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D3.5 Open and Public Repository of Executable Scenarios

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Executive Summary

In this deliverable, we report on the Open Repository of Executable Scenarios[1], which consists of metamodels and models developed to support the Executable Scenario Workbench[2] (described in Deliverable 3.4).

The following sections of this deliverable will (i) briefly introduce the background and motivation for the Repository of Executable Scenarios, clarifying relations to the other deliverables, (ii) describe the organization of the various artefacts included in the Repository, and (iii) explain how conformance to the ExSce methodology can promote reuse of these artefacts when variations to the original use cases are introduced.

[1] https://sesame-project.github.io/exsce/exsce-repo.html
[2] https://sesame-project.github.io/exsce/exsce-workbench.html

1 Introduction

As mentioned above, the Repository of Executable Scenarios consists of models and metamodels developed to support the Executable Scenario Workbench, whose final version is described in Deliverable 3.4. The prominent representatives of these artefacts are curated and presented on the landing page[3] of the Repository. The remaining part of this section will briefly go over the background and motivation for the Repository and the relation of this deliverable to others in the project.

1.1 Background and Motivation

As described in our Design Concept and Methodology Deliverable (D3.1), Executable Scenario consists of the following ingredients:

Executable Scenario Concept Executable Scenarios (ExSce) are model-based narrative descriptions of robotic missions guiding the engineering of MRS applications. An ExSce supports the definition of scenarios, composed of mission-relevant and mission-plausible information. On the one hand, by mission-relevant information we refer to, among others, the environment and its dynamics, time and events, objects (e.g., inspected building) and subjects (e.g., human operators) and their potential behaviour. On the other hand, the mission-plausible information describes acceptance criteria that enable the verification and validation of MRS requirements. Both, mission-plausible and mission-relevant information are computer-interpretable models and hence enable the transformation into artefacts which can be executed in different contexts such as in simulators or on real robots.

Executable Scenario Methodology To put the ExSce concept into action, the ExSce methodology enables the structured development of MRS from stakeholders' scenarios. Hence, it comprises both a tailorable process model and associated tools that guide and support the stakeholders in (i) specifying scenarios; (ii) transforming them to executable artefacts; (iii) executing those artefacts; (iv) assuring the quality of the MRS in those scenarios; and (v) generalizing those scenarios.

Executable Scenario Workbench The ExSce Workbench is a collection of tools that supports stakeholders in carrying out one or more activities of the ExSce Methodology.

As such, many artefacts are produced to support the tools in the ExSce Workbench in showcasing the stakeholder activities in the ExSce Methodology. Examples include specification and transformation of environment and acceptance criteria models with FloorPlan DSL[4] and `bdd-dsl`[5], transformation and execution of robot models with `kindyngen`[6], and generalization of scenario models with ExSce Management[7].

This motivates the organization and curation of these artefacts into a repository where we can better present how they are used by our tools to support our methodology. This organization is described in further detail in Section 2, whereas Section 3 describes how the Repository can promote reuse of these artefacts for future use cases.

1.2 Relations to Other Deliverables

The Repository of Executable Scenarios contains metamodels and models created during the development and application of tools in the ExSce Workbench (D3.4) and Exce Management (D3.3) to support the ExSce Concept and Methodology. Therefore, they serve as concrete suggestions and examples of how to *represent* and

[3] `https://sesame-project.github.io/exsce/exsce-repo.html`
[4] `https://github.com/sesame-project/FloorPlan-DSL`
[5] `https://hbrs-sesame.github.io/bdd-dsl/`
[6] `https://github.com/hbrs-sesame/kindyngen`
[7] `https://hbrs-sesame.github.io/exsce_management/`

compose models for different aspects of a Multi-Robot Systems (MRS) scenario. The realization of concrete models, however, requires contribution from developers to support their specific use cases and scenarios. When possible, these tailored models can reuse artefacts from the Repository with appropriate adaptations and/or extensions. In the Multi-Robot Collaborative Rescue Mission (D2.5), for example, specification of the robot models, kinematic and dynamics constraints, and missions can be created from our current metamodels. Specifying temporal dependencies between tasks and different robot behaviours requires development of additional metamodels, the process of which can benefit from applying our ExSce Methodology. In another example, acceptance criteria produced as the result of safety (D4.6) & security (D5.6) analysis performed in the respective deliverables can be modelled using `bdd-dsl` as BDD scenarios.

2 Organization of the Repository of Executable Scenarios

As mentioned in Section 1, a selection of the metamodels and models developed to support ExSce is presented on the corresponding GitHub page[8]. This page links to the curated artefacts, which themselves are independently hosted and maintained on different pages and GitHub repositories depending on the context in which they are created or the tools they support.

On this page, we first present the selected metamodels, sorted by the domains they target. We briefly describe and link to each metamodel, many of which are uploaded to the `hbrs-sesame/metamodels`[9] and `comp-rob2b/metamodels`[10] GitHub repositories. Descriptions of the included domains and metamodels are currently added manually, but we plan to encode such information in the metamodels themselves, e.g. through the use of RDF Schema[11] in the future. Their descriptions can then be automatically generated when changes occur, simplifying the maintenance effort.

Finding a single structure to organize models composed of these metamodels and various artefacts produced from transformations using our tools can be challenging, since they often involve intertwining domains and may concern different stakeholder activities. As such, we present our models through a list of tutorials showcasing how they can be composed and transformed to serve specific stakeholder workflows. The tutorials can then link to our models while describing how they are used in the context of each workflow. For example, the BDD modelling tutorial[12] includes links to the BDD scenario templates and variants for a pickup task, as well as the Jinja[13] template which can be used to generate Gherkin[14] feature files for automated testing. Many of our models are hosted on the `hbrs-sesame/models`[15] GitHub repository.

[8] https://sesame-project.github.io/exsce/exsce-repo.html
[9] https://github.com/hbrs-sesame/metamodels
[10] https://github.com/comp-rob2b/metamodels
[11] https://www.w3.org/TR/rdf-schema/
[12] https://hbrs-sesame.github.io/bdd-dsl/bdd-tutorial-feature-gen.html
[13] https://jinja.palletsprojects.com/
[14] https://cucumber.io/docs/gherkin/reference/
[15] https://github.com/hbrs-sesame/models

3 Reusing Executable Scenarios

Executable Scenarios consist of the metamodels and models developed to support the ExSce Concept and Methodology. Reusability of these artefacts can be realized through several means:

- Users can compose new models from our metamodels and reuse our existing models when suitable to tailor to specific use cases. This process is enabled and simplified by applying established best practices in the design process of these metamodels and models to ensure their *composability*. More details on what we meant by composability can be found on our kinematic chain modelling tutorial[16], which is also included in our final version of the ExSce Workbench (D3.4).
- Furthermore, the reuse of our artefacts is also supported by our tutorials, which include descriptions of how to compose models from our metamodels in the context of the specific workflows that each tutorial aims to demonstrate. These tutorials also showcase how variations can be introduced to the models to adapt to new use cases, as well as how they can be transformed to integrate with existing tools and libraries. Users can then emulate our tutorials to create new models or extend ours according to their needs. If the existing tools developed for ExSce do not match the desired workflows, users are encouraged to develop new tools to enrich the ExSce ecosystem. In addition to being presented on the repository's GitHub page[17], these tutorials are also included in the ExSce Workbench deliverable (D3.4).

Examples of how to reuse the metamodels and models developed for ExSce include:

- Models[18] of the Kinova Gen3[19], which compose of the geometry, kinematic chain, and dynamics metamodels, can be reused for different robot configurations, e.g. two arms mounted on a mobile base, or with different end-effectors.
- Users can choose to vary an existing environment, e.g. floor plan[20] of a building at our university, by adding dynamics objects[21], or vary the generation process[22] that produces 3D models for use in simulation.
- The tutorial for `bdd-dsl`[23] shows how BDD scenario templates can be created for a pickup task. The tutorial then shows how this template can be reused by introducing variations to specify acceptance criteria for concrete scenarios.
- Our approach to Executable Scenario Management (D3.3) reuses artefacts generated from FloorPlan DSL to carry out experiments for collecting provenance data for scenario generalization[24].

[16] https://github.com/comp-rob2b/modelling-tutorial/tree/main#discussion-about-composable-models
[17] https://sesame-project.github.io/exsce/exsce-repo.html#tutorials
[18] https://github.com/comp-rob2b/robot-models/tree/main/kinova/gen3/7dof
[19] https://www.kinovarobotics.com/product/gen3-robots
[20] https://github.com/hbrs-sesame/FloorPlan-DSL/blob/main/models/examples/hbrs.floorplan
[21] https://github.com/hbrs-sesame/floorplan-object-modelling-and-placement/blob/master/docs/tutorial.md
[22] https://github.com/hbrs-sesame/FloorPlan-DSL/blob/main/docs/Variation.md
[23] https://hbrs-sesame.github.io/bdd-dsl/
[24] https://hbrs-sesame.github.io/exsce_management/generalization.html

4 Conclusions

The purpose of this deliverable is to report on the Repository of Executable Scenarios, which consists of metamodels and models developed to support the Executable Scenario Concept and Methodology. To this end, we first briefly went over the background on the Executable Scenario approach, which provides context to the organization of the various artefacts produced for ExSce. We then described the organization our metamodels and models in more detail, clarifying the reasoning behind how we choose how to present our metamodels and models. Finally, we explain how reusability can be fostered by both the composable design of our metamodels and models, as well as through several tutorials showcasing how these artefacts can be extended and/or transformed for reuse in different use cases and stakeholders workflows.