June 2020

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Issue

Safe4RAIL2

Safe architecture for Robust distributed Application Integration in roLling stock

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Message from Coordinator:
Outlook for this year

Welcome to the third issue of Safe4RAIL-2 newsletter. This newsletter comes in a moment when the whole world is going through a very challenging situation due to COVID-19. Safe4RAIL-2 is no stranger to that, and several project activities needed to be rearranged or rescheduled. However, due to the strong commitment of project partners, most activities have continued during this period. My deepest gratitude for all of them.

The project activities in the first months of 2020 have been focused on the development of the different TCMS devices (i.e. Drive-by-Data network devices, wireless equipment, and HVAC subsystem). 2020 will see the finalization of these components, and their integration in the demonstrators of CONNECTA-2 project. We are also expecting to continue with the dissemination of the project activities, as we did in the "Technical Seminar on Advanced Architectures and Components for Next-Generation TCMS" we had on January 21st in Brussels.

The current issue of the newsletter is focused on WP3, which deals with Functional Distribution Framework (FDF) and Simulation Framework (SF). These are two technological blocks which provide a strong improvement for the development, integration and testing of train subsystems. The FDF allows a seamless and flexible distribution of train subsystems in different hardware and software elements, thus meeting the various configurations required by train manufacturers. In addition, the SF allows testing train subsystems either locally or remotely, and either using real subsystems (i.e. Hardware-in-the-loop testing) or simulated ones (i.e. Sofware-in-the-loop).

I hope you find the content of this newsletter useful and interesting. I hope also that the global situation stabilizes very soon, and we can provide you further updates on the progress of the project in a few months. All the best for everyone, and take care.

Spotlight on WP3:
Functional Distribution Framework & Simulation Framework

Functional Distribution Framework and Simulation Framework: Simplify and Economize

The development of new technology and the creation of cutting-edge architectural concepts in automotive and avionic industries have led to significant and fast progress in safety, security and in the integration of new functions. To achieve similar industry developments in railway systems and take advantage of cross-industry synergies, the European railway industry has given high priority to address the most common issues hindering the rolling stock efficiency, system optimization and interoperability within.

Under this background, the project "Safe4RAIL - Safe architecture for Robust distributed Application Integration in roLling stock" provided a holistic architectural approach for building the next generation of Train Control and Monitoring Systems (TCMS). The main achievement of Safe4RAIL was to define a fundamentally simplified electronic architecture and a common distributed/shared embedded computing and communication infrastructure for modular integration of all safety-, time- and mission-critical, and non-critical train functions.

The Functional Distribution Framework (FDF) and the Simulation Framework (SF) are two pillars of such approach, enabling to reduce the diversity and complexity of architecture and engineering, integration and certification costs. The first one aims at having isolated but integrated applications instead of dedicated equipment for each train function. On the other hand, the Simulation Framework allows to test TCMS in a virtualized environment where all train subsystems can be simulated.

The goal of Safe4RAIL-2 Work Package 3 is to implement and integrate an HVAC (Heating, ventilation, and air conditioning) train subsystem in the previously mentioned FDF and SF. These frameworks are being developed by CONNECTA-2 project in the context of two laboratory demonstrators, an Urban demo and a Regional demo, each using different platforms. Moreover, for this purpose, the HVAC Application Profile is being applied, which will ensure the interoperability of train applications by different vendors.

Functional Distribution Framework – An Integrated Modular Architecture for TCMS

The FDF is considered nuclear for the achievement of a simplified architecture for TCMS. The objective is to develop a framework for modular integration of TCMS applications, in order to host distributed safety-critical (up to SIL4) and non-critical application side-by-side on the same hardware platform in distributed TCMS systems. In the end, **the aim is to have isolated but integrated applications instead of dedicated equipment (HW, SW, I/O) for each train function.** For this purpose, the FDF provides an execution environment that ensures:

- A common API and Services
- Portable Applications between different FDF Implementations
- Abstraction from the underlying network protocols and hardware

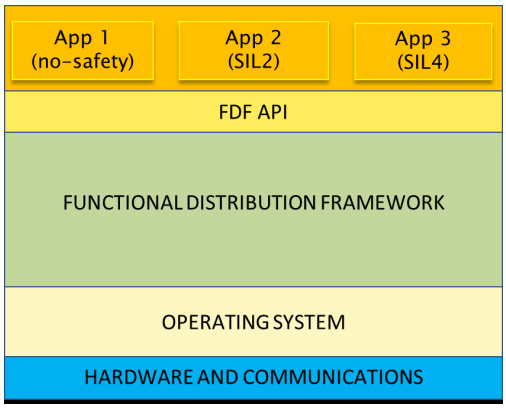

Fig. 1: Functional Distribution Framework

This solution enables that multiple applications can be installed and run within a single control computer. The system will guarantee the functional safety and freedom from interference as well as the interoperability for applications on different operating systems and platforms. This means **the FDF can be considered a Middleware which abstracts the applications from the underlying hardware, Operating System and communications.** Consequently, by applying this solution, the following substantial benefits are achieved:

- Reduced number, diversity and complexity of equipment
- Reduced safety and certification tasks and complexity
- Reduced complexity of deployment for subsystem providers
- Drastic reduction of obsolescence costs
- Hardware and communication abstraction
- Same application can run on different FDF implementations

Simulation Framework – Virtual Placement in the Market

In the development process of today's railway systems, the integration and testing of components are crucial steps, which require a high dedication and cost. These processes can be improved by using a distributed simulation and validation framework which provides the following features:

- Simulation of train communication networks with co-simulated end systems
- Early validation of functionality, timing, reliability and safety
- Distributed co-simulation of components located at manufacturer's sites being connected via heterogeneous communication networks such as the Internet
- Generic interface to support various simulation tools and devices

The Simulation Framework achieves all these features by a set of tools used for Train Virtualization, Simulation and Communications Emulation. **It has the ability to test TCMS in a virtualized environment, where all train subsystems can be simulated.** Besides, it allows both Software-in-the-loop and Hardware-in-the-loop testing, which enables the testing and refinement of a given application or equipment prior to its integration in the final environment. In order to validate the Software-in-the-loop approach, the objective of Safe4RAIL-2 is to deploy an HVAC plant model in a Simulation Host and check its correct reaction to the commands sent from a control application. Moreover, the remote Hardware-in-the-loop testing will be carried out by sending commands through the Simulation Framework from the same HVAC control application to a real HVAC device located remotely.

Application Profiles – Standardization Subsystems

Application Profiles were born to ease the complex subsystem integration process resulting from the diversity of solutions the subsystem suppliers can offer. **Application Profiles define a common communication between the TCMS and the different subsystems residing in a train.**

The outcomes of this concept can be listed as follows:

- Reduced engineering costs due to standardization of:
  - Requirements for the subsystem
  - Interface between TCMS and the subsystem
  - Documentation
  - Tests
- Reduced project duration due to less negotiations between subsystem supplier and integrator
- Reduction of problems during system introduction phase, due to less changes in software and hardware components

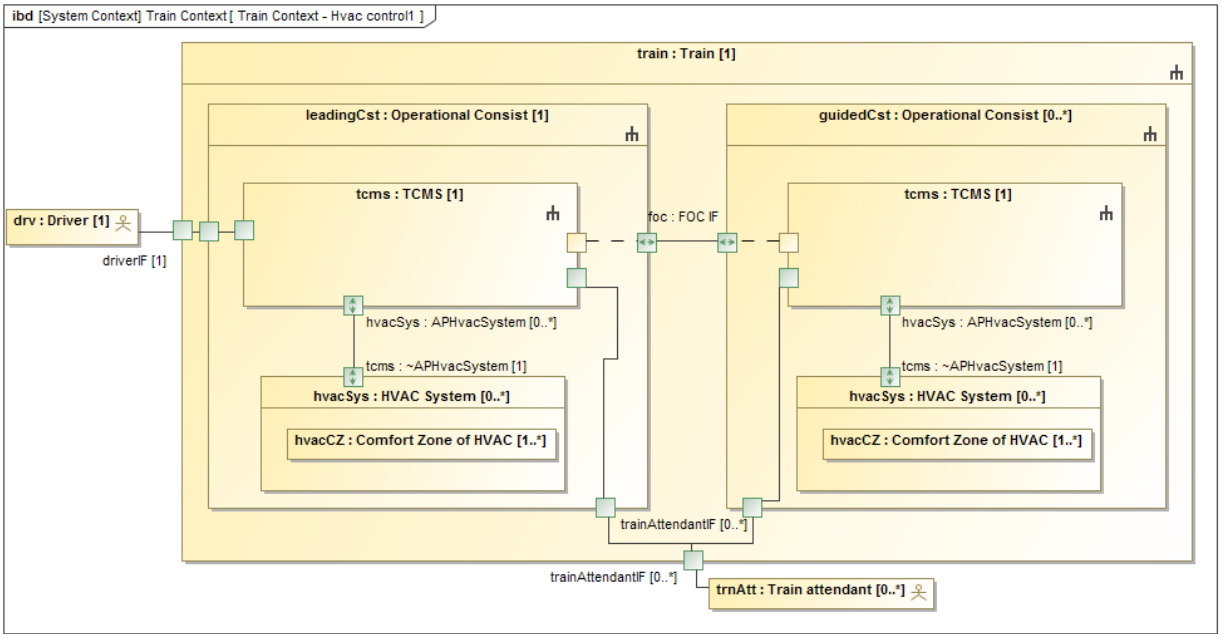

Fig. 2: Application Profiles

Public Deliverables Submitted

From M13 to M18, three public deliverables have been finalized and released on our project **website**:

Deliverable D2.2 "LTE Equipment: Design, implementation and impact analysis" (interim version) includes a State-of-the-Art review of wireless technologies for WLTB, as well as design blocks for LTE equipment supporting D2D and multicast for wireless train backbone communication.

Deliverable D2.6 "Wireless Consist Network Report" (interim version) addresses a State-of-the-Art review of wireless technologies for WLCN and a harmonized architecture for the future wireless consist network supporting the integration of various wireless technologies.

Deliverable D4.3 "Initial Report and updated plan on dissemination & communication activities" (interim version) provides a record of activities related to dissemination that have been undertaken in the first 15 months of the project as well as a list of those activities which are planned for the upcoming period. Besides dissemination activities, a list of completed as well as planned communication activities is included.

Ongoing Activities

WP1 TSN-based Drive-by-Data

Within WP1, the following activities with respect to architecture design and prototype implementation have been carried out:

- Ethernet Switches for NG-TCN: The architecture design for the backbone and local switches to support the new features with the collaboration of CONNECTA-2 project partners has been completed. Now we are in the implementation of the prototypes for the development architecture.
- End-Devices for NG-TCN: The early version of the PCIe card and the end device are implemented. In this stage, we are in the testing of these prototypes, before delivering them to the CONNECTA-2 partners.
- Bridging across ECN and ETB: the fail operational clock synchronization to couple the ECN and ETB network has been developed and prototyped.

WP2 Future Wireless TCMS

During the last few months, the LTE V2X WLTB specification has been completed and the prototype is under development. Following the identification of non-compliancy limitations of the 3GPP LTE V2X Rel. 14 specification for the WLTB requirements, WLTB specific services (group management, mesh, ..) are being implemented as overlay over the LTE V2X technology. Ethernet (L2) support has been included as well as statistical LTE V2X scheduling emulation, enabling the evaluation of the WLTB radio device under growing number of other WLTB radio devices.

Challenging environments for the WLTB have also been identified and defined: train depot, train station, tunnels, and high-speed mobility. The evaluation of the LTE V2X WLTB radio device in a train depot has been conducted, illustrating the need to rely on short range, possibly multi-hop, transmissions to maximize the reliability of ETBN traffic.

Towards Virtual Coupling, wireless TSN has been investigated in various standards (IEEE, IETF, 3GPP), and the analysis of its impact on LTE V2X and 5G technologies is in progress.

WP3 Functional Distribution Framework and Simulation Framework

Functional Distribution Framework

- The HVAC control application has been completed to cover all Use Cases.
- Regional Demonstrator: there has been substantial progress on TRDP and OPC-UA support on the demonstrator. A new RTA-VRTE release is expected soon, which will cover several features requested by CONNECTA-2.
- Urban Demonstrator: a compilation and integration of the HVAC control application was successful for the real target, and a verification vector will ensure its proper behaviour.
- Train-Wide Service Registry: Its specification, architecture and implementation are ready. Safe4RAIL-2 and CONNECTA-2 are now evaluating the integration scenarios on the demonstrators.

Simulation Framework

- HVAC plant models: fully functional FMU models have been completed which satisfy the needs of the different simulation platforms.
- Regional Demonstrator: HVAC plant models have been successfully loaded on the Simulation platforms.
- Urban Demonstrator: a communication bridge, an HVAC mock-up and a TRDP gateway have been developed, towards the realization of a Remote Hardware-In-the-Loop (HIL) testing of the HVAC subsystem.

Scientific Publication

A paper describing advanced architectures and components for the Next-Generation Train Control and Monitoring System, has been written and accepted to TRA2020, which is available at the project **website**.

Past Meetings

ETBN Inauguration Workshop
Västeras, Sweden
10th September 2019

1st Joint Advisory Board Meeting
San Sebastian, Spain
30th September 2019

General Assembly Meeting
San Sebastian, Spain
2nd October 2019

Regional Demonstrator
1st Pre-Integration Meeting
Hennigsdorf, Germany
9th of October 2019

OpenAirInterface Training
Sophia Antipolis, France
16th of October 2019

Regional Demonstrator
2nd Pre-Integration Meeting
Munich, Germany
4th of November 2019

Urban Demonstrator - HVAC Application on Integrity FDF
1st Pre-Integration Meeting
Beasain, Spain
12th of November 2019

AUTOSAR Adaptive Platform Training
Stuttgart, Germany
12th of November 2019

Urban Demonstrator - HVAC Application on Integrity FDF
2nd Pre-Integration Meeting
Mondragon, Spain
27th of November 2019

WP1 & WP3 Integration Workshop
Erlangen, Germany
3rd of December 2019

Technical Seminar on Advanced Architectures and Components for Next-Generation TCMS
Brussels, Belgium
21st of January 2020

2nd Executive Board Meeting
Brussels, Belgium
22nd of January 2020

Drive-by-Data Integration Workshop
Mannheim, Germany
5th of February 2020

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