CARRYING THE CAN

CAN HAS BEEN THE MAIN COMMUNICATION PROTOCOL USED IN INDUSTRIAL VEHICLES, BUT THE LATEST TRENDS HAVE SEEN ETHERNET TECHNOLOGY GAINING INCREASING USE FOR WHEN CAN CAN'T QUITE MANAGE ON ITS OWN

Rear view of the CCpilot XA

Several technologies from sectors such as the automotive and factory automation industries have influenced industrial vehicle OEMs over time and, as a result, new solutions have been developed that provide collaboration and savings through economies of scale. One of the common denominators where synergy benefits have not yet been exploited in full is the communication bus.

CAN is proven, mature, and widely supported. However, it also has a few weaknesses, such as the limits in its bus and branch line length and its general throughput. Also, if a single bus, be it wired or wireless, could serve all vehicle systems, from control systems to infotainment, then it would simplify and reduce the cost of vehicle construction.

On this basis, and keeping in mind that overall data volumes and real-time responsiveness requirements are likely to grow, the bus performance issue clearly needs to be addressed. At the same time, the benefits of CAN should not be forgotten.

Ethernet, when added with real-time services, can fulfil the requirements of a deterministic, flexible, high-performance, open, general-purpose next-generation bus for vehicles. With throughput of 1Gb/s available today, it can outscore FlexRay, which has quite a limited application base in the high-end car industry. FlexRay also has some critical limits in bus topology and length, and it is not clear how open it would really be beyond the automotive sector. Ethernet is also gaining ground in the research plans of key FlexRay deployers, giving even more opportunity and leverage for a cross-sector technology push.

Ethernet emerged in factories some 10 years ago, with initial concerns on safety, speed, and timing. The issues were tackled with controlled isolation of process network from business network, and by improved network design. Today, it is used widely in automation. Using the higher bus speeds on Ethernet cuts down the amount of data collisions and lost data, and delays are no longer an issue. Switches can optimise speed and service quality, and enable devices to connect to the bus at different speeds.

Wide selection of Ethernet protocols

The mixture of protocols for Ethernet use is wide and numerous, and there is no clear winner that would fit with all requirements and architectures. And still, there is the choice to use plain TCP/IP. Admittedly, Ethernet would benefit from better consolidation to overcome the current wide set of standards.

Several protocols can be run in the same bus, but with some limitations, however. In any case, devices need to speak the same language to understand each other. For reference, to name a few of most frequently used protocols in industrial automation, we can mention Ethernet/IP, Profinet, Modbus TCP, Ethernet Powerlink, and EtherCAT.

To facilitate the re-use of existing solutions on a device profile level, some migration paths can be identified. Migration from CANopen is one of the inevitable questions, due to its large installed base in vehicles. Protocols that contain a CANopen profile, such as Ethernet/Powerlink, EtherCAT, SafetyNet p, and Varan, are most interesting in this sense. An evolution path also exists from Profibus and DeviceNet to Ethernet. If a migration path can be found, re-use is more likely to pay off.

One key requirement for a protocol to succeed is for it to be supported by several network device brands, as most vehicle OEMs are desirous to avoid a vendor lock-in situation. Another pitfall, which works against the openness of Ethernet, is that some specific protocol implementations can turn out to be tied with proprietary circuits.

Some of the protocols have large overheads, often leading to the need for a specific FPGA to manage the processing load of driving the bus traffic. This also leads to a situation where a protocol cannot be supported with a software-only solution.

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LEFT: **Control modules with both CAN and Ethernet may act as nodes, connecting CAN segments to an Ethernet back end**

System architecture aspects

The automotive industry, in particular, has proven methods for building a diversified, almost personal offering with a foundation in platform thinking. The industrial automation sector can brag about complete standardised enterprises on one network, vertically from a single sensor on the factory floor to a remote ERP system, and beyond that.

Equally well, industrial vehicle OEMs can benefit from technologies that increase product value and share platform development, therefore saving cost and shortening time-to-market. With a market that requires ever shorter cycles for new product releases, the ability to be fast, flexible, and efficient in system development is becoming increasingly important. Furthermore, efficient maintenance also has a visible effect on the total system cost. Savings arise from reduced material and labour costs throughout the vehicle life cycle.

Deployed CAN-based systems will sometimes be kept due to environmental requirements, as ruggedised modules might not yet be available for a totally Ethernet-based control system. Ethernet muxes and switches are not typically enclosured with an IP classification against rough environments. Also on sensor level, the available selection is not yet very wide when it comes to rugged environments. A missing classification would cause a deviation to the whole control system, which is, of course, not tolerable. In such cases, a mixed topology of Ethernet acting as an in-vehicle backbone of one or more downstream CANbuses can be applicable. Utilities such as CAN-to-Ethernet gateway can be used to enable, for example, service laptop use in the field.

Safety compliance requirements will also drive hardware module choices. This is a growing area in every industrial vehicle subsector, with legal requirements leading to a wave of next-generation control system design, often enforced with safety certification. This will have an impact on the communication subsystem as well, setting specific requirements in fault tolerance and recoverability. Some of these will need to be addressed on the protocol layer, but in total, Ethernet is not a blocking factor for building a safety-certified control system.

Converging applications

Ethernet is growing into a universal networking interface, as it is familiar to most IT support and office environments. When compared with CAN, it is easier to use and maintain, and the infrastructure is competitively priced and often readily available.

In-vehicle control systems increasingly expand system boundaries, which calls for interaction with neighbouring systems and the introduction of new kinds of data feeds through sensor fusion. For example, the detection of other objects at the worksite, as part of safety at the workplace, requires several cameras to cover all blind spots beyond operator vision. This typically leads to high data volumes and demanding requirements on communication throughput reliability.

Other in-vehicle systems such as infotainment and navigation are increasingly creeping into the cabin as well. User experience requirements on such systems originate from consumer electronics, with fancy and entertaining user interfaces. In time, they will have their impact on industrial control systems as well, evolving from co-existence to convergence. For the operator load, system usability, and safety, it is still critical that the operator's focus remains on his or her main task.

The machine operator is not the only beneficiary in the game. Remotely connected systems, such as fleet management, yard management, ERP, and other back-office systems interact with the vehicle. Looking at the total picture, new communication architectures can also have a role in helping to achieve a smaller environmental footprint in the industrial vehicle sector.

Having several interfaces available in a single controller or display computer makes it possible to design a well-integrated system with more functional software, saving both cabin space and system costs. This also enables the designer to place more functions in the same, easy-to-reach position for ergonomy and lower load for the operator. **iVT**

Marko Elo is R&D manager at CrossControl Oy, Finland. He has worked in the field of industrial systems since 1990

CONTACT
www.crosscontrol.com
info@crosscontrol.com