# CAN and Ethernet – similar but different

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***Introduction***

*Ethernet is significantly older than CAN. While Ethernet was invented in 1973 but published in 1976, CAN was created in 1983 and published in 1987. Both networks had the reason for their invention in common: The need for various devices to communicate. This article outlines the differences between CAN and Industrial Ethernet and shows some of the challenges of Industrial Ethernet with some technical background. Furthermore it raises the question: Why switching to Ethernet at all?*

CAN and Ethernet have the need for communication in common. Other characteristics are different, for example the kind of devices the networks are used for. From the very beginning CAN was intended to transfer small packets of control data in hard real time, while Ethernet was created to move large amount of data. For Ethernet, being deterministic or real-time was not part of the plan. Common is also their creation as busses. CAN is still a bus, Ethernet not anymore. The switch to twisted pair and star topology as well as the use of multiport bridges made Ethernet even more of a "data lorry".

At first Ethernet shared with CAN the idea of a bus: All nodes were "listening on the same wire", the Yellow Cable or the RG58, the Cheapernet. This topology was limited to 10 Mbit/s. Only Half Duplex communication was possible. Upon transition to 100 Mbit/s the common basics of CAN and Ethernet vanished completely when the Ethernet topology changed to point to point topology with Twisted Pair cables. The Full-Duplex Mode, introduced by the Ethernet Multi Port Bridges, which was called "Switches", took over and the Half Duplex Mode, used by the repeaters, also called "Hubs", disappeared.

In the Half Duplex Mode every network message was seen everywhere in the network. On the face of it this seems to be an advantage, especially considering that Hubs cause a very small delay. Figure 1 shows the typical delay of a hub. The significant effect is that in a Half Duplex network only one node can communicate, while all other nodes are quiet. Every node on the network sees all valid data packets, which is good for Real-Time Control such as it is used in CAN networks, but bad for a "data lorry" network, since other nodes could be communicating during this time.

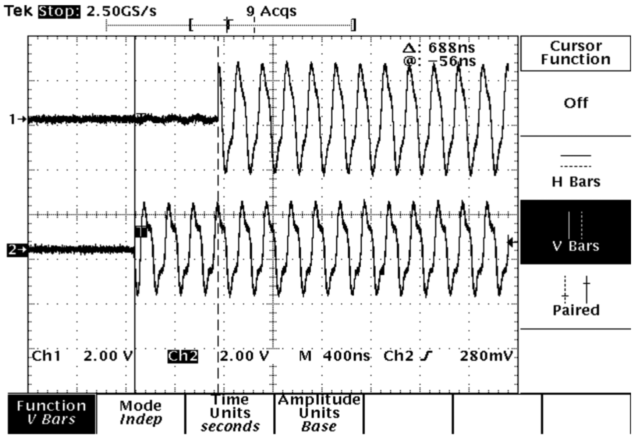


*Figure 1: Delay caused by a Hub*

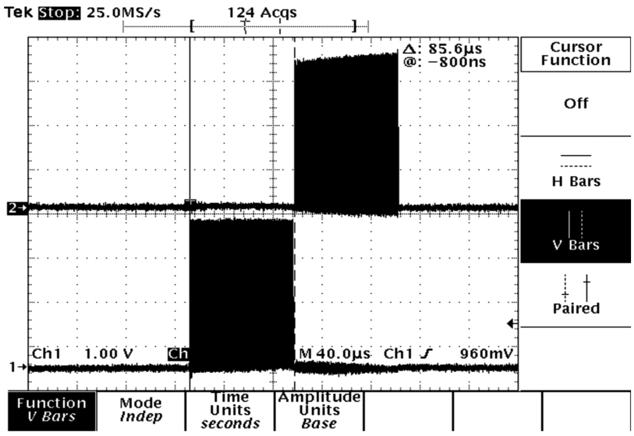


*Figure 2: Delay introduced by a Switch (best case)*

Full Duplex uses Ethernet Switches, and Switches cause delays by storing packets and sending them out randomly – or not, if something goes wrong. A switched Ethernet network with its highway-like infrastructure provides a perfect base for the Ethernet "data lorries".

## The hardware

Connecting CAN to the bus takes little effort: Take a CPU or MCU with on-board CAN controller, some optional optical isolators, a CAN transceiver, and a connector. For software connectivity (e.g. CANopen) a protocol library is needed, in a perfect world coming with a GUI Design

Tool to ease up and speed up the development process.

Connecting Office Ethernet is not significantly more complicated than CAN. The components are similar: Take a PHY (equivalent to the transceiver), an Ethernet transformer (equivalent to the optical isolator) and a RJ45 connector.

Connecting to Industrial Ethernet is not that simple since many aspects need to be taken into consideration. The components are basically the same; however Industrial proof equipment needs to be used. A protocol library with corresponding Design Tools is needed for the software here as well – in a perfect world the libraries would be compatible with other protocol libraries.

## Star vs. line structure

Different than CAN, Ethernet is connected in star structure: One single Ethernet port is connected to an Ethernet Switch. For obvious reasons this doesn't always make sense in Industrial Ethernet applications. To accomplish a line structure an Ethernet Switch or Ethernet Hub needs to be built into the unit.

Since nothing is easy when it comes to Industrial Ethernet, specific line structure components need to be incorporated – e.g. a Managed Switch, an extremely low latency Ethernet Hub for Powerlink, an Ethercat slave controller for Ethercat, or a managed Ethernet switch for Profinet and Ethernet/IP.

## Powerlink

Powerlink was among the first Industrial Ethernet networks. It adopted the CAN in Automation communication scheme as well as profiles and was considered the CANopen on Ethernet for quite some time. It needs specialized hardware to take advantage of Ethernet's features while maintaining industrial suitability. This hardware is an extremely low latency Hub and a special MAC, which can reply to messages with a dynamic answer in hardware, roughly comparable with CAN's Remote Transmission Request. These components are usually carried by a FPGA. Only in very rare and very specific use cases, standard Ethernet components are suitable. Powerlink claims full management of the network and only grants access to "regular" (TCP/IP) network traffic in the ASND cycle.

## Ethercat

Ethercat comes with a completely modified Layer 2, always needing an Ethercat Slave Controller (ESC) – the physical layer component of Ethercat. These ESCs are available by Beckhoff as IP-Cores for FPGA or ASIC component. Some semiconductor manufacturers have integrated ESCs in their CPU/ MCU designs. Ethercat claims full access to the network as well and allows for "regular" (TCP/IP) network traffic with the EoE (Ethernet over EtherCAT) mailbox protocol.

## Profinet and Ethernet/IP

Different than Ethercat and Powerlink, Profinet and Ethernet/IP work with standard components only except for Profinet IRT. Both protocols can be integrated in standard network environments and are able to use existing network stacks (e.g. TCP/IP Stacks). While Ethernet/IP uses only regular UDP/TCP communication, Profinet uses a proprietary scheme for real time data. Both protocols represent the most significant market share.

## Conclusion

Application requirements can sway the decision in favor of Ethernet or CAN. While CAN is designed for Industrial Automation, Ethernet is made ready for Industrial Automation. Both work fine, however they are based on different paradigms. ◀