" A CONSOLIDATED EU DIGITAL INDUSTRIAL PLATFORM FOR ROBOTICS "

[An enabler]

Papyrus4Robotics, a RobMoSys-Compliant Toolset for Composable Models and Software

The Business

RobMoSys envisions an integration approach built on top of current code-centric platforms by means of systematic development and application of modern model-driven methods and tools.
This enables system-of-systems type of integration, which occurs at all levels of abstraction and interaction, rather than merely at the code level.

The Challenge

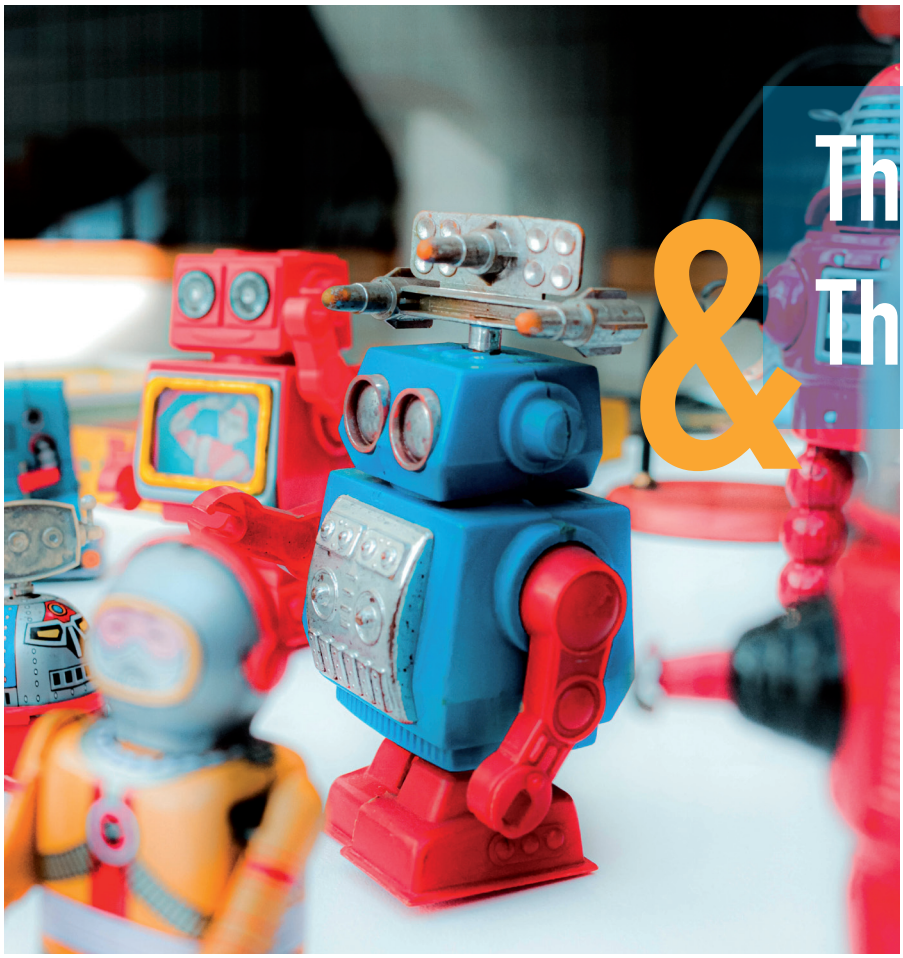
The current approach to developing robotics software is fundamentally code-centric and fragmented into numerous, often incompatible, frameworks. Consequently, software engineering of robotics applications is still in an early "craft" stage when compared to other domains such as automotive or avionics.

The Solution

RobMoSys provides a consolidated EU Digital Industrial Platform for Robotics, which (a) establishes a common methodology for software development, (b) improves tools and fosters interoperability through model interchange and, (c) facilitates composability. One of the primary assets of the RobMoSys ecosystem is the Papyrus4Robotics toolset. Papyrus4Robotics is an adaptation of the generic Papyrus tool, which provides a model-based graphical development environment specifically designed for RobMoSys.

The Benefits

Papyrus4Robotics provides the following core advantages:
(a) facilitates reuse of robotics assets in different contexts (different robots, robot versions, upgrades, etc.) by means of dedicated configuration and instantiation tools;
(b) eases the exploitation of safety standards used in certification processes;
(c) enables robot designers to integrate modules developed in other environments into their own proprietary environments.



The Business & The Challenge

The Business

The objective of RobMoSys is to manage the interfaces between the various roles involved in developing robotics systems (robotics experts, domain experts, component suppliers, system builders, as well as installation, deployment and operation specialists). It enables efficient and systematic separation of concerns by providing a set of high-level model-driven methods and tools for composition-based engineering of robotics systems. The vision behind RobMoSys is to provide an agile, multi-domain, model-driven, European-initiated software ecosystem for robotics development. It consists of a specialized set of facilities with both vertical and horizontal integration capabilities, enabling both broad-spectrum software products and software-related services. This ecosystem is able to rapidly address new functions and domains at a fraction of today's development costs.
RobMoSys aims at introducing a disruptive change in software-related robotics development by establishing a common methodology based on (1) the use of composable software models, and (2) by providing powerful tool chains that directly support that methodology. To encompass a very broad spectrum of different stakeholder groups, RobMoSys targets a high degree of openness, in terms of both tools and assets (e.g. models, patterns and libraries).

The Challenge

The current robotics software development landscape is primarily code-centric and highly fragmented into numerous and often incompatible component-based frameworks. It is characterized by a series of stand-alone tools, written in different programming languages, with sometimes overlapping capabilities, ranging from specialized coding facilities to sophisticated simulation environments. However, even the best of these tools still needs to be adapted to better support agility and interoperability, and to provide cleaner separation of concerns to support a variety of different engineering roles that may be focusing on different abstraction levels. In general, robotics software engineering is still in a "craft" stage compared to software engineering in more advanced domains such as automotive and avionics. In contrast, compare this to the AUTOSAR standard developed in the automotive domain. It combines the model-driven and component-based approaches to enable agile value chains involving car manufacturers, parts suppliers, and IT developers. This is definitely not the case in any of the emerging robotics application domains – at least not yet. There is no standard for software development that would enable the combination and interaction of components independently of any specific software infrastructure. There is also no general characterization of common robotics functionalities, such as "planning", "sensing" and "control" (in the broader sense of these terms), nor is there a general support framework that addresses the quality aspects of these systems, such as safety or reliability.
The challenge then is to define and support a structured methodology which eases the adoption of role-based software engineering approaches. This would enable the development of infrastructure-independent and easily interoperable solutions, as well as the development of tooling that can be customized to manage configurations in a composable and agile manner.

The Solution

«Solving critical issues in the area of robotics software development observed in industry.»

[For interested early adopters, it outlines a clear migration path for a step-by-step integration of existing model-driven software and tool assets into the RobMoSys ecosystem.]

The Solution

RobMoSys represents a consolidated EU Digital Industrial Platform for Robotics, which establishes a common methodology for software development, improves tools and fosters interoperability by model interchange and composability. The RobMoSys approach aims at solving critical issues in the area of robotics software development observed in industry. Moreover, for interested early adopters, it outlines a clear migration path for a step-by-step integration of existing model-driven software and tool assets into the RobMoSys ecosystem.

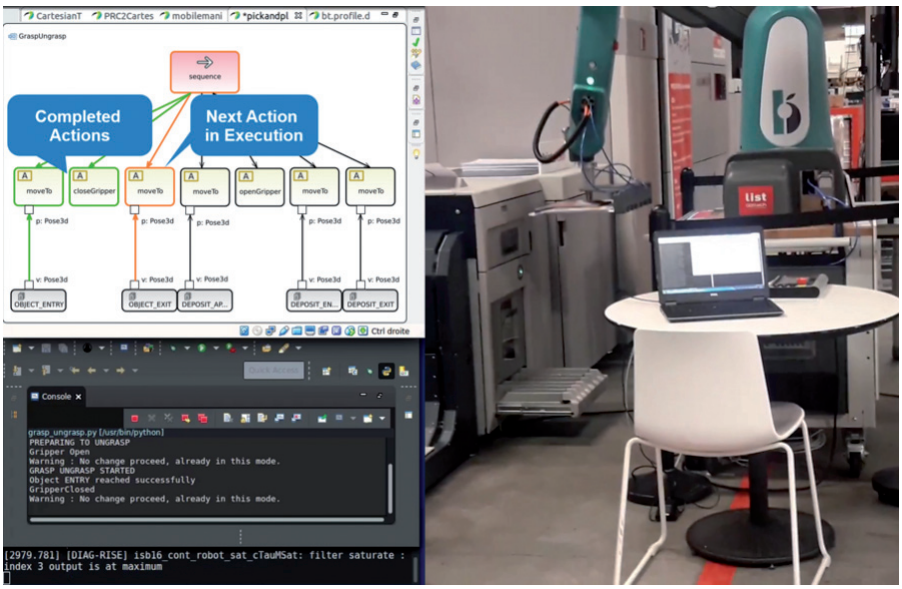
One of the main RobMoSys ecosystem components is the Papyrus4Robotics toolset. This is an adaptation of the Papyrus toolset that provides a graphical model-based development environment customized for RobMoSys. Currently, Papyrus4Robotics supports:

• Modular and Role-Based Design. Different robotics stakeholders can perform the tasks of their respective role at the appropriate abstraction level.

• Agile Risk Assessment. Robot behavior can be specified and configured by defining task models using basic robot capabilities. Risk assessment is performed assessing operational hazard situations and mitigation measures based on those task models, which is a mandatory step in the certification of robotics systems.

• Compositional Safety Analysis. Robotics software component suppliers specify potential faults and their propagation through component ports. Then the robotic system integrator uses component fault models to analyze system-level propagation and fault trees.

• Robustness Simulation. Robustness of robotics systems can be assessed against faults injected in controlled experiments. Papyrus4Robotics can then generate the code of controllers, including the fragments of the injected faults. Generated code enables evaluation of safety properties by means of normal and faulty simulations.



The Benefits

« RobMoSys provides separation of concerns by defining stakeholder-specific viewpoints. »

The Benefits

The primary benefits of Papyrus4Robotics and RobMoSys include:

• RobMoSys defines modeling constructs (the RobMoSys Metamodel) that are specific to the robotics domain (from low-level concepts such as communication patterns used in robotics middleware to high-level concepts such as Mission, Tasks, and World Models). At present, there is no modelling language with such a rich set of features specific to robotics that are, nevertheless, generic enough to be applicable to different domains (healthcare robotics, industrial robots, service robots, etc.).

• Despite the availability of numerous software development frameworks, robotics software developers have a difficult time in constructing reusable software components that are easily configurable. The availability of such components could greatly accelerate software production and reduce the time-to-market. Papyrus4Robotics enables the definition of such configurable components and the reuse of these components in different contexts (different robots, robot versions, upgrades, etc.) simply by means of configuration and instantiation tools.

• As a key principle, RobMoSys provides separation of concerns by defining stakeholder-specific viewpoints (component builder, integrator, task/skill configuration manager, etc.). This capability is provided by Papyrus4Robotics, which allows users to configure their environment to support different roles and viewpoints for easy access to pertinent information.

• The growing complexity of robotics applications and their increasing safety and certification requirements are not easily managed without a customized development approach. Papyrus4Robotics increases the quality of robotics components and systems by connecting to state-of-the-art tools and techniques, such as FMEA, FTA and risk assessments based on safety standards (e.g., ISO 10218 for industrial robots and ISO/TS 15066 for collaborative robots). Papyrus4Robotics also enables the execution of model-based simulations using fault injection techniques to test system robustness against specific system-level and software-level faults, as recommended by functional safety standards such as IEC 61508 (widely used in robotics electronic components).

• RobMoSys enables distribution of robotics software with a description and information about its quality, maturity and usage constraints, since it directly supports the concept of Robotics Datasheets via Papyrus4Robotics. The datasheets of building blocks include all information that is necessary to integrate them into a system.

• RobMoSys enables integrators or end-users to integrate modules that were developed in external environments into their proprietary environments. This is done by bridging facilities (code generators), which adapt a platform-independent model to a model for a specific target platform. Papyrus4Robotics currently provides such bridges for OROCOS and ROS2.

RobMoSys
→ robmosys.eu

H2020 Innovation Action

Partners: CEA (Coordinator), Siemens, COMAU, PAL Robotics, TU Munich, KU Leuven, TS Ulm, EUnited, Eclipse Foundations.

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