Abstract for MBSE2022 Workshop

Applicable workshop objectives:

- T4 – Discuss the role of existing, evolving and emerging standards to address interoperability and semantic modelling to support digital continuity
- S-3 – Collaboration in an international, competitive and heterogeneous market place (e.g. evolution and adoption of standards and tools, legal and contractual aspects, data governance)
- S-1 – The vision for (model based) systems and software engineering in the next decade; opportunities and challenges, risks and rewards

Title: "SysML Version 2 - Final Stretch"

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This presentation is the third in a series on the development of the SysML version 2 standard. At MBSE2020 *"What to Expect from SysML Version 2?"* [6] was presented, and at MBSE2021 *"SysML Version 2 Approaching Industrial Use"* [7]. Since September 2021, the international SysML v2 Submission Team (SST) has been working hard to complete the content of the *final submission* of the specifications to OMG as well as the open source pilot tool implementations that fully implement the new specifications and are used for continuous validation. The SST has produced monthly releases of both specifications and pilot implementations on GitHub, and will continue to do so until the scheduled final submission deadline in November 2022, actually just before the MBSE2022 workshop.

The submission consists of three specifications [4]:

1. Kernel Modeling Language (KerML) – version 1.0
2. OMG Systems Modeling Language (SysML) – version 2.0
3. Systems Modeling Application Programming Interface (API) and Services – version 1.0

In addition, training material on the textual and the graphical notation is provided as well as a number of open source SysML v2 modelling tools:

- A web-browser based Jupyter Lab notebook tool targeted at systems engineers / end-users. This tool provides textual notation modelling capabilities as well as on-the-fly, automated visualization of the SysML v2 models in its graphical notation [4], [5]
- An Eclipse EMF based language workbench, targeted at KerML and SysML v2 language developers and MBSE tool developers [4], [5]
- An OpenAPI (v3) compatible REST-API implementation of the Systems Modeling API and Services specification, targeted at SysML v2 and general MBSE infrastructure / server developers. The REST-API is implemented using the HTTP(S) protocol with the GET, PUT, POST, DELETE methods, and JSON or JSON-LD object serialization [5]
- Additional utilities that provide useful capabilities, such as syntax highlighting profiles for popular editors like the Visual Code and JetBrains environments. [5]

Most software is released under the LGPL license. The GitHub repositories at [4] and [5] also contain many documented examples of SysML v2 models.

Also worth mentioning is that Annex C of the SysML v2 specification contains a full machine readable mapping from SysML v1 to SysML v2 concepts in order to support automated v1 to v2 model conversions.

In the ongoing adoption of Model-Based Systems Engineering (MBSE) the Systems Modeling Language (SysML) standard [1] from the Object Management Group (OMG) plays a major role, as it is de facto the only implemented international standard in direct support of MBSE. SysML version 1.0 was released in 2008. Thereafter, every few years an updated version was released, up to the current v1.6 in December 2019. In addition, in 2017 SysML was adopted as the ISO/IEC 19514 standard. Since approximately 2012, SysML is increasingly used in many industry sectors where complex systems are being developed: automotive, large infrastructure projects, aerospace and defence, mainly in Europe, the US, Canada and Japan, by industry as well as governmental agencies.

In the meantime three of the major SysML tool vendors – Dassault Systèmes, Sparx and IBM – have publicly announced that they will implement and support the new SysML standard. Also many industrial and academic MBSE developers are using the pilot implementation software as a basis to develop their own prototypes, and provide feedback to the SST. A number of models of significant size and complexity have already been realized. The SST actively promotes such participation very much in order to ensure the robustness and adequacy of the standard, and has set up a public Google Group for Q&A and discussions.

As reported earlier, the development of SysML v2 started in 2015 with extensive user needs collection and the formulation of a comprehensive Request for Proposal (RFP), the OMG equivalent of a requirements specification for a new standard or major upgrade. Two RFPs were produced: one for the language [2] and one for the API and Services [3]. Subsequently from 2018 to date, the SST has been developing SysML v2, both the Language and the API and Services parts as listed above. The SST consists of more than 180 experts from more than 80 organisations, that cover a wide range of industrial, academic, commercial, and institutional interests in systems engineering of complex systems. Both end-users and developers from many industry sectors are well represented. The RFPs contain a large set of requirements that drive the development. Major points to be addressed are:

- lowering of the SysML learning curve;
- unification on how structure and behaviour are decomposed;
- full and simple access to (deeply) nested structures and behaviours;
- addition of a full textual notation, in addition to clean-up and improvements of the abstract language and graphical notation;
- integration of a powerful expression language;
- development of semantically rich normative model libraries;
- much better support for multiple viewpoints and views for the same model information.

The current presentation will provide a summary overview of the capabilities of SysML version 2:

1. New simplified SysML meta-model, which is founded on a minimal set of key concepts.
2. The normative libraries, that provide all SysML basic concepts directly at the user modelling level (M1 for the experts) and thereby constitute a powerful and straightforward extension mechanism that replaces the profile and stereotypes approach of SysML v1 and UML.
3. The new textual notation, including a very powerful expression and constraint language, as well as the upgraded graphical notation, and the integral, flexible viewpoint / view capabilities. These overcome many limitations of the SysML v1 Block Definition and Internal Block Diagrams. They also provide much better and more precise ways to define interfaces and connections, including in deeply nested structures. Then there is the integrated approach to model behaviour (activities, functional architecture, time-based sequences, finite state machines, 4D lifecycle objects), both in

precise textual notation and in diagrams that can be mixed and matched, which was requested by many users.

4. Much improved support for requirements engineering and use case definition, leveraging the parameterised constraint definition capabilities in SysML v2 and unification of concepts.
5. Support for variant modelling and product line engineering built into the language and/or connectable to external variant modelling tools.
6. The built-in meta-data and user-defined keywords functionality.
7. The extensive library in support of quantities, units, scales and dimensions, that covers all of ISO/IEC 80000 (International System of Quantities and SI) and US Customary Units. This library now also fully supports vector and tensor quantities as well as multi-dimensional coordinate systems and coordinate transformations.
8. The libraries for basic geometry modelling and the interfacing with 3D modelling standards and tools, to supporting specification of basic shapes as well coordinate frames and transformations to define enveloping shapes and stay-out volumes for the physical parts of an architecture.
9. The much-improved support for integrating SysML v2 models with external analysis and simulation paradigms and tools, founded on much more precise execution semantics.
10. The way compatibility with SysML v1 is ensured via a standardised transformation specification from SysML v1 to SysML v2.

As part of the presentation a demonstration of key SysML v2 capabilities using the pilot implementation tools will be provided. The presentation will wrap-up with an overview of the expected further developments beyond the final submission in November, discussing the further processes inside and outside OMG to achieve maturity.

The author has been an active member of the SysML v1 task forces since 2009 as well as the SysML v2 RFP working group and is currently a core member of the SysML v2 Submission Team (SST) at OMG.

References

[1] Systems Modeling Language, OMG, https://www.omg.org/spec/SysML/, last version 1.6, November 2019

[2] Systems Modeling Language (SysML®) v2 Request For Proposal (RFP), OMG, December 2017, https://www.omg.org/cgi-bin/doc.cgi?ad/2017-12-2

[3] Systems Modeling Language (SysML®) v2 API and Services Request For Proposal (RFP), OMG, June 2018, https://www.omg.org/cgi-bin/doc.cgi?ad/2018-6-3

[4] Systems Modeling Language (SysML®) v2 monthly public releases at:
https://github.com/Systems-Modeling/SysML-v2-Release
Note: this comprises the specifications as well as training material and pilot implementation software releases.

[5] Systems Modeling Language (SysML®) v2 open source pilot implementations:
https://github.com/Systems-Modeling/SysML-v2-Pilot-Implementation
https://github.com/Systems-Modeling/SysML-v2-API-Services
https://github.com/Systems-Modeling/SysML-v2-API-Java-Client
https://github.com/Systems-Modeling/SysML-v2-API-Python-Client

[6] Hans Peter de Koning, "What to Expect from SysML v2", 2020, presented at MBSE2020,
see https://indico.esa.int/event/329/contributions/5528/attachments/3886/5614/1740_-_Presentation_-_What_to_Expect_from_SysML_Version_2.pdf

[7] Hans Peter de Koning, "SysML Version 2 Approaching Industrial Use", 2021, presented at MBSE2021,
see https://indico.esa.int/event/386/contributions/6223/attachments/4266/6445/1015%20-%20SysML%20Version%202%20Approaching%20Industrial%20Use.pdf

[8] General information on the OMG Systems Modeling Language (SysML), see http://www.omgsysml.org

[9] General information on MBSE across all industry sectors, INCOSE/OMG MBSE Wiki at
http://www.omgwiki.org/MBSE/doku.php