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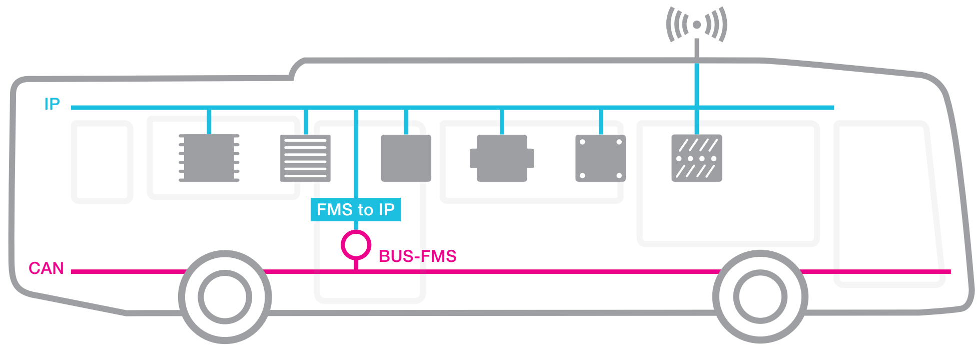
FMS data to support service and maintenance
FMS Interface

Picture 1: IP Bus and CAN Bus – two separate data areas connected by the Bus-FMS interface, respectively, the application "FMS to IP".



FMS data to support service and maintenance

The increasing complexity of the electronic architecture of a bus and a lack of trained personnel for maintenance and service is a growing challenge for bus operators in public transport. This applies already for conventional buses and will emerge with transition to eMobility.

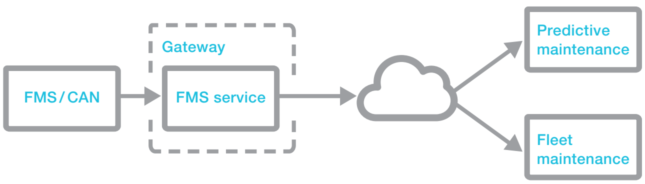
It is not only the cost of maintenance and service itself – which is quite a large part of the total cost. It is that service and maintenance have a great impact on availability and therefore will influence operational cost as well. More and more operators are working to install strategies for predictive maintenance and service – to achieve lower cost, higher efficiency in their workshops and last but not least higher customer satisfaction through less failures. The FMS interface opens the door to condition-based maintenance as a first step in this direction.

The FMS standard

The FMS interface goes back to a common initiative by some major truck OEMs but has been extended to bus-specific parameters as well. According to the standard FMS.04 and as minimum scope, the FMS as an interface to a SAE J1939 CAN bus today provides data including:

- Engine and ambient temperature
- Air supply pressure
- Door status
- Alternator speed
- FMS TellTales
- and more

Picture 2: Forwarding data from FMS to the cloud being relevant for fleet and predictive maintenance.



This scope can be extended on individual settings by the bus manufacturer.

Based on data, as e.g., the temperature data in combination with data from other components like the transmission, an early-warning logic for failure or malfunction of the cooling circuit of the bus can be realized. Another example is the electric system of a bus including the batteries, generator, etc., where repeated voltage drops indicate, e.g., an upcoming breakdown of the battery – which would lead to a breakdown of the complete bus.

Even more supportive are the "TellTales", which control the warning lights on the driver's dashboard. If the TellTales are directly forwarded to the back-office resp. the workshop, the maintenance personnel are always up to date about the status of a bus and are able to plan countermeasures without delay. Returning to a depot, a bus with a malfunction is already scheduled for maintenance, necessary parts are prepared and off-time can be reduced to a minimum without any setup or waiting time.

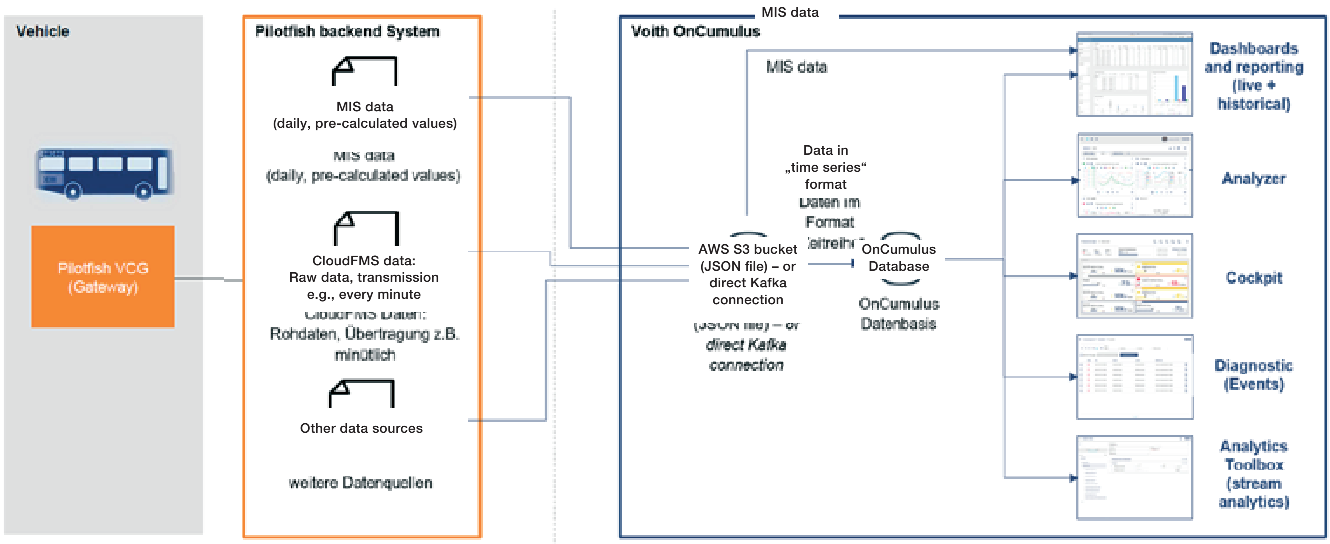
Application of data from the FMS

A vehicle gateway already uses data from the FMS interface as position of load and brake pedal, fuel consumption, etc., for applications being installed like, e.g., a driver assist system to improve the fuel economy. In addition to this, other data usable for predictive maintenance can be forwarded by a separate application ("FMS service") to the cloud, see Picture 2.
As such an application uses the same input signals from the FMS, hence on the vehicle side there is no additional installation effort. On the back-office side, the data from the FMS are forwarded to the operator via an API.

Data storage and analysis in the cloud

Picture 2 shows the FMS application ("FMS service") in the vehicle gateway and the connectivity to an arbitrary cloud. All data are forwarded and stored in JSON Line Format (JSONL) with each line containing a data entry/valid JSON object. This approach also implies that the amount of data is quite manageable. So, a bus with a typical setup of the FMS will consume around 50 MB/month. Having the data available in the cloud, the monitoring of the data from all buses themselves is to be handled by the analytic system and appropriate tools. Such tools allow deployment, e.g., physical rules to the time series and so to enable arbitrary analyses. They also allow for defining, e.g., thresholds and in case of exceeding the levels to trigger event or warning messages. Therefore, the workshop manager can reduce his attention to predefined divergences. He will get an alert only if a vehicle reaches the critical value to trigger the necessary actions. This approach of "Management by Exception" helps to focus the workshop manager's attention to the really critical items and not to be overloaded with a tremendous amount of data – just another contribution to increase the efficiency in daily work.

Picture 3: Data flow from a vehicle gateway via cloud to the operator's cloud and analyzing tool – Exemplary Picture only!



Example: Maintenance of the coolant circuit

A quite easily detectable malfunction is the overheating of the coolant circuit of the engine. Reasons for this are manifold as, e.g., bad maintenance of the heat exchanger or an insufficient level of the coolant fluid. Overheating can lead to severe damages of engine and transmission and in the end even a source for fire in the engine department.

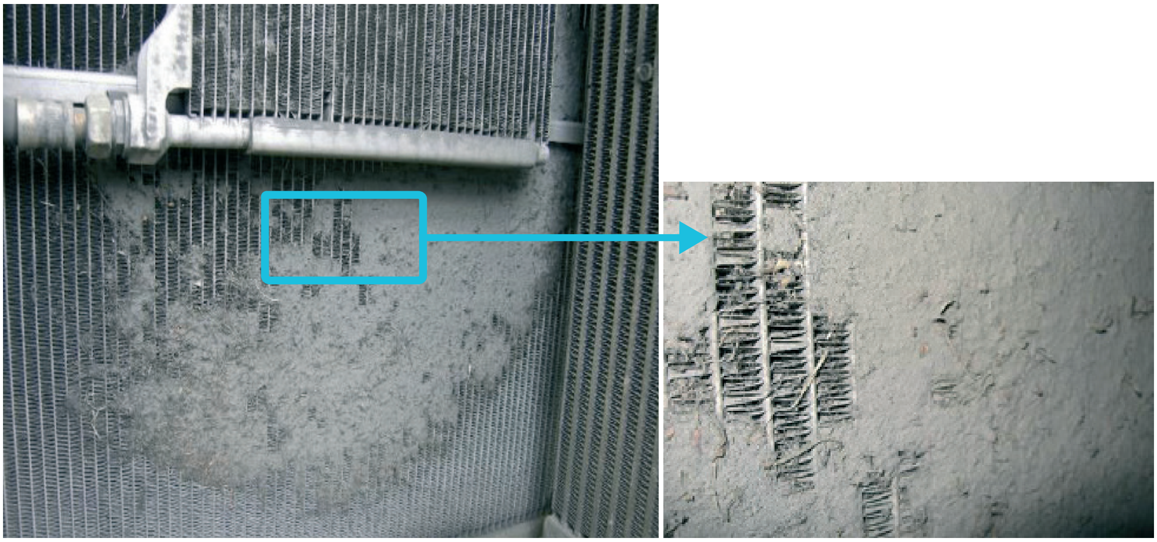
The most appropriate data to monitor the coolant circuit are the temperature of the coolant fluid and the ambient temperature. The difference between both reflects the efficiency of the heat exchanger and its state of maintenance. Picture 4 shows a heat exchanger of a bus in a very bad condition. The heat exchanger is widely blocked by dust and dirt caused by insufficient maintenance and cleaning. Dust and dirt are not only blocking the air flow through the heat exchanger but also act as an „insulating layer" hindering the energy flow from the coolant fluid to the ambient air.

The reduced efficiency of the heat exchanger can be easily detected by means of the mentioned values from the FMS, the coolant temperature in combination with the ambient temperature, see Picture 5.

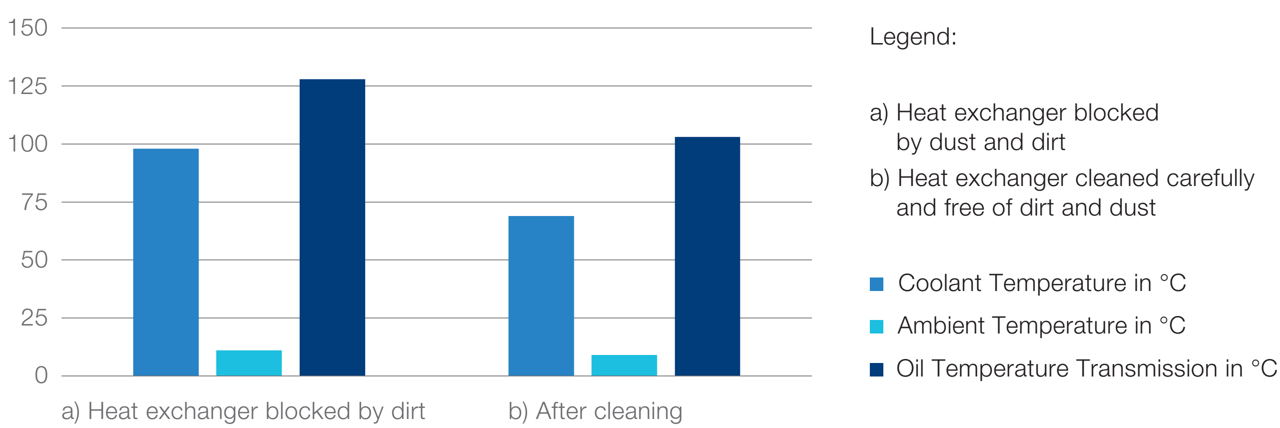
As shown in Picture 5, after an efficient and careful cleaning, the temperature of the coolant fluid was reduced significantly. The difference in the ambient temperature dropped down by 27 degrees, and the reduction of the coolant temperature was reflected in the oil temperature of the transmission, too. The temperature in the oil sump of the transmission was reduced by about 26 degrees.

Knowing that a reduction of the oil temperature by 10 degrees doubles the lifetime of the oil, the reduction by 26 degrees is equivalent to increasing the life of the transmission oil by a factor of 6 – an important aspect in reducing cost and lowering the environmental impact with less oil usage.

Picture 4: Example for a heat exchanger in a bus, widely blocked by dirt due to insufficient maintenance.
Source: Voith



Picture 5: Coolant temperature and temperature of ambient air



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