Predictive maintenance in CANopen Lift

Predictive maintenance in CANopen Lift is a number of measures to determine condition of devices in an operational lift facility and to estimate the maintenance needs for these devices or for the whole facility. Condition monitoring is a continuously-performed measure of predictive maintenance to estimate the equipment condition.

CANopen Lift is not the first application where predictive maintenance applies. There are numerous applications involving equipment evaluation for the very same purposes and so multiple methodologies are deployed to achieve the maintenance goals.

It was an imperative thought for the CAN in Automation (CiA) special interest group (SIG) lift control to start the development of condition-monitoring handling for CANopen Lift applications. The SIG even assigned a separate task force (TF condition monitoring) with dedicated experts to address this issue. As a base for specifying the parameters and functionality of condition monitoring, the task force used the VDMA 24582 standard sheet. The German-language VDMA 24582 document "Feldbusneutrale Referenzarchitektur für Condition Monitoring in der Fabrikautomation" means translated "Fieldbus-independent reference architecture for condition monitoring in factory automation". It considers the goals of approved and standardized condition monitoring methodology for automation in embedded networks, such as CANopen networks.

The CANopen-based communication in lift control networks is well established for about 15 years. In context of predictive maintenance, it is used to collect interconnected device's condition data and to transfer it via the CANopen network to the equipment evaluating the maintenance needs and suggesting the next action steps.

Estimating the maintenance needs

The VDMA 24582 provides a concept for collection of condition monitoring data to effectively estimate the maintenance needs. The CiA 417 CANopen Lift specification developed by CiA, adopted this concept for lift applications. The base concept idea is to identify the functions to be monitored with regard to the function, application, and automation-function location reference (see Figure 1).

The function-based view classifies the functions in a system, e.g. counter (electrical: trip counter), timers (electrical: hour meter, mechanical: life cycle door drive), temperature (electrical: motor temperature). The application-based ▷

Function-based view	Application or component-based view	Automation-based view

Figure 1: VDMA 24582 function identification viewpoints (Source: CAN in Automation)

view identifies which part of the system or sub-system has to be monitored, for example a car door unit (door controller temperature, etc.). Finally, the automation-based view serves to identify the function location, e.g. light barrier, frequency inverter, etc.

CANopen Lift monitoring

Due to the Classical CAN data link layer specifics, such as the 8-byte process data payload, the SIG lift control has defined a small pool of monitored functions. These functions can be delivered by the most of lift devices to minimize network traffic. For example, the hour meter information can be measured by a lift host controller and also

Figure 2: Simplified VDMA 24582-based CANopen Lift monitoring function block structure (Source: CAN in Automation)

by the inverter. This practice allows individual information about each device state, whereas the door drive temperature should be provided by a door controller only.

Subsequently, the function viewpoint leads to the VDMA 24582-based CANopen Lift monitoring function block with the structure given in Figure 2. The standardized approach to the system state, function identification, and input data including thresholds leads to certain output data. The output data is used to identify the status of the lift device and to decide which maintenance mode should be selected. It is also used to indicate the current condition of the device e.g. with help of the so-called visual traffic lights (status lights).

Conditional monitoring example

To understand how the CANopen Lift conditional monitoring practically works, an example is necessary. The example shown in Figure 3 should help to understand the CANopen Lift condition monitoring principles. CiA 417 already specifies parameters (data objects) for condition monitoring, which can be seen in Figure 3.

In the UML (unified modeling language) activity diagram, the objects 6080_h and 6081_h provide identification and location of the monitored function (data point). For instance, the motor temperature is a monitored function defined in the object 6081_h. It is submitted using MPDO 1 (multiplex process data object) for the door 3 by a car door unit, which is located in the 3rd floor in the lift 1. ▷
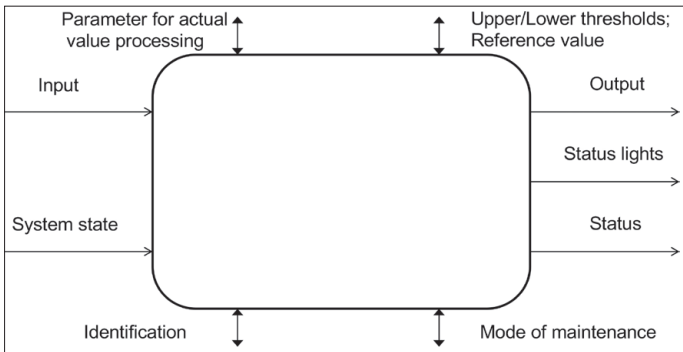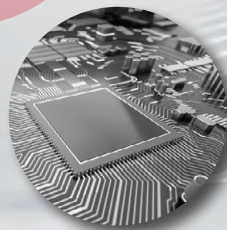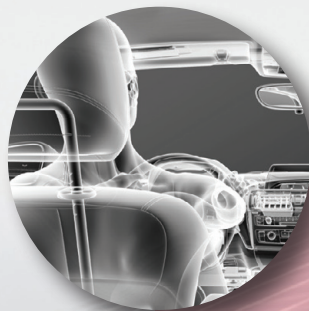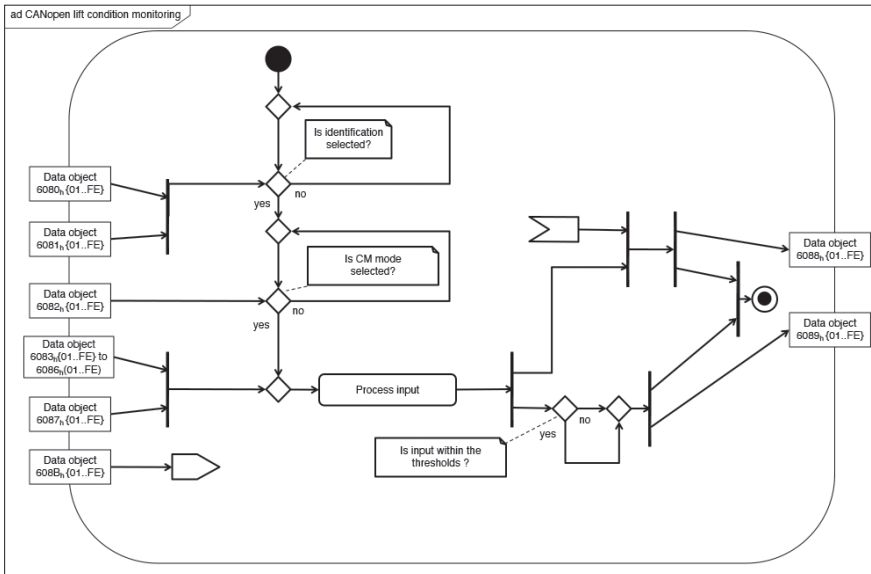
Figure 3: UML activity diagram example of the simplified CANopen Lift monitoring (Source: CAN in Automation)

depending on the reached threshold type, e.g. yellow for warning and red for critical. If the temperature remains within the thresholds, then the green light status condition is generated. The object 6089_h provides not only the status lights but also the maintenance strategy that can be set by a lift operator i.e. condition monitoring only or also preventive and predictive maintenance measures.

The condition monitoring strategy specified in CiA 417 is considered as a check up of the component/device status at regular or irregular time intervals. Depending on the status, a manufacturer-specific predictive maintenance entity decides what to do with the lift device or the whole lift facility. The preventive strategy is a scheduled data point acquisition of the output value for exceeding thresholds over a period of time or in case of a monitoring state change. The predictive strategy, on the other hand, is used when the device maintenance is required. Both preventive and predictive maintenance require collection of the monitored data in the style of conditional monitoring strategy.

The condition monitoring mode is an internal operation mode (see object 6082_h) at which the status and the function data is acquired e.g. manual, learning, simulation, etc. If it is selected, the input can be processed resulting with the output value (see object 6088_h) and checking the threshold conditions for the motor temperature. The lift operator selects the maintenance mode on its own. Does the temperature exceed a threshold (see objects 6083_h to 6086_h), then the certain status light condition (see object 6089_h) is generated

Use of the status lights offers the lift operator a simple way to decide either to dispatch a technician for the motor maintenance or to replace the motor due to according ▷
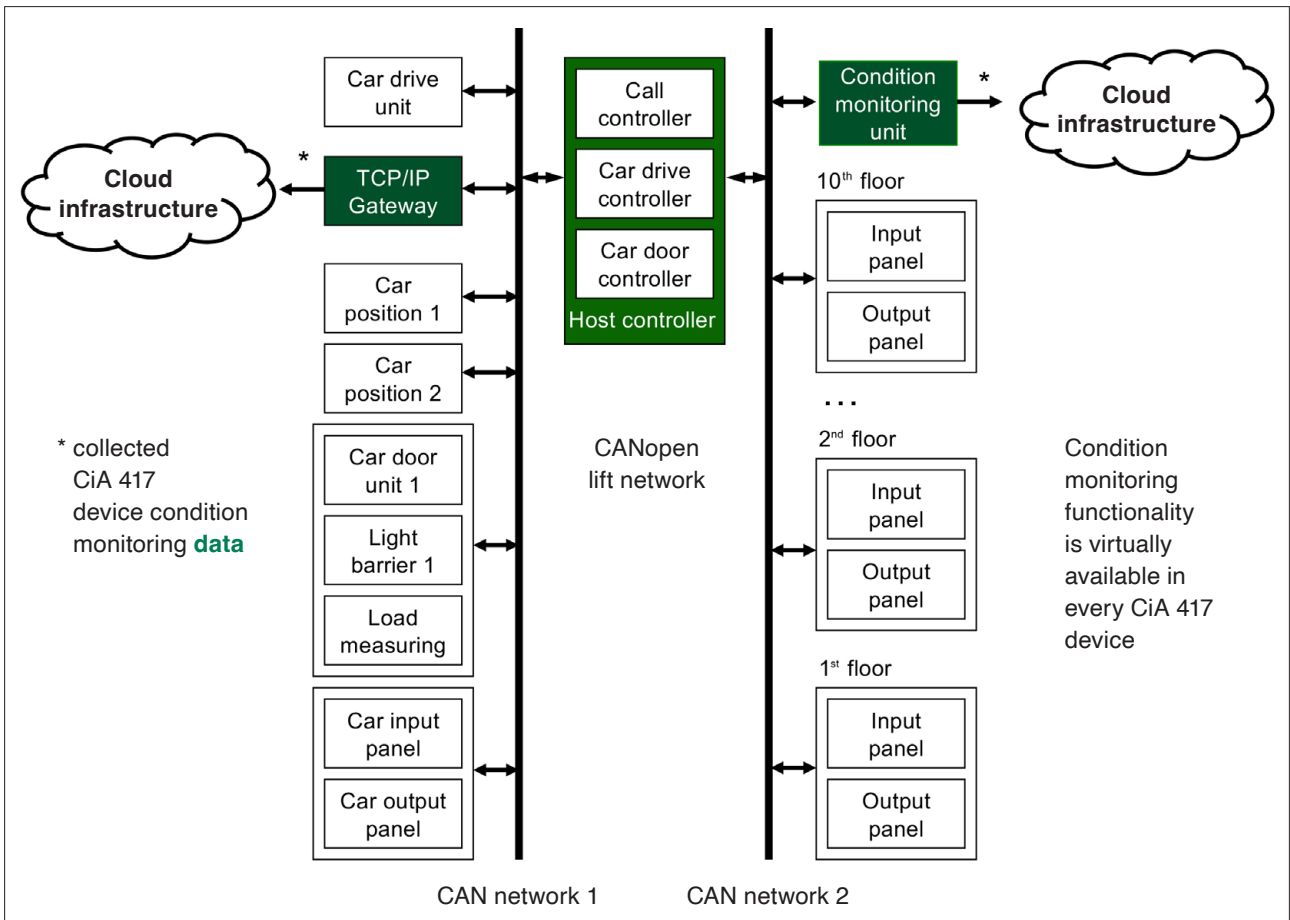

Figure 4: Example of a simplified CANopen lift network (Source: CAN in Automation)

visual traffic light indication. The CANopen Lift profile (CiA 417) provides also a status indication, whether the whole lift application is OK or not. This is indicated by the value 0000_h in object 6081_h. CiA 417 also provides a specific configuration for each monitored function, so the user can decide which data points are monitored and have to be submitted via CAN. This is possible using the object $608B_h$.

Example lift application

An example lift application network is shown in Figure 4. The monitored function can be submitted by the related lift device or the lift host controller. The data can be collected by the lift host controller and provided to the end user via an edge gateway into the cloud infrastructure. Independently, there is a condition monitoring unit as a virtual device (software or hardware) that is able to collect the data in parallel to the lift host controller and transmit it independently to the higher-level hierarchical networks or IoT (Internet of Things) infrastructure. The CiA 309 document specifies a data interface (gateway) between CANopen embedded networks and TCP/IP-based networks. Such a getaway device can be used as a monitored-data collector if neither the lift host controller nor the condition monitoring unit do not support any communication beyond the embedded lift network. Many lift host controllers already provide an Ethernet interface or even wireless and/or mobile connections. Even an edge-gateway capable condition monitoring unit (if designed in a hardware) may offer such external connections. Thus, the condition data of the lift devices and the host controller can be acquired in different ways and the lift operator can meet a maintenance strategy based on the collected data.

Conclusion

Collection of big data amounts from the CANopen lift sensors and control devices was initially discussed by the CiA TF (task force) conditional monitoring, but rejected. It is not in the scope of the SIG lift control, because it would require higher data throughput as it is possible with Classical CAN. The upcoming technologies such as CAN FD and CAN XL are capable to overcome the Classical CAN throughput limitations and allow instant data collection. For the moment, more than 30 specified condition monitoring functions in CiA 417 seem to cover the predictive maintenance requirements of the CANopen Lift community. ◄

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