Ethernet links CANopen domain controllers

Structuring the vehicle network architecture into separate domains becomes highly meaningful. A powerful unit can be used to perform all domain-related tasks.

Domains separated by Ethernet interfaces using a ring topology (Source: TTControl)

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The agricultural machinery market is advancing as fast as many other high-tech sectors, and we see more and more start-ups and large companies moving into the market. Major trends such as connectivity and automation, as well as the growing ecosystem of software and hardware that needs to coexist and interoperate, bring new challenges that must be addressed in the very first stages of the development of a mobile machinery – right at the drawing board. Above all, a machine will no longer be an independent entity, but will likely exist as part of a group of machines that form a higher entity. All of these trends and technologies bring about three direct consequences for the electronic architecture of a vehicle:

- Higher bandwidth requirements are imposed on the vehicle´s communication channels.
- The machine's electronics are becoming increasingly complex.
- Security must be improved.

Bandwidth requirements

In general, and across all verticals of mobile machinery markets, there is an increase in the amount of data being transmitted. Newer, more complex sensors and cameras produce more data that needs to be processed by the control units and displays. Furthermore, the connectivity between different control units in different areas of the machine requires reliable data distribution over the electronic network.

Modern agricultural machines, such as tractors or highly automated harvesters, employ numerous CAN networks to enable communication within the control system, for example engine CAN or vehicle CAN. For this purpose – depending on the application – the CAN-based Isobus (ISO 11783) is used in addition to allow communication with implements such as trailers. SAE J1939 is often used as a basic protocol for these CAN networks, which specifies a bit rate of 250 kbit/s. In the case of Isobus, an implement that offers virtual terminal client functionality must transmit the associated object pool to the Isobus universal terminal in the machine.

Illustration of vehicle architecture with a central communication node (Source: TTControl)

Depending on the specific features and functionality of the implement, this object pool can take up to a few megabytes. At 250 kbit/s the transfer of data that occurs at start-up can take a significant amount of time, especially considering protocol overheads and the fact that the communication protocol is contention based and that the CAN network must be shared with other devices. The bandwidth requirements of new technologies, such as the continuously increasing resolution of displays, IP cameras (in some cases with surround view functionality), sophisticated fleet management systems using technologies from the IoT/Industry 4.0 world, as well as increasing automation of machine functions all exceed the currently available bandwidth by orders of magnitude. A single IP camera creates a data throughput in the range of 10 Mbit/s.

A modern CAN-based system which includes complex gateways often has an overall bandwidth of approximately 1 Mbit/s to 2 Mbit/s, whilst future technologies will create a data volume that is up to three orders of magnitude higher than currently available. Several of these functions, especially the automation functions in the area of drive, steering, and working functions also set strict requirements on functional safety, security, and real-time capability. These requirements come to the fore when automation functions have to share the physical communication medium with other services, for example in a steer-by-wire system that shares a network with the diagnosis system that has cloud access.

In this case, it must be ensured that in the event of problems in the diagnosis system, the automation function continues to have guaranteed bandwidth and latencies, so that the steering continues to work reliably and safely, despite any unwanted network load created by the diagnosis system. At this point the need for different paths and routes for data arises in order to transverse vehicles without compromising intended functionalities of each particular block. This can be achieved by utilizing alternative transport technologies which operate side by side to create multiple network domains within the same architecture.

Traditional control protocols can be implemented using CAN-based protocols, whereas bandwidth intensive applications and components can utilize the added capacity of Ethernet technology. Data then flows from one interface to the other as needed by the application. At the intersection of the different interfaces a central communication node ensures that the data is properly and efficiently transmitted from source to destination. This communication node, or gateway, allows for the separation of different "zones" and enables the implementation of very complex systems using a segmented and scalable approach. It is worth noting that in the automotive market, which has very similar requirements to the agricultural market, the use of Ethernet is now pervasive, and standards based.

Suppliers of Automotive Ethernet (100Base-T1, 1000Base-T1) Socs are now in full production and the adoption rate is increasing. Adoption of the technology in the mobile machine market is slower but will grow in the coming years as the applications demand it. Standard Ethernet (100Base-TX, 100Base-TX) is also present in many devices in the off-highway market, such as displays or telematics nodes, as it provides a way to connect to the machine with service computers and diagnostics tools. Many industry players are already working on solutions to address the increasing needs of bandwidth and capacity of machine architectures. Most notably the AEF and the group of companies that contribute to the Isobus standard have been working on the High Speed Isobus standard, which provides gigabit grade connections over unshielded twisted pairs and is based on existing Ethernet technology.

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