Chapter 14
Architecture Description Languages for the Automotive Domain

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ABSTRACT
The embedded electronic architecture of a modern vehicle is a distributed system composed of several tenths of nodes. The development of these systems relies on a cooperative process involving several partners (carmakers and several suppliers). In such highly competitive domain, three main factors have to be taken into account: the design and production costs, the performance, comfort, and quality of driving, and several stringent safety requirements. In order to fulfill these requirements in such a context, it is vital for the different stakeholders to master the effects of the different sources of complexity. One way to reach this goal is to provide them with a common modeling language capable of representing the system at all its design steps and a common reference architecture in terms of components and organization. This chapter illustrates this approach. It focuses on EAST-ADL, an architecture description language dedicated to the automotive domain. Its links to the reference architecture defined by the AUTOSAR consortium are given. The chapter focuses especially on the ability offered by EAST-ADL to support the validation and verification (V&V) activities in order to fulfill the safety requirements.

INTRODUCTION
Over the past twenty years, the number of computer-based systems embedded in the different functional domains of cars has increased significantly. This trend has been driven by economical and technological factors. Thus, in the 90’s and early 00’s, the reliability and performance levels of hardware components and the flexibility offered by software technologies led to gradually replacing hydro-me-
Mechanical control systems with computer-controlled systems. Today, computer-based systems are used to realize innovative functions in the domain of vehicle and passenger safety, such as “active steering” (introduced in the BMW X5 in 2007). Tomorrow, they are expected to play an important role in reducing fuel consumption. It is expected that the embedded electronic architecture for the next generation of vehicles will be composed of 30 electronic control units (or ECU for short) for low-end vehicles and up to 80 ECU for high-end.

The development of an embedded electronic architecture is a cooperative work involving an OEM (Original Equipment Manufacturer, or carmaker) and several Tier 1 suppliers (a Tier 1 supplier sells its production to OEMs; a Tier 2 supplier sells its production to Tier 1 suppliers; etc.). The result of this work is a complex distributed system, integrating several heterogeneous communication networks, and subject to stringent safety requirements. The importance of the safety concerns will further increase in the next decade because of the emerging ISO 26262 standards (Schubotz, 2008) that are likely to influence the certification process for embedded systems of the automotive domain in terms of dependability guarantee. In a highly competitive domain like the automotive industry, the design and production costs must be kept as low as possible. In this context, it is vital for the different stakeholders to master the complexity of the design of the embedded electronic architecture. One way to reach this goal is to use a modeling language capable of representing the system at all its design steps and common to all the actors involved in the design process. Ideally, this language must be based on a reference architecture defining the target of the design process.

In the last 10 years, the European automotive industry has conducted several R&D projects to define such a modeling language and the accompanying reference architecture. For the modeling language, these efforts have led to the definition of several “Architecture Description Languages” (or ADL for short) such as AIL_Transport (Elloy and Simonot-Lion, 2002), or EAST-ADL (Freund, Gurrieri, Lönn, Eden, Migge, Reiser, et al., 2004) and its successor EAST-ADL2 (Cuenot et al., 2008). Concerning the reference architecture, it is defined today in the AUTOSAR (AUTomotive Open System Architecture) standards.

This chapter focuses on the modeling language. It is organized as follows: in the next section, an overview of AUTOSAR is given, and the main principles of ADLs are recapitulated. Then, in the following one, the EAST-ADL, an ADL dedicated to the automotive domain, is presented with a focus on the support it provides concerning the validation and verification (V&V) activities. This is illustrated in section “Example: Timing Analysis” with a case study. The last section concludes the chapter.

BACKGROUND

Reference Architectures for the Automotive Domain

A reference architecture defines the overall organization and the models of computation and communication used to implement computer-based systems of a certain domain. The most famous reference architecture is the OSI model for networked communication systems.

Concerning critical embedded systems, several reference architectures have been proposed. Similar to the OSI model, they usually rely on a layered architecture style, where each layer offers a set of services to the upper layer that hides the details of the underlying execution platform. The typical organization consists of a top layer that hosts the application components; a middleware layer that abstracts the distribution of the application among the physical nodes; a basic software layer that controls the access to the hardware resources.

Hence, in the domain of avionics systems, the “Integrated Modular Avionics” reference ar-
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