Modeling and simulation of ERTMS with VDM

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Course: E18 - Modeling of Critical Systems

Abstract

Modeling of critical systems is an important tool in software engineering, as it allows us to design a system from specification and verify its properties in a controlled environment early in the development process. In this report, we use the Vienna Development Method (VDM) to model, simulate and verify a subset of the specifications for the safety-critical European Rail Traffic Management System (ERTMS) level 2 focusing on those properties of ERTMS that concern interlocking of tracks and safety of the trains. In ERTMS, these features are controlled by the European Train Control System (ETCS) component. With VDM, we can perform system design analysis and model verification to catch potential faults early before the system is constructed in an implementation language like Java and deployed to a real system. We start by defining requirements and invariants based on the ERTMS/ETCS specification and then use VDM to design a formal model followed by model-checking. The abstract implementation of ERTMS detailed in this report provide a simple but fundamental understanding of the signaling system's behavior and how to describe its constraints.

Keywords: ERTMS, ETCS, VDM, formal methods, interlocking, safety

1. Introduction

The European Rail Traffic Management System (ERTMS) is a signaling and control system developed in the start 2000's too address the interoperability issues with cross-border ail traffic in Europe. Currently many European countries have their own national stand-alone signaling and control system implemented by a certain set of rules that differ from each country. ERTMS is designed to replace the national systems to make rail transport

more frictionless, improve rail capacity and more attractive to consumers. It consists of two primary parts, the European Train Control and Command System (ETCS) to govern the positions and safety of trains, known as the Interlocking (ITL), and the GSM-R radio communications system to send messages between trains and the Radio Block Center (RBC). There a three different levels of ERTMS, L1, L2 and L3. We consider L2 in this report. L2 introduces the RBC, a Eurobalise that register train movement and omits any track side signaling equipment. For a train to enter a new track section, it must requests a movement authority (MoA) for that section from the RBC, which will be further explained in section X.

Figure 1 shows the essential components of ERTMS level 2. The train control (EVC) requests movement authorities from the RBC over GSM-R. A typical national rail way will have multiple RBC's for each region. The RBC's communicate with a central interlocking service, that receives the physical location of trains using the Eurobalises, in order to either grant or deny movement authority to a train.

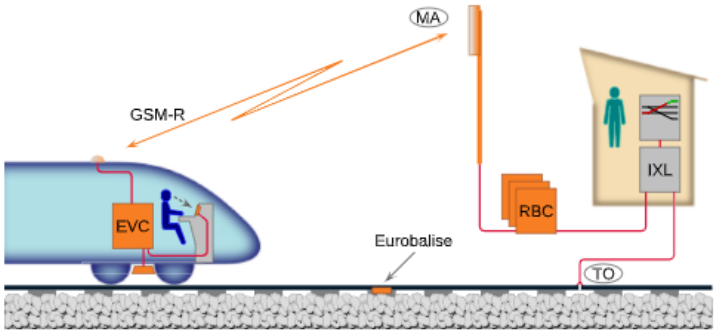

Figure 1: An overview of the components in ERTMS/ETCS level 2.

- Bullet point one
- Bullet point two

1. Numbered list item one
2. Numbered list item two

1.1. Subsection One

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Treatment 2	0.0015681	0.910
Treatment 3	0.0009271	0.296

Table 1: Table caption

1.2. Subsection Two

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2. The Second Section

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