Implementing a Transformation from BPMN to CSP+T with ATL: Lessons Learnt

Aleksander González[1], Luis E. Mendoza[1], Manuel I. Capel[2] and María A. Pérez[1]

[1] Processes and Systems Department, Simón Bolivar University
PO Box 89000, Caracas, 1080-A, Venezuela

[2] Software Engineering Department, University of Granada
Aynadamar Campus, 18071, Granada, Spain

Abstract. Among the challenges to face in order to promote the use of techniques of formal verification in organizational environments, there is the possibility of offering the integration of features provided by a Model Transformation Language (MTL) as part of a tool very used by business analysts, and from which formal specifications of a model can be generated. This article presents the use of MTL ATLAS Transformation Language (ATL) as a transformation artefact within the domains of Business Process Modelling Notation (BPMN) and Communicating Sequential Processes + Time (CSP+T). It discusses the main difficulties encountered and the lessons learnt when building BTRANSFORMER; a tool developed for the Eclipse platform, which allows us to generate a formal specification in the CSP+T notation from a business process model designed with BPMN. This learning is valid for those who are interested in formalizing a Business Process Modelling Language (BPML) by means of a process calculus or another formal notation.

1 Introduction

Business Processes (BP) must be properly and formally specified in order to be able to verify properties, such as scope, structure, performance, capacity, structural consistency and concurrency, i.e., those properties of BP which can provide support to the critical success factors of any organization. Formal specification languages and process algebras, which allow for the exhaustive verification of BP behaviour [17], are used to carry out the formalization of models obtained from Business Process Modelling (BPM). Not only require these notations an understanding of the business rules, but of the formal notation's descriptive capacity, within this specific interpretation domain, by the business modeller. Moreover, there exists reluctance from industry to adopt formal methods. An alternative way to directly using process algebras is to automate the formal representation of BP models, and thus we propose a set of transformation rules that generate a formal Process Calculus (PC)-based notation specification from a BP model.

Two types of tools for formal verification of business artefacts are generally offered to business analysts at moment, those within the first one provide answers to the

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user directly [8], they are generally aimed at a small universe of users, and the formal representation of the verification mechanism is implicit in the response; whereas tools in the second one offer a response to the user through making use of a programming language, thereby the transformation rule is specified by programming in this language. In both cases the development and support of all functions (modelling and verification) falls in the responsibility of the developer entity that offers the tool.

Aiming at the automatic verification of BPM, the Laboratory for Research in Information Systems (LISI) at Simón Bolívar University and the research group in Concurrent Systems (SC) at the University of Granada created the BTRANSFORMER tool. The Model Transformation Language (MTL) ATLAS Transformation Language (ATL) has been selected to implement this tool. BTRANSFORMER allows us to generate a formal specification of a BP model described with Business Process Modelling Notation (BPMN) [10] notation. Communicating Sequential Processes + Time (CSP+T) [18], based in Communicating Sequential Processes (CSP) [14], is used here to describe the formal model generated.

The BTRANSFORMER tool seeks to promote the use of MTL in verification environments, and thus modelling tools and model-checkers can be separately supported. MTL allows us to make use of the benefits of both kinds of tools, without specifically supporting any of the two. As a result of this strategy, the development support effort and further maintenance of the models becomes significantly reduced. This tool was developed as part of a research that seeks to accomplish the following goals,

1. (a) to determine which MTL and tool are more appropriate for being used in a given context, and (b) to provide access to the benefits of a MTL to business analysts.
2. How can we express the syntactic relationship, in a specific MTL, between two domains to be made correspondent.
3. How to determine inconsistencies in a non-formal model by making use of a formal notation.

This article describes the challenges and solutions for succeeding with the development of BTRANSFORMER tool. Section 2 describes the challenges faced. Section 3 presents a brief description of ATL. In section 4, it is discussed how to improve the expressiveness of the rules. Section 6 discusses the integration of components under the Eclipse platform and section 7 presents the creation of the deployment environment. Finally, some conclusions and recommendations for future work are presented.

2 BTransformer: Background and Challenges

There are currently tools that allow the generation of distinct specifications, written in different versions of CSP, of a BPMN model. OWorkflow [11] is a tool that allows transforming a BPMN (ILOG JViews BPMN Modeler) model into a Timed CSP specification [17] and then to verify it with FDR [4]. This tool is implemented in Haskell. In addition, we can also mention a plugin that uses the editor of Intalio [3] to verify a BPMN model with the PAT model checker [15].

However, all these tools are specific to FDR and other specific software verification tools, and in none of them an MTL has been used for the definition of the transformation rules. Now, BTRANSFORMER, which is based on using an MTL, can be considered a tool that promotes the maintainability and portability of transformation rules between models and development platforms, respectively. Within the proposed transformation method, we use an intermediate CSP+T model that will allow us to work with different verification tools, following an incremental mode, in the future. Additionally, our proposal allows time management during the transformation phase without using external elements to standard BPMN 2.0 and with a complexity less than of the Timed CSP formalism.

At moment, it is possible to generate a formal specification to determine (with the help of a Model-Checker —MC) whether two collaborative processes are consistent or not according to [5]. In the future, it is expected to additionally generate the input specification of a MC and, based on the model checker response, to suggest changes in the model.

From the implementation side, BTRANSFORMER has been designed as a plugin for the Eclipse platform, and it is capable of transforming BPMN models designed with Intalio and to generate a text file with its specification written in CSP+T.

BTRANSFORMER consists of three components (see Fig. 1):

- `UITransformation`, which makes use of the facilities for platform's interfaces extension, and the Intalio editor for creating BPMN models.
- `Utils`, consisting of a set of classes to handle the persistence and format evaluation, so that the user can additionally specify them in more detail.
- `Transformation`, which makes use of ATL language interpretation services to define the correspondence between BPMN and CSP domains.

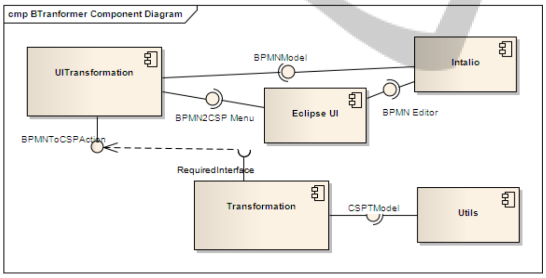

Fig. 1. UML Component Diagram of BTRANSFORMER tool.

To successfully implement the developed components, it has been necessary to face the following three challenges:

1. To ensure that the transformation rules are expressive. In this way, it is promoted that the rules are expressed correctly and it improves their readability for the purpose of maintainability.
2. To evaluate different components and integrate them. Thus, the reuse of components and the interoperability assurance between components and with the new ones to be developed are promoted.
3. To create the deployment environment that allows the user to apply the transformation. It has been crucial to have found a familiar environment to the BP analysts in order to ensure the usability of our tool.

3 ATLAS Transformation Language

ATLAS Transformation Language (ATL) is a proposal of ATLAS Group at INRIA & LINA at the University of Nantes and it was developed as part of the AMMA (ATLAS Model Management Architecture) platform [1, 2]. ATL shares common characteristics and the same set of requirements that have been defined in QVT RFP [2]. Compatible with the OMG standards, ATL makes it possible to describe model to model transformations and defines pre and post conditions in Object Constraint Language (OCL) [6]. ATL allows applying the transformation pattern of Fig. 2. In this pattern a source model `Ma` is transformed into a target model `Mb`, and the transformation is defined by a definition or program (`mma2mmb.atl`). Source and objective models conform to the metamodels `Mma` and `Mmb`. In their turn, the metamodels conform to the Meta Object Facility (MOF) Metamodel [1, 2].

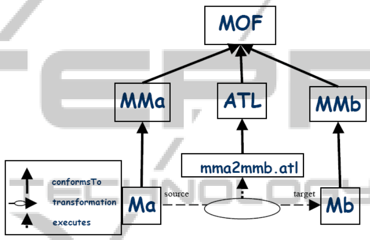

Fig. 2. Overview of ATL transformational approach [2].

BTRANSFORMER allows the implementation in ATL of the rules for transforming a BPMN model into a specification written in CSP+T. It has been possible to define these rules thanks to the ATL development environment within Eclipse.

There are different metamodels of BPMN [7], which also capture a range process concepts, shared with other languages of business process modelling. We selected the BPMN[1] metamodel proposed by OMG because, besides being implemented by several tools, it focuses on the syntax of the language and not on the concepts represented by the language (semantics). Additionally, the chosen metamodel allows us to select the right subset of the metamodel elements, with which we have worked, and not the entire metamodel that also includes concepts related to the Eclipse platform. According to the BPMN metamodel used by the Eclipse consortium shown in Fig. 3, it is possible to link elements `Activity` with `SequenceEdges`. `Task`, `Event` and `Gateways` elements are of the class `Activity`. A class `Activity` may be associated with one or more `Subprocess` classes, and with one `Lane` (or none at all). A `Pool` can be composed of one or more lanes.

Each of these classes is represented by a corresponding Meta Object Facility (MOF) element that is used by the ATL language. The MOF element of an Activity is `bpmn!Activity`, that of the `SequenceEdges`, is `bpmn!SequenceEdges`, and so on for each one of the elements.

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[1] Although this metamodel was initially proposed for version 1.2 of BPMN, it still remains valid for the transformation of BPMN in version 2.0 [12], since the latter is an extension of the former one.

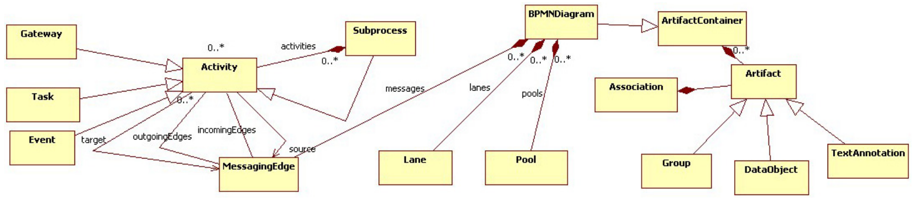


Fig. 3. BPMN metamodel. Adapted from Eclipse.org.

As for CSP, there is already a metamodel accepted for this process algebra [13, 16]. Figure 4 shows the metamodel adapted for this proposal to consider messages, as well as temporal operators of CSP+T, as additional operators of CSP.

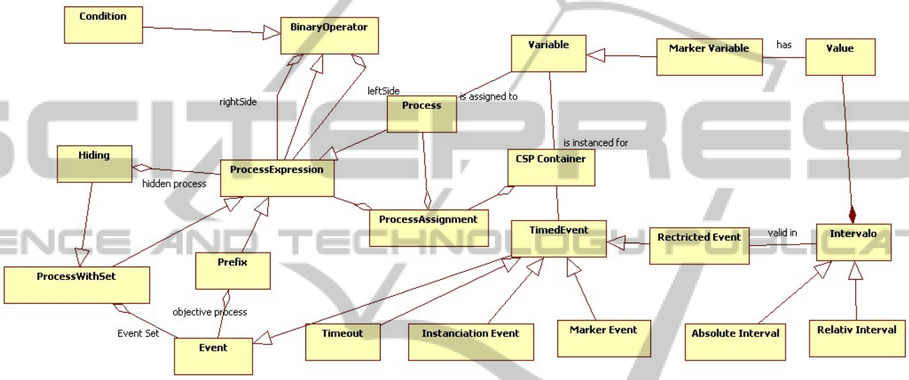


Fig. 4. CSP+T metamodel. Adapted from [13, 16].

ATL maps each class element to a corresponding expression type. Thus the `Process` element in the metamodel becomes a csp `data!Process` data type, the element ProcessExpression is a `csp!ProcessExpression` and so on. Using these types of elements it is now possible to map the BPMN metamodel elements to a `ProcessExpression` of CSP. In order to be able to generate a specification in CSP+T from a BPMN model the following set of rules has been defined:

- The transformation of any BPMN activity is a CSP+T process.
- The Transformation of a sequence flow between BPMN activities becomes a sequence of terms in CSP+T.
- Transformation of Gateway becomes a concurrence operator in CSP+T.
- Messages are transformed into CSP+T messages.
- Transformations of (temporal) annotations are transformed into CSP+T associated intervals.

A verification process is made of two stages: the first one is to validate that the model is correctly and completely defined. In the second one the definition is translated to CSP+T, from which the specification for an MC can be obtained. This work focuses on the translation between BPMN and CSP+T, and it is assumed that the business process model is correct and complete before transforming it. This transformation assumes the semantics of BPMN proposed by Wong and Gibbons [4].

4 Expressiveness of the Proposed Rules

When the declarative style of ATL is used, a correspondence rule consists of a relationship between two metamodels, rather than a set of instructions, and cannot be considered a set of programming sentences (for, while, among others). A rule of transformation under the paradigm of a Model Transformation Language (MTL), such as ATL one, is an association between two metamodels. In the rule presented, a bpmn `element!Sequence`, between two `bpmn!Activity`, is related to a `csp!BinaryOperator`, which expresses the sequencing between two processes (each process is the representation of an activity).

Activity sequencing is expressed in the CSP+T metamodel as a Binary Condition instance that uses the infix operator ";" to connect both parts. This specification is written in a resource or file rule.atl. Fig. 5 includes the specification of the CSP+T expression proposed by the metamodel, so that the reader can identify a variable for each MOF element of the metamodel. With these variables the desired element is specified, which conforms to a CSP+T model.

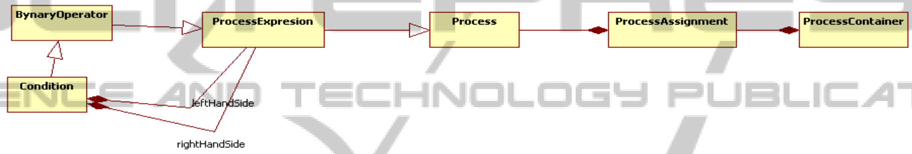


Fig. 5. Condition operator specified within the CSP+T metamodel.

In ATL this rule is expressed in the following way:

```
rule  Secuency2Relations {
 from  BPMN3 : bpmn!SequenceEdge
 to     i1 : csp!ProcessIdentifier(name <- BPMN3.source.processName),
        i2 : csp!ProcessIdentifier(name <- BPMN3.target.processName),
        i  : csp!ProcessIdentifier(name <- ';'),
        p1 : csp!Process( processIdentifier <- i1),
        p2 : csp!Process(processIdentifier <- i2),
        p  : csp!Condition(expression <- ';',leftHandSide <- p1,
             rightHandSide <- p2),
        pAssig : csp!ProcessAssignment(processIdentifier <- i, process
<- p),
        cspContainer : csp!CspContainer(name <- 'Container',
                       processAssignments <- pAssig, expression <-
                       BPMN3.source.name + ';' + BPMN3.target.name) }
```

We can then see the declaration of the `csp!Condition` expression, in which `leftHandSide` and `rightHandSide` are assigned to processes `p1` and `p2`, respectively. Each one of these processes has its respective `processIdentifier`. And finally, `pAssig` and `cspContainer` are declared to assign process `p` to the container. It should be noted that ATL is a hybrid language, which eased to perform some testing, following an imperative style, before obtaining a dominance of the declarative style of this language. It is not always possible to use a declarative style for transformation rules.

5 Evaluation and Integration of Different Components

Although the Eclipse platform allows working under the component-based software development model, a considerable effort is required to integrate and choose the right different components or plugins. This is because vendors provide varying degrees of support and conditions for their plugins, and because they must be well adapted to the target platform, and thus these conditions are not always satisfactory. Table 1 presents a brief comparison of the evaluated components.

Table 1. Components evaluated.

Plugin	Eclipse version	Advantages	Disadvantages
TGG Interpreter	3.4	Visual language	Lack of documentation for carrying out the deployment
SMART QVT	3.5.1	Declarative language	Minimum Integration support
ATL	3.6.1	Plugin integrated with a recent version of Eclipse	Significant effort needed for construction of the integration environment
Intalio[2]	3.6.1	Plugin integrated with a recent version of Eclipse	The only plugin found for editing BPMN models.

In Table 1, a comparative of components addressing some representative MTL (TGG, QVT and hybrids [2]), under the Eclipse platform, can be seen. The plugins of ATL and Intalio developed for the latest version of the platform were selected, which in their turn facilitated the installation of both components. The documentation for the deployment of ATL is available, whilst for the rest is quite limited. Although this is not the case described here, should another transformation be selected, and no plugin to handle some of source or target models involved can be found, the MTL plugin must be migrated to another version of the platform in which it exists, or it has to be developed anew in any other case.

6 Deployment Environment Construction

In order for the end-user to make use of the proposed software tool, a set of deployable components must be built, in addition to integrate the different components, which belong to the development environment, into a unique version of the platform. To accomplish that it must not be necessary to use the entire development environment, but to only run a set of rules.

In the case of the BTRANSFORMER tool, the rules stated so far allow us to generate the model CSP+T associated with a BPMN model. As shown in Fig. 6, through an additional transformation, named `CSPT2Latex.atl`, the set of instructions associated with each one of the elements of the model CSP+T is obtained. This set of expressions is used by the `Utils` component to generate a specification in LaTeX.

Finally, a service that runs the transformations using the Eclipse interface must be built. This service is defined overriding one of the classes that correspond to a button

[2] Although this plugin works with BPMN version 1.2; the specifications that it generates comply with version 2.0 [12].

located in the component Eclipse UI. This button invokes a plugin that executes the transformations within an Eclipse environment generated with ATL Wizard. In Figure 7, the result of a model and its specification can be seen.

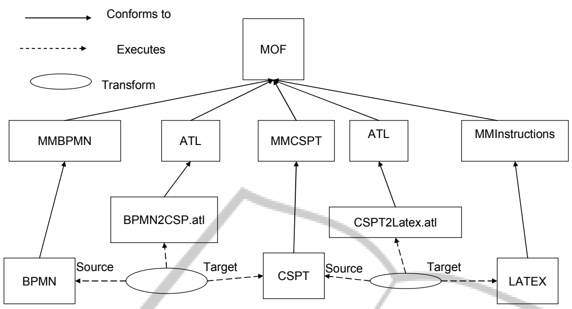
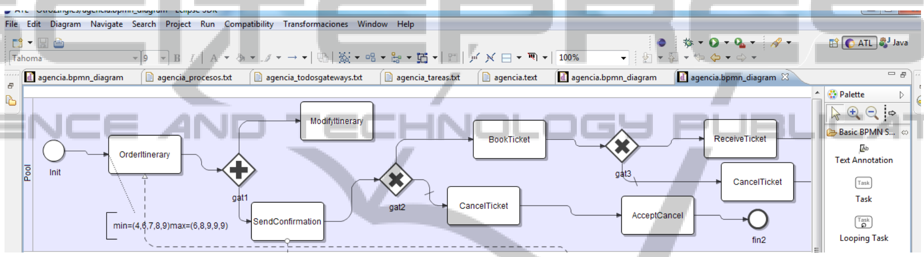


Fig. 6. How the metamodels are involved in the transformation.



$[[\,P(OrderItinerary) =]]$
$I(1860 : 1870)\, OrderItinerary.INIT; Init.INIT \rightarrow SKIP; gat1.INIT \rightarrow SKIP; BookinTravelAgency?message1 \rightarrow SKIP; I(2400 : 2410)\, OrderItinerary.STOP$
$[[P(ModifyItinerary) =]]$
$gat1.INIT \rightarrow SKIP$
$[[P(SendConfirmation) =]]$
$gat1.INIT \rightarrow SKIP; gat2.INIT \rightarrow SKIP; SendConfirmation!message2 \rightarrow SKIP$
$[[P(BookTicket) =]]$
$gat2.INIT \rightarrow SKIP; gat3.INIT \rightarrow SKIP; I(1860 : 1870)\, BookTicket.INIT; Book.INIT \rightarrow SKIP; I(2400 : 2410)\, BookTicket.STOP$

Fig. 7. Screenshot of BTRANSFORMER tool invocation and fragment of results.

7 Lessons Learnt

Among the lessons learnt, we can say that promoting the use of declarative expressions when writing the rules must be considered mandatory. In this way, to understand and maintain the code in the future becomes easier. Additionally, the developer can then focus more on what the transformation means, and not on how it executes. In this way a better understanding of the rules will be achieved, and it also facilitates the transformation into another MTL, where necessary.

Secondly, the tools that implement an MTL must offer facilities for executing transformations outside the programming environment. In this sense ATL presents two advantages: (1) it is built on a well-known platform and easy to use for any Java developer, and (2) there are various examples[3] that include this deployment. However, it has been necessary to adapt the proposed plugin for the ATL Wizard in order to produce a sequence of transformations, as well as to link it to the Eclipse interface.

Finally, component-based platforms facilitate the development of the MTL development environment; it is due to the fact that model editing and manipulation will remain the responsibility of the third party, as well as all the difficulties in doing so might arise.

8 Conclusions

A software tool named BTRANSFORMER that helps the verification of business process models (BPM) has been proposed in this article. Initially described in the Eclipse platform and its editor Intalio [3], BTRANSFORMER automatically transforms BPM into the formal specification language CSP+T [18] (an extension with discrete-time of the CSP process algebra [14]). From a technological point of view, several challenges have been confronted in this work. They mainly consisted of extending, adapting and making work together several software components: BPMN editor, MTL, plugins previously available and which are supported by the common platform Eclipse.

ATLAS language services [1] have been adjusted to work with the selected plugins to carry out the transformation from BPMN models into CSP+T process terms. In this respect, the declarative style of the ATLAS language allowed us to carry out the definition of the correspondence rules between models in a way that is understandable, easy to modify and transport; and therefore useful if we want to experiment with another MTL in the future. A friendly configuration of the environment, useful to its foreseeable users (business analyst, stakeholder, etc.), has been developed, which saves the CSP+T output models according to various formats.

The creation of BPMN models using Intalio has allowed us to easily check, before transformation, their consistency by using the correspondence rules declared in ATLAS. The generation of the output according to various formats has been facilitated by the flexibility that presents the Eclipse platform to integrate different components and software tools.

BTRANSFORMER is currently working as a pre-processing tool of a "state of the art" model-checker that accepts the CSP [14] process algebra as the system's model formal specification language. An example of these model-checkers is FDR2 [4]. In the future, we plan BTRANSFORMER can collaboratively work with other model-checkers, within an environment of business process modelling that allows a partial and incremental modification of these models. As well as to facilitate the modular verification using an infrastructure of compositional verification, called Formal Compositional Verification Approach (FCVA) [9], [10].

As future work we plan to evaluate the migration of the tool into some of the plugins launched by OMG for the 2011 version of BPMN[4].

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[3] See http://www.eclipse.org/m2m/atl/atlTransformations/ for more detail.

[4] http://planet.jboss.org/post/new_bpmn_2_0_eclipse_editor.
http://docs.codehaus.org/display/ACT/Activiti+BPMN+2.0+Eclipse+Plugin.

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