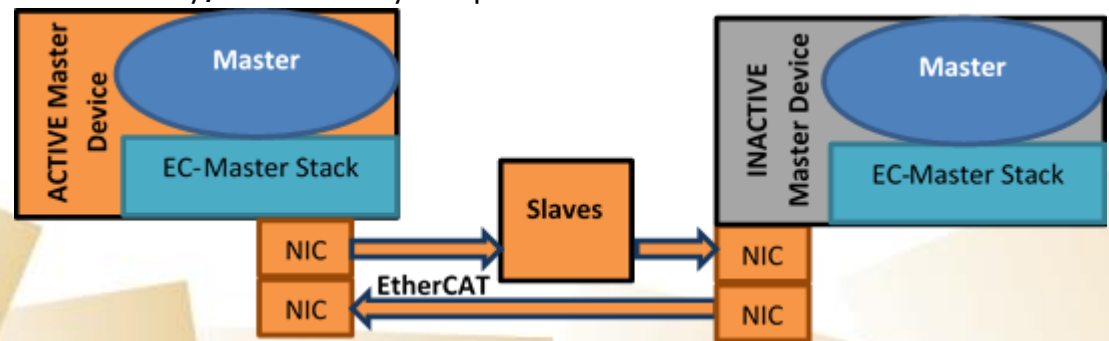
- Support Junction Redundancy with Distributed Clocks



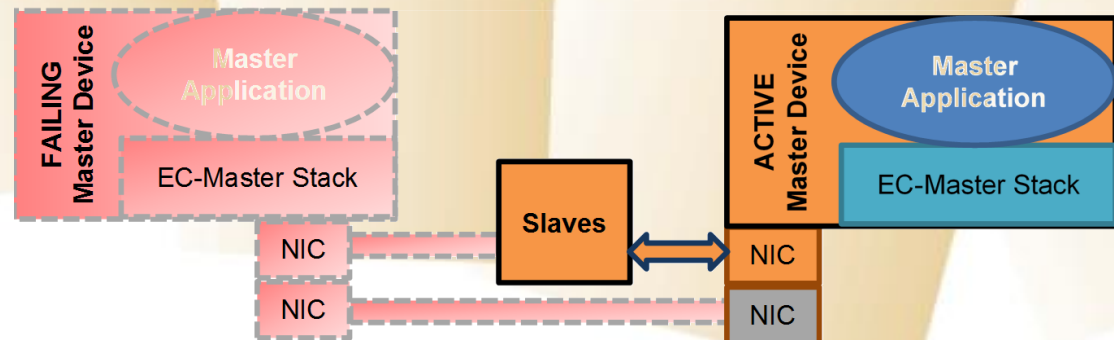
- Create local ring cable redundancy using junction devices
- Stay operational in case of a break in the local ring
- Multiple local rings supported

# Feature Pack: Master Redundancy

- Cable Redundancy
  - hot plugging (or removal) of additional slaves is possible
  - Cable break: all devices are still able to work
- Hot Standby
  - inactive master takes over active master activity, devices stay in operation



- Failover: The Backup Master takes over



# Feature Pack: Master Object Dictionary (1)

- According to Modular Device Profile (MDP) Profile Number 1100
- Use Case: Application requires to access information about
  - Slaves in configuration file, slaves detected on network
  - Number of sent/received frames, slave status, ...

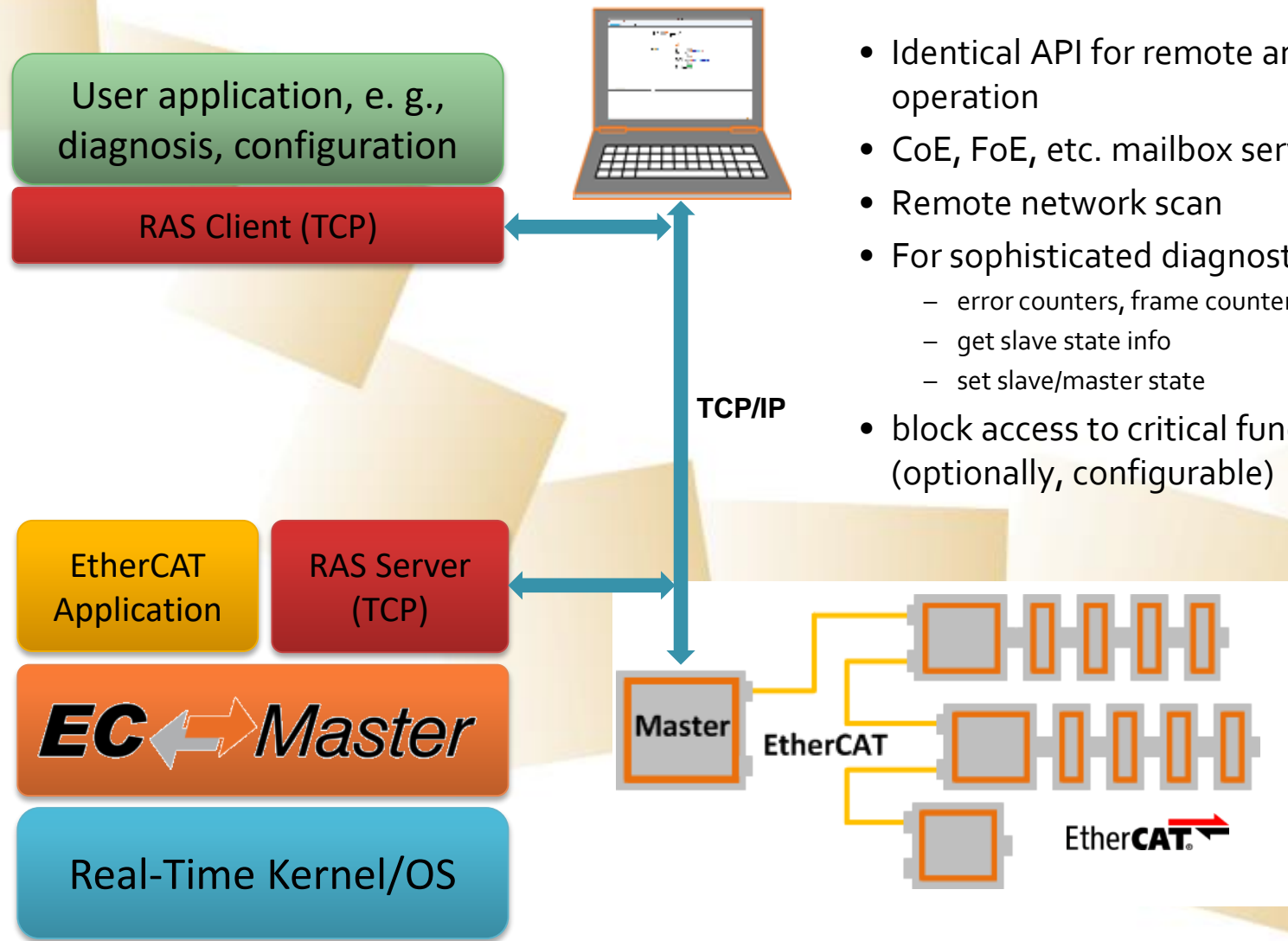
Index (hex)	Object Dictionary Area
0x0000-0x0FFF	Data Type Area
0x1000-0x1FFF	Communication Area
0x8000-0x8FFF	Configuration Area (Expected configuration of the EtherCAT slaves)
0x9000-0x9FFF	Information Area (Detected configuration of the EtherCAT slaves)
0xA000-0xAFFF	Diagnosis Area (Diagnosis of the EtherCAT slaves)
0xF000-0xFFFF	Device Area

# Feature Pack: Master Object Dictionary (2)

## Information Data

Index	SubIndex	Name	Data Type	Access	Description
0x9000	1	Fixed Station Address	UINT <sub>16</sub>	RO	Fixed Station Address of the first EtherCAT Slave found (same value as 0xF040:01)
	5	Vendor ID	UINT <sub>32</sub>	RO	Vendor ID of the first EtherCAT Slave found (entry 0x1018:01 of the EtherCAT slave)
	6	Product Code	UINT <sub>32</sub>	RO	Product Code of the first EtherCAT Slave found (entry 0x1018:02 of the EtherCAT slave)
	7	Revision	UINT <sub>32</sub>	RO	Revision of the first EtherCAT Slave found (entry 0x1018:03 of the EtherCAT slave)
	8	Revision	UINT <sub>32</sub>	RO	Revision of the first EtherCAT Slave found (entry 0x1018:04 of the EtherCAT slave)
	32	DL Status	UINT <sub>16</sub>	RO	DL Status (Register 0x110-0x111) of the first EtherCAT found
0x9001	1	Fixed Station Address	UINT <sub>16</sub>	RO	Fixed Station Address of the second EtherCAT Slave found (same value as 0xF040:02)
...		...			

# Feature Pack: Remote Access - Overview



- Identical API for remote and local operation
- CoE, FoE, etc. mailbox services
- Remote network scan
- For sophisticated diagnostics
  - error counters, frame counters (OD)
  - get slave state info
  - set slave/master state
- block access to critical function calls (optionally, configurable)



- Access EC-Master (use the API calls) from a remote system
  - Example: Access EC-Master which is running in VxWorks control system from a Notebook that is running Windows XP (e.g. read master or slave status)
- Access EC-Master (use the API calls) from a second Windows process or executable
  - Example: Access EC-Master which is running inside a Windows CE controller process (control.exe) from a second Windows CE diagnostics process (diag.exe)
- Very useful in combination with the Master Object Dictionary feature pack for diagnostics

## Key benefits

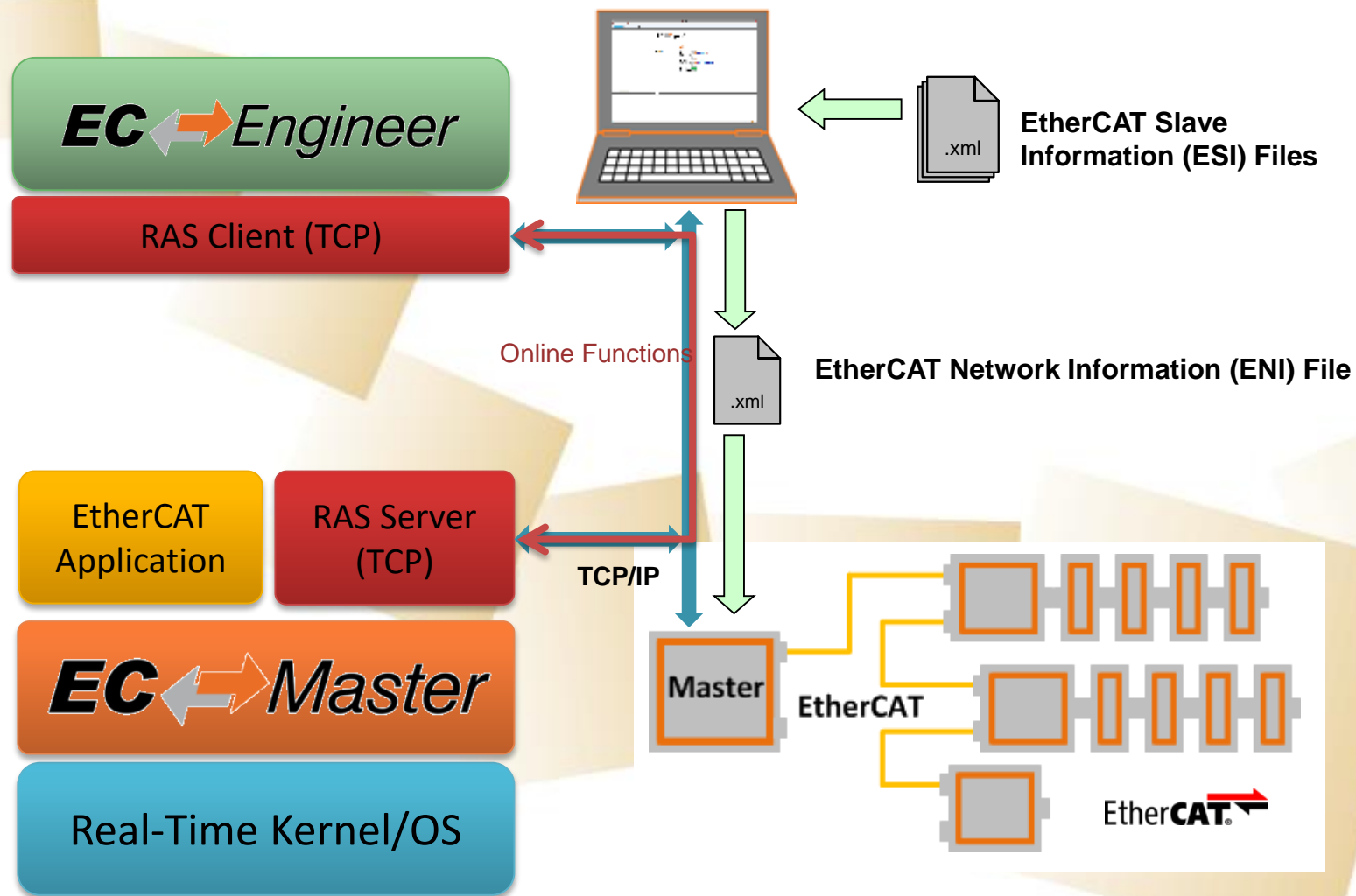
- Out-of-the-box for the most popular operating systems  
→ Get it running on your system in one day!
- High scalability  
→ small footprint embedded systems: remove features  
→ high end systems: all ETG.1500 features available
- Reliable and robust implementation  
→ Field proven in several 10000 systems!
- Sophisticated diagnosis functions  
→ Detect state change problems and frame loss errors easily
- High performance and hard real-time  
→ Low CPU load due to optimized link layers
- Easy to integrate  
→ Various example applications and comprehensive user manuals
- No runtime license activation required  
→ License sticker

**EC** ↔ *Engineer*

# ETHERCAT CONFIGURATION AND DIAGNOSIS TOOL

# EtherCAT System Architecture

**EC** ↔ **Engineer**



# Operating Modes

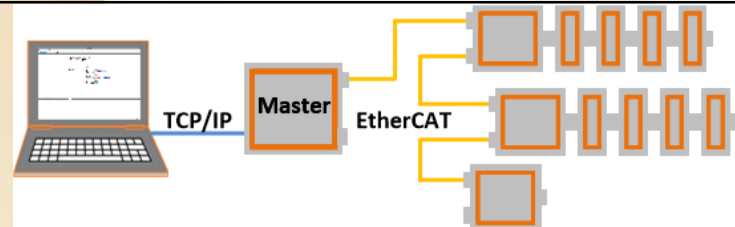
Offline **Configuration:**  
(In the Office)



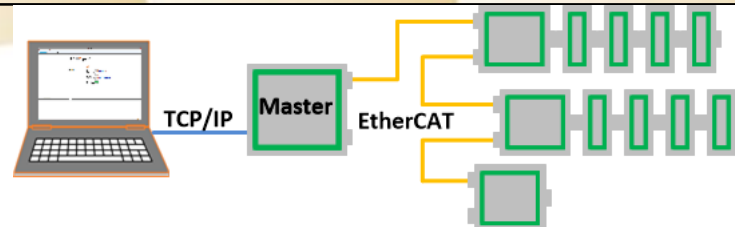
Online **Configuration:**  
Slaves connected to  
Engineering System



Remote **Configuration:**  
Slaves connected to  
Target System



Remote **Diagnosis:**  
Slaves connected to  
Target System



# Build an configuration in less steps

The screenshot displays the EC-Engineer software interface, showing the configuration of an EtherCAT network. The interface is divided into several panes:

- Left Pane (EtherCAT Network-Editor):** Shows a tree view of the network configuration. The root is "Bus (Class-A Master)", which contains 17 slaves. Slaves 001-008 are of type "Slave" and Slave 009 is of type "VIPA 053-1EC00". Each slave has associated terminals (e.g., 001: Terminals [032-1BB30]).
- Right Pane (General):** Shows the "Station Address" set to 10.
- Bottom Left Pane (Short Info):** Provides details for the selected slave (Slave\_009 [VIPA 053-1EC00] (0009)), including its name, description, and vendor (Yaskawa Electric Corporation).
- Bottom Right Pane (Messages):** Shows a log of events, including "Configuration saved to D:\Temp\config.ecc" and "EC-Engineer ready. Version 0.9.9".
- Right Pane (Modules):** Shows the configuration of digital input and output modules for the selected slave, including terminal addresses and module types.

# Comprehensive diagnostic

The screenshot shows the 'EC-Engineer' software interface in 'Diagnosis Mode'. The left sidebar displays a tree view of the EtherCAT network, with 'Slave\_003 [EL2004] (0003)' selected. The main panel is titled 'Variables' and contains a table with columns: Name, Datatype, Group Info, Offset, Size, and Value.

Name	Datatype	Group Info	Offset	Size	Value
Slave_003 [EL2004] (EL2004).Channel 1.Output	BOOL	[Default]	OUT : 121.0	0.1	0
Slave_003 [EL2004] (EL2004).Channel 2.Output	BOOL	[Default]	OUT : 121.1	0.1	1
Slave_003 [EL2004] (EL2004).Channel 3.Output	BOOL	[Default]	OUT : 121.2	0.1	0
Slave_003 [EL2004] (EL2004).Channel 4.Output	BOOL	[Default]	OUT : 121.2	0.1	0

Below the table, there is a 'Chart' section with a graph showing values from 0 to 1. Below that is an 'Edit Variables' section with a 'Value:' input field.

The screenshot shows the 'EC-Engineer' software interface in 'Diagnosis Mode', with the 'CoE Object-Dictionary' tab selected. The left sidebar shows 'Slave\_011 [VIPA 053-1EC00] (0011)' selected. The main panel displays a table of CoE objects with columns: Index, Name, Value, Type, and Flags.

Index	Name	Value	Type	Flags
0x1000	Device Type	5001 (0x1389)	UDINT	--- ( RO RO RO )
0x1008	Device Name	VIPA 053-1EC00	STRING(14)	--- ( RO RO RO )
0x1009	Hardware Version	01	STRING(3)	--- ( RO RO RO )
0x100A	Software Version	1.29	STRING(4)	--- ( RO RO RO )
0x100B	System Version	3 (0x03)	USINT	--- ( RO RO RO )
0x1018	Identity			
0x1600	RxPDO Map			
0x1601	RxPDO Map			
0x1603	RxPDO Map			
0x1604	RxPDO Map			
0x1A02	TxPDO Map			
0x1A03	TxPDO Map			
0x1A05	TxPDO Map			
0x1AFF	Status PDO			

Below the table is an 'Edit Value' section with a 'Value:' input field and an 'Update' button.

# Powerful "Line crossed" detection

The screenshot shows the EC-Engineer software interface. The main window displays a network diagram with several nodes and connections. A red 'X' and the text 'Line Crossed' are overlaid on a connection between nodes 1021 and 1022, indicating a detected error. The 'Line Crossed Analyzer' window is open, showing a list of slaves with their AutoInc Address and Type. The entry for address 65516 and type EK1100 is highlighted in red, indicating it is incorrectly connected.

**Line Crossed Analyzer**

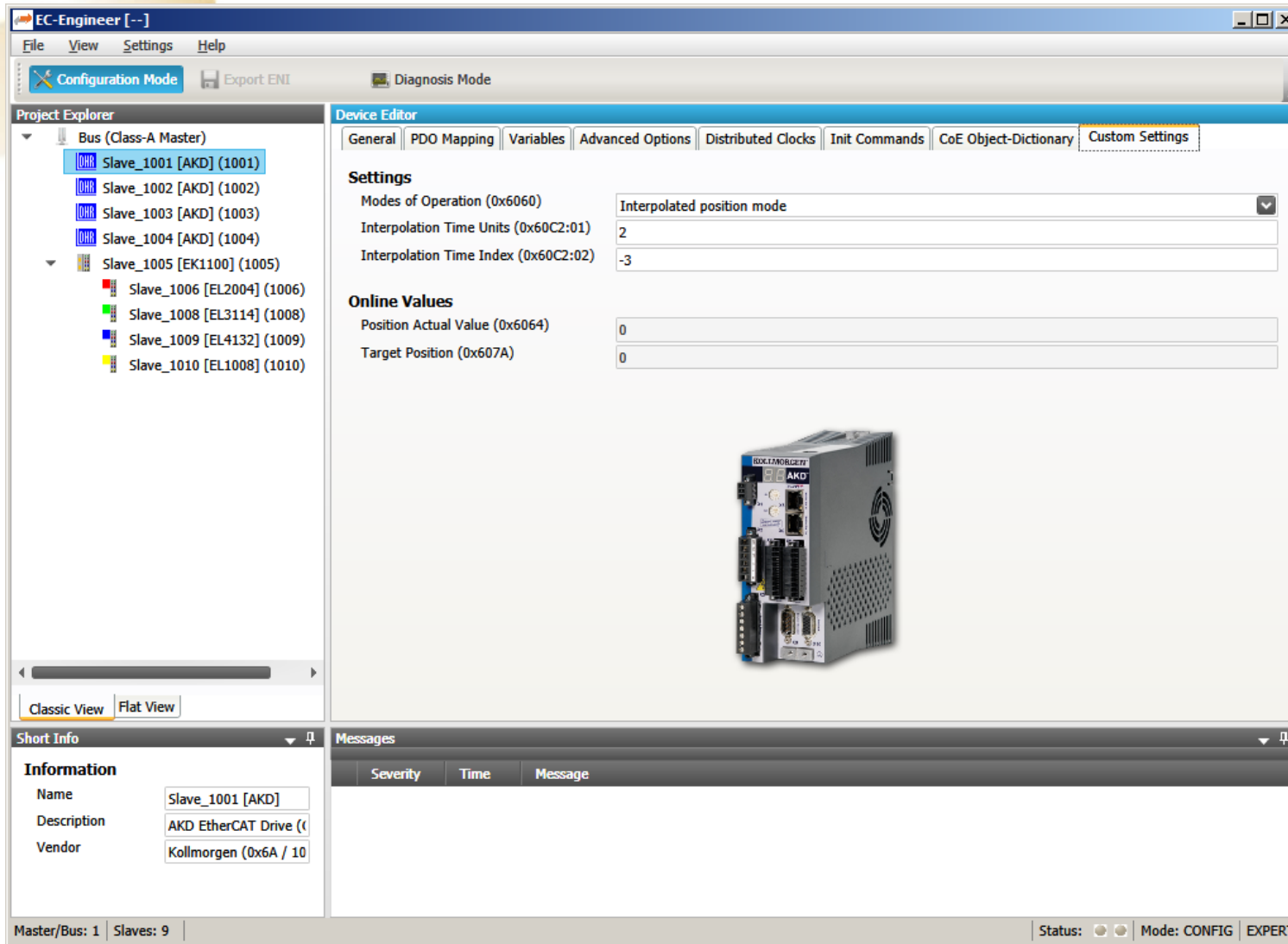
List of slaves  
In the list you can see all connected slaves. The red ones are incorrectly connected

AutoInc Address	Type
65521	EL1094
65520	EK1110
65519	BK1120
65518	VIPA 053-1EC00
65517	EK1122
65516	EK1100
65515	EL2202-0100
65514	EL2202-0100
65513	EL1114
65512	EL7031
65511	EL7201



# EC-Engineer SDK

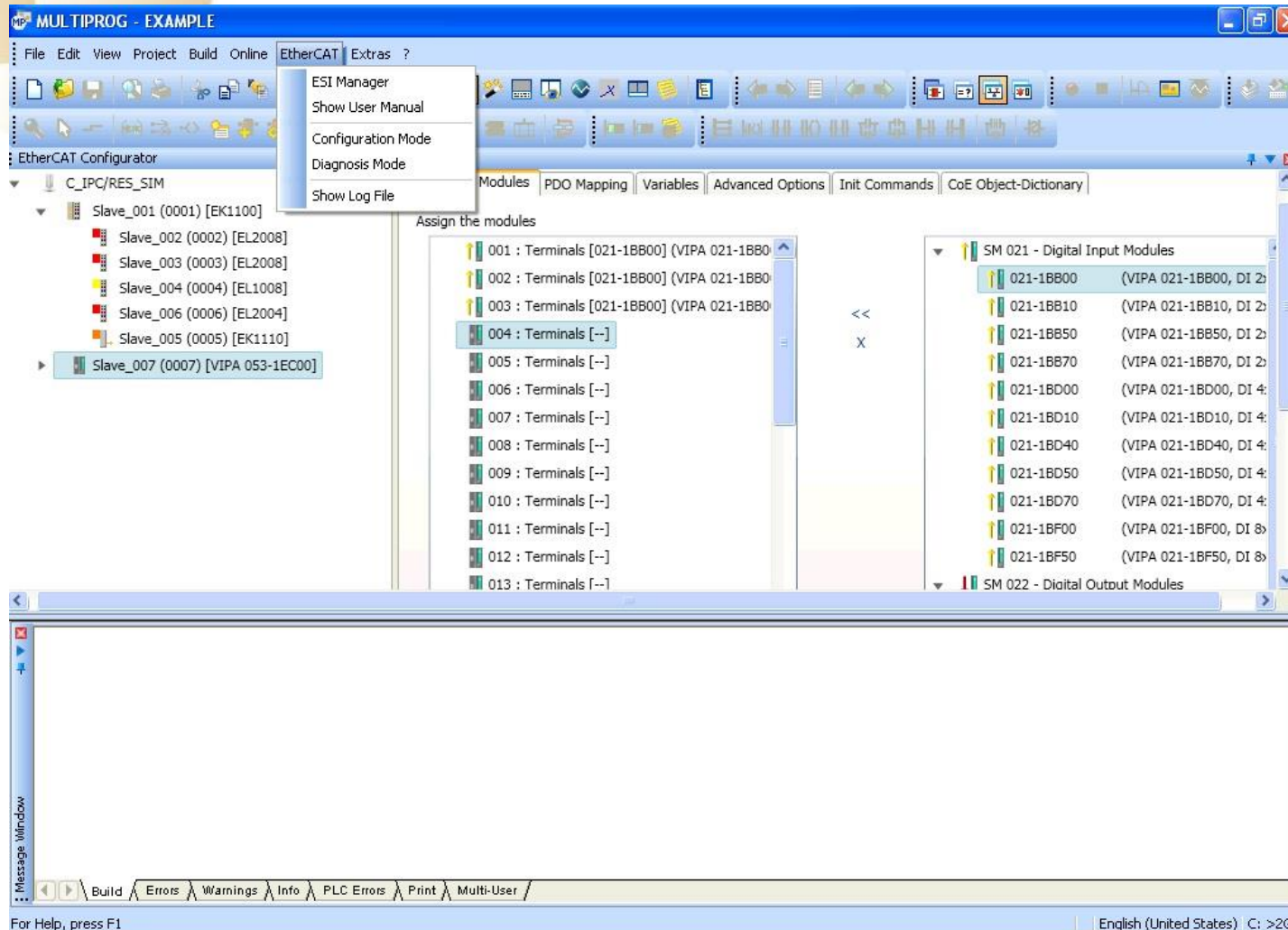
- Customer enhancements of EC-Engineer (e.g. special EtherCAT slave handling)



# EC-Engineer SDK



- Integration into existing tools
- Example: Phoenix Contact Software Multiprog PLC programming environment



# EC-Engineer Brand Labeling Kit

The screenshot shows the EtherCAT Configurator software interface. A yellow arrow points to the window title bar, which contains the text "EtherCAT Configurator". Another yellow arrow points to the "schleicher" logo in the center of the main workspace. A third yellow arrow points to a message in the "Messages" pane at the bottom, which reads "SE-Engineer".

**Window Title**

**Company Logo**

**Product Name**

**Messages**

Severity	Time	Message
INF	08:01:56	SE-Engineer

Networks: 0 | Slaves: 0 | State: [ ] | Mode: CONFIG | EXPERT

# Key benefits

- Powerful online functions together with EC-Master
  - Network scan local and remote, compare configured and found slaves (network mismatch view)
  - Access to states, variables, object dictionary, ESC register, EEPROM, etc.
- Easy to use - modern design
  - Build an configuration in less steps
  - Only reasonable settings and options are visible
  - Hide expert settings if not required
- Restriction to the essentials
  - Options and dialogs can be restricted to those features which the control system supports, e. g. available cycle times, support of mailbox protocols, DC synchronization or Hot Connect.
  - Predefined EMI (EtherCAT Master Information) files for Class A and Class B are included and will serve as templates to enhance or restrict the function according to the customer needs
- Fixed process data memory layout
  - Define a group of slaves or a single slave with fixed offsets in the process image. The layout don't change if new devices are added.
- CSV export for process data variable layout
- Adjustable/Extensible (Software Development Kit available)
  - Adjust to customer needs or integrate into customer engineering environment



**EC**  **Lyser**

# ETHERCAT DIAGNOSIS TOOL

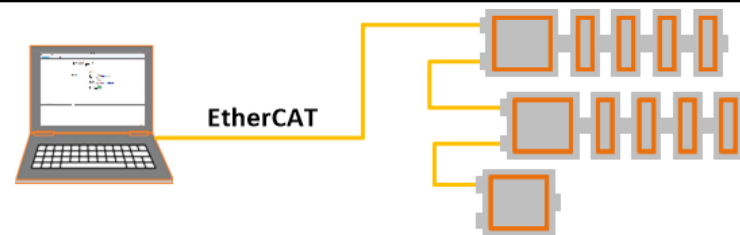
## Feature overview

- Analyze EtherCAT networks operated by EC-Master
- Find out the possible reasons for transmission errors due to
  - bad cables and connectors
  - vibrations that cause transmission interruptions
  - system degradation caused by high temperatures, oxidation, mechanic failure
  - electromagnetic fields, electrostatic discharge
- Sophisticated diagnosis functions (according to EC-Engineer)
  - Graphical display of the network topology
  - Compare actually connected slaves with configured slaves
  - Edit and view master state, slave states and process data
  - Access to master and slave object dictionaries (SDO Up- and Download)
  - Display Slave Error Register 0x300 ff.
  - Edit EtherCAT Slave Controller (ESC) Registers
  - And more

# Operation Modes

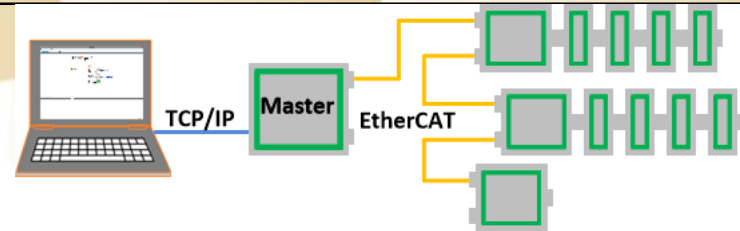
1. Local: Based on integrated EtherCAT master
  - Connect all slaves to notebook/PC, normal control system is stopped
  - Provide ENI file to set network into OP state

*Local Diagnosis:*  
Slaves connected to  
Notebook/PC



2. Remote: Network operated by original target system
  - Based RAS protocol, RAS server has to run on control system
  - Collect information while machine is running

*Remote Diagnosis:*  
Slaves connected to  
Control System





EC-Lyser

File View Network Settings Help

Stop Diagnosis Run Diagnosis

Project Explorer

Device Editor

General Variables ESC Register EEPROM Extended Diagnosis DC Diagnosis CoE Object-Dictionary

**Common Error Counter** Clear Error Counters

Processing Unit Error Counter

PDI Error Counter

**Port 0 (In port)**

Invalid Frame Counter

RX Error Counter

Lost Link Counter

Forwarded RX Error Counter

**Port 1**

Invalid Frame Counter

RX Error Counter

Lost Link Counter

Forwarded RX Error Counter

**Port 2**

Invalid Frame Counter

RX Error Counter

Lost Link Counter

Forwarded RX Error Counter

**Port 3**

Invalid Frame Counter

RX Error Counter

Lost Link Counter

Forwarded RX Error Counter

100%

Classic View Flat View Topology View

Short Info

**Information**

Name

Vendor

Product Code

Revision Number

Messages

Severity	Time	Message

Networks: 1 Slaves: 26

Status: ● Mode: DIAGNOSIS EXPERT

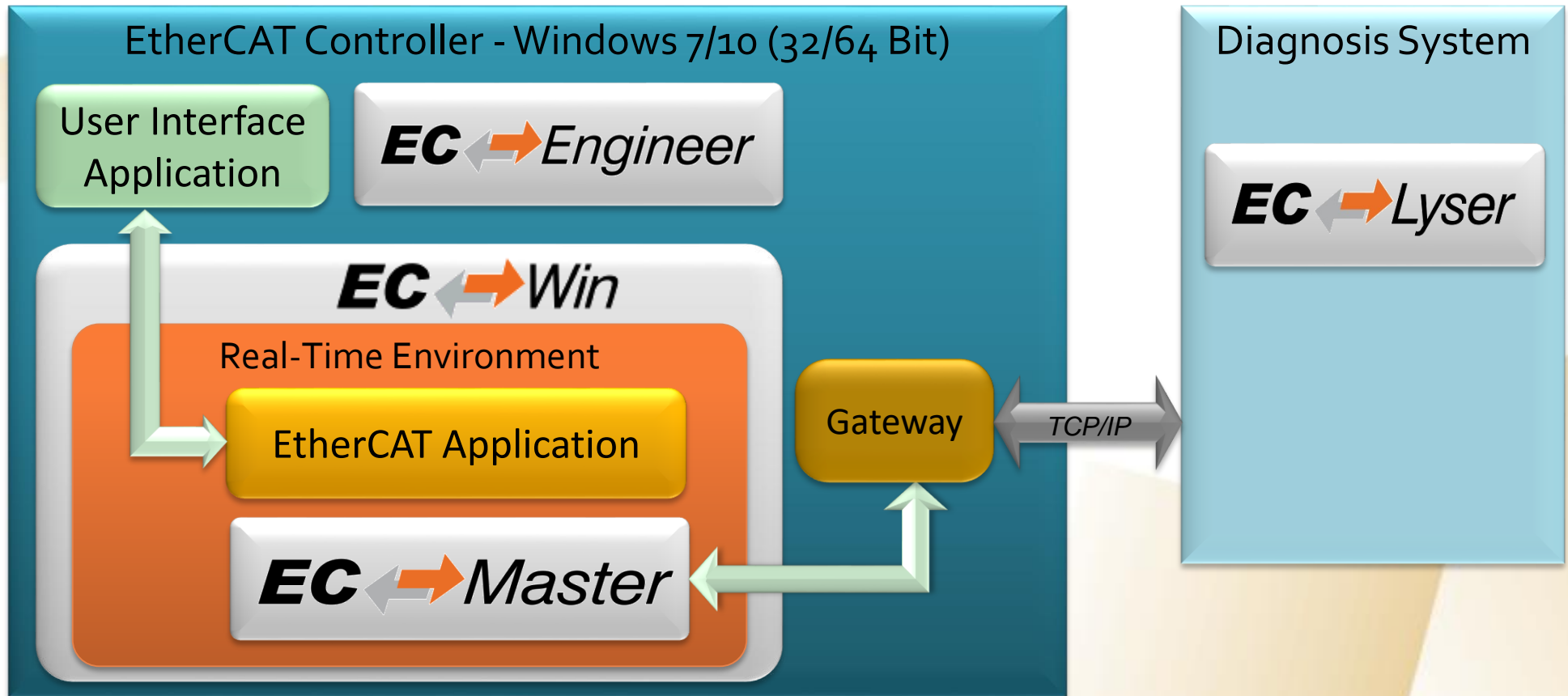




***EC***  ***Win***

# WINDOWS ETHERCAT REAL-TIME PLATFORM

# EC-Win System Architecture

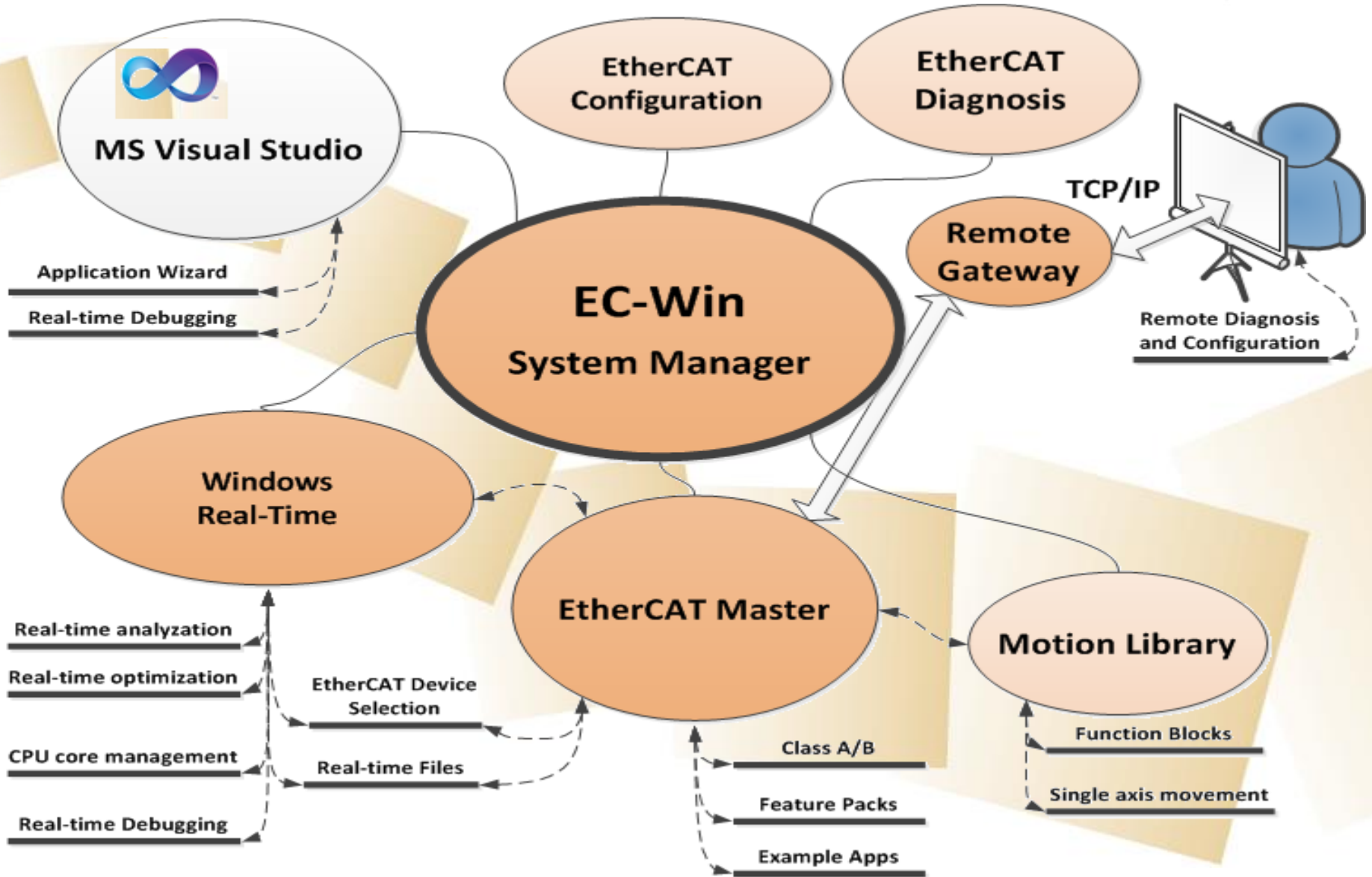


- Windows: All applications are non deterministic
- Real-time part runs on separate real-time environment

## EC-Win – Core Components

- Windows Real-time extension (standalone product: RT-Win)
- EtherCAT Master Stack (standalone product: EC-Master)
  - Running in the real-time environment
- System Manager
  - The whole development process is controlled from within this easy-to-use tool
- Visual Studio Application Wizard
  - Easily create own EtherCAT projects based on shipped demos
- Remote TCP/IP Gateway to connect external tools with master
  - No extra IP address or network bridging required!
  - Available for acontis tools (EC-Engineer, EC-Lyser) and for customer's own tools

# Fully integrated Windows EtherCAT platform



The screenshot shows the System Manager application window with the following structure:

- System Manager** (Title Bar)
- Menu Bar:** File, View, Tools, Run, Help
- Toolbar:** Includes icons for back, refresh, search, save, success, monitor, double-headed arrow, play, power, and settings.
- Left Panel (Tree View):**
  - My Computer
    - Global Settings
      - CPU Assignment
      - Realtime Optimizations
    - EtherCAT Compatible Devices
      - RTL8169 EtherCAT Driver (Realtek Gigabit Ethernet Controller)
      - Realtek PCIe GBE Family Controller
    - RTOS Files
      - ecmaster.log
      - ecmaster\_dcm.log
      - ecmaster\_mot.log
      - ENI
      - MotionConfig.xml
    - Memory Areas
    - RTOS #1 (On Time RTOS-32)
      - Settings
        - RAM
      - Devices
        - RTOS Serial port (COM2)
        - RTOS Intel(R) PRO/1000 PT Server Adapter
      - Application
        - ECMasterDemoMotion

- Main Panel (ECMasterDemoMotion Settings (Debug)):**
- General**
  - OS Image: C:\Program Files (x86)\acontis\_technologies\EC-WinRTOS-32\SDK\On Time RTOS-32 5.0 Evaluat
  - Parameters: "-i8254x 0x01020000 1 -v 3 -t 0 -b 1000 -perf -sp 3 -f ENI -log ecmaster -cfg MotionConfig.xml"
  - Change...
- Configuration**
  - EtherCAT Network Information File (ENI)
    - ENI-File: C:\config\motdemoENI.xml [Browse]
  - Motion Cfg-File: C:\config\MotionConfig.xml [Browse]
  - EC-Engineer Configuration File (ECC)
    - ECC-File: c:\config\motdemo.ecc [Browse]
    - EtherCAT Network Configuration
- Diagnosis**
  - EC-Lyser: EtherCAT Diagnosis
- Development**
  - Project Folder: C:\Program Files (x86)\acontis\_technologies\EC-WinRTOS-32\workspaces\motdemodbg\project
  - Open Project with Visual Studio...
- Status Bar:**
- Show EtherCAT Devices Only
- RTOS Stopped
- Workspace: C:\Program Files (x86)\acontis\_technologies\EC-WinRTOS-32\workspaces\motdemodbg

## Key benefits

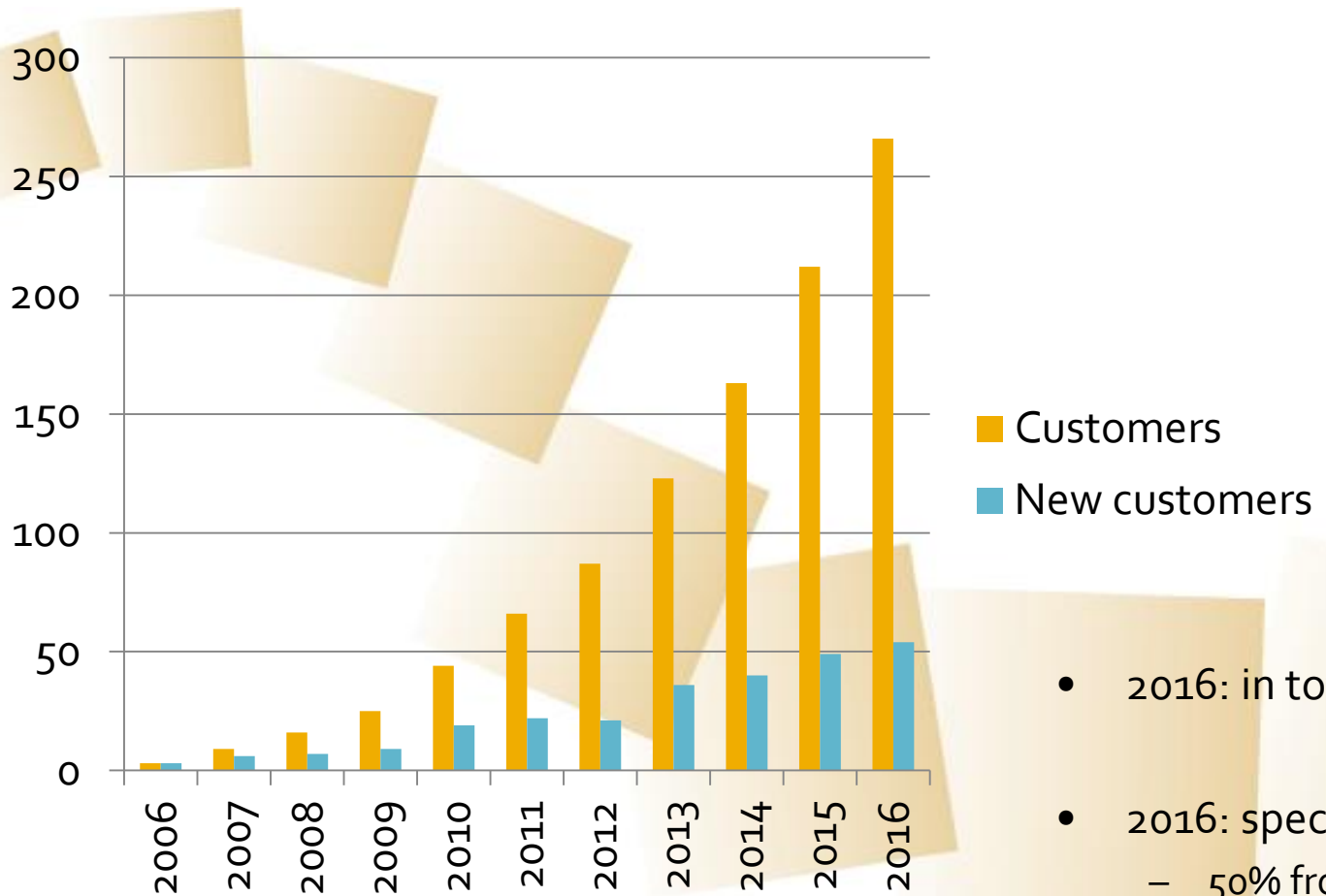
- Fully integrated EtherCAT real-time solution
  - one vendor, one support contact
  - Acontis has expertise for Windows real-time extensions back to 1994 and is leading provider for EtherCAT software since 2005
  - System Manager tool: One-stop tool for the whole product
- Hypervisor based real-time extension
  - full isolation between Windows and real-time part
- Support for symmetric multiprocessing (SMP)
  - use more than one CPU core for the real-time part
- Extreme fast Windows real-time Extension
  - Includes On Time RTOS-32 license, the fastest RTOS on the market
- Development and debugging with Visual Studio 2005 .. 2013
- External TCP/IP Gateway
  - Remote connection for EC-Lyser/EC-Engineer using the Windows IP address
- Licensing: No software activation or USB dongle



# ACONTIS MARKET ACCEPTANCE



# EtherCAT OEM Software Customers



- 2016: in total 54 new OEM customers
- 2016: specifically strong growth in Asia
  - 50% from Asia
  - 25% from China



# EtherCAT Products – Markets and Customers

## Industrial Automation

Omron (JP)  
Yaskawa (JP/US/DE)  
Kollmorgen (US)  
Bosch/Rexroth (DE)  
Panasonic SUNX (JP)  
Adlink (TW)  
Hanwha Techwin (KR)  
Shanghai Electric (CN)  
Lenze (DE)  
Delta Electronics (TW)  
Bachmann elect. (AT)  
Prima Electro (IT)  
fscut (CN)  
Krones (DE)  
ACS Motion Control (IL)  
Bobst Group (CH)  
Precitec (CH, DE)  
Ricoh (JP)  
ITRI/MSL (TW)

## Semiconductor

No. 1 Equipment Provider (US)  
No. 1 Wafer Fabrication Provider (US)  
No. 1 Lithography Provider (US/NL)  
Zeiss SMT (DE)  
Varian Semiconductor (US)

## Robotics

**KUKA Roboter (DE)**  
Cloos (DE)  
Yaskawa (JP/US)  
energid (US)  
ABB (CN), Panda (CN), HIT Robot (CN)  
Turin (CN), Jari (CN)

## Energy

GE/Alstom (ES)  
AREVA (FR)  
Enerflow (CA)  
Mitsubishi Heavy Industries (JP)

## Test/Measurement

No. 1 HIL Provider (US)  
No. 1 MsrmtEquip (US)  
Jenoptik (DE)  
MKS Instruments (US)  
Leica Geosystems (CH)  
Formula 1 team (UK)  
Brooks Instruments (NL)  
JUMO (DE)  
Instron (DE)  
Toyota (JP)  
ABB (SE)  
Weiss Umwelt (DE)

## Others

No. 1 Agric Mobiles (US)  
No. 1 Show Biz. (US)  
No. 1 Smart Phone (US)  
MEN (DE)

## Aerospace

No. 1 US Gov. Organization  
No. 1 US Airplane vendor  
CAE (CA)  
Clemessy (FR)  
IHI Aerospace (JP)


## Medical

“Under NDA” (NL)  
Curexo/Robodoc (US)  
Medtronic (US)  
Hocomo (CH)  
Cascination (CH)

## CNC

Hurco (US)  
ISG (DE)  
Prima Electro (IT)  
ESAB/ATAS (DE)  
GSK (CN)

# Markets using Real-time and EtherCAT products from acontis



KUKA Roboter (GER)

Robotics



Under NDA (USA)

Semiconductor



ACS Motion Control (ISR)

CNC



# Markets using EtherCAT products from acontis




VIPA (GER)

Industrial Automation



HURCO (USA)

CNC




Kristl & Seibt (AUT)

Test & Measurement




# Markets using Real-time and EtherCAT products from acontis




Alstom / Ikerlan (ESP)

Energy



Under NDA (USA)

Semiconductor



Under NDA (NLD)

Medical



# Why use acontis Products?

- Used by >200 OEM customers world-wide: de-facto standard besides TwinCAT
- Feature richness
  - All ETG defined features and feature-packs supported in real-world projects
  - Excellent diagnosis capabilities
- Scalability
  - Start with small solution (e.g. Class B master stack)
  - Grow with your requirements (feature packs, complementary products)
- Reliable long-term partnership
  - our customers are global leaders in different market segments
  - we are obliged for long-term support
- Your EtherCAT solution will be fast time-to-market
  - Out-of-the box for many operating systems
  - Get in running on your system in one day
- Get support from our agents in your local language
- Your EtherCAT solution will be more competitive than your competitors!



# KUKA Roboter (GER)



- Application:
  - New Generation Industrial Robot Controller
  - Integrated Safety Controller
- Acontis Products
  - EC-Master Class A Master Stack
  - FPs: Hot Connect, Remote API
  - VxWin
- Challenges
  - Symmetric Multiprocessing
  - High Performance
  - Remote Diagnosis and Configuration

# VIPA (GER)

# EtherCAT®



## PLC with EtherCAT fieldbus

- EC-Master Class A Master Stack
- FPs: Hot Connect, Master OD, EoE Endpoint, Remote API
- ARM with embedded OS

## Engineering Suite

- Integration of EC-Engineer with own design/theme
- Online functions using RAS client

Gerät	EtherCAT_Slave_1	EtherCAT_Slave_2	EtherCAT_Slave_3	EtherCAT_Slave_4	EtherCAT_Slave_5	EtherCAT_Slave_7
Slot	0	1	2	3	4	5
Baugruppe	3M 0538C	DOBDC24V	DOBDC24V	DOBDC24V	DOBDC24V	DOBDC24V
Bestellnummer	053-1E000	021-18F00	022-18F00	022-18F00	022-18F00	022-18F00
E-Adresse	8181	2	11	11	12	0
A-Adresse						
E-Adresse (DPR)						
A-Adresse (DPR)						
Kommentar						

# acontis technology – behind the stage!

