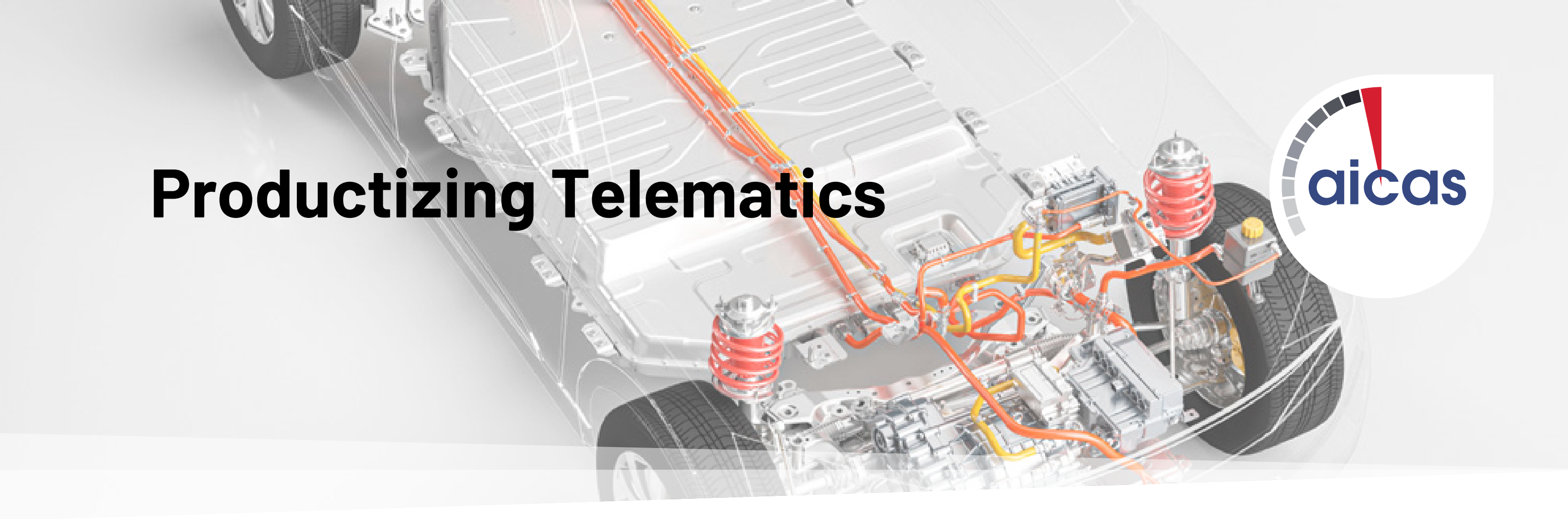

Productizing Telematics

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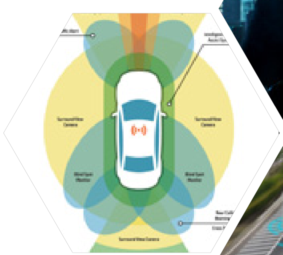
Introduction

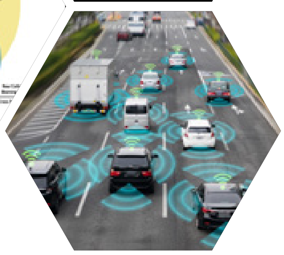
Modern vehicles are equipped with various sensors that can monitor the status of the vehicle and the driver. The telematics data generated from those sensors not only improve driving safety, but also create the possibility of many innovative services.

Telematic Control Unit (TCU) is an embedded device on a vehicle that collects the information of the vehicle and sends it to a remote system for analysis. A typical TCU may consist of a processing unit, a localization device (e.g., global positioning system, GPS), and a communication device (e.g., cell modem). The main purpose of having onboard telematic control units is to collect the vehicle status remotely, so that the services can be provided anytime and anywhere.

Use Cases

As an extension of the TCU's original goal, modern systems in the automotive industry tend to provide more features in order to enable more powerful services. In the following, some use cases are listed.





Anti-Theft Solution: The vehicle's location can be transmitted to the service provider periodically or on demand, so that the owner or law enforcement agencies can trace stolen vehicles.

Crash detection: When a vehicle is either actively or passively involved in a car accident, the incident and the vehicle status can be reported to the owner or the insurance companies to clarify liability.

Emergency Assistance: In a situation like collision or serious malfunction of the vehicle, where the emergency assistance must be deployed immediately, services like eCall or OnStar can get informed via TCU and provide assistance rapidly.

Driving Behavior: Certain performance parameters are recorded and analyzed to build patterns of driving behavior. Based on these parameters, advice can be provided to improve performance, efficiency, or safety.

Usage Based Insurance: The insurance companies calculate their risk based on driving patterns and offer "pay-as-you-drive" policies. Drivers can drive more consciously and more responsibly according to the desired insurance rate they want to take.

Fleet Management: The TCU provides the essential information for optimizing dispatching, scheduling and maintenance of fleets of vehicles.

Carsharing: A subset of fleet management, nevertheless distributed and consumer oriented. The members of the carsharing community can acquire a vehicle with a condition that is preferable to their travel plan. The maintenance team can keep the vehicle's availability more efficiently.

Predictive Maintenance: The automotive OEMs use TCU to collect Diagnostic Trouble Code (DTC) or the live status of vehicles, and by doing so are able to predict the lifetime of parts. This information can be used for notifying the owner about necessary maintenance or for preventing a large-scale callback action.

Communication/Information Gateway: As high-speed wireless connections (LTE or 5G) become available on the TCU systems, they can provide internet connections to other devices within the vehicle via short range connections, such as WiFi or Bluetooth.

Firmware Over-The-Air (OTA): Since TCU devices may have access to both the onboard field buses (e.g., CAN, LIN, MOST, and FlexRay) and the internet, they become an ideal point to provide services to upgrade the firmware on other in-vehicle embedded devices. The OEMs can remotely push new features and bug fixes without asking the users to bring the vehicle to the dealership.

High-Definition Map: One of the essential enabling technologies for autonomous driving is the high-definition map. A live update of road conditions and landscape changes relies on the reports generated by the onboard sensors (e.g., camera, LIDAR, RADAR, ultrasonic ranging sensors, etc.) via the TCU's internet connections. The service provider can then share the map with the subscribers via the TCU.

Autonomous Driving: Autonomous vehicles rely not only on the perception built around the onboard sensors but also on the interactions between other vehicles and the infrastructure. In this context, the TCU system is equipped with various communication facilities such as Dedicated Short-Range Communication (DSRC), in addition to the traditional cellular networks, to exploit timely and localized traffic information and improve driving decisions.

Emission Monitoring: With vehicle data collected by the TCU systems, the community is able to better estimate the emissions in any area at any time. Regulations can be made accordingly to balance quality of life and environment protection.

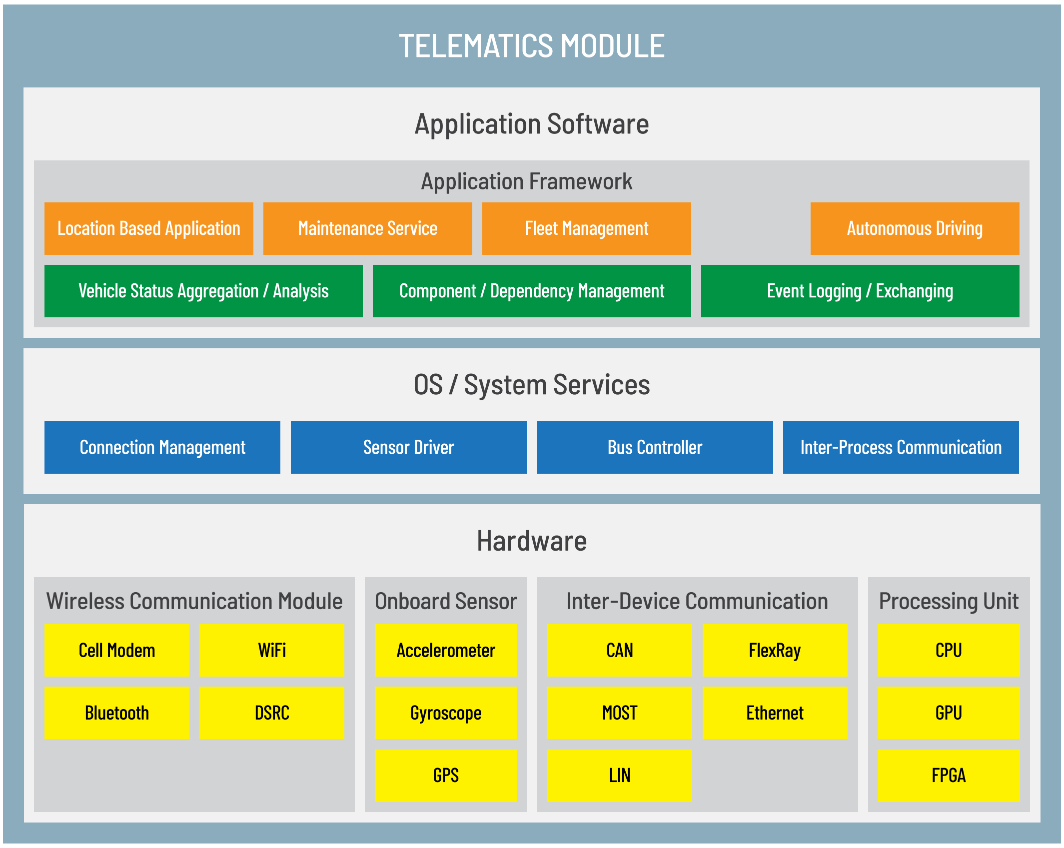
TCU Architecture

To accomplish the features required by the aforementioned use cases, the TCU systems are integrated with various hardware and software components. Depending on the services a TCU provides, the architecture can be simple or complex. The functionality of the components can be categorized into three categories:

Sensing: The essential feature of the TCU is obtaining the vehicle status. Onboard sensors such as accelerometers, gyroscopes, or GPS provide basic information such as acceleration, velocity, bearing and location. If more information is required, the TCU needs to use Inter-Device communication (e.g., CAN bus) to interrogate other sensing devices in the vehicle.

Computation: The raw data generated by the sensor devices can be huge, especially the data produced by the image sensors. In order to reduce traffic for transmitting the data, as well as latency between devices and back-end services, pre-processing of the data is desired. In addition to general processors, GPUs or FGPAs are commonly used for better efficiency and performance.

Communication: To convey the telematics data or even provide the gateway functionality to other in-vehicle devices, various communication facilities are integrated. While cellular modems (e.g., LTE and 5G) are becoming the de facto components for the TCU, other communication technologies such as WiFi, Bluetooth, and DSRC are used in situations where bandwidth, locality, or inter-connectivity should be taken into account.



Demanded Features on Telematics Systems

The ecosystem of telematics systems involves five stakeholders, namely **Automotive OEMs, Telematics Tier-1 Suppliers, Telematics Service Providers, Telematics Application Developers,** and **End Customers**. Each of them demands various features to tackle problems they encounter during the life cycle of the telematics products.

Automotive OEMs, Automotive

- Easily configured to support various vehicle lines
- Applications / services can be transferred across tier-1 devices
- Debugging and tracing

Telematics Tier-1 Suppliers

- Easily ported to various platforms
- Easily configured to support various OEM requirements
- Debugging and tracing

Telematics Service Providers

- Unified access to vehicle data
- Secured communication and authenticated data

End Customers

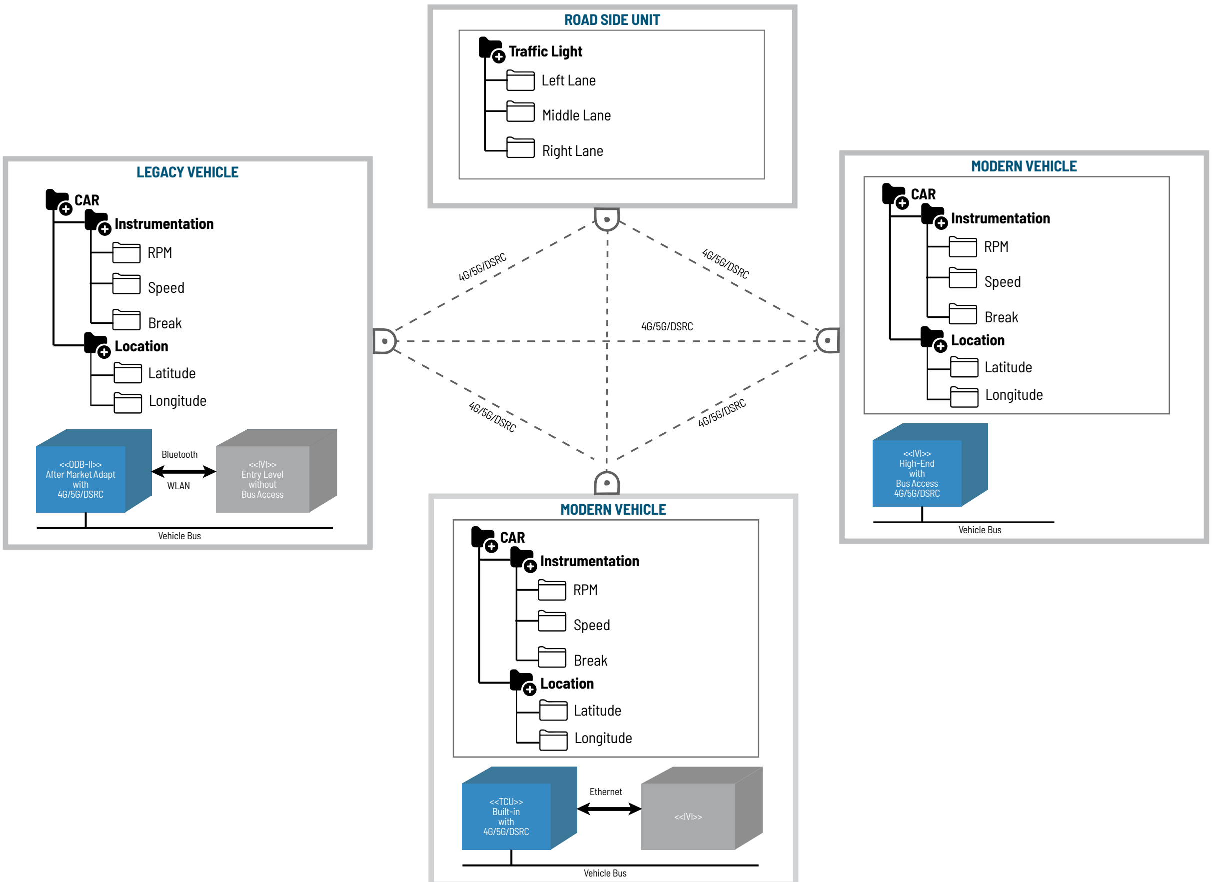
- Easy to operate
- User data can be transferred to another vehicle

Telematics Application Developers

- Unified access to vehicle data
- Simulation tools
- Debugging and tracing

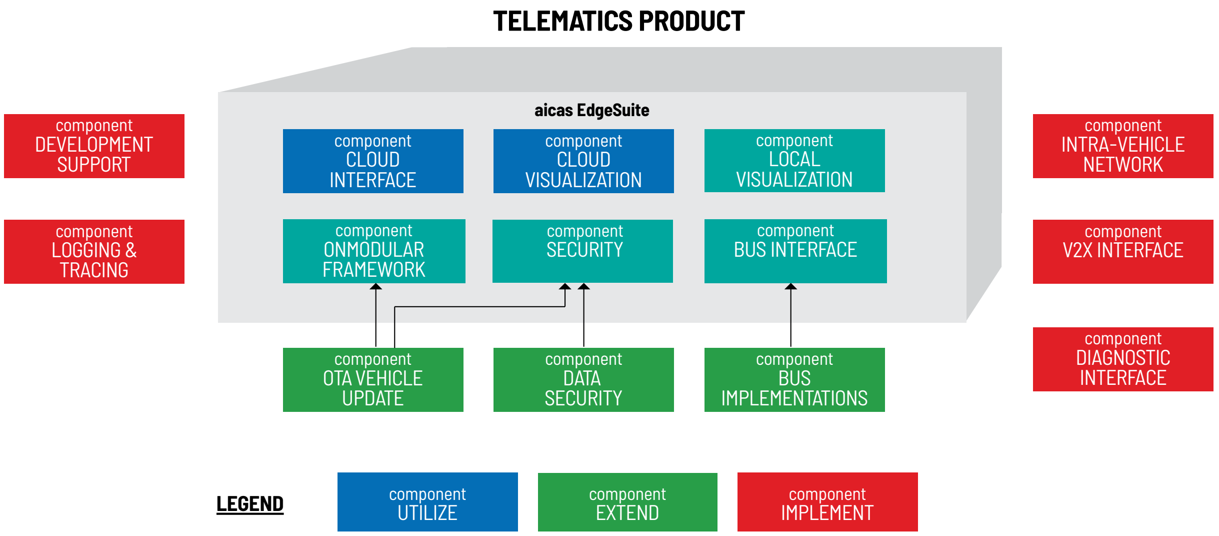
Features provided by Jamaica Telematics Product

In the connected vehicle era of the future, vehicles will connect with the road infrastructure and other vehicles using onboard wireless communication technologies to provide services collaboratively. The connected vehicles exchange vehicle information to each other to react to the road situation. Heterogeneous network is therefore formed as depicted in the following diagram:



Considering the environment JamaicaCAR typically runs on, the position of the Jamaica telematics product will most likely be located on a gateway or a TCU, where the sensors are connected via onboard I/Os or field buses. In addition, an aftermarket smart OBD adapter can also host the Jamaica telematics product to provide value-added features to enable telematics services.

aicas EdgeSuite provides modular components that can be easily reconfigured and delivered on demand. EdgeSuite integrates edge computing and cloud services to support data processing for embedded devices. This provides a foundation for the features, which can be developed around the ecosystem of the telematics market. On top of that, several directions can be pointed out to enrich the product itself and fulfill the demands of various parties.



Intra-Vehicle Network

Telematics applications may require access to other devices in the vehicle to provide integrated services. Therefore, common intra-vehicle network interfaces need to be integrated. For instance, Bluetooth, WiFi, NFC can be used for data connectivity, user authentication, sensor acquisition, etc. Implementing these interfaces can enhance the perception of the telematics applications around the data generated within the vehicle.

V2X Interface: Unified Access to Vehicle Data

Since the vehicle data generated by the telematics devices will most likely be consumed not only by the vehicle itself, but also by the road infrastructure, by other vehicles, or by the service providers in the cloud, inter-cooperation will be the most important issue around OEMs, service providers, and application developers. The same issue has been discussed in the operational technology and one of the notable solutions is OPC/UA. Recent research shows the feasibility of applying OPC/UA on vehicle telematics data for road vehicles or autonomous industrial transporting platforms *[1-5]*. In this direction, several features can be provided:

- CAN DBC to OPC/UA conversion: DBC is one of the most commonly used formats to describe the specification of the sensor values communicated via CAN bus. Each vehicle product line of each OEM has a specific definition of its CAN message format. In order to support as many vehicle lines as possible while providing unified access to the consumers of the vehicle data, a mechanism to convert and represent different CAN message formats to OPC/UA vehicle data structure needs to be implemented.
- OPC/UA vehicle sensor service: Once the vehicle data can be represented via a unified structure, an OPC/UA service that provides access to the vehicle sensor data can be provided regardless of the transport protocol used underneath (e.g. Ethernet, DSRC, 5G, etc.)

Diagnostic Interface

Diagnostic services provide owners and technicians with access to the status of various vehicle subsystems by sending diagnostic requests to specific ECUs, that control respective subsystems. Those requests can be issued either through the Onboard Diagnostics (OBD) port, or an interface device connecting to the vehicle data bus. A telematics service based on the diagnostics feature can then be provided on the following in-vehicle devices:

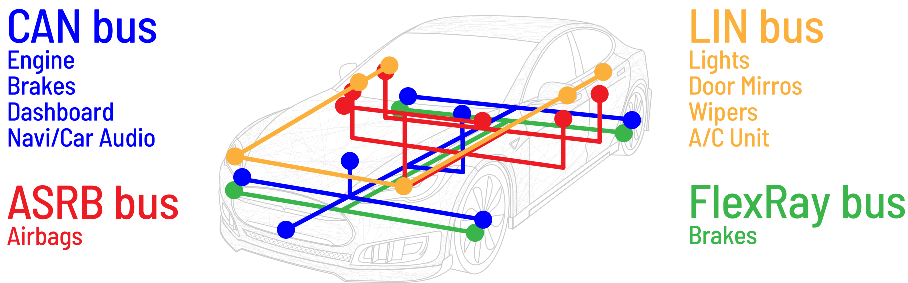
Infotainment system:
- Graphical user interface
- Might/Might not have internet
- Might/Might not have sensor/bus connections

Telematics device:
- No graphical user interface
- Must have internet
- Must have sensor/bus connections

OBD adapter:
- No graphical user interface
- Might/Might not have internet
- Must have a set of mandatory sensor/bus connections

JamaicaCAR can provide diagnostic services on the above mentioned three devices with the following features implemented:

- CAN Request / Response: implement (or integrate native supported) transport protocol (ISO 15765-2) to carry the diagnostics messages.
- OBD-II PID (Onboard diagnostics Parameter ID) specification model: implement a reconfigurable service provider based on a model specifying the Unified Diagnostic Services (UDS, ISO 14229-1), as well as the OEM proprietary services.
- OBD-II PID service implementation: implement PID services, so that an application can utilize the diagnostic services with the provided API.

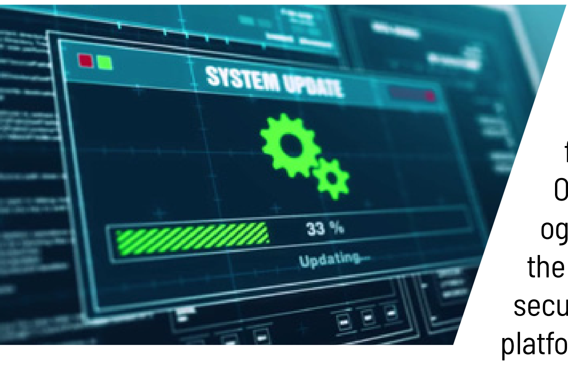


Bus Implementation

The essential component to obtain telematics data is the bus connection. Modern vehicles contain various buses to connect the sensors and actuators, for instance, CAN, LIN, MOST, etc. The telematics product needs to implement common bus interfaces, e.g., CAN, and implement additional bus interfaces on project demands.

Data Security

Telematics data are, on the one hand, valuable to the stakeholders, but, on the other hand, vulnerable due to opening the door to the remote systems via network connections. For the service providers, it is important to make sure the data collected from the device are authentic. Therefore, providing user and device level authentication is crucial for the services to be successful. Depending on the hardware support, JamaicaCAR should support this feature with software or hardware assisted implementation.



Over-the-Air (OTA) Vehicle Updates

To overcome the contradicting requirements of the rapidly changing market demands and the long development cycle of vehicles, a reconfigurable vehicle will become a trend for the future vehicle architecture. Over-the-Air updates for vehicle systems are the key enabling technology to establish the reconfigurable vehicle system. JamaicaCAR provides the foundation with modular architecture and data security for flexible and secure OTA updates. To meet the automotive requirement, the integration of platform dependent security and connectivity features should be provided. In addition to that, updating ECUs through the internal connectivity provided by the platform is required.

Logging and Tracing

One of the major issues for analyzing problems of in-vehicle systems is to collect the debugging logs from various sub-systems. A unified logging mechanism can be helpful for remote or postmortem analysis, since it provides a centralized location for all sub-systems. For example, GENIVI defines a log and trace interface based [6] on the protocol specified in the AUTOSAR standard 4.0 DLT (Diagnostic Log and Trace).

As JamaicaCAR integrates the communication and sensing features of an in-vehicle device, two aspects should be considered:

- As data sink of the DLT: collect logs and traces from other subsystems and process/store/forward the data to the back-end system.
- As data source of the DLT: the logs and traces generated by the framework of the applications running on it itself can be redirected to the DLT logger running on the system.

Development tools

Application developers who work on in-vehicle devices often encounter the issue that the problems observed in the field can not be reproduced in the development environment. This increases the effort spent for investigating the problem and reduces customer satisfaction. As solution provider, the following features should be included in our development tools:

- Sensor specification (e.g., CAN DBC) to sensor data generator / monitor: a tool that can take the sensor specification for specific OEMs and generate sensor data according to the user specified value or replay the data recorded in the vehicle.
- Universal access to the vehicle network: SAE J2534 is defined in order to provide unified access to automotive ECUs regardless of the communication protocol used by the ECU. Many CAN bus adapters support SAE J2534 to provide vehicle access to desktop applications. Supporting SAE J2534 API makes the Jamaica development environment cooperate with different vehicle connectors.
- Secured remote shell to the device: a software component which can be deployed and activated remotely to target devices to provide a secured remote shell access to debug the system and configuration issues.
- Simulator: a simulator that can work with other tools provided by Jamaica products, which is authentic enough for the application developers to develop their application.
- IDE integration: the tools are preferably integrated to popular IDE.

Reference Applications

The connected vehicle has become a trend for the current and future automotive design. The use cases have been discussed broadly among the automotive industry. The major suppliers have targeted some common applications and even provided turnkey solutions from the chipset upwards. The key to success is actually to find the niche or provide a better alternative.

OBD-II - IVI Connector

Although modern in-vehicle infotainment systems are equipped with larger displays and stronger computation power, their access to the vehicle data might be restricted due to many reasons (e.g., security, data ownership, etc.). The older built-in or aftermarket IVI systems might not even have access to the vehicle data. OBD-II adapters provide vehicle data for which access is opened by the OEMs that allow the applications to provide innovative services.

A typical IVI system normally provides some sort of local or personal area network (e.g., WLAN or Bluetooth), which can be used to communicate with a smart OBD-II adapter. Several possible configurations are available:

- IVI doesn't have access to vehicle data nor internet connection: It can use an OBD-II adapter as the source of the vehicle data and as the gateway to the cloud. The application on IVI can act solely as user interface and data processor.
- IVI doesn't have access to the vehicle data, but has internet connection: OBD-II can provide vehicle data to the IVI applications. The data can be pre-processed to reduce the internet data volume.
- IVI has access to the vehicle data, but doesn't have internet connection: OBD-II only provides internet access to IVI.

With OPC/UA describing the vehicle data on an OBD-II adapter, it is easy to define a new end-point for aggregated data. This can reduce the data needed to be transported via wireless media and can be integrated with different OEMs or service providers.

Logging and Replaying Debug Data

With the capability of deploying software components on a runtime system in the field, it is possible to collect the debug data in the field as needed. Those data can be stored locally or sent back to the developer where the data can be replayed on the development environment.

Firmware Over-the-Air Update

Using the existing software component management mechanism on JamaicaCAR and EdgeSuite, it is possible to develop a solid FOTA update service for the ECUs. Based on the vehicle and the ECU types, the corresponding protocol, which can communicate with the ECU, can be installed at runtime. The new firmware can then be downloaded and updated to the ECU.

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[6] https://github.com/GENIVI/dlt-daemon

Get in touch with us to learn more about our solutions!

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