System Structure and Parameterization

Smart Systems Engineering – SmartSE
System Structure and Parameterization

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1 Introduction

The Smart Systems Engineering (SmartSE) project group focuses on distributed collaborative system development between partners using systems engineering methods and standards. A key aspect of this collaborative development is the exchange of simulation models between partners. That is why the FMI standard was of interest to the SmartSE group from the very start and remains so. Complex systems are, however, increasingly being represented by multiple models. This means that numerous individual models are interconnected to form a model network. If these model networks are to be exchanged in practice, it is essential that not only the models themselves but also their interconnections and parameterization are exchanged. This is something that the SSP standard provides for. This white paper is intended to provide an introduction to the SSP standard, the use cases addressed and the benefits of using the standard. The description of a demonstrator supports this objective.

1.1 System Structure and Parameterization (SSP)

The System Structure and Parameterization (SSP) standard was developed by the Modelica Association with the aim of creating and making available a data exchange format for describing simulation-capable system structures based on functional mock-up units (FMU). A single FMU can provide technical and organizational metadata for the FMU in question. However, when it comes to simulating complex systems, individual FMUs are often interconnected to create FMU networks in which the FMUs can be structured both hierarchically and functionally. Functional structuring refers to the unit comprising an FMU and its input and output ports, via which information can be exchanged between the FMUs. Cross-FMU structure and meta information cannot be described or transferred using the Functional Mockup Interface (FMI) standard alone. This is where the SSP standard comes in. The standard is intended to describe the overarching structures and thus makes it possible for them to be exchanged. SSP is an umbrella format comprising multiple subformats that are bundled together in a zip container containing all the components of the system structure package (SSP).

- The system structure description (SSD) is a mandatory part of every system structure package that is used to describe hierarchical and functional structures of a whole FMU network.
- A system structure parameter values (SSV) element is used to describe parameters and external parameter sets that can be applied to an FMU, thus parameterizing it.
- A system structure parameter mapping (SSM) is used to describe parameter mappings that may be required to parameterize FMUs.
- A system structure signal dictionary (SSB) is used to describe signals.

The SSV, SSM and SSB subformats are optional and can be referenced from the SSD subformat. The included FMUs are also referenced from the SSD. Figure 1 shows the structure of a system structure package and also provides a look at the structure of the SSD subformat. The contents of the SSV, SSM and SSB subformats can in principle also be embedded directly in the SSD.
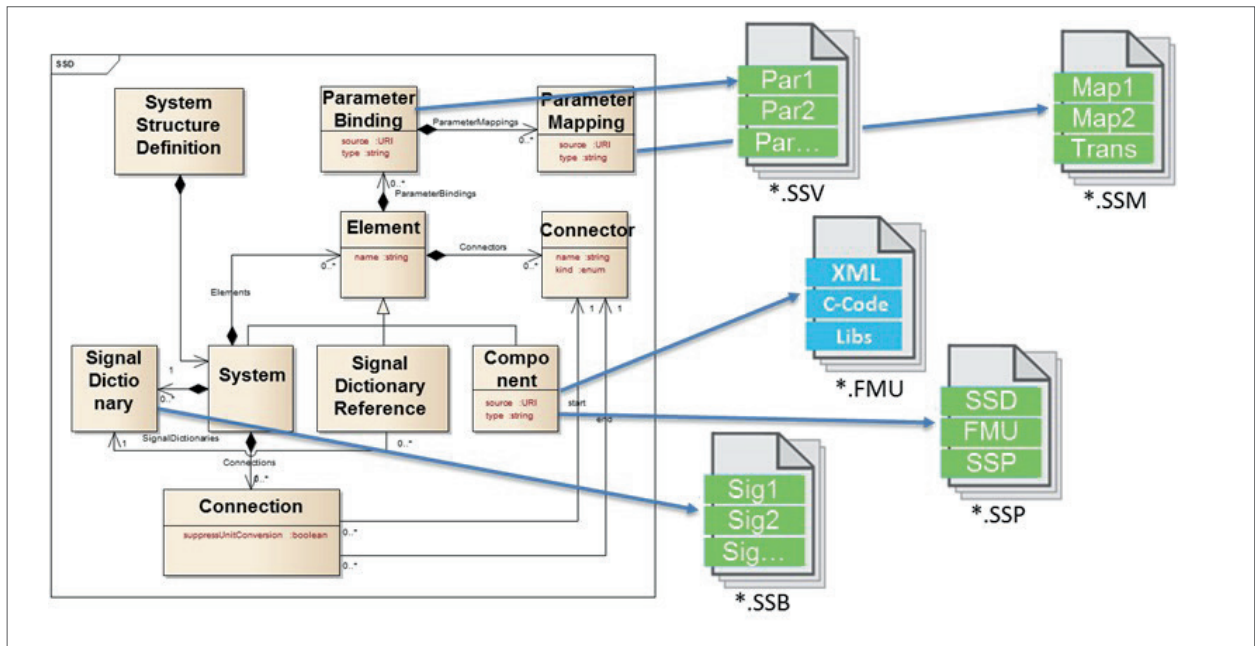
Figure 1: Internal structure of a system structure package (image: https://ssp-standard.org/)

1.2 Basis for SSP

The SSP standard is based on existing standardized formats for structuring information and for data coding, such as XSD (W3C XML Schema Definition Language) and XML (W3C Extensible Markup Language: W3C XML). SSP also references the Modelica Association's Functional Mock-up Interface (FMI) standard.

- XSD: XML Schemas express shared vocabularies and allow machines to carry out rules made by people. They provide a means of defining the structure, content and semantics of XML documents. (Reference: https://www.w3.org/XML/Schema)
- XML: Extensible Markup Language (XML) is a simple, very flexible text format derived from SGML (ISO 8879). Originally designed to meet the challenges of large-scale electronic publishing, XML is also playing an increasingly important role in the exchange of a wide variety of data on the web and elsewhere. (Reference: https://www.w3.org/XML/)
- FMI and FMU: The Functional Mock-up Interface (FMI) is a free standard that defines a container (FMU) and an interface (FMI) for exchanging dynamic models using a combination of XML files, binaries and C code zipped into a single file. It is supported by over 150 tools and maintained as a Modelica Association Project on GitHub. The code has been released under a 2-clause BSD license; the documents under a CC BY-SA license. (Reference: https://fmi-standard.org/)