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# On Transforming a High-Level Specification to an Executable Domain Model for Domain-Driven Design

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***Abstract*—Domain-driven design (DDD) aims to iteratively develop software around a realistic model of the problem domain, that is both a thorough grasp of the domain requirements and technically feasible to deploy. Current works, approaches and methodologies that transform a high-level specification (UML behavior models) into source code aim to simplify software development and bring the software to market quickly. However, transforming a high-level specification into an executable domain model for DDD is challenging and requires a precise of the domain model at high-level abstraction with UML Activity diagram and UML/OCL Class diagram. In this paper, we propose a technique to obtain a precise specification (an executable model in DCSL and AGL) of the domain model for DDD by a transformation from a specification at high-level abstraction (with UML Class and Activity diagrams). We develop a support tool for our method using Acceleo to automatically transform into source code and executable models in DCSL and AGL based on jDomainApp, a Java software framework.**

***Index Terms*—DDD, DSL, UML/OCL, Class diagram, Activity diagram**

## I. Introduction

Domain-driven design (DDD) [1] aims to iteratively develop software around a realistic model of the problem domain, that is both a thorough grasp of the domain requirements and technically feasible to deploy. The Model-Driven Development (MDD) [2] approach moves the focus of the development from the code to the models of the system to generate all the required artifacts. In our recent work, we incorporated domain behaviors into a domain model for a composition of both structural and behavioral aspects of the domain, namely AGL [3]. Realizing the difficulty of defining a precise specification at a high-level abstraction (with UML Class and Activity diagrams) and transform it into a DCSL [4] and AGL specification (so-called $AGL^+$ specification) of the domain model for DDD to generate software artifacts.

The high-level specification UML Activity and Class diagram is one of the behavioral models used for modeling the global behavior of systems, it models both data and control flow in the system. Meta modeling for DSL [5] to construct conceptual model of the domain as a UML/OCL class diagram using abstract syntax model suitable for embedding in to a host object oriented programming language (OOPL). The UML [6] involves the construction of an object-oriented model of the abstract syntax optionally, the concrete notation and semantics of the target language [7]. The proposed a high-level specification has main aim: automatic generation the $AGL^+$ specification.

Our approach involves domain model (UML Activity and Class diagram) and transform model to text as we input a specification at high-level abstraction role as the input domain model to transforming source code ($AGL^+$ specification) for the usage of the DDD methodology of the host programming language (such as Java). In this work, we define a domain model (a high-level specification abstraction) and a technique for transforming the rules to $AGL^+$ specification. To demonstrate our method, we use Acceleo [8] to transform a domain model to $AGL^+$ and use a Java framework [9] called jDomainApp generated software through a case study to that shows how the $AGL^+$ specification can be applied to real-world software.

To summarize, the main contributions of this paper are as follows:

- A technique to obtain a precise specification (an executable model in DCSL and AGL) of the domain model for DDD by a transformation from a specification at a high-level abstraction (with UML Class and Activity diagrams).
- A tool support for our method on transforming and implementing software artifact generation for domain-driven design.

The rest of the paper is organized as follows: Section II we provide a detailed discussion on our motivat-

ing example, specifying precisely domain models for a DDD approach and research questions. Section III briefly discusses how a specification at a high-level abstraction and transformed into a DCSL and AGL specification. Section IV we present the transformation UML activity diagrams into AGL as we provide a detailed the algorithm: AD2AGL (input, output, computations) and the rules (templates in Acceleo to automate the generation process). Section V we demonstrate the tool support for transforming from UML/OCL diagrams specification into the $AGL^+$ specification and generating software from the $AGL^+$ specification. Section VI concludes the paper.

## II. Motivating Example and Background

### A. Motivating Example

We use the order management domain OrderMan [6, p. 396] as our motivating example. The OrderMan is complex piece of software model, which is adapted from the OMG/UML specification with activity diagram and class diagram together with OCL constraints. Figure 1 shows an input domain model for OrderMan. To use it as the specification a full input model contains various kinds of `ControlNodes`. A `DecisionNode` after ReceivedOrder illustrates branching based on two possible conditions: OrderRejected or OrderAccepted. FillOrder is followed by a `ForkNode` that passes control to both to SendInvoice and ShipOrder nodes. The `JoinNode` indicates that control will be passed to the `MergeNode` when both ShipOrder and AcceptPayment are completed. As a `MergeNode` will simply pass the token along, the EndOrder node will be executed.

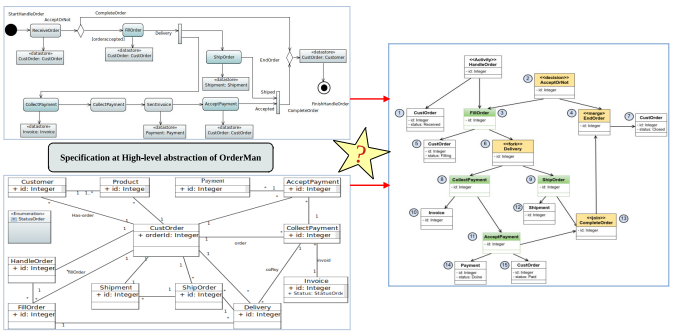



Fig. 1. Motivating Example

Our research problem, We deal with the domain problem using a four-step solution. Firstly, we specific a precise UML Activity diagram of the of the OrderMan and the guards for coordinate nodes. Secondly, we combined the UML Class diagram with the OCL constraints. Within our DDD approach [4] this domain model would be represented in DCSL. With these two steps, we employ a technique to obtain a precise specification at a high-level abstraction (with UML Class and Activity diagrams) which is show in the right Figure 1 , in which we created the input domain model then moved on to the next step. Thirdly, there is a major challenge in this step, which is in the process of transforming the domain model to AGL and DCSL specification, then combine them into a $AGL^+$ to obtain activity graph configuration (AGC) of the unified model which consists of activity graph (AGraph), activity node (ANode), and module action (MAct) of AGL. We use annotations to represent AGC (@AGraph, @ANode, MAct) and DCSL in our recent work [3]. Then, Finally we execute $AGL^+$ of the domain model for DDD JDA: jDomainApp [9].

A Class diagram [6] describes the structure of a system by showing the classes of the systems, their attributes, and the relationships among the classes. UML class diagrams, OCL is the language of choice for defining constraints going beyond simple multiplicity and type constraints in Figure 2.

The UML Activity Diagram is often used to model the overall system behavior and to show the entire business process flow. Many approaches and methodologies have been proposed for the automatic source code generation from the UML Activity Diagram [16]–[18]. The authors of [17] used a modified DFS (depth-first search) algorithm to generate a set of paths from the Activity Diagram. Since the number of concepts and the metamodel for UML [6] Activity diagram is very large, only "the most essential" of AD are considered in this paper. On the other hand, we focus on those AD elements which directly influence the generation of source code from movement semantics. For example the Figure 2 an HandleOrder (a new instance of the class `HandleOrder` is created) is received by the action `ReceiveOrder` (the operation `initHandleOrder`() of the class `HandleOrder` is invoked).Then, if the condition guard (`Self.rejectOrder`()) of the decision node is not true (the order is not rejected), the flow goes to the next step: the action FillOrder (`Self.fillOrder`()). After that, the fork node splits the path of the control flow into two parallel tasks. On the left path, the action ShipOrder (call of the operation `shipOrder`()) is executed. On the right path, to handle billing and payment processing, the action PayOrder (`Self.payOrder`()) is handled. When the two paths are accomplished, the join node may take place and the action EndOrder (`Self.EndOrder`()) is achieved. Returning back to the above decision node, if the order is rejected, the flow is passed directly to the action `EndOrder`.

### B. Specifying Precisely Domain Models for a Domain-Driven Design

#### Domain-Driven Design (DDD)

Object-oriented domain-driven design (DDD) [1], [10] aims to develop complex software (iteratively) around a realistic domain model, which both thoroughly captures the domain requirements and is technically feasible for implementation. This requires close collaboration among all the stakeholders (including the domain experts and the technical team members), using a ubiquitous language [1]

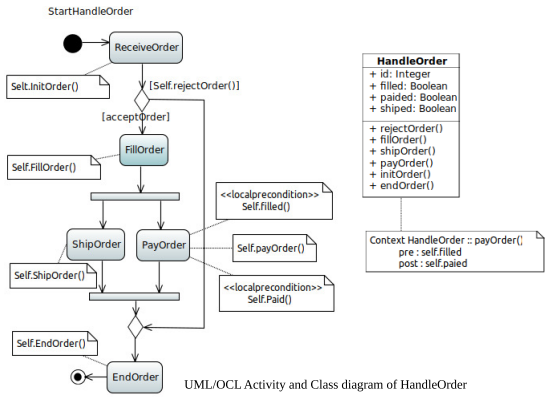



Fig. 2. The UML/OCL Activity and Class diagram of HandleOrder of OrderMan

to construct the domain model (that satisfies the domain requirements) and resulting a object oriented implementation of this model. In practice, complex software requires a scalable architecture and a highly productive software development method. This work uses DDD to refer specifically to object-oriented DDD. Within the DDD approach domain model tends to be the heart of software. Two main features of DDD are: (1) feasibility, i.e., a domain model should be the code and vice versa, and (2) satisfiability, i.e., the domain model would satisfy the domain requirements that are expressed in a ubiquitous language [1]. This language is defined for stakeholders, including the domain experts and developers, in an iterative and agile process of eliciting the domain requirements. To construct DDD software from a domain model the domain model is feasible for implementation in a host OOPL [11].

*A DCSL and AGL specification*

Annotation-Based Domain Specific Language (aDSL) is coined in [12] as an attempt to formalise the notion of fragmentary, internal DSL [13] for the use of annotation to define DSLs. An aDSL is defined based on a set of meta-concepts that are common to two popular host OOPLs, the Java [14] and the C# [15]. **Domain class specification language** (**DCSL**) [4] is a horizontal aDSL developed by us to express domain models. There are an *annotation-based domain specific language* (aDSL) [12] named *Domain class specification language* (DCSL) in order to express the domain models.

In this work we use feature of DCSL is that its meta-concepts model the domain-specific terms composed of the core OOPL meta-concepts and constraints. More specifically, the meta-concept **Domain Class** is composed of the meta-concept `Class` and a constraint captured by an annotation named `DClass`, which states whether or not the class is mutable. Similarly, the meta-concept **Domain Field** is composed of the meta-concept `Field` with a set of state space constraints, represented by an annotation named `DAttr`. The meta-concept `AssociativeField` represents the **Domain Field** that realizes one end of the association between two domain classes. DCSL supports all three types of association: one-to-one (abbr. one-one), one-to-many (abbr. one-many), and many-to-many (abbr. many-many). Finally, the meta-concept **Domain Method** is composed of `Method` and commonly used constraints and behavioral types that are imposed on instances of domain classes. The essential behavioral types are represented by an annotation named `DOpt` and another annotation named `AttrRef`. The latter references the domain field that is the primary subject of a method's behavior.

In current work [3], we proposed language, AGL (Activity Graph Language) to incorporating domain behaviors into a domain model: AGL is defined to represent the domain behaviors for the incorporation. Each domain behavior, described at a high level using a UML Activity diagram and domain-model based statements, is translated into a specification with two parts: (1) a part of the unified class model with new activity classes, and (2) the activity graph logic of the input activity and the mappings to connect the activity with the unified class model

The AGL specification aims to specify the activity graph logic of the input activity and to maintain the synchronization of current execution states (w.r.t the activity) with current states of the domain (w.r.t the unified class model).

In order for developers to create software artifacts following the DDD approach, they must encode the unified domain model in DCSL and AGL, resulting in a Java program that has two main components: (1) The DCSL unified model, which includes component and domain classes (UML/OCL class diagram); (2) The AGL specification for the activity graphs (UML Activity diagram). It is important to note that both the DCSL and AGL specifications (namely $AGL^+$ specification, which incorporates AGL into DCSL) are encoded in Java.

*The AGL+ specification of OrderMan, resulting in a generated software*

The activity diagram specified by the AGL for the `HandleOrder` activity class. Using the annotation mechanism in Java, the HandleOrder object can be treated as an AGraph object, allowing it to represent and manage the activity diagram. The AGraph object enables to handle each of its ANodes, such as the ANode w.r.t node 14 in Listing 1, as well as the domain class referred to by the ANode, in this case, the `Payment` class. For example, Listing 1 illustrates the annotation used to express the AGL specification of the `HandleOrder` activity class. The class diagram specified by the DCSL for the class `HandleOrder` of OrderMan, which is written in Java. Listing 2 provides an example class `HandleOrder` is specified with `DClass.serialisable` = `false`. The domain field name is mutable `DAttr.mutable` = `false`.

Listing 1. The activity diagram `HandleOrder` in Java `AGraph`

```
/**Activity graph configuration in AGL */
@AGraph(nodes={...
  /* 14 */
```

```
  @ANode(label="14:Payment", zone="11:AcceptPayment",
  refCls=Payment.class, serviceCls=DataController.class,
  outNodes={"15:CustOrder"},
  actSeq={
    @MAct(actName=newObject, endStates={NewObject}),
    @MAct(actName=setDataFieldValues, attribNames={"invoice"},
    endStates={Created})
  }), ...
})
/**END: activity graph configuration */
```

Listing 2. DCSL specification of `HandleOrder` written in Java

```
/** DCSL specification of \clazz{HandleOrder} written in Java*/
@DClass(serialisable=false, singleton=true)
public class HandleOrder {
  @DAttr(name = "id", id = true, auto = true, type = Type.
       Integer, length = 5,
  optional = false, mutable = false)
  private int id;
  private static int idCounter = 0;
  ...}
```

### C. Research Questions

To Achieve this goal proposes two primary challenges that motivate our work:

How can we obtain an $AGL^+$ specification by a model transformation from a specification of the domain model at high-level abstraction with UML Activity Diagram and UML/OCL class diagram?

## III. Overview of Our Approach

This section explains our basic idea on transforming a high-level specification to an executable domain model for domain-driven design. Figure 3 overviews our proposed

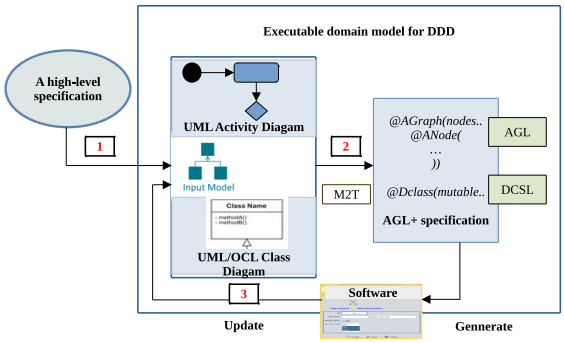



Fig. 3. Overview of Our Approach

technique. This technique conceptually consists in iteratively performing three steps.

Step 1 (The construct domain model takes input): We take a specification with UML/OCL Class Diagram (CD) and Activity Diagram (AD) as input. To achieve target of $AGL^+$ specification, we transform the CD input to the DCSL specification and the AD input to the AGL specification. A detailed technical to generate $AGL^+$ specification in source code from high-level specification AD and CD in Section IV. Here, we consider the $AGL^+$ specification as an extended domain model in MOSA [4]. It is expressed in AGL and DCSL as extends the conventional DDD's domain model [1] with the executable domain model.

Step 2 (The AD2AGL transformation): This step transforms the input AD specification into an AGL specification and then composes it with DCSL specification, which is implemented in DDD as a GUI- and module-based software. This software is presented to the domain expert in order to get feedback.

Step 3 (The updated and the cycle): if there is feedback, then the input domain model will be updated and the cycle continues. If, on the other hand, the domain expert is satisfied with the models; then the cycle ends.

## IV. Transforming ADs to the AGL Specification

### A. Algorithm AD2AGL

This section represent a algorithm to generate source code from high-level specification Activity diagram (AD) into the Activity Graph Language (AGL) so-call Algorithm AD2AGL. Algorithm .1 AD2AGL: input AD and output corresponding AGL, annotation realized in Java; e.g. `@AGraph`, `@ANodeand@MAct`, etc.

**Algorithm .1:** AD2AGL- Transformation from Activity Diagram to Activity Graph Language

**input :** AD a high-level specification
**output :** AGL specification
Create a Java package with the name of AD
Perform Depth First Search on AD keeping initialNode as the starting vertex.
  2.1 Visit node N, say $e_n$
  2.2 Identify the the next node N based on the edge (with outgoing edge of N is node $e_x$, $x \in$ ($ControlNode$ : $d-decisionnode, f-fork\ node, m-mergenode, j-joinnode, ActionNode : s-sequentialnode$)
  2.3 Check the node $e_x$
  2.3.1 if the node $e_x$== $e_s$ ($e_s$ is the sequential node)
  *callSequentialAGL()*
  Visit next node $e_x$
  2.3.2. if the node $e_x$== $e_d$ ($e_d$ is the decision node)
  *calldecisionAGL()*
  Visit next node $e_x$
  2.3.3. if the node $e_x$== $e_f$ ($e_f$ is the fork node)
  *callforkAGL()*
  Visit next node $e_x$
  2.3.4. if the node $e_x$== $e_m$ ($e_m$ is the merge node)
  *callmergeAGL()*
  Visit next node $e_x$
  2.3.5. if the node $e_x$== $e_j$ ($e_j$ is the join node)
  *calljoinAGL()*
  Visit next node $e_x$, callAction()
  Repeat step 2.1 to 2.3 until all nodes have been visited (meet finalNode)
**Return** AGL

First, it creates a java package with the name of the domain class of the AGL. Second, using algorithm Depth

First Search on AD to visit all nodes in the activity graph. An AGL specification will be added whenever a new action node is visited. As per UML [6], activity diagram is considered as a graph. An activity graph [17], AG, is a hextuple which contains nodes $N$, edges $E$, events *eve*, guard conditions *gua*, local variables *var*, and set of objects *obj*. A node can be of two types, *ActionNode* and *ControlNode*. *ActionNode* includes *action node, acceptEvent node, sendSignal node* and *callAction()*. The *CallAction* node is used to represent a function call in the activity diagram. *ControlNode* includes *initial node, final node, sequential node, decision node, merge node, and fork and join node* in the Table 22. Third, It checks each node in the AD and all action nodes and control nodes, and calls subfunctions for the respective cases to write the AGL specification. When visiting the current node, it calls the subfunctions *callSequentialAGL()*, *calldecisionAGL()*, *callforkAGL()*, *callmergeAGL()* and *calljoinAGL()*. The algorithm adds an AGL specification according to the annotation-based textual concrete syntax model for AGL that is defined in [3]. Four, it repeats step *callAction()* until all nodes have been visited (meet finalNode).

TABLE I
MAPPING THE FORMALISATION ELEMENTS TO METAMODEL

| Element in metamodel | Components in formalisation |
|---|---|
| activity diagram | AD |
| activityNode | N |
| activityEdge | E |
| events | eve |
| valueSpecification | gua |
| variable | var |
| objects | obj |
| Visit the next node | callAction() |
| Control node | subfunctions |

In the Algorithm .2 is the algorithm sub-algorithm for sequential node: *callsequentialAGL()* and it depicted in Figure 4.

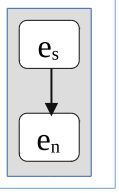
| Sequential specification in Ad | Desciption in algorithm: *callsequentialAGL()* |
|---|---|
| sequential pattern (n>1)   | the name of current node (action node): $e_s$ |
| | the name of current node (action node): $e_n$ |
| | the name of the incoming edge of the current node "as" |

Fig. 4. The sequential specification in AD and denote in algorithm

In the Algorithm .3 is the algorithm sub-algorithm for decision node: *calldecisionAGL()* and it depicted in Figure 5.

In the Algorithm .4 is the algorithm sub-algorithm for fork node: *callforkAGL()* and it depicted in Figure 6.

**Algorithm .2:** algorithm sub-algorithm for sequential node *callsequentialAGL()*

**input :** Current node $e_s$
**output :** AGL sequential specification
1 2.3.1.1 Add a AGL specification code
2 **ANode**{refCls=name of node $e_s$, seviceCls=DataController, outClses=[the next node $e_s$, say $e_n$] actSeq=[MAct{actName=newObject, pstStates=[Created]}] init=true}
3 **ANode**{refCls=name of node $e_n$, seviceCls=DataController, actSeq=[ MAct{actName=newObject, pstStates=[NewObject]}, MAct{actName=setDataFieldValue, fieldNames=["as"] pstStates=[Created]}]}
4 2.3.1.2 Visit next node $e_n$
5 2.3.1.3 Back to step 2.1

**Algorithm .3:** algorithm sub-algorithm for decision node *calldecisionAGL()*

**input :** Current node $e_n$
**output :** AGL decision specification
1 2.3.2.1 Add a AGL specification code
2 **ANode**{refCls=name of current node $e_n$, seviceCls=DataController, outClses=[the next node $e_n$, say $e_d$] actSeq=[MAct{actName=newObject, pstStates=[Created]}] init=true}
3 **ANode**{refCls=name of node $e_d$, nodeType=Decision seviceCls=DataController, outClses=[the next node $e_d$, say $e_{d1}$, $e_{dn}$ and data store node $e_{dk}$]}
4 **ANode**{refCls= name of node $e_{d1}$, serviceCls=DataController actSeq=[ MAct{actName=newObject, pstStates=[NewObject]}, MAct{actName=setDataFieldValues, fieldNames=["ad"] pstStates=[Created]}] }
5 **ANode**{refCls= $e_{dn}$,serviceCls=DataController actSeq=[ MAct{actName=newObject, pstStates=[Newobject]}, MAct{actName=setDataFieldValues, fieldNames=["ad"] pstStates=[Created]}]}
6 **ANode**{refCls= $e_{dk}$,nodeType=$k$- specifies the control node type, outClses=$k_{out}$ - specifies the array of output $e_{dk}$ }
7 2.3.2.2 Visit next node $e_n$
8 2.3.2.3 Back to step 2.1

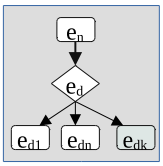
| Decision specification in Ad | Desciption in algorithm: *calldecisionAGL()* |
|---|---|
| decision pattern (if $e_{dk}$ is present then *n>1* else *n>2*)   | the name of the current node (action node): $e_n$ |
| | the name of the decision node: $e_d$ |
| | the name of the nodes thats decision node link to: $e_{d1}$, $e_{dn}$ and $e_{dk}$ ($e_{dk}$ is the data store node) |

Fig. 5. The decision specification in AD and denote in algorithm

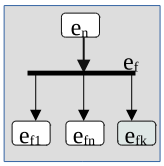
| Fork specification in Ad | Desciption in algorithm: *callforkAGL()* |
|---|---|
| forked pattern (if $e_{fk}$ is present then *n>1* else *n>2*)   | the name of the current node (action node): $e_n$ |
| | the name of the fork node: $e_f$ |
| | the name of the nodes thats fork node links to: $e_{f1}$, $e_{fn}$ and $e_{fk}$ ($e_{fk}$ is the data store node) |

Fig. 6. The fork specification in AD and denote in algorithm

In the Algorithm .5 is the algorithm sub-algorithm for join node: *calljoinAGL()* and it depicted in Figure 7.

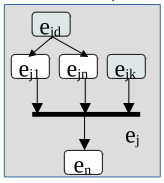
| Join specification in Ad | Desciption in algorithm: *calljoinAGL()* |
|---|---|
| joined pattern (if $e_{jk}$ is present then *n>1* else *n>2*)   | the name of the nodes thats join node links to: $e_{j1}$, $e_{jn}$ and $e_{jk}$ ($e_{jk}$ is the data store node) |
| | - the name of the join node: $e_j$<br>- the next node of $e_j$ is $e_n$ |
| | the name of the data store $e_{jd}$ node, that link to: $e_{j1}$, $e_{jn}$ (target of outgoing edge are $e_{j1}$ and $e_{jn}$) |

Fig. 7. The join specification in AD and denote in algorithm

In the Algorithm .6 is the algorithm sub-algorithm for merge node: *callmergeAGL()* and it depicted in Figure 6.

### B. Rules (templates in Acceleo)

To implement the code generator, the Model-to-Text transformation (M2T) is needed to generate the $AGL^+$. We define the rules (templates in Acceleo) to transform from the high-level specification AD and CD of ORDER-MAN to $AGL^+$ in Listing **??**. Acceleo provides a powerful tooling such as an editor with syntax highlighting, error detection, code completion, refactoring, debugger, profiler, and a traceability API that allows tracing model elements to the generated code and vice versa [8].

**Algorithm .4:** algorithm sub-algorithm for fork node *callforkAGL()*

**input :** Current node $e_n$
**output :** AGL fork specification

1 2.3.3.1 Add a AGL specification code
2 **ANode**{refCls=name of the current node $e_n$, seviceCls=DataController, outClses=[the next node $e_n$, say $e_f$] actSeq=[MAct{actName=newObject, pstStates=[Created]}] init=true}
3 **ANode**{refCls=name of node $e_f$, nodeType=Fork seviceCls=DataController, outClses=[the next node $e_f$, say $e_{f1}$, $e_{fn}$ and data store node $e_{fk}$]}
4 **ANode**{refCls= name of node $e_{f1}$, serviceCls=DataController actSeq=[ MAct{actName=newObject, pstStates=[NewObject]}, MAct{actName=setDataFieldValues, fieldNames=["af"] pstStates=[Created]}] }
5 **ANode**{refCls= $e_{fn}$,serviceCls=DataController actSeq=[ MAct{actName=newObject, pstStates=[Newobject]}, MAct{actName=setDataFieldValues, fieldNames=["af"] pstStates=[Created]}]} **ANode**{refCls= $e_{fk}$,nodeType=$k$- specifies the control node type, outClses=$k_{out}$ - specifies the array of output $e_{dk}$ }
6 2.3.3.2 Visit next node $e_n$
7 2.3.3.3 Back to step 2.1

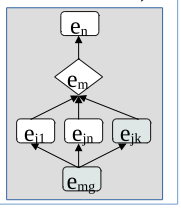
| Merge specification in Ad | Desciption in algorithm: *callmergeAGL()* |
|---|---|
| merged pattern (if $e_{mk}$ is present then *n>1* else *n>2*)   | the name of the nodes thats join node links to: $e_{m1}$, $e_{mn}$ and $e_{mk}$ ($e_{mk}$ is the data store node) |
| | - the name of the join node: $e_m$<br>- the next node of $e_m$ is $e_n$ |
| | the name of the data store $e_{mg}$ node, that link to: $e_{j1}$, $e_{jn}$, $e_{mk}$ (target of outgoing edge are $e_{j1}$, $e_{jn}$, $e_{mk}$) |

Fig. 8. The merge specification in AD and denote in algorithm

Listing 3. AD2AGL

```
[template public generateElementAGL(aModel : Model)]
[file (aModel.name.concat('.java'), false, 'UTF-8')]
/**AGL specification*/
@Agraph(nodes={
  [for ( e: PackageableElement| packagedElement)]
  [if(e.oclIsKindOf(Activity))]
  [let aActivity : Activity = e.oclAsType(Activity)]
  [for (aActivityNode : ActivityNode | aActivity.node)]
  [let nextNode : ActivityNode = callAction(aActivityNode)]
  [if (nextNode.oclIsKindOf(OpaqueAction))]
  [callSequentialAGL(aActivityNode)/]
  [/if]
  [if (nextNode.oclIsKindOf(DecisionNode))]
  [callDecisionAGL(aActivityNode)/]
  [/if]
  [if (nextNode.oclIsKindOf(ForkNode))]
```

**Algorithm .5:** algorithm sub-algorithm join node *calljoinAGL()*

**input :** Nodes $e_{j1}$, $e_{jn}$ and data store node $e_{jk}$
**output :** AGL join specification

1 2.3.4.1 Add a AGL specification code
2 **ANode**{refCls=name of the current node $e_{j1}$, seviceCls=DataController, outClses=[name of next node $e_{j1}$, say $e_j$] actSeq=[MAct{actName=newObject, pstStates=[Created]}] init=true}
3 **ANode**{refCls=name of node $e_{jn}$, seviceCls=DataController, outClses=[name of the node $e_j$] actSeq=[ MAct{actName=newObject, pstStates=[Created]}] init=true}
4 **ANode**{refCls= name of node $e_{jk}$, nodeType=$k$-specifies the control node type, outClses=[name of the node $e_j$], init=true}
5 **ANode**{refCls=name of the node $e_j$, nodeType=Join, outClses=[name of a data store node of $e_j$, say $e_{jd}$]}
6 **ANode**{refCls=name of the node $e_{jd}$, serviceCls=DataController actSeq=[ MAct{actName=newObject, pstStates=[NewObject]}, MAct{actName=setDataFieldValues, fieldNames=["a1","an"] pstStates=[Created]}] }
7 2.3.4.2 Visit next current node
8 2.3.4.3 Back to step 2.1

**Algorithm .6:** algorithm sub-algorithm merge node *callmergeAGL()*

**input :** Nodes $e_{m1}$, $e_{mn}$ and data store node $e_{mk}$
**output :** AGL merge specification

1 2.3.5.1 Add a AGL specification code
2 **ANode**{refCls=name of the current node $e_{m1}$, seviceCls=DataController, outClses=[The name of the node has a reference to the other node of the $e_m$, say $e_{mg}$] actSeq=[MAct{actName=newObject, pstStates=[Created]}] init=true}
3 **ANode**{refCls=name of node $e_{mn}$, seviceCls=DataController, outClses=[name of the node $e_{mg}$] actSeq=[ MAct{actName=newObject, pstStates=[Created]}] init=true}
4 **ANode**{refCls= name of node $e_{mk}$, nodeType=$k$-specifies the control node type, outClses=[name of the node $e_{mg}$], init=true}
5 **ANode**{refCls=name of the node $e_{mg}$, nodeType=Merge, outClses=[name of merge node $e_m$]}
6 **ANode**{refCls=name of the node $e_m$, serviceCls=DataController actSeq=[ MAct{actName=newObject, pstStates=[NewObject]}, MAct{actName=setDataFieldValues, fieldNames=["a1","an"] pstStates=[Created]}] }
7 2.3.5.2 Visit next current node
8 2.3.5.3 Back to step 2.1

```
[callForkAGL(aActivityNode)/]
[/if]
[if (nextNode.oclIsKindOf(MergeNode))]
[callMergeAGL(aActivityNode)/]
[/if]
[if (nextNode.oclIsKindOf(JoinNode))]
[callJoinAGL(aActivityNode)/]
[/if]
[/let]
[/for][/let][/if][/for]}
```

We define the rules (templates in Acceleo) to transform of each kind of control node and action node in the UML AD. Due to space constraints, we will only illustrate the Decisional node in this paper. For more information on the other nodes (

## V. Tool Support

In this section, we present a case study of order products management OrderMan to illustrate our method of transforming the high-level specification activity diagram of OrderMan to AGL, using Acceleo. Acceleo provides powerful tooling such as an editor with syntax highlighting, error detection, code completion, refactoring, debugger, profiler, and a traceability API that allows tracing model elements to the generated code and vice versa [8]. On the top of Figure 9 shows the AD of OrderMan, which is the input model of our method, at the bottom left show the Acceleo code (template) to perform the conversion to the HandleOrder code, which is the output of our method at the bottom right.

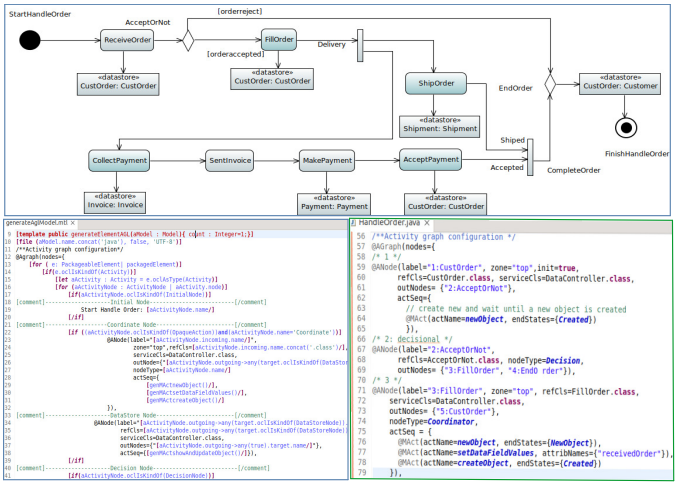



Fig. 9. Using Acceleo transformation AD of OrderMan to AGL, HandleOrder realized in Java

Next, we compose the AGL with the DCSL, which is taken as input to automatically generate and implement our method. Figure 10 demonstrates the implementation

of our method, using a supporting tool built on JDomainApp, a Java software framework

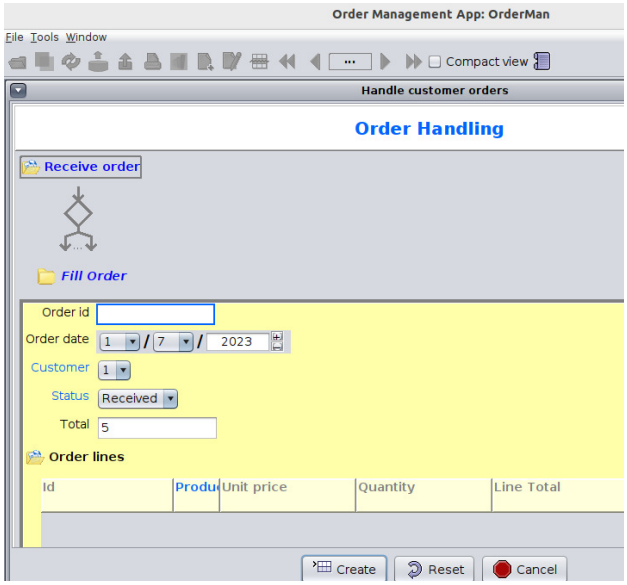



Fig. 10. The GUI of the Orderman software generated by the tool.

Conceptually, the tool consists of three key components: model manager, view manager, and object manager. The **model manager** is responsible for registering the AGL.

**Discussion:**

Limitations of the method (the points would be part of our future work):

The AD specification as combination of domain behavior patterns The DCSL specification is directly and manually writen in Java: it should be obtained by a transformation from the input UML/OCL class diagram (or a DCSL model in graphical form)

The compostion of DCSL and AGL is manually performed.

## VI. Conclusion and future work

In this paper, we introduce a technique to generate source code from high-level specification into the behavioral pattern of Activity Graph Language for developing object-oriented, domain-driven software. Our approach involves compact pattern of the activity graph configuration of the Unified model within the MOSA architecture by: (1) derived from high-level specification include domain-specific features from the UML Activity diagram; (2) transformation (M2T - AD to AGL) and composition into aDSL and AGL using the annotation attachment feature of the host OOPL.

We systematically developed a compact, a transformation from Ad to AGL. We implemented our method as part of a Java framework and demonstrated the effectiveness of AGL pattern in designing real-world software.

In the future, we plan to develop an Eclipse plug-in for our method and create fully AGL. Depending on the requirements specification. We also intend to develop a technique for automatically transforming a high-level requirements specification (use case) into a complex software systems.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