AN ACTIVITY ORIENTED VISUAL MODELLING LANGUAGE WITH AUTOMATIC TRANSLATION TO DIFFERENT PARADIGMS

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ABSTRACT

The traditional approach for discrete event simulation modelling includes visual support diagrams for modeller-client communication purposes (model interpretation and validation) and also to act as the basis for simulation language program construction.

Although modern simulation packages use powerful graphical interfaces for programming and animation purposes, these packages still require enormous simulation expertise to construct a simulation program. This work suggests the use of the Activity Cycle Diagrams-ACD (activity based philosophy) concepts for modeller-client communication, but also to act as an automatic generator of simulation programs under different paradigms - event scheduling (Basic Simulation Facility – Simulation Library) and Process Flow (ARENA – Simulation Environment) philosophies, thus eliminating any programming effort and expertise.

1 INTRODUCTION

The use of visual support diagrams to help the programming step of a simulation project is very common. Even when generic programming languages were replaced by specific purpose simulation languages the use of paper diagrams remained as a previous step to programming. [34] [25]. These diagrams were conveniently abstracted serving as support to the communication between the simulation client and the modeller (simulation expert), but also helping the construction of the corresponding computational programs [6] [29].

Modern simulation languages introduced new powerful graphical interfaces, but these interfaces are clearly programmer oriented, raising the difficulty in communicating with the client and still requiring enormous simulation expertise to use them [11].

In this paper, we still suggest the use of a (simple) graphical support as a representation of what the client formally needs, but these diagrams will also act as the source to the automatic generation of simulation programs.

The visual language chosen is the Activities Cycle Diagrams (ACD), for its simplicity and efficiency in representing real operating systems. [10] [25]

This mechanism also implied the construction of translation grammars. These grammars were written according to a modular specification of visual languages, based on attribute grammars [15] in MASOViLa (Modular Attribute-based Specification Of Visual Languages) [27] [9] [36]. Our translation engine uses a pattern matching rewriting mechanism.

Using Activity philosophy for modelling, then generating simulation programs based on event philosophy and in process philosophy, three major simulation approaches [4] were explored and linked.

2 LAYOUT AND ANIMATION ORIENTED SIMULATION ENVIRONMENTS

As already referred, appropriate diagrams were in use for many years to support the communication among people interested in a particular simulation. The simulation expert would then translate these models into a simulation language or even a general purpose programming language. As far as graphical support became available, an enormous variety of simulation environments emerged.[16]. **Graphical facilities** were then used to essentially represent a **system layout for animation purposes**.

Animation is recognized as an important aspect of simulation. However **when** the modelling process is **focused on animation**, several disadvantages may arise:

1. The **model may be overwhelmed** by many modules and accessory configurations.

2. Such a model, with increased complexity, will be **difficult for the client** to understand.

3. The analysis of a static model (in the first stages) based on the layout will not add much over its photograph or scheme. Thus the **semantic validation** will be left for the **animation** phase.

3 PROJECT MAIN STEPS

The main steps of this research work are summarized below:

1. The **choice of** an **easy** to use and widely spread visual language : Activity Cycle Diagrams (**ACD**).

2. **Formalization of ACDs** (keeping it simple), allocating to each graphical object the information required by the model.

3. Specification of a **file format** to represent the referred graphical objects (XML).

4. Implementation of a **graphical editor** to draw the models.

5. Implementation of a compiler’s **compiler** for visual/graphical 2D languages.

6. Specification of a **grammar** for the ACD language.

7. Implementation of **two compilers** - the first compiler generates the simulation program code in **JavaBSF**, and the other one generates the **Arena** program (using both Arena modules and new developed modules in VBA code).

3.1 Programming tools

The main programming language used was **Java** [21] [5]. Several sets of classes were implemented (corresponding to about nine thousand lines of code). Visual Basic for Applications (**VBA**) was also used, both in ARENA and in Microsoft VISIO. A template was built in **ARENA (**Professional Edition**)** [18] with activities and queues to implement an activity-based executive on a process-oriented environment.

3.2 About the use of Graphics in Visual Modelling and Programming

The idea behind this work is to enhance the **utilization of graphical facilities in modelling**, making it a great contribution to **automatic generation of simulation programs**, keeping it simple and portable.

Graphical facilities are more helpful when they **support model semantic** than when it is based on system layout and animation.

Furthermore the utilization of a **simple** axiomatic set may be **accessible** to more potential users and clients.

The use of an **activity-based philosophy** seems to be semantically richer and more simulation oriented than process flow or event scheduling.

The strategy was to create a completely **open system**, since the graphical editor creates a text file in XML (eXtended Markup Language). This is compatible with any graphical editor using the established syntax. The compiler uses an XML file and a grammar to build a program in an object simulation language.

3.3 Translation

Our first **ACDs compiler** generates a Java program according to the **event scheduling** philosophy. Although this is computationally highly efficient it is harder to program. In other words we could say that it is more computer friendly than programmer friendly. The complex compiler developed allows an easier translation by the computer.

By developing a template with new blocks for **Arena (process oriented)**, we were able to simulate ACDs using Arena objects built according to an activity based philosophy.

Using these two compilers/translators, we explored deeply on three major modelling philosophies [25] [29], making automatic translation mechanisms between them.

4 PROJECT MAIN TASKS

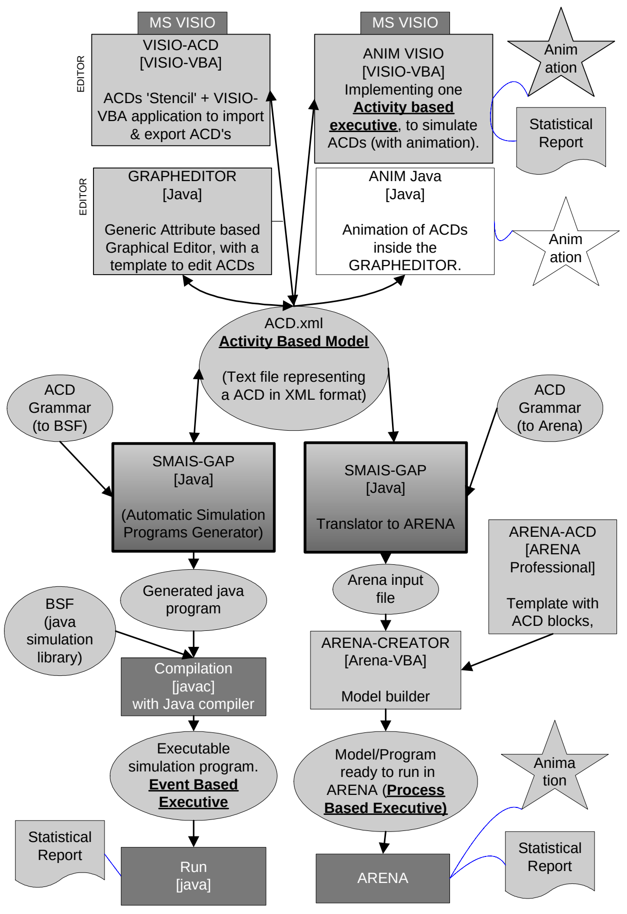

MS VISIO
VISIO-ACD [VISIO-VBA]
ACDs 'Stencil' + VISIO-VBA application to import & export ACD's
EDITOR
MS VISIO
ANIM VISIO [VISIO-VBA] Implementing one Activity based executive, to simulate ACDs (with animation).
Animation
Statistical Report
GRAPHEDITOR [Java]
Generic Attribute based Graphical Editor, with a template to edit ACDs
EDITOR
ANIM Java [Java]
Animation of ACDs inside the GRAPHEDITOR.
Animation
ACD.xml
Activity Based Model
(Text file representing a ACD in XML format)
ACD Grammar (to BSF)
ACD Grammar (to Arena)
SMAIS-GAP [Java]
(Automatic Simulation Programs Generator)
SMAIS-GAP [Java]
Translator to ARENA
ARENA-ACD [ARENA Professional]
Template with ACD blocks,
Generated java program
Arena input file
BSF (java simulation library)
Compilation [javac] with Java compiler
ARENA-CREATOR [Arena-VBA]
Model builder
Executable simulation program. Event Based Executive
Model/Program ready to run in ARENA (Process Based Executive)
Animation
Statistical Report
Run [java]
ARENA
Statistical Report

Figure 1: Project Map Diagram

The above diagram illustrates the interdependencies between the main tools and contributions of our project:

■ **ACD.xml** «*in the centre of diagram*» represents the chosen format to physically support the models: a text file in XML. (See also Figure 13 and Figure 14)

⬉ **GRAPHEDITOR** «*upper left zone of the diagram*» is the graphical editor that was specifically built for this purpose (see also Figure 9). Microsoft Visio was also customised to deal with ACD XML files – **VISIO-ACD**.

⬈ **ANIM VISIO** - «*upper right zone*» simulates and animates ACDs inside MS VISIO. The **ANIM-Java** tool will animate ACDs in the GRAPHEDITOR (is not yet completed, as signalled in the diagram by white background).

⬋ **SMAIS-GAP** is the major tool of this project «*lower left section*» allowing the translation of an ACD (activity-based) into a program (event-based) (see also Figure 15, Figure 16 and Figure 17). It uses the **ACD Grammar (to BSF)** (see also Figure 10 and Figure 12).

⬊ **SMAIS-GAP** using the **ACD Grammar (to Arena)** «*lower right section*» refers to the translation to **Arena input file**. **ARENA-CREATOR**, using that input file, builds a model with blocks from **ARENA-ACD** template (see also Figure 18, Figure 19 and Figure 21).

5 ACTIVITY CYCLE DIAGRAMS (ACD)

ACDs were widely used mainly with older languages (e.g. ECSL [6], HOCUS) to schematically specify the system's behaviour, through each assumed entity cycle diagram. These entity cycles explicitly refer the active states into **activities** and passive states into **queues**. This graphical language just requires the use of three types of graphical objects: **Rectangles** (activities), **Circles** (queues) and **Arrows** (links).

For an activity to start, it is necessary that entities exist in the preceding queues in the required number and with the adequate attributes. When these conditions hold, it is possible to start the activity. When the activity ends, the entities involved are moved to consequent queues.

The **complete model** consists of the Activity Cycle Diagrams of all the classes of entities, together. Interactions between entities take place at activities. Figure 2 represents the basic activity concept, with one activity in the middle that starts when each precedent queue has one required entity. When the activity ends, the entities are moved to the consequent queues.

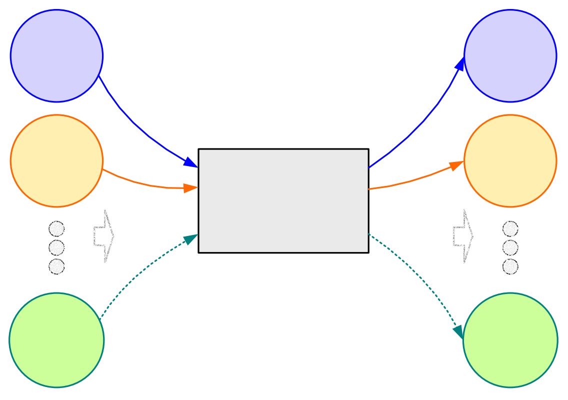


Figure 2: Activity concept

The simplicity inherent to the activity concept and to the ACD facilitates its easy understanding for **validation and teaching purposes**. It has been advocated that the ACD is useful for **research** discrete event simulation studies.

5.1 Example: the Bartender Problem

In this illustrative example we have a barman that serves customers in a bartender [6] [29].

Entities of class **CUSTOMER**, are initially OUTSIDE. They ARRIVE and then WAIT for activity POUR. When served they are READY to DRINK. After that, if they NEED to drink more they go to queue WAIT, otherwise they leave to OUTSIDE. The ACD of CUSTOMER is described below (Figure 3).

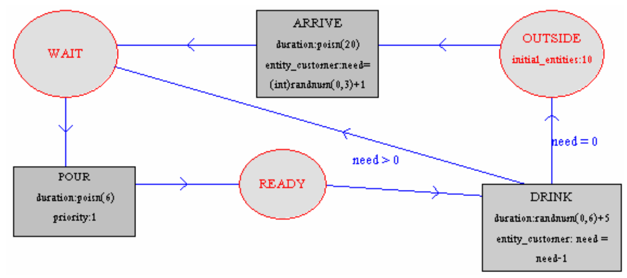


Figure 3: CUSTOMER ACD

Entities of class **BARMAN**, are waiting in the queue IDLE and they can either participate in the activity POUR or WASH:

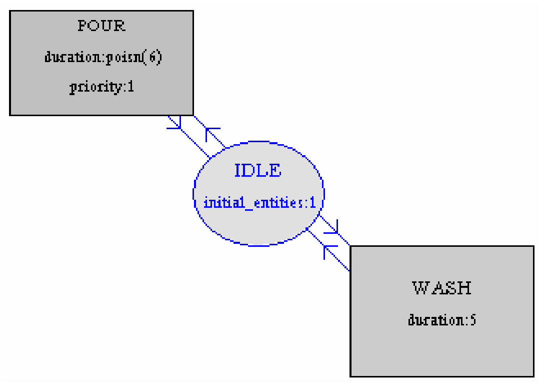


Figure 4: BARMAN ACD

Entities of class **GLASS** are initially in the queue DIRTY. After being WASHed (in batches of size 3), they wait in the queue CLEAN. When there are 1 customer waiting, 1 barman idle and 1 glass clean, then POUR activity begins. Once FULL, the glass goes to activity DRINK. The ACD of GLASS is in Figure 5.

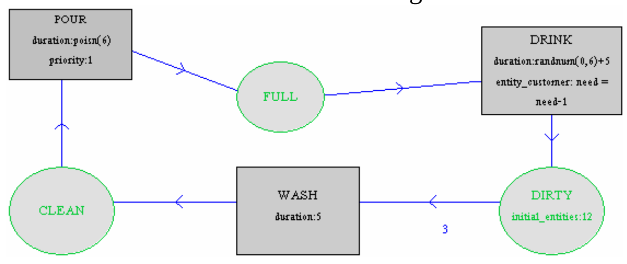


Figure 5: GLASS ACD

This problem instance parameters are:

Activities duration:

- ARRIVE: Poisson distribution, average=20.
- POUR: Poisson, average=6 [poisn(6)].
- WASH: Fixed = 5.
- DRINK: 5 + Uniform distribution between 0 and 6 [5+randnum(0,6)].

Entities initial allocation:

- CUSTOMER: 20 in queue OUTSIDE.
- BARMAN: 1 in queue IDLE.
- GLASS: 12 in queue DIRTY.

Entities class setup:

- CUSTOMER: have one attribute: NEED.

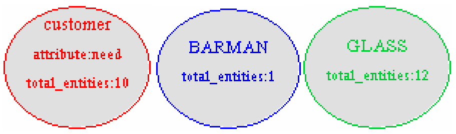


Figure 6: ENTITIES setup

Attributes:

- ARRIVE: Customer attribute NEED is initialized with : (int)randnum(0,3) + 1 → {1,2,3,4}
- DRINK: Customer attribute NEED is decremented. After this activity, customer attribute NEED is evaluated to decide customers destination.

Simulation setup:

- DURATION: 1000 time units.
- WARM_UP: 120 time units.
- SEED: 123543.

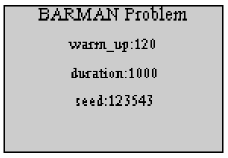


Figure 7: Simulation setup

The following ACD (Figure 8) include all system information:

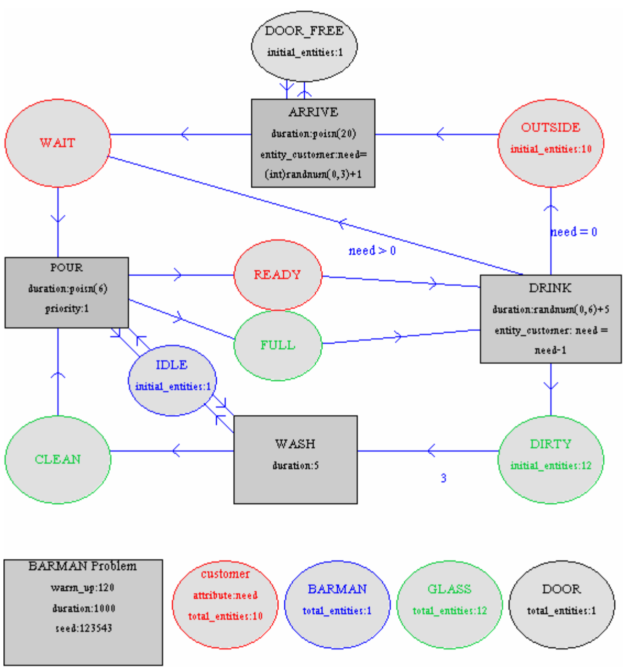
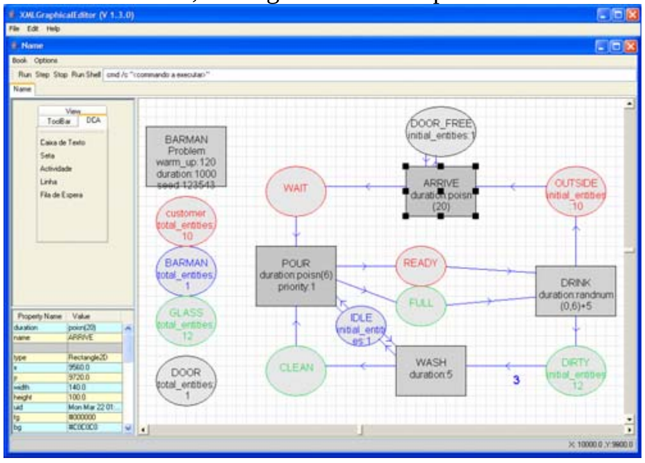


Figure 8: Global ACD

DOOR is an auxiliary entity used to control the Customer's arrives (one at a time). It is well described in [29].

The following image (Figure 9) shows a screenshot of the GRAPHEDITOR, editing the bartender problem.


XMLGraphicalEditor (V 1.3.0)
File Edit Help
Name
Book Options
Run Step Stop Run Shell cmd /c "<commando a executar>"
Name
View
ToolBar DCA
Caixa de Texto
Seta
Actividade
Linha
Fila de Espera
BARMAN Problem warm_up: 120 duration: 1000 seed 123543
DOOR_FREE initial_entities: 1
WAIT
ARRIVE duration:poisn (20)
OUTSIDE initial_entities 10
customer total_entities 10
BARMAN total_entities 1
GLASS total_entities 12
DOOR total_entities 1
POUR duration:poisn(6) priority:1
READY
FULL
DRINK duration:randnum (0,6)+5
IDLE initial_entities:1
CLEAN
WASH duration:5
3
DIRTY initial_entities 12
X: 10000.0 Y:9800.0

Property Name	Value
duration	poisn(20)
name	ARRIVE
type	Rectangle2D
x	9560.0
y	9720.0
width	140.0
height	100.0
uid	Mon Mar 22 01:
fg	#000000
bg	#C0C0C0

Figure 9: GRAPHEDITOR Screenshot

5.2 ACD Language Formalization

Some authors suggest modifications in ACD language, (e.g. [8]), but in our opinion that compromises the ACD simplicity.
A significant contribution of our work consisted on the development of the ACD language formalization embedding in the diagrams all the information required for the simulation.

1- We added attributes to the visual objects:

- 'duration' and ['priority'] in **activities**. ('priority' is a value setting the activity priority over other activities. Higher value means higher priority).

- Entities **attributes** changing in activities. (EX: In the DRINK activity of the example model, the customer 'need' attribute is decremented by one. (activity attribute 'entity_customer' = "need=need-1")).

- ['initial_entities'] in **queues**.

2- In order to include global information on the simulation a rectangle alone (called **simulation setup**) is used with the following attributes :

- 'model_name' – Model_Name_String
- 'duration' - **Simulation time**
- 'warm-up' - initialization time.

3-For global attributes and features of each **entity**, one ellipse alone is created with:

-'entity_name' – name of the entity

-'total_entities' – number of total entities of this kind that will exist in the simulation.

- ['attribute']* - used zero or more times to declare entity attributes. (EX: customers have one attribute: 'need').

- ['sort'] –expression establishing the queue sorting rule. Value is defaulted to 1. If defined, the queue will not be FIFO, this attribute must have an expression, elements are sorted in ascending order based on the evaluated expression over each arriving entity. May be used to create virtually, multi-queues.

4-Arrows

- Arrow ending on activities:

'label' have the number of need entities (entering throw this arrow in the activity) to start the activity (this implements batches). Default value is 1 (if omitted). (EX: 3 is the batch number of 'glasses' to start 'WASH').

- Arrow leaving from activities:

'label' have conditions to decide which destination queue will be chosen (usually based on attributes values). EX: 'need' attribute is used to decide if the 'customer' go OUTSIDE or WAITING after drinking.

6 THE GRAMMAR AND TRANSLATION

To create the AIMS compiler, we wrote a set of rules in Visual MASOViLa notation [9]. Each rule synthesizes one new symbol. We developed rules for *queue (3)*, for *activity (9)*, for *entity (3)*, for *input_link (1)*, for *output_link (1)*, for *simulation (5)*, and also for syntactical and semantic *error* detection (10) – see Figure 11.

We include bellow one expression example, with textual explanation, visual representation and the generated Java code (portion of the compiler code).
The next graph (Figure 10) is the rule that transforms an *arrow* in an *output_link*, when it is connected from an *activity* to a *queue***.** The new *output_link* symbol, receives all attributes from *arrow* symbol. Furthermore it synthesizes the Link's attribute *origin* from the *activity*'s attribute name, the attribute *destination* from the *queue*'s attribute name and also the *condition* attribute from *arrow label*.

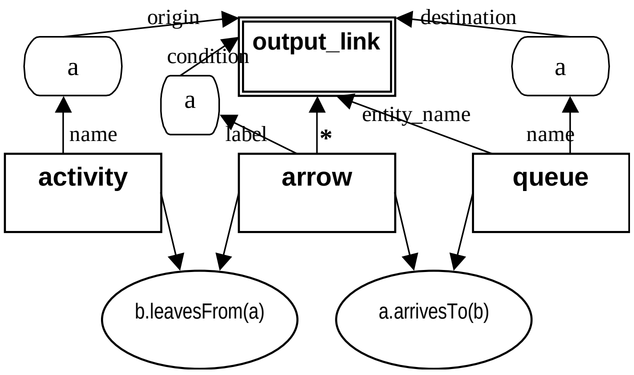


Figure 10: Output_link rule written in Visual MASOViLa

Java corresponding code:
```
  public static Symbol output_link(Vector args){
    Symbol activity = (Symbol) args.get(0);
    Symbol arrow = (Symbol) args.get(1);
    Symbol queue = (Symbol) args.get(2);
    if(((Arrow)(arrow.get("container")))
      .leavesFrom((Container)
      (activity.get("container"))  ) &&
    ((Arow)(arrow.get("container")))
      .arrivesTo((Container)
      (queue.get("container")))       )
    {Symbol res = new Symbol(arrow);
      res.put("origin",activity.get("name"));
      res.put("destination",queue.get("name"));
      res.put("condition",queue.get("label"));
      res.put("entity_name",queue.get("entity_name"));
      return res;
    }else return null;
}//& output_link
```

Figure 11: - Java code for Output_link rule.

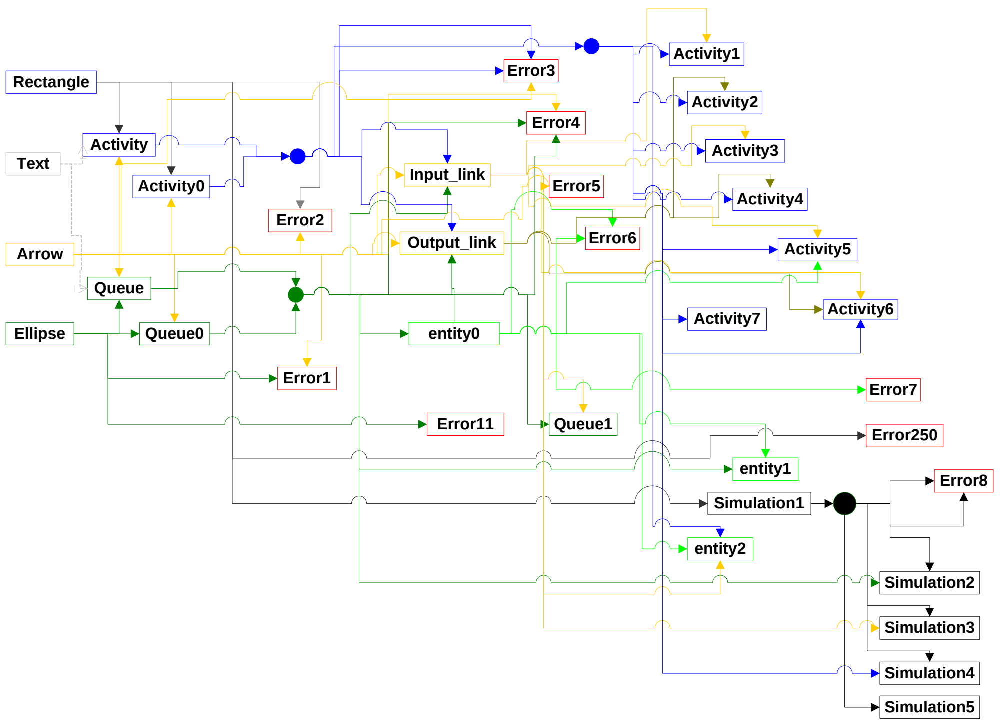


Figure 12: Graph with the grammar rules interfaces, and interdependencies

The Output_link rule is just one example that can be found in the central region of Figure 12:
The translation is archived by an engine (the SMAIS-GAP) that successively searches patterns in the Diagram under analysis to try to apply each grammar rule (in a specific order). Applying a rule, means rewriting or creating one symbol in the Diagram (some rules may also remove symbols from the diagram).

To the Output_link rule, the engine must know that this rule needs: one activity, one arrow and one queue. The engine then picks all combinations of symbols from the diagram under analysis, submitting different sequences with (activity, arrow, queue), to the rule. The rule will then return *null* if the symbols are inappropriate, or return a new symbol to the diagram. Attributes of each new symbol are “richer” than previous (collecting pieces of code). For this grammar, after several rule modifications, the generated program is represented within an attribute of a synthesized symbol (*simulation*).

7 XML FILE INTERCHANGE FORMAT

The objective was to give birth to a proven visual language (an example of a complete program written in this language can be found in Figure 8). This program is not dependent on the translator/compiler used. We defined an XML format (eXtended Markup Language) making possible to store it with all the attributes and to transfer it to any application in a text file (since to keep it in bitmap format (as a photo) would not obviously be appropriated).

In Figure 13 we can find the DTD corresponding to the defined XML format. In Figure 14 we can see a portion of one XML file corresponding to the barman problem. Each file is a book: a collection of sheets. Each sheet contains one ACD diagram. (Obviously, books can have one only sheet).

```
<?xml version='1.0' encoding='UTF-8'?>
<!--
<?xml version="1.0"?>
<!DOCTYPE Book SYSTEM "ACD.dtd">
<BOOK>
...
</Book>
-->
<!ELEMENT Visible (PCDATA)>
<!ELEMENT Value (PCDATA)>
<!ELEMENT Property (Visible|Type|Value)*>
<!ATTLISTProperty
  Name CDATA IMPLIED
 >
<!ELEMENT Foreground (PCDATA)>
<!ELEMENT Background (PCDATA)>
<!ELEMENT Type (PCDATA)>
<!ELEMENT Y (PCDATA)>
<!ELEMENT X (PCDATA)>
<!ELEMENT Shape
  (Property|Foreground|Background|Type|Height|Wi
  dth|Y|X)*>
<!ATTLIST Shape
  Type CDATA IMPLIED
  Uid CDATA IMPLIED
 >
<!ELEMENT Height (PCDATA)>
<!ELEMENT Width (PCDATA)>

<!ELEMENT WorkSheet(Shape|Height|Width)*>
<!ATTLIST WorkSheet
  Order CDATA IMPLIED
  Name CDATA IMPLIED
 >
<!ELEMENT Book (WorkSheet)*>
<!ATTLIST Book
```

Figure 13: DTD file (XML specification)

```
<?xml version="1.0" encoding="ISO-8859-1" ?>
- <!--
 Last Saved on Sat Jan 08 22:28:37 BST 2005
  -->
- <Book Name="Bartender">
- <WorkSheet Name="Global ACD" Order="0">
  <Width>860</Width>
  <Height>580</Height>
- <Shape Uid="001" Type="Rectangle2D">
  <X>9280.0</X>
  <Y>9900.0</Y>
  <Width>140.0</Width>
  <Height>80.0</Height>
  <Type>Rectangle2D</Type>
  <Background>#C0C0C0</Background>
  <Foreground>#000000</Foreground>
- <Property Name="name">
  <Value>POUR</Value>
  <Type>String</Type>
  <Visible>true</Visible>
  </Property>
- <Property Name="priority">
  <Value>1</Value>
  <Type>String</Type>
  <Visible>true</Visible>
  </Property>
- <Property Name="duration">
  <Value>poisn(6)</Value>
  <Type>String</Type>
  <Visible>true</Visible>
  </Property>
  </Shape>

   ...
  </WorkSheet>
  </Book>
```

Figure 14: Part of an XML file (representing one ACD object.

8 JAVA-BSF – AUTOMATIC PROGRAM GENERATION

Running SMAIS-GAP, using the "ACD GRAMMAR (to BSF)" and giving the XML file as input program, we get the generated "bsfProgram.java", see Figure 15.

```
------------------- ( 1 - Generation ) ----------------------------
Starting S+ (ACD->BSF generation):
      C:\Documents and Settings\LSD\SMAIS_ROOT\ACD.xml ->
C:\Documents and Settings\LSD\SMAIS_ROOT\bsfPack\bsfProgram.java

C:\Documents and Settings\LSD\SMAIS_ROOT\ACD.xml -> Read 36 Graphical
Symbols. In [341ms]
.........................................................................................................
.................................
C:\Documents and Settings\LSD\SMAIS_ROOT\bsfPack\bsfProgram.java <-
Generated Program with 335 lines. [9654ms]

----------------------- ( 2 - Compilation ) ----------------------
C:\jdk1.5.0\bin\javac "bsfPack\BsfProgram.java"
```

Figure 15: Screenshot of Script running, calling SMAISGAP (Generation) and compiling it

The generated program is a low-level simulation program written in a general purpose programming language including an event-driven executive that uses a java simulation library – BSF (Basic Simulation Facility).
In this Example, SMAIS-GAP read the 36 graphical objects from the file 'ACD.xml' and generated a fully commented program with 335 lines in about 10 seconds.
An extract of the automatically generated program from the Bartender ACD, (including all comments) can be found below in Figure 16.

```
//|||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||| #####   #
//||PROGRAM AUTOMATICALLY GENERATED BY AIMS(JavaBSF version 1.9) #       #
//||         Authors: lsd & agr @dps.uminho.pt                   #####  #####
//||       URL: www.dps.uminho.pt/oio/simulation                    #    #
//|||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||| #####   #

// Program 'BARMAN Problem' Generated by S+ : Universidade do Minho,

//Queues Declaration and constants definition:
  static int  FEvent = 1;  //File to hold futur events
  static int  CLEAN = 2;  //queue to entity:GLASS
  static int  FULL = 3;  //queue to entity:GLASS
  static int  DIRTY = 4;  //queue to entity:GLASS
  static int  DOOR_FREE = 5;  //queue to entity:DOOR
  static int  READY = 6;  //queue to entity:customer
  static int  WAIT = 7;  //queue to entity:customer
  static int  OUTSIDE = 8;  //queue to entity:customer
  static int  IDLE = 9;  //queue to entity:BARMAN
  static int  ARRIVE_DOOR = 10;  //entity: DOOR in activity: ARRIVE
  static int  ARRIVE_customer = 11;  //entity: customer in activity: ARRIVE
  static int  POUR_customer = 12;  //entity: customer in activity: POUR
  static int  DRINK_customer = 13;  //entity: customer in activity: DRINK
  static int  POUR_GLASS = 14;  //entity: GLASS in activity: POUR
  static int  POUR_BARMAN = 15;  //entity: BARMAN in activity: POUR
  static int  DRINK_GLASS = 16;  //entity: GLASS in activity: DRINK
  static int  WASH_BARMAN = 17;  //entity: BARMAN in activity: WASH
  static int  WASH_GLASS = 18;  //entity: GLASS in activity: WASH

//Events List Declaration and constants definition
  static int  Code_End_simulation = 1; //Code to the last event: "end of
simulation"
  static int  Code_End_ARRIVE = 2;   //Code to the event: "end of ARRIVE"
  static int  Code_End_WASH = 3;   //Code to the event: "end of WASH"
  static int  Code_End_DRINK = 4;   //Code to the event: "end of DRINK"
  static int  Code_End_POUR = 5;   //Code to the event: "end of POUR"

  static int total_number_of_events=5;

  static int  code_warm_up=0;
  static int  code_report=99;
        o o o
//============= Program Main Loop =============

 while (event_code != Code_End_simulation){
  r=Bsf.remove(FEvent,Clock);
    event_code=r.at2;
    Clock=r.time;
  if (event_code==Code_End_ARRIVE) end_of_ARRIVE();
  if (event_code==Code_End_WASH) end_of_WASH();
  if (event_code==Code_End_DRINK) end_of_DRINK();
  if (event_code==Code_End_POUR) end_of_POUR();
  if (event_code==code_warm_up) Bsf.reset_statistic(Clock);
 } //& MainLoop
System.out.println(Bsf.report(Clock));
} //& main

//@@@@@@@@@@    Activities BEGIN   @@@@@@@@@@@
public void begin_of_WASH(){
 while(true){
  if( Bsf.number_in_queue(IDLE)<1) return;  //BARMAN available?
  if( Bsf.number_in_queue(DIRTY)<3) return;  //GLASS available?
  Bsf.set_distribution(WASH);
  int duration= (int)5;
 //Schedulle end of WASH activity:
  Bsf.insert(FEvent, Clock, Clock+duration, Code_End_WASH);
  r=Bsf.remove(IDLE,Clock);    //remove one BARMAN from queue IDLE
(returns r.time,r.at1,r.at2)
  Bsf.insert(WASH_BARMAN,Clock,Clock+duration,r.at2);       //puts one
BARMAN in the activity WASH
 for(int i=3;i>0;i--){ // 3 GLASS(s) necessary for this activity:WASH
  r=Bsf.remove(DIRTY,Clock);    //remove one GLASS from queue DIRTY
(returns r.time,r.at1,r.at2)
  Bsf.insert(WASH_GLASS,Clock,Clock+duration,r.at2);  //puts one GLASS in
the activity WASH
 }
```

```
  }
} //& begin_of_WASH

        o o o

//@@@@@@@@@@     Activities END     @@@@@@@@@@@@
public void end_of_WASH(){
   r=Bsf.remove(WASH_BARMAN,Clock); //(returns r.time,r.at1,r.at2)
   Bsf.insert(IDLE,Clock,Clock,r.at2);
  for ( int i=3; i>0; i--){
   r=Bsf.remove(WASH_GLASS,Clock); //(returns r.time,r.at1,r.at2)
   Bsf.insert(CLEAN,Clock,Clock,r.at2);
  }
   //Attempts to start subsequent activities that may be viabilized
   begin_of_POUR();  //priority=1
   begin_of_WASH();
} //& end_of_WASH

        o o o

//End of Program 'BARMAN Problem'
```

Figure 16: Extract of Java generated simulation program

Figure 17, below, contains a screenshot of the bartender program execution, with configurable initial entities allocation, progressive running bar and final report.

```
----------------------------- ( 3 - Execution ) ------------------
INIT:    12GLASS>DIRTY    1DOOR>DOOR_FREE    10customer>OUTSIDE
1BARMAN>IDLE
...10%...20%...30%...40%...50%...60%...70%...80%...90%..100%  [in 40ms]

Relatorio em t = 1000 (Warm-up period 0-120)
Fila                          In     Out    Now     Av-stay    Av-len
 1 FEvent                    267     264      3       9.189     2.614
 2 CLEAN                     101      94      7      75.511     7.669
 3 FULL                       94      94      0       0.000     0.000
 4 DIRTY                      96      93      3      22.129     2.365
 5 DOOR_FREE                  45      45      0       0.000     0.000
 6 READY                      94      94      0       0.000     0.000
 7 WAIT                       94      94      0       2.138     0.228
 8 OUTSIDE                    52      45      7     147.667     7.334
 9 IDLE                      125     125      0       1.328     0.189
10 ARRIVE_DOOR                46      45      1      19.844     1.000
11 ARRIVE_customer            46      45      1      19.844     1.000
12 POUR_customer              95      94      1       5.947     0.635
13 DRINK_customer             94      93      1       7.516     0.802
14 POUR_GLASS                 95      94      1       5.947     0.635
15 POUR_BARMAN                95      94      1       5.947     0.635
16 DRINK_GLASS                94      93      1       7.516     0.802
17 WASH_BARMAN                31      31      0       5.000     0.176
18 WASH_GLASS                 93      93      0       5.000     0.528
```

Figure 17: Screenshot of program execution and final statistical report

This task (automatic translation) is quite complex since it implies different abstraction levels, from an high level (activity based approach) to a much lower level (event-driven approach) using a generic programming language.

9 ARENA MODEL CREATOR

The hard part of this task was to create an activity-based executive over a process-oriented environment. The executive developed shows to be more efficient than a three-phase approach since we used a message passing mechanism that only tries to start an activity when entities have arrived to one of its predecessor queues.
Given that we generate a model into a high-level simulation environment it becomes possible to overcome limitation of the activity-based approach since the model may be completed in ARENA.

Figure 18 and Figure 19 illustrate the model as automatically created in Arena for the Bartender Problem and a Screenshot of animation phase. Figure 20 have details of two activities with predefined statistics. Figure 21 have a screenshot with part of the logic template (code) of the activity block.

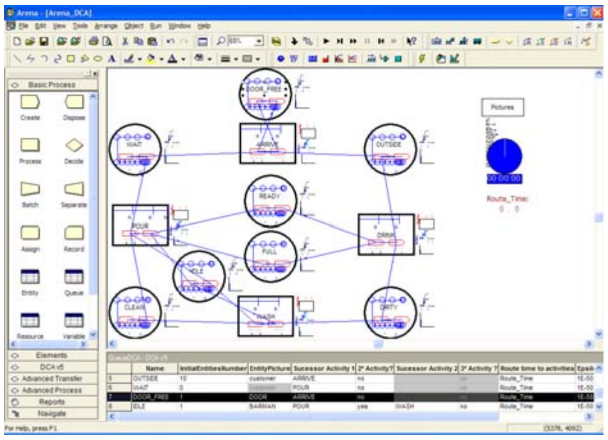


Figure 18: Screenshot of automatically builded model in Arena (Bartender

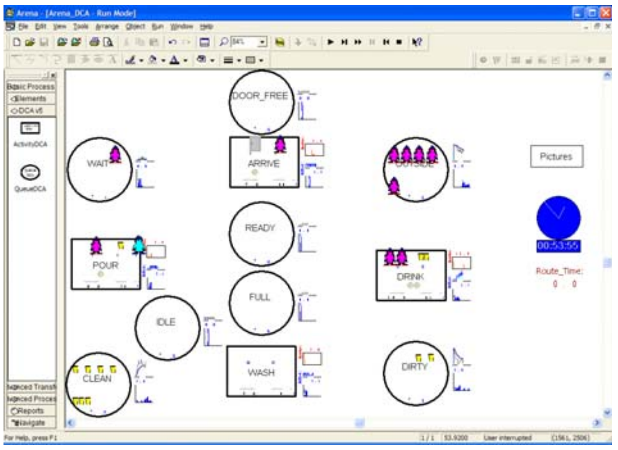


Figure 19: Screenshot of animations in Arena (Bartender)

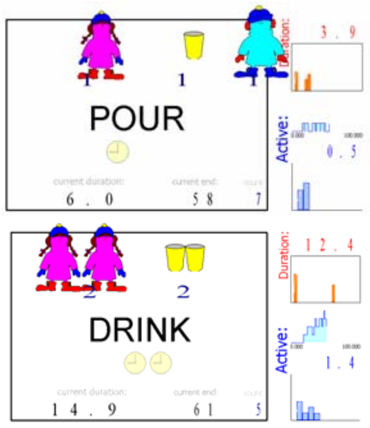
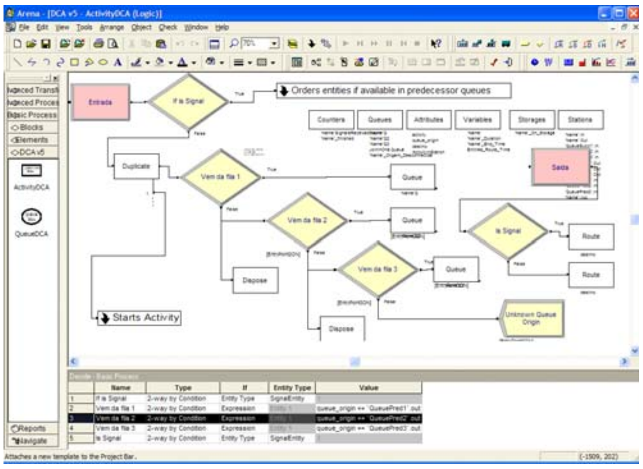


Figure 20: Screenshot of Arena animation details, with statistics (Bartender)



	Name	Type	If	Entity Type	Value
1	If is Signal	2-way by Condition	Entity Type	SignalEntity	
2	Vem da fila 1	2-way by Condition	Expression	Entity 1	queue_origin == `QueuePred1`.out
3	Vem da fila 2	2-way by Condition	Expression	Entity 1	queue_origin == `QueuePred2`.out
4	Vem da fila 3	2-way by Condition	Expression	Entity 1	queue_origin == `QueuePred3`.out
5	Is Signal	2-way by Condition	Entity Type	SignalEntity	

Attaches a new template to the Project Bar. (-1509, 202)

Figure 21: Activity definition - Part of Arena Logic Template.

CONCLUSION

The work presented in this paper could constitute a major step towards the generalisation of the use of simulation. In fact, we suggest the use of a simple interface (Activities Cycle Diagrams) to model a real situation. Then we present a tool capable of generating a simulation program. Based on event scheduling simulation modelling philosophy, our tool automatically generates a program to use Basic Simulation Facility routines. Based on process flow simulation modelling philosophy, our tool automatically generates an ARENA program. Furthermore the mentioned automatic generation of simulation programs does not require expertise in simulation.

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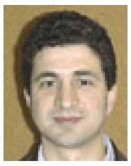

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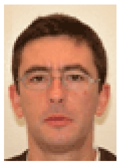

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