Multi-bus logger as IoT gateway in networked mobile applications

Technical article

Figure 1: Vehicle fleet testing – a classic remote monitoring application

Test, measurement and condition monitoring on the Internet: an overview of the various requirements for autonomous data acquisition systems for monitoring machinery and vehicles and available flexible solutions.

Whether the "Internet of Things" will indeed experience a major breakthrough in the networking of consumer devices such as refrigerators and toothbrushes, and whether all applications to be pioneered there actually meet urgent needs – this is currently controversial. However, in industrial environments there are certainly many promising applications for networked data acquisition and monitoring to be found – with a massive potential for savings in resources, energy and preventable wear and tear. Here, bus loggers play a central role as data acquisition systems for communication buses and as intelligent gateways to the Internet.

Bus systems and protocols

Field and vehicle buses as digital communication protocols are available in many different forms. The CAN bus is particularly widespread in vehicles with its numerous control units (ECUs), as well as in machinery and industrial systems. Its latest version as an accelerated CAN FD variant will probably give it a good boost for the future. However, other bus systems with elevated data rates and capacity are also of great importance, such as FlexRay and XCPoE in the automotive sector, ARINC and AFDX in the field of avionics, MVB and IPTCom in the railway sector, and EtherCAT and PROFINET in the industrial branch.

Tasks for a networked logger

Monitoring of vehicles, mobile or stationary machinery and industrial facilities is generally autonomous and unmanned, without the user having any notice at all. Current operating data are typically to be collected to, e.g., establish a load history. The aim of such "condition monitoring" can be to identify early signs of wear and tear, and in the sense of predictive maintenance, to be able to take service measures in a timely manner. Thus, serious failures with subsequent and expensive machine downtime can be avoided. For this purpose, the acquired data must be collected and evaluated within a central entity. This allows global access to status information and enables automated alarm and notification mechanisms to be implemented. With such a connection to an Internet-based IT infrastructure ("cloud"), the monitored machinery becomes part of the "Internet of Things" (IoT). Access to data from many distributed objects also opens up completely new applications and business models. In addition to maintenance, the statistics gained about real life operating conditions can also be helpful for improvements and further development. In the case of electric vehicles, for example, fleet tests are recording movement profiles (via GPS), which are then correlated with operating and performance data to support the development of intelligent charging strategies and driver assistance.

Demanding requirements

The most important discipline for an IoT data logger is in its networking: access to the Internet can be achieved via Ethernet or WLAN for stationary applications. In mobile applications or remote and inaccessible systems, however, a direct data connection via mobile radio networks is the medium of choice, i.e., a connection via GPRS, UMTS or LTE. In addition to the costs involved, it is important to consider in this case the limited transmission bandwidth, as well as possibly unstable connections. Therefore, IoT loggers need to implement robust data transfer mechanisms that can tolerate such unreliable conditions. The limitation of data volume leads to a demand for powerful possibilities of local signal processing within the logger itself.

Local data analysis: the key to efficient monitoring

In order to reduce the amount of data to be transmitted, zip compression, for example, can be used as a standard method of lossless compression. However, it is even more effective to actually condense and reduce the information through preprocessing and analysis.

Such data refinement may already consist of simple statistics such as averaging, filtering and rms values, as well as more sophisticated analyses, such as spectral analysis or classifying methods for strength analysis and detection of material fatigue for example. Also, calculations involving multiple channels, such as with electrical or mechanical power analysis, ensure a significant reduction in data. Instead of raw data, only meaningful result values are transmitted. Another possibility for condensing information is found in triggered data acquisition. Instead of continuously recording all data, only relevant events are stored.

The list of possibilities is quite long. What is crucial, however, is that each application requires specially tailored functions, calculations and analyses.

An intelligent data logger should therefore be able to support the user on an easy-to-use platform when creating and adapting their individual solution – preferably without profound programming or firmware adaptation. This approach is consistently followed by imc Meßsysteme GmbH, with its real-time signal processing system imc Online FAMOS.

Multi-fieldbus: flexibility and mediation capabilities

Many applications demand data capture from several bus systems of different types in parallel. This multi-fieldbus operation requires a flexible logger that can be equipped with different types and numbers of bus interfaces. In the interest of high-performance scalability, each interface is equipped with its own processor for decoding tasks. Thus, the performance of the entire system remains stable and predictable.

If the system also has a superordinate signal processing platform (such as imc Online FAMOS), it can even function as a multi-bus gateway: it not only interfaces with the Internet or the cloud, but it can also mediate and route between different buses. This is useful in the current “hybrid” configurations with CAN and CAN-FD buses, which will still be necessary for some time to come. Because existing “conventional” standard CAN hardware cannot coexist with fast CAN-FD devices (ECUs) on the same bus, a division into separate networks is necessary. An intelligent bus logger can even perform rest bus simulation tasks, i.e., the “emulation” of non-existent components and ECUs in a prototype, for example, whose CAN messages (e.g., enable signals) have to be simulated and output to allow operation of the overall system.

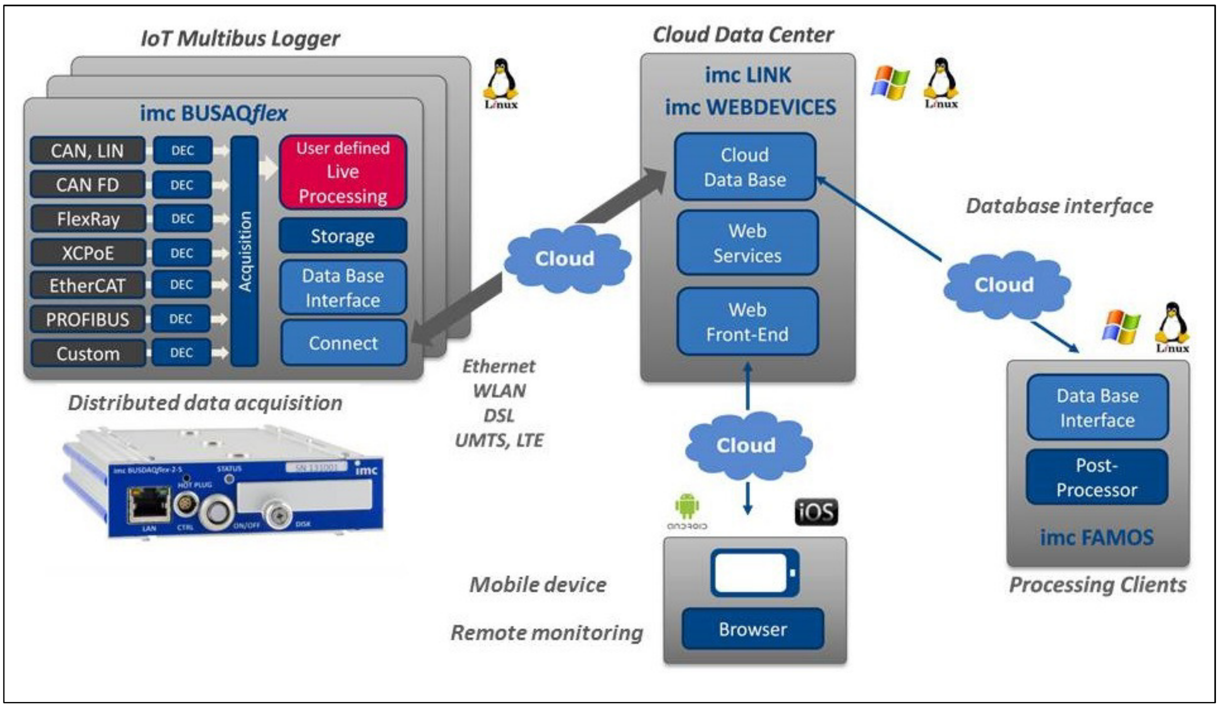

Figure 2: Remote monitoring with distributed multi-bus loggers as IoT gateway to flexible cloud services

Decode or dump the protocol?

Digital buses serve as a medium for sometimes thousands of different information channels, each coded by the protocol. With CAN, for example, they are packaged in messages with IDs whose assignments are defined in standardized formats such as dbc or Fibex. Therefore, depending on the tasks to be performed, it is important to decide whether the logger is to record the entire data stream as a “protocol channel” in its entirety, or whether individual channels are decoded and extracted. Both approaches have advantages and disadvantages and, depending on the application, their justification: all bus data are stored when the entire data stream is logged as a “dump”. Thus, nothing can be lost. The disadvantage of this method is the high data volume and that the data cannot be interpreted and analyzed online.

This is not so in the case of channel decoding, which extracts individual channels live on the basis of the decoding rules (e.g., dbc), scales them and maps them to real physical quantities. This is a prerequisite for any further intelligent real-time processing, such as the creation of trigger conditions, mathematical analysis, reduction, filters, etc. and can limit the memory requirement to the actually relevant level. However, it requires corresponding processor resources and is therefore limited to a finite number of channels. In addition, any forgotten channels cannot be subsequently added. Only the channels that have been configured in advance are available.

With its concept of the “Online BusDecoder”, imc offers a flexible alternative, in addition to direct live decoding. It is based on embedding the decoding information of all potentially relevant channels into the protocol channel which still records the entire data traffic (“dump”). However, channels can now be extracted from the data stream at any time and any place along the further signal processing chain: starting with the internal signal analysis platform of the logger, via the transport process into the cloud, then to subsequent post-processing routines running there. This combines the advantages of both approaches and simplifies management because the encoding information is encapsulated in the protocol channel and thus always remains consistent.

Robust operation under demanding conditions

The typical applications for bus loggers of this type dictate demanding operating conditions with respect to ambient temperatures, sealing and vibration, which would make conventional PC technology a critical choice. Furthermore, the decoding and signal analysis algorithms to be integrated impose real-time requirements that the Windows platforms is not able to cope with. Therefore, devices of this type are usually based on embedded technology with ARM processors or the like and powerful FPGAs for hardware support of the time-critical data paths. This ensures the necessary performance, but proves demanding, as it does not allow for drawing software and firmware functionality by simply falling back on standard PC components.

In addition, potentially precarious power supply conditions require a very wide input voltage range, as well as measures to ensure data integrity in the event of an abrupt power failure. In this case, an integrated UPS buffering system can guarantee the safe completion of the measurement data files on the system and avoid potential damage of the file system. Thus, the device's data pool remains intact until the completion of the data transfer, e.g., to a NAS or a cloud environment.

Furthermore, a low-power design should also implement a sleep mode from which a measurement can selectively be resumed (wake-on CAN) within a short response time. Often it is also necessary to activate the autarkic devices via a control signal: for example, in the vehicle via the ignition switch. This can be done by supplying the device directly from this node, or use it as a control signal for switch ON or wake up from sleep mode. In this context, further digital inputs and outputs (DIO) are also helpful. They allow for including status and control signals of the test object and its environment.

Scalable solutions

With imc BUSDAQ*flex*, imc offers a family of multi-bus loggers that meet these diverse requirements and functionalities. The imc Online FAMOS real-time signal processing platform integrated in the device plays a central role. It can execute almost any analysis algorithms, which the user can edit in simple form as line-by-line mathematical formulas and complex function calls.

This way, intelligent local preprocessing not only ensures efficiency with data transfer and storage, but it also supports and promotes the cloud server so that modern big data approaches and advanced data mining can unfold their enormous potential.

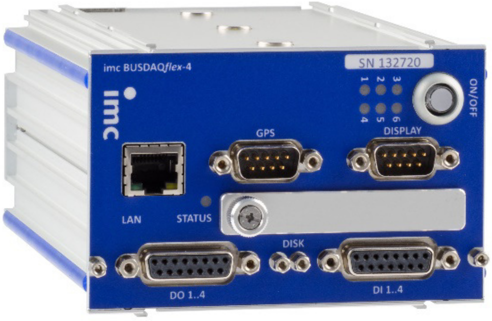

Figure 3: imc BUSDAQ*flex* as a 4-node CAN-logger

Expansion with analog sensors

The family is complemented by additional CAN-based measurement modules in the same housing form, which can be directly docked with a tool-free click-connection – both mechanically and electrically. If required, the system can also be expanded with imc CANSAS*flex* modules, providing additional analog frontends with sensor and signal conditioning as well as digitization. This way, in addition to field buses, physical sensors can also be directly integrated into the measurement system.

Figure 4: the imc BUSDAQ*flex* data logger with additional imc CANSAS*flex* analog measurement modules

Protocols and services for IoT applications

For the realization of distributed Internet applications, modern loggers must support standardized interfaces and protocols. The imc devices provide, for example, an ftp server for transfer of measurement data and setup configurations, a “broadcast” monitoring of selected status variables by means of UDP protocol, and a web server for direct https calls, e.g., from tablets or smartphones. For cloud solutions, whether implemented as a public cloud with worldwide access, or as a corporate cloud solution within a protected company network, synchronization mechanisms are offered to transfer the stored data onboard from the device to a NAS or to upload it to a cloud database.

Holistic approach

As a provider of complete solutions, imc offers an integrated and flexible overall system: from individual sensor adaptation via real-time platform processing, to cloud services for mobile devices. At all levels, users are provided with standard components that enable tailor-made solutions to be implemented. Depending on their own experience, expertise and expectations, customers create this by themselves or can rely on a turnkey, complete solution as an engineering service from imc.

Figure 5: Monitoring via web server for mobile devices

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For over 25 years, imc Meßsysteme GmbH has been developing, manufacturing and selling hardware and software solutions worldwide in the field of physical measurement technology. Whether in a vehicle, on a test bench or monitoring plants and machinery – data acquisition with imc systems is considered productive, user-friendly and profitable. So whether needed in research, development, testing or commissioning, imc offers complete turnkey solutions, as well as standardized measurement devices and software products.

imc measurement systems work in mechanical and mechatronic applications offering up to 100 kHz per channel with most popular sensors for measuring physical quantities, such as pressure, force, speed, vibration, noise, temperature, voltage or current. The spectrum of imc measurement products and services ranges from simple data recording via integrated real-time calculations, to the integration of models and complete automation of test benches.

Founded in 1988 and headquartered in Berlin, imc Meßsysteme GmbH employs around 160 employees who are continuously working hard to further develop the product portfolio. Internationally, imc products are distributed and sold through our 25 partner companies.

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