FMI Layered Standard for Network Communication v1.0 released - enabling the simulation of virtual ECUs with FMI 3.0

Increasingly complex supply chains and functional diversity in the creation of virtual ECUs (vECUs) require standardization to ensure the simple and cost-efficient exchange of vECUs for users of Software-in-the-Loop (SiL) testing solutions. The Functional Mock-up Interface (FMI) is the de facto industry standard for model exchange and co-simulation with more than 250 tool supporting it. FMI versions 1.0 and 2.0 are already well-established for creating vECUs, but the capabilities for these applications have been significantly improved with the release of FMI 3.0 in 2022. Additionally, FMI 3.0 allows for the specification of layered standards. These are defined based on the FMI 3.0 core standard and extend its capability for specific usage domains. And now version v1.0 of the FMI Layered Standard for Network Communication (FMI-LS-BUS) has been released by the FMI Project!

CAN, CAN FD, CAN XL, LIN, FlexRay and Ethernet are network technologies that have been applied successfully over many years by all automotive OEMs worldwide. Virtualizing ECUs and then simulating such vECUs requires connecting them using a virtual version of these network technologies.

fmi Functional Mock-Up Interface
Layered Standard for Network Communication
FMI-LS-BUS v1.0

The layered standard defines what input and output variables, and which FMI 3.0 features are used and how to emulate a transport layer for such network traffic. At this point it should be explicitly mentioned that this layered standard not only relates to automotive buses but can also be extended to buses from other domains in the future.

There are two base use cases enabled:

- **Physical Signal Abstraction (or High-Cut)** to simply transport physical signal values between virtual ECUs: The network properties are largely idealized: Infinite bandwidth, zero-delay etc. Signals, groups of signals and their properties (e.g., units) are usually derived from existing and validated standard network topology description formats, such as DBC, LDF, Fibex and ARXML.
- **Network Abstraction (or Low-Cut)** to realize virtualized bus driver implementations: This transport layer emulation allows anything from idealized to more detailed network simulations, including bandwidth restrictions, message arbitration and delays. It forwards the network payloads using binary variables. The Low-Cut abstraction layer is meant to allow virtualized bus driver implementations, including feedback from the physical drivers about transmission status or network node states. Since the Network Abstraction layer is protocol-independent, it can also be used for the simulation of non-automotive control units, e.g., from the field of industrial automation.

The FMI Layered Standard for Network Communication (FMI-LS-BUS) has been created in a collaborative effort by a working group within the FMI Project with contributions from Akkodis, Altair, AVL, Beckhoff, Bosch, dSPACE, PMSF and Synopsys.

The FMI Steering Committee has now released the version v1.0 of the FMI 3.0 Layered Standard for Network Communication (FMI-LS-BUS). This version includes the common Physical Signal Abstraction, that fits for all bus types, and the Network Abstraction that supports CAN, CAN FD, CAN XL.

Additionally, a pre-release of FMI-LS-BS v1.1.0-beta was published supporting the next planned bus types FlexRay and Ethernet. A chronological overview of the supported and planned bus types can be found in the FMI-LS-BUS Roadmap.

The new Layered Standard has been heavily tested during the development, and already is supported by the following tools: Altair Twin Activate, dSPACE SystemDesk, dSPACE VEOS, Model.CONNECT, Synopsys Silver, Vector SIL Kit, and Vector vVIRTUALtarget (for more information see https://github.com/modelica/fmi-ls-bus)

The FMI Layered Standard for Network Communication is accompanied by other layered standards to improve the simulation of vECUs:

- FMI-LS-XCP (v1.0 released, see https://github.com/modelica/fmi-ls-xcp) which enables the measurements via the ASAM XCP standard
- FMI-LS-STRUCT The FMI Layered Standard for the Structuring of data (FMI-LS-STRUCT, v1.0-alpha available, see https://github.com/modelica/fmi-ls-struct) which defines support for maps.

Together they represent a significant part of the functionality required for carrying out SiL tests in vECUs by using the popular FMI 3.0 standard. They enable the faster exchange of vECUs and give users the option of tool freedom when creating and simulating vECUs. Ultimately, this reduces the process complexity for exchanging and makes it significantly more cost-efficient to create and simulate vECUs.

More Information:

- FMI Layered Standard for Network Communication (FMI-LS-BUS) (Standard v1.0.0), (Github repository and Issue tracker)
- Presentation at the International ASAM Conference 2024: "The Functional Mock-up Interface (FMI), layered standards and ASAM standards - Enabling seamless SiL simulation of vECUs": A recorded presentation with a demonstration (Slides)(Video)
- The new FMI Layered Standard for Network Communication will be presented by its developers at the16th International Modelica and FMI Conference in Lucerne, Sept 8-10 2025, in a talk "FMI Layered Standard for Network Communication: Applications in Networked ECU Development".

About the Modelica Association Project FMI

The Functional Mock-up Interface is a free standard that defines a container and an interface to exchange dynamic simulation models using a combination of XML files, binaries and C code, distributed as a ZIP file. It is supported by 250+ tools and developed in a Modelica Association Project under the roof of the Modelica Association.

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About the Modelica Association

The Modelica Association (MA) is a non-profit organization incorporated in Sweden with the mission to develop open-access, royalty-free, coordinated standards for the development and verification of cyber-physical systems. The open and royalty-free nature of the standards supports a rich eco-system of open-source and commercial solutions.

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