AN UML ACTIVITIES DIAGRAMS TRANSLATION INTO EVENT B SUPPORTING THE SPECIFICATION AND THE VERIFICATION OF WORKFLOW APPLICATION MODELS

From UML Activities Diagrams to Event B

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Abstract: This paper exposes the transformation of UML activity diagrams into Event B for the specification and the verification of parallel and distributed workflow applications. With this transformation, UML models could be verified by verifying derived event B models. The design is initially expressed graphically with UML and translated into Event B. The resulting model is then enriched with invariants describing dynamic properties such as deadlock freeness, livelock freeness and reachability. The approach uses activity diagrams meta-model.

1 INTRODUCTION

Distributed and parallel applications are characterized by a high complexity. Increasingly, they became omnipresent in critical calculation domain. These applications need great care in their development and their implementation. They require an adequate software specification technique and a suitable development method. The used specification formalisms need to be comprehensive, allowing communication between developers and customers, expressive, and precise. The semi-formal language UML (Jacobson and Booch, 1998) has become a standard notation for describing analysis and design models of complex software systems. Developers and their customers intuitively grasp the general structure of a model and thus have good basis for discussing system requirements. UML is widely used for domain such as telecommunications (Holz, 1997) and distributed web application (Conallen, 1999). Recently, UML has been used for modeling parallel and distributed applications (Pllana and Fahring, 2002). However, the fact that UML lacks a precise semantic is a serious drawback of UML-based techniques. The implementation of UML specifications often drags of important leeway due to a wrong interpretation of these specifications. On the other hand, formal methods, including event B method that we deal with here, are the mathematical foundation for software. They increase the quality of distributed and parallel applications development and perform the reliability of the applications. Regarding to the UML's drawbacks and to the capacity of the formal methods to defeat such inconvenient, it would be better to integrate formal method in the modeling process with UML. In this context, we provide a specification and verification technique for workflow applications using UML activity diagrams (UML AD) and the event B method. The distributed and parallel workflow application is initially modeled graphically with an UML activity diagram. After that, the resulting graphical model is translated into an Event B model. This allows developers to rigorously verify UML specifications by analyzing derived B specifications. This paper addresses translation in event B of UML AD. The approach focus on the activity diagrams meta-model (Group, 2003), we transform different UML AD's constructs their operational semantic. The resulting model is then enriched with invariants describing required properties to be checked (Safety, reachability, liveness) with a B tool. Proof obligations are produced from events in order to state that the invariant condition is preserved in the initialization and by each event. The verification of activity diagrams properties is done by analyzing derived Event B specification; if these proofs succeed we can state that the graphical model is verified. This

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paper is structured as follows. Section 2 presents the kernel of our proposal, it presents the proposed approach UML AD and Event B. Section 3 discusses the interest of this approach for the verification and the validation of distributed and parallel applications.

2 THE PROPOSED APPROACH

The purpose of our approach is to produce a B specification from a giving UML AD in order to verify and check its dynamic properties (Bjorner, 1987) such as deadlock freeness. The proposed translation gives not only a syntactical translation, but also a formal semantic using the Event B method semantic. Consequently, we have to focus both on the activity diagram and its meta-model in order to have a coherent translation (Vidal, 2006).

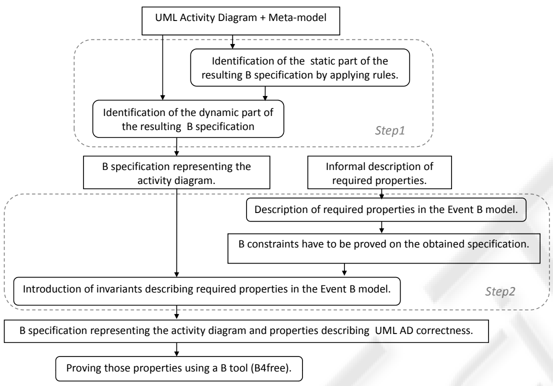


Figure 1: Overview of the translation process.

The translation process illustrated in 1, proceeds in three steps. The first one consists of identifying the body of the B specification from an UML AD by applying a set of rules divided into structural rules and semantics ones. The second step enriches the resulting model by relevant properties that will be proved in the third step using a B prover (Pllana and Fahring, 2002). The verification of these properties ensures the correctness and the validation of the UML AD.

2.1 The Translation Approach: Step1

The main goal of this step 1 is to translate an activity diagram into a B specification, this translation deals with both the syntactical and semantics of UML AD. The syntactical translation is based on the UML Activity diagram and its meta-model. We associate to each activity diagram concept a translation rule describing its equivalent construction in event B.

Rule 1. *An activity diagram is translated into a B model.*

ActivityNode can be described by their type (action node, initial node, decision node .) and an attribute *id* to verify their uniqueness, consequently. This abstract class can be seen as a description of a set of objects identified by two attributes: *id* and *type*. We suggested so to translate an abstract class $ActivityNode$ into an abstract set and all the derived classes are transformed into data included in this abstract set. The most appropriate B expression is the B record (Abrial, 1996).

$$rec(ident1 : x, ident2 : y, , identn : t)$$

Where $(x, y, ..t, E_1, E_2, , E_N)$ are respectively the values and type of fields $(ident_1, ident_2, ident_n)$. Since the derived nodes are identified by their identifier and their type, we propose to specify two fields for the record: field Id_node to identify the node and field and Type to indicate its type. The abstract class is so translated into the following B record:

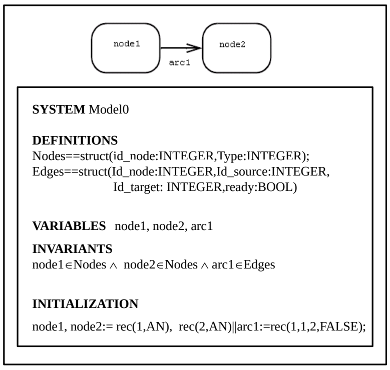
$$Nodes = Struct(Id - node : integer, Type : String).$$

In that manner, each node is considered as data record of Nodes and then is translated into $rec(Id = a, Type = b)$.

Rule 2. *The abstract class ActivityNode is translated into a B record: $Nodes = Struct(Id - node : integer, Type : String)$, in the clause DEFINITION of the B model, and having as elements the different nodes defined in the activity diagram that we aim to translate. The nodes are then translated into variables $node_i$, declared in the VARIABLES clause and typed in the INVARIANT clause: $node_i \in Nodes$.*

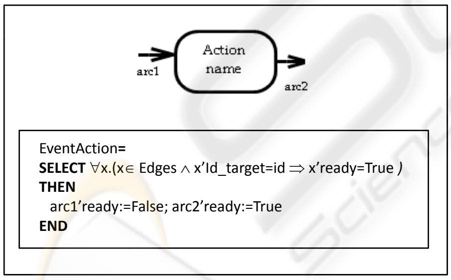
The abstract class $ActivityEdge$ is related with the class $ActivityNode$ by two relations: target and source. Hence, each edge has only one target node and one source node. Besides to this relation, the activity diagrams meta-model specifies other relation with the class $ValueSpecification : guard$, to indicate that an edge is carrying tokens or not. We propose so to specify four fields to describe those relations:Id-edge, Id-source, Id-target and Ready to indicate if the edge is carrying tokens or not.

Rule 3. *The abstract class ActivityEdge is translated into a B record: $Edges = (Id_edge : integer, id_source : integer, Id_target : integer, ready : boolean)$, declared in the clause $DEFINITION$ of the B model, and having as elements the different edges defined in the activity diagram that we aim to translate. The edges are then translated into variables $edge_i$, declared in the VARIABLES clause and typed in the INVARIANTS clause: $arc_i \in Edges$.*

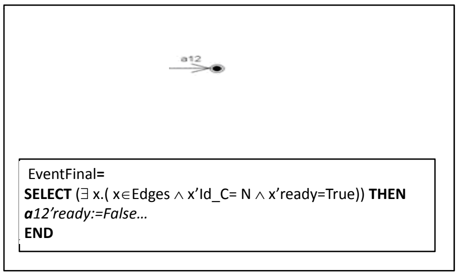


The semantics translation focuses on the meaning of each concept. An action node is being executing when all its incoming control and data tokens are available. We suggest converting an action node into an event B stating in its guard that all the incoming edges are ready. Consequently, we propose an universal predicate Q witch verifies for each edge included in the record Edges if it has as target the action node that we aim to translate and if its field ready is evaluated to true.

Rule 4. *An action node N is interpreted as event B having as structure: SELECT guard THEN substitutions END, its guard consist of the predicate* $Q = \forall x(x \in Edges \wedge x'Id_{t}arget = N \Rightarrow x'ready = True)$ *while its substitution denotes the disabling of the incoming edges and the enabling of the outgoing one.*



Rule 5. *The initial node is interpreted as an instruction, asserted in the clause INITIALISATION, initializing its outgoing edges field ready at true. Translation of Fork/Join Node. A fork node is used to describe parallel behaviors, while Join node is used to synchronize concurrent flows. It has to wait for the enabling of all its incoming edges and then it disables them and enables its outgoing one. A fork node is converted into an event: SELECT guard THEN substitutions END, which enables simultaneously the outgoing flows once the incoming one is enabled.*



Rule 6. *A final node N is interpreted as an event B having as structure: SELECT guard THEN substitutions END, where the guard consists of the predicate* $Q = \exists x(x \in Edges \wedge x'Id_{t}arget = N \wedge x'ready = True)$, *while its substitutions denote the disabling of all the edges.*

2.2 Step2: Proof Generation

Giving an UML Activity Diagram, we aim through translating it into B specification at verifying required properties which are mainly: deadlock freeness, livelock freeness and reachability. An event B model deadlocks when there is no held guard. Thus, we have to verify that there is always at least a valid guard. For example, consider $G_1, G_2, ..., G_n$ which denote the guards of all the events, the coherence constraint, denoted CC, can be formulated by the condition: $CC = G_1 \vee G_2 \vee ... \vee G_n$. To prove that this constraint always holds, we have to prove its satisfaction after each hidden event. We have so to assert it in the INVARIANT clause since it is checked for any hidden event. The activity diagram is then coherent if the initialization satisfies the Invariants and if an event holds, it preserves also Invariants. Having identified the B specification of the UML AD of **??**, we will now focus on proving the coherence constraint, asserted in the INVARIANT clause. We start by identifying the Guard of each event:

$GuardofEventAction = \forall x(x \in Edges \wedge x'Id_{t}arget = 2 \Rightarrow x'ready = True) \equiv arc1'ready = True \wedge arc4'ready = True$
$GuardofEventAction = \forall x(x \in Edges \wedge x'Id_{t}arget = 2 \Rightarrow x'ready = True) \equiv arc2'ready = True$
$GuardofEventObject = \exists x(x \in Edges \wedge x'Id_{t}arget = 4 \Rightarrow x'ready = True) \equiv arc3'ready = True$
$GuardofEventFinal = \exists x(x \in Edges \wedge x'Id_{t}arget = 5 \Rightarrow x'ready = True) \equiv arc5'ready = True.$

3 CONCLUSIONS

The main contribution of this work is related to The translation of UML activity diagrams into the event B abstract system formalism. The translation covers syntactical a semantic views of UML AD. We have focused both on the UML activity model and its met-model in order to avoid lack of information while translating. The current work fills a gap between the widely practiced UML AD for workflow modelling and the emerging proof based on abstract machines, refinement and theorem proving. In the proposed approach, a workflow application is initially modelled graphically with UML activity diagrams. After that, the resulting graphical model is translated into Event B model. Required properties for UML AD are then added as invariants in the resulting model. These properties are verified by the use of an event B tool. Hence UML AD could be verified. We have so proposed a set of generic rules describing UML activity diagram in event B. The derived static part of the resulting event B model capture the syntax of UML AD and events capture the semantics of UML AD evolution.

REFERENCES

Abrial, J.-R. (1996). Abrial, j-r. (1996) extending b without changing it (for developing distributed systems). In *Habrias, editor, First B Conference, Putting Into Pratice Methods and Tools for Information System Design*, Nantes, France.

Bjorner, D. (1987). Vdm a formal method at work. In *Proc. of VDM Europe Symposium*. Springer-Verlag. LNCS, editor.

Conallen, J. (1999). Modeling web application architectures with uml. In *Communications of the ACM, 42 (10)*.

Holz, E. (1997). Application of uml within the scope of new telecommunication architectures. In *In GROOM Workshop on UML, Mannheim*. Physical Verlag.

Jacobson, J. and Booch, G. (1998). The unified modeling language reference manual. In *Addison- Wesley*.

OMG (2003). Unified modeling language superstructure. http://www.omg.org/ technology/documents/formal/uml.htm.

Pllana, S. and Fahring, T. (2002). Modeling parallel aplications with uml. In *In 15th International conferences on parallel and distributed computing systems*, USA-ISCA.

Vidal, J. S. (2006). Matrise de la cohrence des modles uml d'applications, approche par l'analyse des risques lis au langage uml. In *thse de doctorat, Institut National des Sciences Appliques de Toulouse, France*.