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EtherCAT: One Machine Network

EtherCAT is becoming the most popular machine protocol. Why? Unmatched performance, the highest precision and real openness make the difference to other Ethernet industrial protocols.

EtherCAT is the acronym for Ethernet for Control Automation Technology. It is an Ethernet (IEEE 802.3) compliant BUS, developed to be used in an industrial environment.

In recent times, the use of Ethernet industrial protocols has become more and more popular: EtherNet/IP, EtherCAT, and others are common terms that have been added to our vocabulary. All these protocols have a common physical media: Ethernet.

The most common Standard Ethernet is the 100-Base-TX + RJ45 connector:

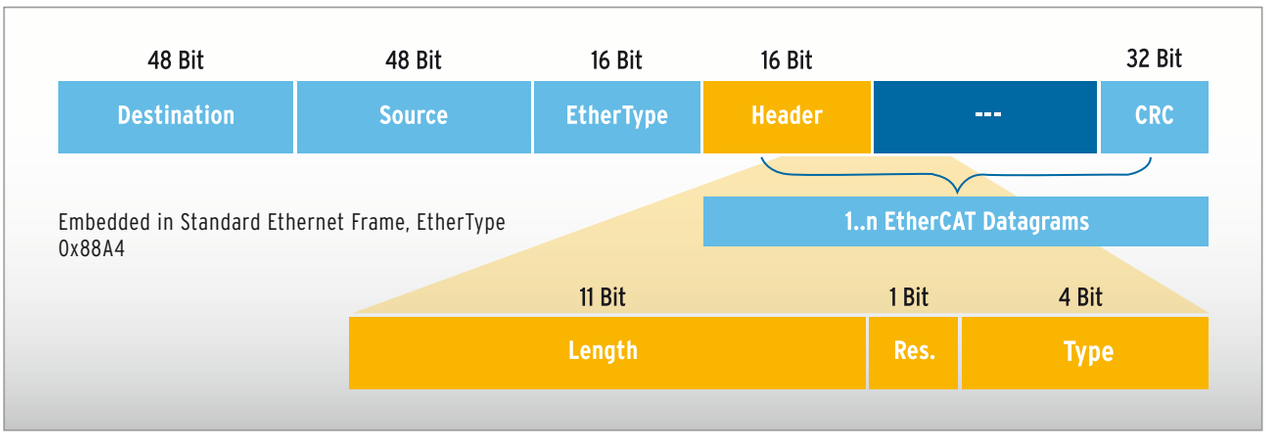
- Proven technology
- Up to 100 meters between devices
- Good noise immunity (Industrial Cable)
- Affordable/cost-effective cables
- Easy to manipulate, crimp, etc.

There are thousands of kilometers of Ethernet cables, in offices, homes and public infrastructures. It is possible to purchase cables of a reasonable quality, in every computer shop. However, in factory application it is recommended to use industrial cable versions (CAT 5 or higher), in addition to industrial class connectors.

The right Network for the right purpose

Common sense and good manners, recommends us to better use a spoon rather than a fork when eating soup, this is because a spoon has a better design for handling liquids. A similar approach can be taken for Industrial Ethernet Protocols, as not all protocols exhibit the same performance and features.

- Ethernet/IP is an excellent network for controller to controller applications with a natural integration in Company Corporative Networks. Using standard Ethernet hardware, EtherNet/IP is the



perfect Factory Automation Network where the data size exchanged by node is high.

• EtherCAT exhibits outstanding performance with devices that exchange few amount of bytes but require very deterministic and fast communication cycles. In addition due to the 'on the fly' data exchange EtherCAT is hardly affected by the number of nodes, it is the perfect Machine Network.

Both networks, Ethernet/IP and EtherCAT are open networks, represented in the ODVA and EtherCAT Technology Group.

This article, will highlight some aspects that make EtherCAT a very special Machine Network, and Omron's de-facto standard for Machine Automation.

EtherCAT throughput

EtherCAT uses standard IEEE 802.3 Ethernet frames. The EtherCAT telegrams (EtherType 0x88A4) are encapsulated inside the standard Ethernet frame. The Ethernet frame was originally designed to handle large amount of data, and most of the Ethernet Industrial I/O protocols do not make efficient use of the Datagram space.

Imagine that the Ethernet Frame is a large school Bus with about 1500 seats (bytes). Only a few seats, can be occupied by a passenger and therefore in order to transport 1500 people a lot of school Buses will be required. A consequence of this will be that the highways (bandwidth) would rapidly collapse during rush hour.

It would be desirable to make a more efficient use of a large school Bus (Datagram). If just one Bus was used, traffic jams on the highway (bandwidth usage) would be dramatically reduced.

As expected, this is exactly what EtherCAT does, by allocating data from several nodes in the same Ethernet Message, so that bandwidth usage is more efficient than other Industrial Ethernet networks.

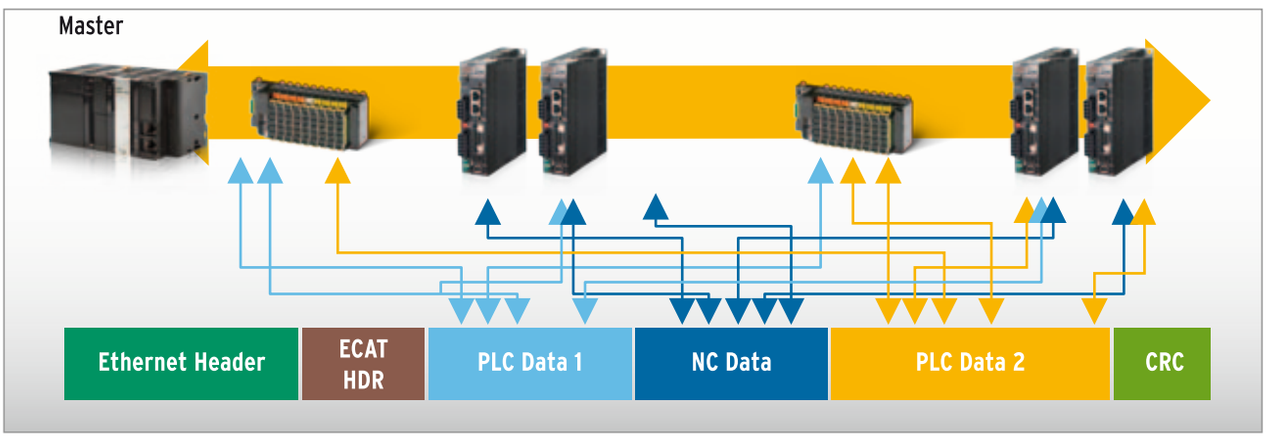
Data exchange 'on the fly'

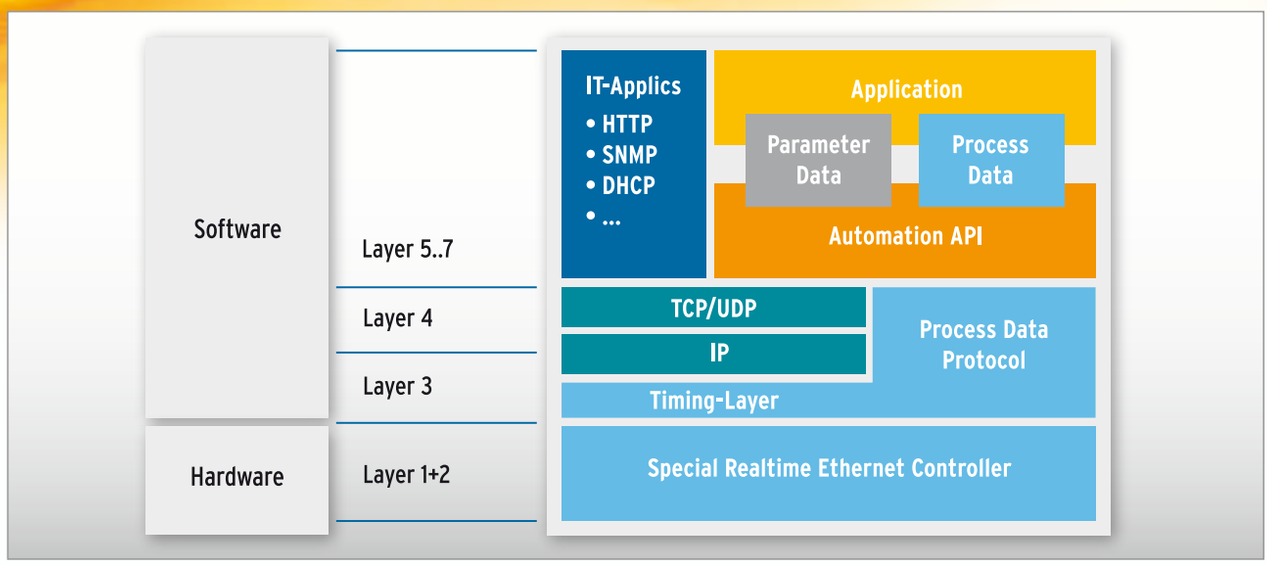
Thinking about the previous school Bus example – the Bus stops at each Bus station (node). It would be fantastic to have a method that allows passengers (data) to get In and Out of the Bus without the need for stopping! However, as we know this is something that is impossible for a school Bus, it is, however, possible for EtherCAT.

EtherCAT Slave nodes exchange data 'on the fly'. In order to exchange data as quickly as possible this task is performed at hardware level, by means of a specific EtherCAT Slave 'chip'.

There is a big difference in performance between Ethernet Networks that just use the Software layers of the OSI model (layers 3 to 7), and Ethernet Networks, like EtherCAT that have dedicated hardware, affecting OSI layers 1 and 2.

odva.org, ethercat.org





Throughput and precision: Distributed Clocks

The throughput of a network is a measure of the quantity of information that can be transmitted in a certain time. Throughput is determined by the bandwidth, but as explained before, the efficiency and the implementation of the protocol also makes a difference.

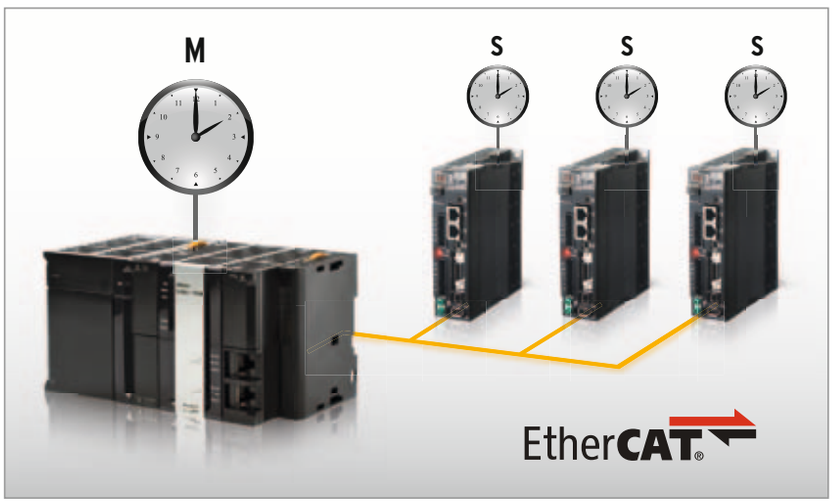
EtherCAT has a superb throughput, but 'brut force' without control is not always the best option.

Precision is also a fundamental parameter to determine the health of a network.

An ideal network will update data in a fixed period and with no fluctuation. Using the example of the school Bus, the Bus must exchange passengers at each Bus stop, day after day at the same time, e.g. 10:00 o'clock. When the Bus is advanced or delayed, let's say by +/- 5 minutes, this causes big problems for the passengers who are affected by this undesired random behaviour. This time fluctuation in a periodic transmission process is named jitter, the higher the jitter the worse the precision.

A network intended to be used for Motion Control applications must have a very low jitter or implement compensation mechanisms. EtherCAT has by design a very low jitter, efficient usage of the bandwidth and reliable data exchange is executed at hardware level. However this jitter is influenced by many factors, such as cable length, number of nodes, temperature etc.

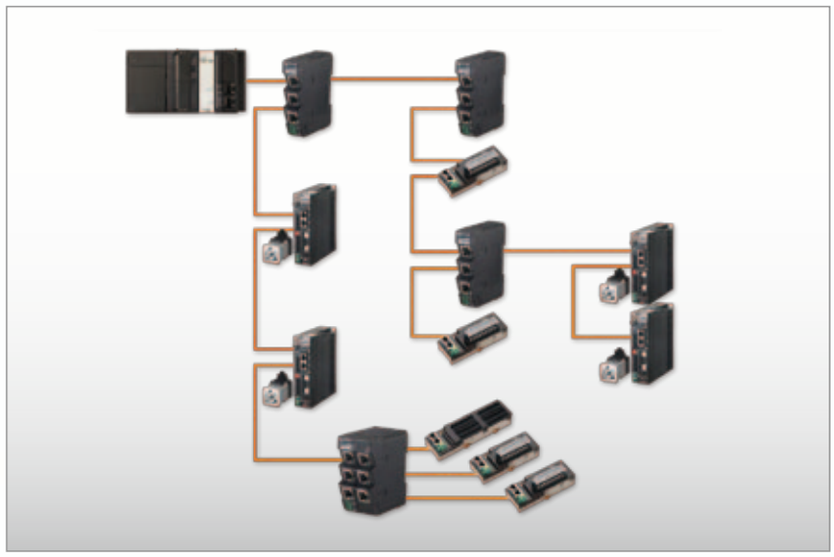
The distributed clock mechanism, implemented in the EtherCAT is a compensation mechanism that reduces the already minimum jitter of the network to a negligible value of less than << 1 µs! This technique is based on implementing clocks in the different nodes of the network, these clocks are precisely synchronized and data transmission has a time print, therefore any potential jitter can be compensated by the slaves.



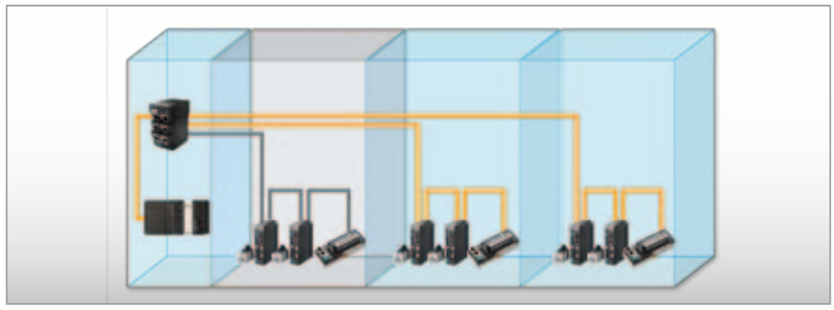
EtherCAT topology

One of the features that makes EtherCAT attractive as a device network, is that in contrast to many other Ethernet networks, a daisy-chain network can be established with no need for additional Ethernet switches. All EtherCAT slaves have at least an IN port and an OUT port so that the EtherCAT telegram easily flows though the network, with no need for additional hardware.

When the application requires different topologies: daisy-chain, tree or star, Omron's GX-JC branching units, can be used.



Branching units also allow a hot-swap of devices without affecting the performance of the other network segments.



EtherCAT: Open network

The EtherCAT Technology Group is the official standardization entity that defines the EtherCAT standards. EtherCAT follows international standards (IEC 61158, IEC 61784-2, IEC 61800-7, ISO 15745, E54 20 etc.)

EtherCAT includes more than 1750 members (August 2011), becoming the largest fieldbus organization in the world, with ETG offices in Germany, USA, Japan, China and Korea.

In particular, Omron masters and drives support CANopen over EtherCAT (CoE), with the CIA-402 Drive Profile, which qualifies the Sysmac system for demanding motion control applications.

Omron guarantees the optimum performance of Omron EtherCAT slaves in combination with Omron Sysmac NJ Controller, and because of the openness of EtherCAT, also 3rd party slaves (i.e pneumatic devices) can be integrated into the Sysmac system. For this purpose, Omron has established several certification laboratories worldwide, formally called "Tsunagi" laboratories, that will perform the required interoperability tests.

Conclusions

EtherCAT is an Ethernet open standard that is being adopted by more and more manufacturers. Our commitment to EtherCAT has resulted in an increasing number of products, including: Controllers, Rotary and Linear Drives, Inverters, I/O modules, Vision systems, EtherCAT Safety (coming soon) and more, qualifying EtherCAT as a real Machine Network.

For further information please order our Sysmac Brochure or visit our website industrial.omron.eu