Département Génie Industriel et Informatique

Creation of a BPMN + BPSim metamodel to help the transformation from BPMN + BPSim model into a DEVS model

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Abstract

Enterprises and industries are always looking to improve the performance of their business process and one of the best ways to achieve this improvement is using modeling and simulating techniques. The use of those techniques can bring numerous advantages, like, for example, a better understanding of the process, risk reduction, resource optimization etc. Business Process Modeling and Notation (BPMN) is one of the most famous ways to represent a business process, especially with the Business Process Simulation (BPSim) extension, which can improve the quality and the detail level of the representation. However, a conversion from a BPMN extended with BPSim model to a DEVS model may be needed to better represent and simulate a process. This article will bring an overview of a research which suggests a method to make this transformation, and will be focused on one important step, which is the creation of a BPMN + BPSim metamodel.

Keywords: Business Process Modeling and Notation (BPMN), Discrete Event System Specification (DEVS), Model Transformation, Meta-Modeling, Business Process Simulation (BPSIM), Eclipse Software

1. Introduction

Nowadays, the enterprises and industries have the necessity to better describe and document business processes, which play a vital role in the organization's operation, mostly important for the more complex process with different variants like processing time, number of resources, different sequences flow etc; because of this, was been created business process simulations to accomplish those representations. Business process modeling and simulation is a critical technique used by organizations to improve their operations and decision-making processes. It involves creating computer-based models that replicate real-world scenarios without affecting actual systems. The significance of business process modeling and simulation lies in its multitude of advantages, for example, it helps optimize performance by identifying inefficiencies and bottlenecks, leading to streamlined processes and increased productivity. Also, simulation provides a cost-effective way to test process modifications before implementation, reducing the risk of costly errors. Moreover, it enables organizations to assess potential risks associated with process changes or new initiatives, allowing for proactive risk mitigation.

Certain notations were created to try to standardize those kinds of process representation and, of these notations, can be mentioned the Business Process Modeling and Notation (BPMN). To better utilize BPMN for simulating business processes, BPSim extension can also be used with the BPMN. The open BPSim specification provides a rich set of material on how to configure and assign resources to activities/tasks, how to raise events, decision making and other real-world capabilities. On the other hand, there is also the Discrete Event System Specification (DEVS), a way to model and simulate complex and dynamic systems with discrete event behavior, which is very important for most business processes.

With those ideas in mind and knowing the importance of those kinds of modeling and representation for the modern industrial and business process, which are becoming more

and more complex, emerged the necessity for a standardized representation that encompasses and uses the concepts already recognized in the area. Considering this, this article discusses the creation of a BPMN + BPSim metamodel and, through a transformation language, convert them into DEVS models, with an emphasis on the part of creating a BPMN + BPSim metamodel using the Eclipse software.

The paper is structured as follows: after a brief introduction in section 1, state of the art is presented in section 2. The methodology is detailed in sections 3. Section 4 concludes the paper and discuss future perspectives.

2. State of the art

2.1 Background

BPMN (Business Process Model and Notation) is a graphical notation used for modeling business processes and workflows. It was initiated in 2001 by the Business Process Management Initiative (BPMI), which later merged with the Object Management Group (OMG) in 2005. The goal was to create a standardized notation that could be easily understood by both business users and technical experts. The first version of BPMN, known as BPMN 1.0, was released in 2004. It underwent further refinements, and BPMN 1.1 and BPMN 1.2 were released in subsequent years. In 2011, BPMN 2.0 was introduced, which significantly improved and expanded the notation, adding more features and making it more comprehensive and powerful. Since then, BPMN 2.0 has become the industry standard for modeling business processes and has been widely adopted by organizations and software vendors worldwide and, because of that, the BPMN 2.0 will be the model used for this article.

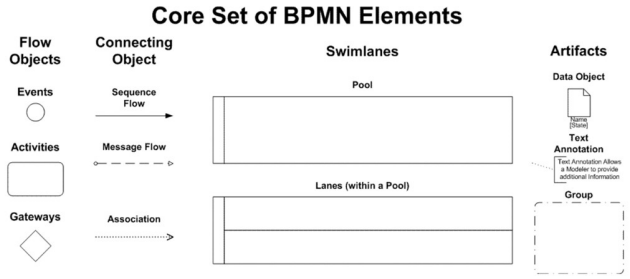

Figure 01. A simplified subset of the Ecore metamodel.

BPSim (Business Process Simulation) specification was introduced as part of BPMN 2.0 and provides a rich set of material on how to configure and assign resources to activities/tasks, how to raise events, decision making and other real-world capabilities. Once configured according to the BPSim specification, a business process model (constructed in BPMN) can be sent to a suitable BPSim simulation engine and run according to the process defined in the BPMN model, using the configuration data attached in the BPSim information. The BPSim specification is very detailed and offers the interested modeler and business strategist an unprecedented flexibility in assigning operating information to a model and then assessing the quality of the solution based on information received back from the Simulation engine.

```
<ElementParameters elementRef="TASK1">
  <TimeParameters>
    <ProcessingTime>
      <DurationParameter value="duration"/>
    </ProcessingTime>
  </TimeParameters>
</ElementParameters>
```

Figure 02. Representation of a specification done by the BPSim.

DEVS stands for "Discrete Event System Specification," and it is a formalism and methodology used for modeling and simulating discrete event systems. It provides a systematic way to represent and analyze complex systems that can be described as a series of events occurring at distinct points in time. In DEVS, a system is modeled as a collection of interacting components, where each component operates independently and reacts to discrete events, such as changes in state or the occurrence of an event. The system's behavior is determined by how these components interact and respond to events. DEVS provides a formal way to describe the dynamic behavior of a system, allowing for mathematical analysis, verification, and simulation. It is widely used in various fields, including computer science, engineering, operations research, and modeling complex systems like communication networks, manufacturing processes, transportation systems, and more. By using DEVS, researchers and engineers can gain insights into the behavior of complex systems and evaluate different scenarios in a controlled and structured manner.

For all of those representations, metamodels can be created. In the realm of software engineering and model-driven development, metamodels serve as powerful tools that lay the foundation for creating and interpreting models within a specific domain. A metamodel can be thought of as a "model of a model," offering a higher-level abstraction that defines the structure, rules, and relationships of other models.

Knowing this background, this article is based on a study about transformation and simulation of a BPMN model that has been extended using BPSIM into simulation models/sub-models that complies with the DEVS formalism to verify and simulate model properties and will be focused in the creation of a metamodel of a BPMN extended with BPSim using the Eclipse software, that will

be used to be converted to a DEVS metamodel in the future.

2.2 The Eclipse software

Eclipse is an open-source integrated development environment (IDE) originally developed by IBM; It was released as an open-source project under the Eclipse Public License (EPL) in November 2001. The Eclipse Foundation was created in 2004 to oversee the development and evolution of the Eclipse platform. Since then, Eclipse has grown into a robust ecosystem with various projects and tools, becoming one of the most widely used IDEs in the software development industry. The platform is built using Java and supports multiple programming languages, including Java, C/C++, Python, and more.

With a modular architecture, developers can enhance Eclipse's capabilities by installing additional plug-ins and extensions tailored to their specific needs. The software offers several plug-ins and tools that support BPMN simulation and creation, like the BPMN2 Modeler who is an Eclipse plug-in that provides a graphical editor for creating BPMN diagrams. It allows you to model business processes, design workflows, and visualize the flow of activities and information and the extension called "BPMN Designer," which is a comprehensive BPMN 2.0 modeling tool. It allows for BPMN creation, simulation, and execution, all within the Eclipse IDE. While the BPMN2 Modeler itself does not include a built-in simulation engine; you can integrate external simulation engines into Eclipse. Popular simulation engines like "Simantics" or "Signavio" can be used in combination with the BPMN2 Modeler to execute simulations of your BPMN diagrams.

For this research, the Eclipse software will be used integrate the BPSim into the BPMN and create a metamodel that fits in this junction, which will be used to achieve the final objective who is made the transformation to DEVS model. The software can also be used to make this transformation using a transformation language with some changes.

2.3 Transformation BPMN + BPSim to DEVS

The transformation of a BPMN + BPSim model to a DEVS model is the original research witch this article is based and the final objective. This transformation can bring several advantages especially when dealing with complex systems and in-depth simulations. For example, DEVS is well-suited for modeling complex systems with discrete event behavior. If, for example, a BPMN + BPSim model involves intricate interactions, multiple decision points, and complex event coordination, DEVS may provide a more robust and flexible approach to capture the system's dynamics accurately. So, the need to make such a transformation arose.

To make this transformation, first of all is needed to enrich the BPMN with the BPSim, resulting in a BPMN + BPSim model. After that, the metamodel is created. The BPMN 2.0 OMG specification (OMG, 2013) and BPSIM 2.0 WFMC specifications (WFMC, 2016) define separate metamodels for BPMN and BPSIM. So, is needed to construct a new BPMN+BPSIM metamodel using pre-existing BPMN and BPSIM ones, and this will be the key point of this article. This new BPPN + BPSim metamodel will be transformed in an intermediary metamodel (a model which is neither the BPMN + BPSim metamodel nor the DEVS metamodel), which will be developed to facilitate the desired transformation. To finally finish the transformation to DEVS, is important to notice that there isn't a universal metamodel for DEVS yet, so, because of that, is needed to create one which is based on the BPMN + BPSim elements.

2.4 Transformation language

A specialized transformation language needs to be chosen to realize the transformation between the source (BPMN + BPSim) and the target (DEVS) model. There are several transformations languages such as XSLT (extensible stylesheet language transformation) and ELT (Epsilon Transformation Language), but the most suitable option is the ATL (Atlas Transformation Language), which is a model transformation language based on the Eclipse Modeling Framework (EMF).

2.5 Ecore file

The Ecore is an important type of file when using the Eclipse software, especially on the step of the creation of the BPMN + BPSim metamodel in this research. By the definition done in the book called EMF: Eclipse Modeling Framework, an ecore file is a meta-metamodel which have four classes: The EClass, used to represent a modeled class; EAttribute, used to represent a modeled attribute; EReference, used to represent one end of an association between classes and EDataType, used to represent the type of an attribute. Those classes can be seen in the figure 03.

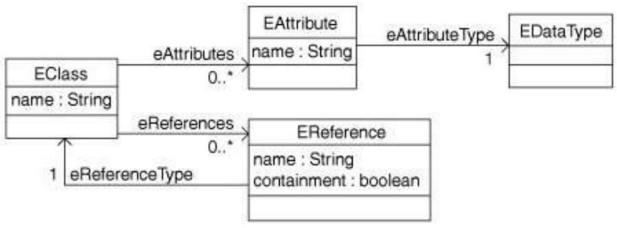

Figure 03. A simplified subset of the Ecore metamodel.

Continuing the definition, when an Ecore file is created, the structure of a series of instances of the model is defined, that is, the specification of the types of objects that make up instances of that model, the relationships between them and the data they contain.

3. Methodology

The final objective of this research is to covert a BPMN model expanded with BPSim, convert it into an intermediary metamodel and, to finish, convert it into a DEVS model. Moreover, the ultimate goal is to create an open, standards-based, and extensible simulation tool that makes this transformation. Based on past research, originally the transformation from a BPMN + BPSim model to a DEVS model was directly, as can be seen in the figure 04.

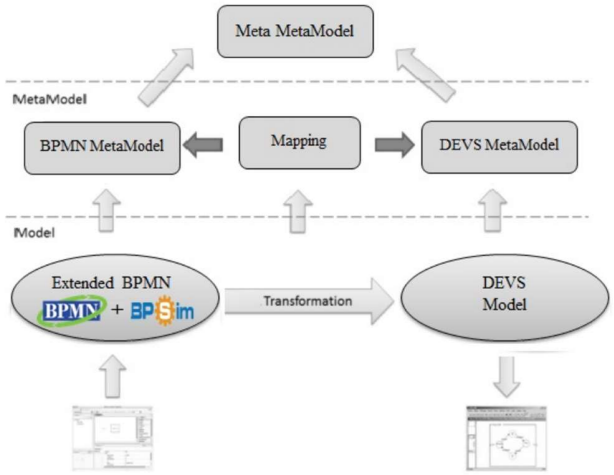

Figure 04. Extension and Transformation architecture.

This figure represents the metamodel approach [OMG 2003] which is one most used and famous transformation techniques from a source to a target, but if some adaptations to better represent the specific transformation that this article concerns (BPMN + BPSim to DEVS).

However, turned easier and simple to make this conversion, especially for the most complexes process, if there was an intermediate model between them. So, one of the objectives of this research is to also create this intermediate metamodel between the source and target models.

Another challenge to achieve the objective of realizing the transformation BPMN + BPSim to DEVS is the creation of a library allowing the conversion between BPMN + BPSim elements to DEVS elements. This library can be done by the creation of mapping rules, which are defined by the links between the source model (BPMN + BPSim) and the target model (DEVS). In other words, the mission is to deduce the corresponding DEVS representation of a BPMN + BPSim element.

The problem is that most of BPMN elements are not yet explored or mapped to a DEVS representation, so, this mapping is not an easy task and need to be done in stages, prioritizing the most used BPMN elements fist. After mapping the corresponding BPMN element to the correct DEVS element, the rules for making the transformation from BPMN + BPSim to DEVS will be similar. In the figure 05 we can see some correlation already done from BPMN to DEVS model.

BPMN	DEVS
Pool	DEVS Coupled Model
Lane	DEVS Coupled Model
Sub process	DEVS Coupled Model
Flow Message Flow* Sequence Flow*	DEVS Atomic Model
Task Basic Task Send Task* Receive Task*	DEVS Atomic Model
Event Start* {Message, Timer, Conditional} Intermediate* {Message, Signal, Conditional} End* {Message, Timer, Conditional}	DEVS Atomic Model
Gateway Exclusive Gateway Inclusive Gateway* Parallel Gateway	DEVS Atomic Model

Figure 05. BPMN to DEVS components.

3.1 Creation of the BPMN + BPSim metamodel

To create the metamodel of a BPMN model expanded with BPSim applications, the Eclipse Software was used, the same software that can also be used to create examples of BPMN model (with or without BPSim extension) and can be used to make the source to target transformation with the ATL transformation language.

First of all, will be needed to add the BPMN Designer extension to the Eclipse software to have to possibility to create BPMN files. Also, with this extension, the software will have important ecore files DC.ecore, BPMNDI.ecore and, most important, the BPMN20.ecore. Right after adding this extension, will be needed to add the bpsim2.ecore, which can be add to Eclipse after being downloaded, drag and drop in the same folder as the other encore files. The final result in the Eclipse software will be like the figures 06 and 07.

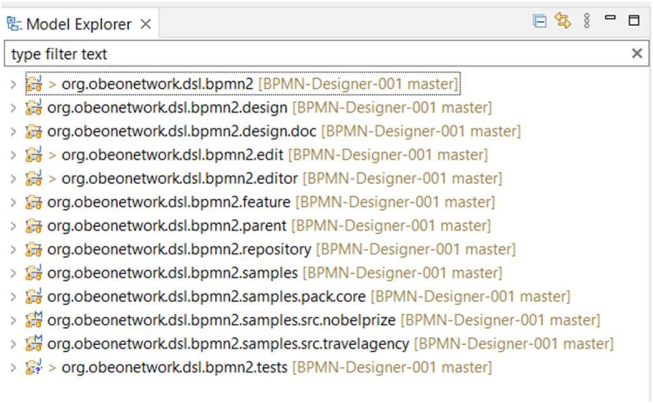

Figure 06. All projects from BPMN Designer

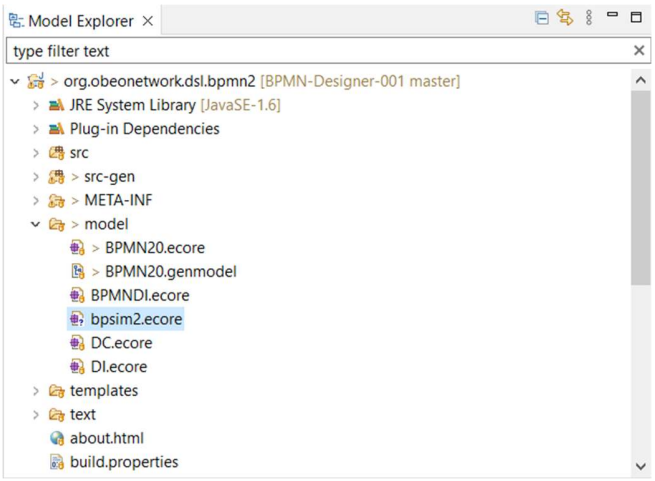

Figure 07. bpsim2.ecore in the BPMN Designer.

To extended the BPMN with the BPSim, will be needed to right click in the BPMN20.ecore file, click in "Load Resource" and select the bpsim2.ecore file from "Browse Workspace". Right after, will be needed to open the BPMN20.ecore file, find the EClass called "Extension" and add a new EReference which will be a BPSimDataType. Then, will be necessary to find the EClass called "Relationship" and add a new EReference which will have the Extension EType. All changes needed to be validated.

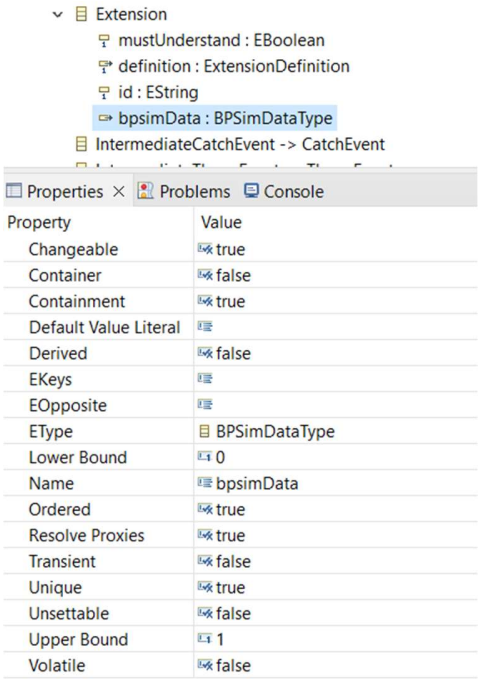

Figure 08. New EReference with the BPSimDataType EType.

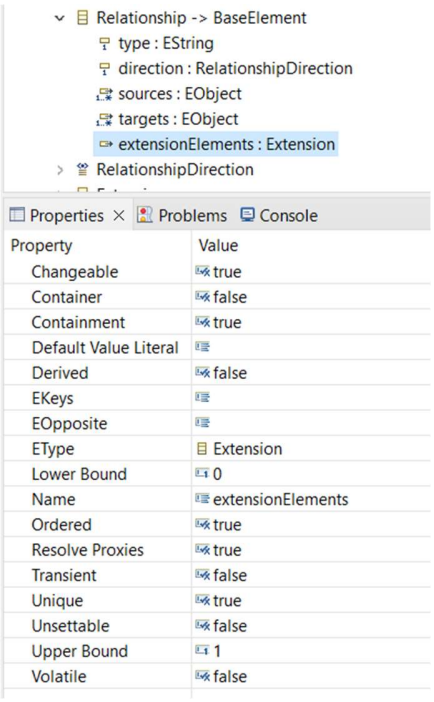

Figure 09. New EReference with the Extension EType.

After the validation of all changes in the ecore file without problems, will be needed to open the BPMN20.genmodel (another file that can be found in the same folder as the ecore files) and find "Extensions" and turn true the possibility of "Children" and "Create Child". Then the file can be saved and will be needed to right click in "Bpmn2" and click in "Generate all". After those steps, will be possible to crate BPMN + BPSim metamodel in the Eclipse software in the runtime application.

To improve the bpsim2.ecore file or the BPMN20.ecore file, new EReference can be created in those ecore files which will result in new possibilities of BPSim functions in the BPMN; for example, the an EReference of the EType "DateTimeParameterType" can be add in "Parameter" in the bpsim2.ecore file to enable the creation of the date and time of something in the process which you want to represent.

As a result of this research, a bpsim2.ecore file was created with some of the most important relations to better represent a BPMN + BPSim metamodel based in some other BPMN + BPSim examples.

4. Results and discussion

As a result of this research, was created a bpsim2.ecore file which can better create a BPMN + BPSim metamodel. These results can be tested by creating a runtime in the Eclipse software and creating a process example and adding new BPSim elements in the BPMN file.

When created the wished process in the BPMN file, to have a code visualization of the metamodel, the user can right click in the file and select "Open With" and select "Text Editor". With this code mode the process details can be visualized and changed in a coding format, which might be better if the person doing the process modeling is more familiar with programming and coding.

Also, the ecore file proved to be well adapted to reproduce examples of existing BPMN + BPSim as can be seen in the figures 10 and 11.

```
<bpmn:relationship type="BPSimData">
  <bpmn:extensionElements>
    <bpsim:BPSimData>
      <bpsim:Scenario name="bike_delivery" author="PragmaDev" created="2022-03-22T14:53:42"
modified="2022-10-13T10:47:14" version="1.0" id="SEM_SYMB_74" description="In this simulation scenario a
bike is used to deliver the pizza to the customers.">
        <bpsim:ScenarioParameters baseTimeUnit="min"
traceFormat="logs+critical_path_heatmap+resource_usage+resource_wait_time_heatmap"
baseCurrencyUnit="EUR" replication="100" seed="123456" traceOutput="true">
          <bpsim:Start>
            <bpsim:DateTimeParameter value="2022-10-04T00:00:00"/>
          </bpsim:Start>
        </bpsim:ScenarioParameters>
        <bpsim:ElementParameters elementRef="SEM_SYMB_10">
          <bpsim:ControlParameters>
            <bpsim:InterTriggerTimer>
              <bpsim:NumericParameter value="10"/>
            </bpsim:InterTriggerTimer>
```

Figure 10. BPMN + BPSim metamodel code example.

```
<relationship id="" type="BPSimData">
  <extensionElements id="_9z_GoRy-Ee6ox8vtDVsoTg">
    <bpsimData>
      <scenario author="Mateus Ximenes" created="2023-07-24T14:53:42" description="In this simulation
scenario a bike is used to deliver the pizza to the customers." id="SEM_SYMB_74"
modified="2023-07-24T10:47:14" name="bike_delivery" version="1.0">
        <scenarioParameters baseCurrencyUnit="EUR" replication="100" seed="123456"
traceFormat="logs+critical_path_heatmap+resource_usage+resource_wait_time_heatmap" traceOutput="true">
          <start>
            <dateTimeParameter value="2022-10-04T00:00:00"/>
          </start>
        </scenarioParameters>
        <elementParameters elementRef="SEM_SYMB_10">
          <controlParameters>
            <interTriggerTimer>
              <numericParameter timeUnit="min" value="10"/>
            </interTriggerTimer>
```

Figure 11. BPMN + BPSim metamodel code generated.

5. Conclusion and perspectives

The article discusses the importance of modeling and simulating business processes for enterprises and industries to improve their performance. It highlights the advantages of using Business Process Modeling and Notation (BPMN) with the Business Process Simulation (BPSim) extension, such as better understanding, risk reduction, and resource optimization.

The research of the article is on the conversion of a BPMN extended with BPSim model to a Discrete Event System Specification (DEVS) model to receive modeling and simulation advantages. To facilitate this transformation, the article proposes the creation of a BPMN + BPSim metamodel, which is the main theme of this article.

The methodology presented in the article involves the use of Eclipse software, specifically the BPMN Designer extension with bpsim2 ecore file, to create the BPMN + BPSim metamodel. The ecore file created to make the metamodel steel needs to get improved to create even better BPMN + BPSim metamodels.

Also, is important to mention that the final goal of this research, right after accomplish the creation of an effective way to made the transformation from BPMN + BPSim to DEVS, is to provide a free, open-source web platform for the modeling and simulation of business processes utilizing BPMN for modeling and DEVS for simulation while making use of BPSIM standards as an extra element for achieving distributed simulations. BPMN will be extended with the BPSIM specification for simulation, and DEVS will be used for operational simulation.

Overall, the article aims to provide a standardized representation that encompasses recognized concepts in the field, helping enterprises model and simulate complex processes more effectively. The creation of the BPMN + BPSim metamodel and its subsequent transformation to a DEVS model would enable more in-depth and accurate simulations, benefiting industries with complex systems and decision-making processes.

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