

Porsche Validates Gateway ECUs Automatically

Real-time analysis in driving trials supplements laboratory tests



On the Panamera, Porsche is implementing the “Porsche Echtzeit (‘real-time’) TRace Analyser” (PETRA) for validation of gateway ECUs. PETRA, which is based on the CANoe test tool, automatically generates gateway tests from routing tables. These tests are used in driving trials, checking the routing functions online. PETRA can be used to conduct analysis later as well, based on recordings of the bus communication as a supplement to the scope of sequential testing in the laboratory. This gives Porsche a test tool for automatically detecting routing errors.

Architecture

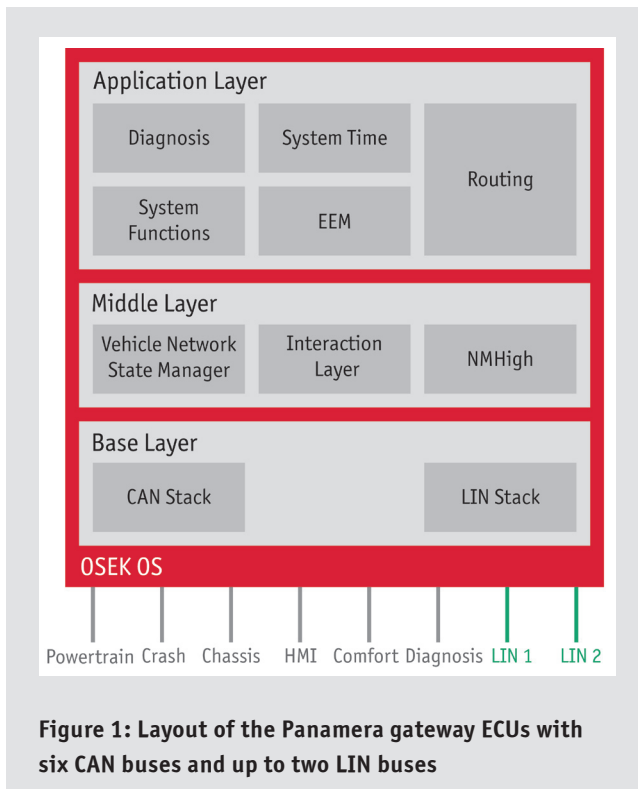
The “Panamera,” available since 2009, is the first production vehicle in the history of the sports car manufacturer to unify a four-door Gran Turismo concept with classic sports car design. Engine options range from a 3.6-liter six-cylinder engine to a 4.8-liter eight-cylinder turbo, spanning a power range from 220 to 368 kW. Depending on the specific model version and options, features may include full-time all-wheel drive, dual-clutch gearbox and a model with hybrid drive, which is currently in development.

The electronics architecture of the Panamera is based on more than 30 CAN ECUs, which are distributed over six CAN networks. It is supplemented by twelve LIN networks with a total of 25 LIN slaves. A MOST bus serves to network the Infotainment systems. The six CAN buses for diagnostics, convenience systems, HMI

(Human Machine Interface), powertrain, chassis and crash safety are all connected – with a maximum of two LIN branches – to a central gateway ECU (Figure 1). Gateways interconnect the various networks in the motor vehicle and provide for fast data exchange across networks.

Intelligent gateway functions

In the motor vehicle, it is important to transfer information between networks as quickly and intelligently as possible. One must consider the different bandwidths of the network buses. As a rule, a periodic message arriving at the receiver end of a High-Speed CAN bus every ten milliseconds cannot be routed by the gateway as quickly as on a target network with a lower bandwidth. The copying rule here could be that the most recent value should



only be sent every 100 milliseconds on the slower bus. Suppressing messages can reduce the volume of data and adapt it to the lower bus speed. In the reverse case – from slow to fast – the gateway may need to repeat the messages in its sending section, i.e. send a message more frequently than it is actually received. Other messages, on the other hand, should be routed as quickly as possible and one-to-one without multiplication or suppression. For this purpose, a routing rule is stored in the gateway for each message to be routed. These rules contain information on the source and target networks and the copying rule.

Integration of gateway ECUs in the vehicle is the responsibility of the automotive OEM. Error-free operation of the gateway is a key prerequisite to ensuring that the networks and ECUs work together properly. In verifying routing behavior, it is absolutely essential to run numerous tests in different driving situations and conduct a detailed analysis. Until now, the focus of laboratory tests was to sequentially check all of the gateway’s routing rules by stimulation of the input signals. On the output bus, the expected results were checked against routing algorithms. At Porsche, these tests are also performed under different physical conditions such as under-voltage and over-voltage as well as various temperature profiles.

Limitations of laboratory tests

Although test data generated in the laboratory with special test or HIL systems does indeed test basic functionality, sporadic errors

are often only revealed under real stress scenarios and in the interplay of all bus systems and ECUs. In particular, stress situations under high bus load and the simultaneous occurrence of certain events can lead to complex errors.

The central gateway of the Panamera routes more than 3,000 different CAN signals over the six CAN buses in fractions of a second; in the process, it must consider 25 different transmit types. The time consuming manual error debugging in test vehicles led Porsche developers to seek a more efficient method of evaluating vehicle network traces in developing the Panamera. Key requirements for the new system were that it should be capable of verifying the gateway data traffic during real test drives and in real-time. However, after initial market inquiries with tool producers and test specialists it became apparent that a suitable tool or test system was neither available nor known.

Porsche Echtzeit ('Real-Time') Trace Analyser

A solution was created in collaboration with specialists from Vector, whose effort led to a tool known as the “Porsche Echtzeit (‘real-time’) TRace Analyser (PETRA). The testing and simulation software CANoe serves as the foundation for PETRA. This tool was optimized for ECU tests and it enables – by means of various configurations – automatic test sequences including rest-of-bus simulations. Furthermore, it offers the ability to replay logged network communication and to create detailed test reports. To implement automatic test sequences, the Test Feature Set (TFS) contained in CANoe provides test functions in the Communication Access Programming Language (CAPL) script language. CAPL uses a C-like syntax in formulating tests; CAPL recognizes special functions, which lets it react to bus-related events such as the receipt of a message. Tests can be set up and parameterized in XML files using predefined test functions and control functions. A complete test run is represented by a test module in CANoe.

PETRA was developed as a contract project by Vector, and together with standard functions of the CANoe TFS, it serves to validate the CAN gateway functions of the central Panamera gateway ECU (Figure 2). It generates the entire CANoe test module components needed to validate a gateway revision level; these components can be used both during test drives as well as offline in the evaluation of data recordings. Routing and copying rules for the messages of multiple buses can be evaluated simultaneously here so that they could focus on specific messages in individual tests. Porsche engineers insisted on wide-ranging filter options right from the start. The gateway developers expressly wanted a system that could check the totality of all messages and be able to analyze individual routing relationships with a simple configuration. In particular, developers wanted to intentionally filter out the special data traffic that result in exceptional situations, for example: in starting the vehicle, shutting down the network, since most test

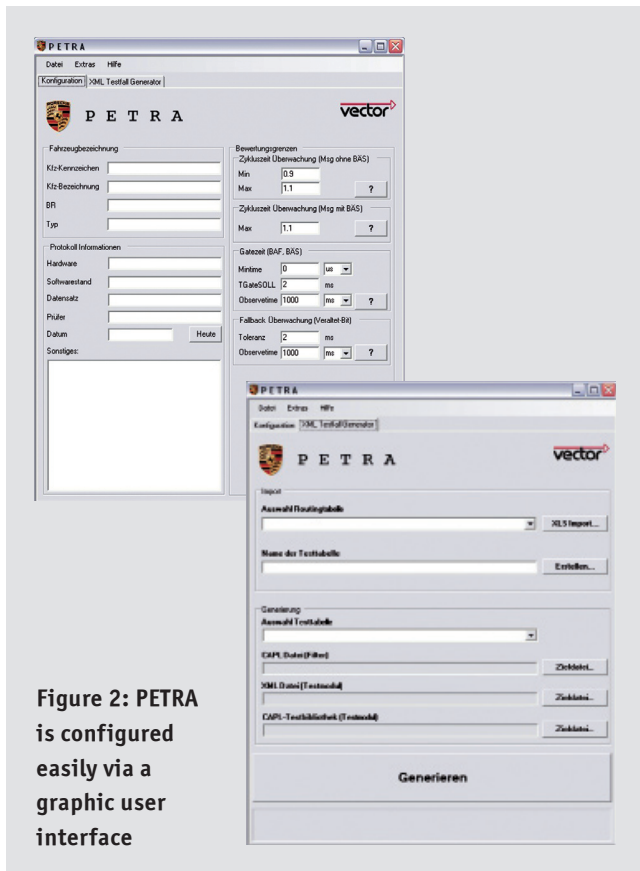


Figure 2: PETRA is configured easily via a graphic user interface

systems generate a massive number of irrelevant error messages in these cases.

Suitable for both online and offline tests

A routing table in Excel format describes all signals and messages to be routed by the gateway. Each line corresponds to a routing rule and defines the way in which a message should be routed. Messages that are routed in their entirety (1:1) are organized into

the following message types: Periodic messages, BÄS messages and BAF messages. BÄS messages (BÄS = immediately on change) are special cases of periodic messages, which the responsible ECU sends in addition to the normal periodic sending as soon as an input value changes – e.g. from a sensor. BAF messages (BAF = on active function) are one-to-one messages that the gateway should route directly and without modifying the cycle times. In addition, the gateway generates and sends messages with signals from different Rx messages (“combined messages”). For each Rx message, the generated message contains a so-called “aged bit.” If the gateway determines that a delay has occurred in incoming periodic messages that exceeds the allowable tolerance, it sets the aged bit before routing the combined message. Active aged bits indicate to the receiving ECUs that the informational content of the combined message has limited validity.

The user can use PETRA to take information from the routing table and automatically generate an extended configuration table, also in Excel format. The test engineer then uses this to select the messages to be analyzed in the gateway data traffic (Figure 3). If a routing relationship is selected in the first column, the test generator considers this line in creating the test configurations. All other messages are ignored in this test. Furthermore, various evaluation limits may be specified, for example tolerances for cycle time monitoring and the allowable gateway time for BAF and BÄS messages. PETRA then automatically creates all of the files needed to execute a test run (Figure 4). Examples include an XML test module with a CAPL test library as well as a CAPL filter that might be used upstream of the Trace Window in the CANoe Measurement Setup. The CAPL pass filter only passes those messages that are needed for the generated monitoring tasks. This covers the basic requirements for a CANoe test run (Figure 5). As a standalone tool, PETRA lets users create test modules without requiring that a CANoe license be installed.

Figure 3: Only the messages selected in the first column are considered in generation of the test configuration

	Pos. No.	Rx ECU	Rx Bus	Rx Message/Function	Rx Signal
Not considered	1	Airbag	CAN_Powertrain	Airbag_01	1 to 1 Message
Considered	1	Airbag	CAN_Powertrain	Airbag_01	1 to 1 Message
Considered	x	Airbag	CAN_Powertrain	Airbag_01	AB_Beltaert_VF
Considered	1	Airbag	CAN_Powertrain	Airbag_01	Monitoring absolet
Considered	1	Airbag	CAN_Powertrain	Airbag_01	AB_Beltaert_VF
Considered	1	Airbag	CAN_Powertrain	Airbag_01	Monitoring absolet

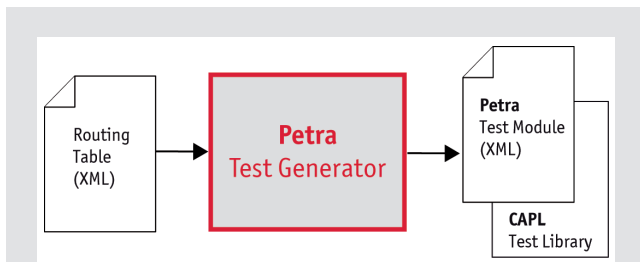


Figure 4: PETRA automatically creates a XML test module and a CAPL test library for test execution.

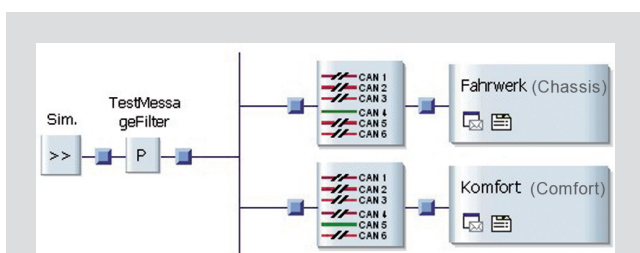


Figure 5: PETRA checks for conformance to routing and copying rules and outputs results in a test report.

Test report speaks the language of the automotive OEM

During the test, the test system creates a detailed report on events that occurred. The test report was optimized for Porsche-specific processes and terminology, so that it can be equally understood by both experts in gateway development and colleagues from other technical departments. The checks seamlessly cover all relevant copying rule violations for the specific message type, and they can operate on either the byte or signal level, depending on the situation. For road tests, the system can be configured so that when an error occurs, a relevant message immediately appears on the screen. This enables immediate repetition any routing errors resulting from operating and driving maneuvers.

In offline tests, log files recorded during the test drives are played back in CANoe via Replay blocks. One helpful debugging feature is the ability to jump directly to the point in the trace data at which an error has occurred. Frequently, events occurring before and after the error yield useful information on the cause of the error. Error statistics provide important indicators on the frequency of errors and "error quality." For example, it might answer questions about whether an error occurs continually or only once every 1,000 kilometers, or whether certain cycle time violations are very large or relatively small on average.

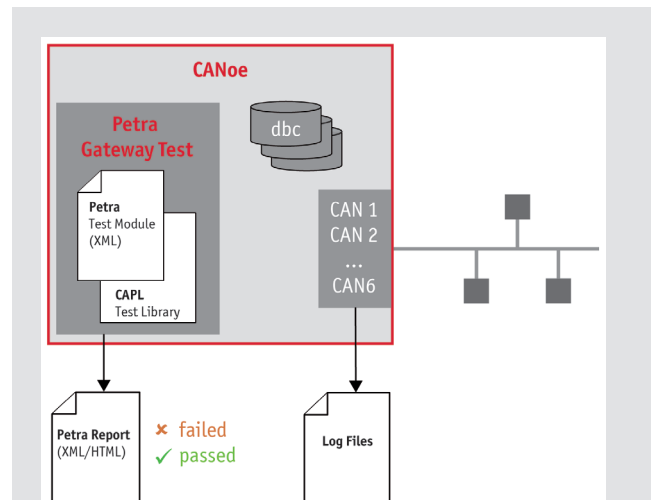


Figure 6: PETRA checks for conformance to routing and copying rules and outputs results in a test report.

Summary and Outlook

The CANoe tool has been used at Porsche for a long time now. In 2007, the existing tool chain was extended and continually enhanced with the addition of the "Porsche Echtzeit ('real-time') TTrace Analyser." PETRA demands very little training effort for employees. The new automated approach to analyzing the routing of real communication data ideally supplements the stimulation-based test scenarios of laboratory tests. Engineers at Porsche and Vector Informatik closely worked together in developing the new gateway validation system. The tool enabled early detection of potential errors during ECU development for the Panamera and attained a high maturity level. The time advantage in analyzing communication data is about 65 percent compared to previous manual debugging. The generator approach lends flexibility to the PETRA concept, which can be applied to future vehicle series and generations. If necessary, other bus systems such as FlexRay or Ethernet could also be integrated in the PETRA concept.

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Figures:

Porsche: initial figure, 2, 3, 5
 Vector: figure 1, 4, 6

Links:

Homepage Porsche: www.porsche.com
 Homepage Vector: www.vector.com
 Product information CANoe: www.vector.com/canoe



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