CAN-based monitoring in refrigerated transports

Perishable food products such as vegetables, fruit, meat or fish require refrigerated transports. Effective cold management is fundamental for maintaining the quality of these products along the supply chain. The use of standardized CAN technology improves monitoring transports ensuring the inter-operability of the system. A variety of sensors and actuators can be integrated in the CAN. Information provided by sensors is exchanged; alarms are triggered in case of anomaly data. Also devices for fleet management, tachograph and satellite communications may be a part of complete system. Technologies such as Wireless Sensor Networks or Radio Frequency Identification may be implemented in an on-line monitoring environment in the future. Thus, the challenge is interconnecting these heterogeneous systems and harmonization of the different interfaces.

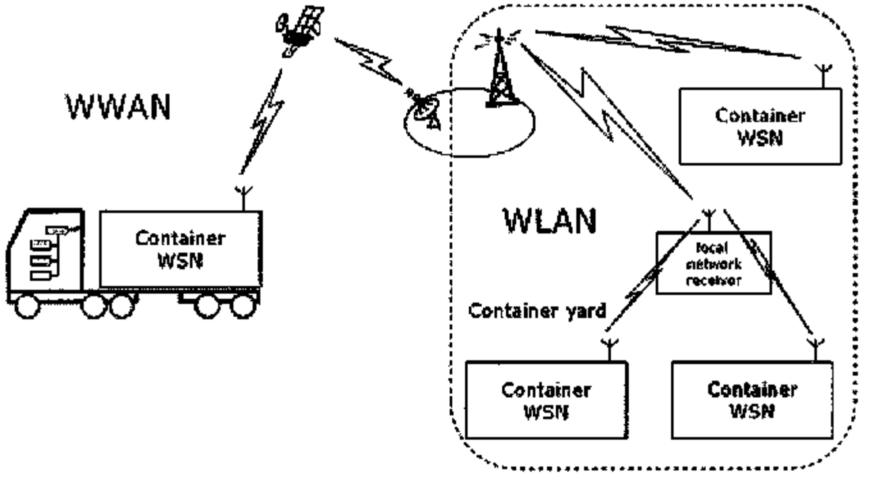

Fig. 1: WWAN, WLAN and WSN in intermodal transport

The quality of perishable food products might change rapidly, because they are submitted to a variety of risks during transport and storage that are responsible for material quality losses. Among them, intrinsic biological and chemical processes that undertake the fresh produce are related to a lack of appropriate control on duration, temperature and humidity, which causes senescence and rots. As a consequence effective cold management is fundamental for maintaining product quality along the supply chain. Quality control and monitoring of goods transportation is of particular interest for the refrigerated transport industry. The major challenge is to ensure a continuous 'cold chain' from producer to consumer. It is essential to ensure that temperature inside the transport units is correct.

Refrigerated road vehicles and containers equipped with embedded cooling systems do the transport. Some of them include monitoring systems, which do not bring complete information about the cargo, typically measuring in a single or very limited number of points.

The use of standardized CAN technology can improve monitoring transports, ensuring the interoperability of the system. A variety of sensors and actuators may be integrated in the CAN. At not-permitted conditions, alerts are released. Connected actuators will be responsible for controlling forced airflow, cold generation and defrosting. But not only sensors and actuators can be part of the network. Also devices for fleet management, such as Global Positioning Systems (GPS), tachograph and satellite communications, can be a part of whole system. And in near future, more emergent technologies such as Wireless Sensor Networks (WSN) or Radio Frequency Identification (RFID) will be ready to implement in the on-line monitoring of perishable goods.

The challenge is the interconnection of the different sub-systems, with different interfaces and profiles, to the CAN as backbone system. The system should comprise multiple types of sensors, with distributed measures depending on location. Authorized supply chain participants will track a container's progress as it travels from the point of stuffing to the point of unloading. Logistics personnel will obtain this information for their shipments from the information network and can use it for supply, factory and route planning.

In-vehicle networks for trucks/trailers

CAN-based systems are the basis for road vehicles (SAE J1939 and ISO 11992) and also for ships (NMEA 2000). The CAN protocol was internationally standardized in 1993 as ISO 11898. It is one of the most commonly used field buses in application domains that have real-time requirements, such as passenger and cargo trains, maritime electronics, aircraft and aerospace electronics, factory automation, industrial machine control, lifts and escalators, building automation, medical equipment and devices.

CAN hardware implementations cover the two lower layers of the OSI reference model (physical layer and data link layer) while higher layer protocols cover the rest of the layers. ▶

Examples of CAN-based higher layer protocols are CANopen, DeviceNet, J1939, etc.

The J1939 application profile defines the CAN-based in-vehicle communication for trucks and buses. A J1939 network connects electronic control units (ECU) towards a truck or trailer system. J1939 specifies, e.g. how to read and write data, but also how to calibrate certain sub-systems. The maximum length of a J1939 network is 40 m, with a maximum number of 30 nodes and data rate of 250 kbit/s, allowing 1 850 messages per second.

The ISO 11992 is a standard defining interchange of digital information on electrical connections between towing and towed vehicles. It specifies a J1939-based application profile for communication between truck and trailer. The ISO 11992 standard is also suitable for road trains with up to five trailers. The address assignment procedure is initiated by the commercial vehicle, which automatically assigns addresses to the towed vehicles.

Parameters and messages for electronically controlled braking systems (e.g. anti-lock braking systems) and for running gear equipment (e.g. steering, suspension and tires) are specified in second part of ISO 11992 specification. The analog parameters are specified by data length, resolution including physical units and offset, data range and type (measured or status). Defined diagnostics services are divided into basic (i.e. vehicle independent identification and information) and enhanced diagnostic applications.

A Special Interest Group (SIG) within CiA is working in the development and maintenance of CANopen gateway profile for trucks (CiA 413). Thus a set of CANopen interface profiles has been developed, specifying gate- ▶

ways to J1939 in-vehicle networks for trucks, buses, trailers and other commercial vehicles. Also interfaces compliant to ISO 11992, SAE J1939-71, or ISO 11783 (Isobus) have been established.

Wireless communication

There are several possibilities to achieve wireless communication for intermodal transport. Wireless Wide Area Network (WWAN) enables long-range communications between containers and the central servers. The communication is facilitated by satellite and cellular systems. Satellite provides ubiquitous coverage, so it can relay GPS data from nearly anywhere in the world. The use of satellites for monitoring refrigerated containers generally fails, when antennas of the containers are shadowed, making data transmission impossible. The same fact applies when containers are stowed inside a deck. Cellular devices make use of surface antennas for transmission. Global System for Mobile communication (GSM) and General Packet Radio Service (GPRS) modems are widely used in commercial solutions in vehicle tracking and fleet management.

Recently 3G-technology (e.g. Universal Mobile Telecommunications System (UMTS)) increasing speed and capacity for voice and data services, has emerged.

Wireless Local Area Network (WLAN) is a flexible data communication protocol implemented to extend or substitute for a Wired Local Area Network, such as Ethernet. The WLAN operates at frequency of 2,4 GHz with an 11-Mbit/s bandwidth. WLAN may provide intermediate range data transfers at ports, in marine vessels, in container yards and terminals. It has a large deployment locating assets in a yard, such as heavy equipment and crane. For RFID readers, handheld devices or in a fixed location WLAN enables for data storage and verification.

Currently there are two standard technologies for Wireless Sensor Network (WSN): ZigBee and Bluetooth. Both are working within the 2,4-GHz frequency band, which provides license free operations, huge spectrum allocation and worldwide compatibility. As power consumption in a sensor network should be extremely low, ZigBee is more suitable for WSNs. Bluetooth works better in applications with large data rates, though it requires more energy consumption. ZigBee provides higher network flexibility than Bluetooth, allowing different topologies and a wider number of nodes (over 65 000). Also transmission range for ZigBee (1 m to 100 m) is longer than for Bluetooth (1 m to 10 m). It is possible to add a gateway that converts wired CAN signals into wireless ZigBee signals and vice versa.

Radio Frequency Identification (RFID) has been increasingly used in logistics and supply chain management in recent years. RFID technology can identify, categorize, and manage the flow of goods and information throughout a supply chain and also provides automatic vehicle and equipment identification. It provides the ability to read a tag wireless and without visibility. Used frequency ranges from 135 kHz to the 5 875 GHz. Multimodal shipping containers use tags operating at 433 MHz or 2,45 GHz. RFID semi-passive hardware instrumented with sensors providing such features as temperature or shock measurement can be very useful for cold chain monitoring.

The RFID readers can be connected to a CAN converter, enabling the use of large quantity of RFID readers. We can find in the market devices that allow the integration of RFID in CAN. These devices are able to read and write to transponders according to ISO 14443 (50 mm) and ISO 15693 (90 mm). CAN in Automation has released the CiA 445 CANopen device profile for RFID readers/writers. The objective of the profile is to enable easy system integration of RFID readers into CAN networks. The device profile will make CiA 445-compliant RFID readers from different manufacturers interchangeable with a minimum of time and configuration effort.

Data recorder/ monitor

The ISO 16844 specifies the CAN interface for interchange of digital information between a road vehicle's tachograph system and vehicle units, and within the tachograph system itself. It specifies parameters of, and requirements for, the physical and data link layers of the electrical connection used in the electronic.

Interface to GPS or other navigation

Electronic monitoring of the location during transport can be achieved via automatic vehicle identification or via Global Positioning Systems (GPS).

The former involves the detection of the conveyance at various critical waypoints along its normal route. It is rather inexpensive since it involves a small number of active systems reporting to a central data processing site. Time between waypoints can be monitored for compliance with regard to expected travel times, though conveyance can be lost when the vehicle changes its normal route.

For the location of containers via GPS the accuracy, availability and integrity of this stand-alone system is not enough. In order to obtain the required performance augmentation systems are used. GPS is currently integrated with RFID in order to locate vessel position as well as those containers that arrive on it. The remote coverage limitation is the main drawback that prevents GPS from tracking individual container positions on land.

Conclusion

The next generation of reefer containers is required to have higher performance than those of today. The innovations in wireless and digital electronics enable applications, which will become very common in future transport vehicles.

The container unit becomes the target for monitoring instead of the tractor. Thus monitoring system is located in the container though optimized to reach as much information as possible from external sources in order to rationalize the amount of sensing units to be installed.

Intelligent transport systems must be compatible with the SAE J1939 and ISO 11992 standards, allowing connection between different sub-networks, as well as filtering and processing messages from sensors. The use of standardized, open network is essential for ensuring the inter-operability of the system. The advantage of having a standard is considerable, since it enables independent development of individual networked components, also allowing manufacturers to use components from different suppliers.

The trouble-free exchange of information between individual subsystems is one of the prerequisites for a rational design and operation of the total system. A European or worldwide harmonization of different interfaces is necessary. The interconnection of these heterogeneous ▶

systems is a challenge that should be faced. (of)

Reference

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