

# An Eclipse plug-in for Public Administration software system modelling and simulation<sup>\*</sup>

Riccardo Cognini, Damiano Falcioni, Andrea Polini,  
Alberto Polzonetti, and Barbara Re

University of Camerino, School of Science and Technology  
Computer Science Section, Camerino, Italy  
`name.surname@unicam.it`  
WWW home page: <http://www.unicam.it>

**Abstract.** According to national and international studies most of information systems development projects perform poorly and often lead to seam failures. These issues seem to be even more prevalent within public sector where among the others political, organizational and technology issues have to find the best combination. Software development in public sector is a quite complex task. Building up a community where all the Public Administration stakeholders share languages and techniques is crucial to support the information systems development and their impact on the society.

In this paper we present a modeling and simulation framework supporting the communication between the domain experts and the IT staff usually challenge due to different backgrounds, perspectives and terminology. We face the modeling challenge considering standard languages such as UML 2.0 and BPMN 2.0. The approach is supported by a plug-in for Eclipse platform permitting to have an integrated environment in which to design and to simulate the information system.

## 1 Introduction

In order to strengthen the penetration of Information and Communication Technologies (ICT) potentialities, Public Administrations (PA) are working toward a structured design of their software systems and services. Models for organizational design require a high degree of knowledge that can be expected only from domain experts. At the same time models for application system design require a high degree of technical precision. Therefore to implement successful software system it is necessary to close the gap between domain and IT experts.

A systematic design and analysis approach is needed to support innovation in PA and to enable e-government development via a plan-do-check-act paradigm. To do that we introduce a multi-perspective representation based on consolidate Enterprise Architecture approaches [1]. We also enable comparability between

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different models and we identify points of interaction among the different model views. This is in line with general principles of modeling in the e-government domain [2]. Starting from a Domain Specific Language (DSL) we define in the past, named eGAML [3]; we propose a practical approach that starting from the Business Process definition supports domain and IT experts to model and then simulate specific views in the PA information systems.

eGAML is based on UML 2.0 and BPMN 2.0 standards and it is encapsulated in an eclipse plug-in that we developed. Several challenges were faced during the definition and development of eGAML. The paper illustrates technical solutions we adopted and eGAML general usage. We provide an overview of tools available to generate both a graphical editor from the DSL meta-models (such as GMF, Graphiti, EuGENia and GEMS), and specific editor for BPMN 2.0 (such as Activiti and jBPM). As a result Eclipse becomes a powerful development environment for PA related software systems.

The paper is structured as follows. Section 2 introduces a brief state of the art review and Section 3 provides an introduction to background technologies. Section 4 describes the work performed in implementing the eGAML meta-model and the simulation algorithm. Finally, Section 5 draws some conclusions.

## 2 State of the art

Several Domain Specific Languages have been developed; most of them are based over the Zachman framework [4]. In the area of e-government we cite the PICTURE-method. It consists of a modeling language and related approach, which guides the application of the language giving a complete overview on organizations practices focusing on Business Process (BP) [5].

For what concern the BP simulation and related tools several attempts have been introduced [6] [7]. Just to cite a few we refer to Protos [8] and ARIS [9] as important and relevant experiences. In the area of commercial software we cite Goldsim Pro [10], eClarus Business Process Modeler [11] or ProModel Process [12]. All of them are mature Business Process Management (BPM) systems with a more or less structured simulation engine.

In the most of modelling and simulation approaches (i) relationships between BP and the other views in the organizations and (ii) domain dependent requirements are missed. We try to introduce them and we provide a plan-do-check-act approach in the design of e-government informative systems.

## 3 Background

### 3.1 EMF supporting tools

In order to design and develop the graphical editor based on the EMF meta-model we compare Graphical Modeling Framework (GMF) [13], Graphiti [14], EuGENia [15] and Generic Eclipse Modeling System (GEMS) [16]. Table 1 sum up the results of our first investigation.

GMF introduces a model-driven approach to generate Eclipse graphical editors from EMF Ecore files. It is a bridge between EMF and Graphical Editing Framework (GEF). We withdraw it after several tests. According to our technical evaluation we realize that developing a good BPMN 2.0 visual editor using this kind of technology is too complex

Graphiti is an Eclipse-based graphics framework to enable easy development of state-of-the-art diagram editors for domain models. The main difference between GMF and Graphiti is that GMF creates a visual editor from EMF file, instead with Graphiti it is possible to create directly the meta model and than the visual editor starting from it. Unfortunately, Graphiti does not support EMF import that in our case is a strict requirement.

EuGENia is a tool that automatically generates the models needed to implement a GMF editor from a single annotated Ecore meta-model. Even if it introduces an interesting approach it does not reduce developing time respect to the GMF-based coding, so according to our analysis we realize to skip it.

GEMS tries to bridge the gap between the communities experienced with visual meta-modeling tools, such as the Generic Modeling Environment, and those built around the Eclipse modeling technologies, such as the EMF and the GMF. The framework provides a knowledge base suitable to assert EMF modeling elements into. Once modeling elements are asserted into the knowledge base, constraints to relationships between model elements can be add via a easily edit interface. GEMS is stable and well tested environment.

	<b>GMF</b>	<b>Graphiti</b>	<b>EuGENia</b>	<b>GEMS</b>
<b>EMF Compatibility</b>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
<b>Create Visual Editor</b>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
<b>Create Automatically Visual Editor</b>	<i>No</i>	<i>No</i>	<i>Yes</i>	<i>Yes</i>
<b>Provide Graphical tool for drawing meta-model (EMF)</b>	<i>No</i>	<i>Yes</i>	<i>No</i>	<i>Yes</i>
<b>Create Automatically RCP-Applications</b>	<i>No</i>	<i>Yes</i>	<i>No</i>	<i>No</i>
<b>Based on GMF</b>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
<b>Stable Version</b>	<i>Yes</i>	<i>No</i>	<i>Yes</i>	<i>Yes</i>
<b>Documentation</b>	<i>+-</i>	<i>+-</i>	<i>+-</i>	<i>++</i>
<b>Editor Usability</b>	<i>+-</i>	<i>--</i>	<i>++</i>	<i>++</i>
<b>Effort</b>	<i>+-</i>	<i>--</i>	<i>+-</i>	<i>++</i>

**Table 1.** EMF supporting tools: overview

According to our first investigation GEMS results the best option to create visual editors bases on customized meta-model. Unfortunately, none of the investigated tools support our choice to rely on standard BPMN 2.0 EMF meta-model. We believe that the main reason for that can be the BPMN 2.0 EMF meta-model incompleteness. In order to solve this issue we decided to relay over a third part BPMN 2.0 Editor based on EMF as following discussed.

### 3.2 BPMN 2.0 and related modeling tools

Business Process Model and Notation (BPMN) is a graphical representation for specifying BP in a BP model. The current version is BPMN 2.0 [17]. It introduces various constructs and two completely new diagram types such as choreography diagram - modeling of the data exchange between different partners, and conversation diagram - giving an overview of several partners and their communication links. Although these novelties are very prominent the majority of the alterations from the past version is the graphic model representation in the form of a meta-model.

We tested several BPMN 2.0 modelers based on Eclipse (Table 2) but in this work we focus only on those based on the BPMN 2.0 EMF meta-model [18]. We refer to Activiti [19] and jBoss [20] communities. Activiti Eclipse Plug-in provides functionalities to design BPMN 2.0 processes and run these processes on the Activiti Engine. For the implementation of visual editor it uses Graphiti, and the BPMN 2.0 specification is based on the Eclipse BPMN 2.0 meta-model. Unfortunately, Activity is not yet complete and it does not provide all BPMN 2.0 elements. Activiti also provides a web-based BPMN2 editor provided by SIGNAVIO that cover all BPMN2 elements, but it is not Eclipse based and we faced several integration problems. Also JBoss Community created a BPMN 2.0 Eclipse plug-in named jBPM. As well as Activiti it does not provide all of BPMN 2.0 elements. After some investigations, we have find imeikas jBoss to be our best choice for modeling BPMN 2.0 processes. According to our investigation it is the most complete and effective BPMN 2.0 modeling tool.

	<b>Activiti</b>	<b>Activiti “Web”</b>	<b>jBoss</b>	<b>jBoss imeikas</b>
<b>Provides all BPMN2 elements</b>	<i>No</i>	<i>Yes</i>	<i>No</i>	<i>Yes</i>
<b>Stable Version</b>	<i>No</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
<b>Integration capabilities</b>	+-	--	++	++
<b>Editor Usability</b>	++	++	+-	++
<b>Effort</b>	++	+-	++	++

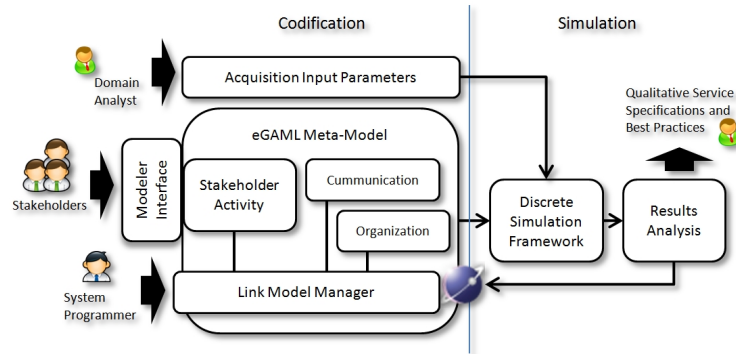
**Table 2.** BPMN 2.0 and related modeling tools: overview

## 4 Modeling and Simulation

### 4.1 Architecture Overview

The framework we have defined for BP modelling and simulation is made available through the development of an Eclipse plug-ins. It permits to have a fully integrated and user-friendly environment, which support domain experts both in the BP specification phase (Fig. 1). In particular, the supported meta-models are created using EMF, while the graphical modeler is supported by GEMS. Using the resulting plug-in, BP developers can define their models according to the rules of the eGaml meta-model [3] as following reported.

- For each Role in the Organization Model, there is a BPMN 2.0 Model and a Communication Model that describe its process and communications respectively.
- Each BPMN 2.0 Model is associated to a Communication Model.
- For each Send (Receive) Task in BPMN 2.0 Model there is a Send (Receive) Task in the Communication Model associated.



**Fig. 1.** Architecture overview

Rules are stored in a parameterized XML file. The approach can be generalized to add a new meta-model and link it with the others defined by eGaml. Simulation is also supported by the plug-in according to the algorithm we have defined. Before launching the simulation BP developers can set different parameters such as the number of stakeholders for each role, the average time needed to complete a task, how much time each stakeholders works, etc. Many statistical functions have been implemented to assess the result of the simulation. It is also possible to know how many times a stakeholder completes his process, or how many times a stakeholder complete a specific task. Results of simulation are shown using histograms created with jFreeChart.

## 4.2 BPMN2, Organization and Communication Meta-model

For what concern meta-model definition we base our work on BPMN 2.0 meta-model as already discussed and we introduce Organization and Communication meta-models.

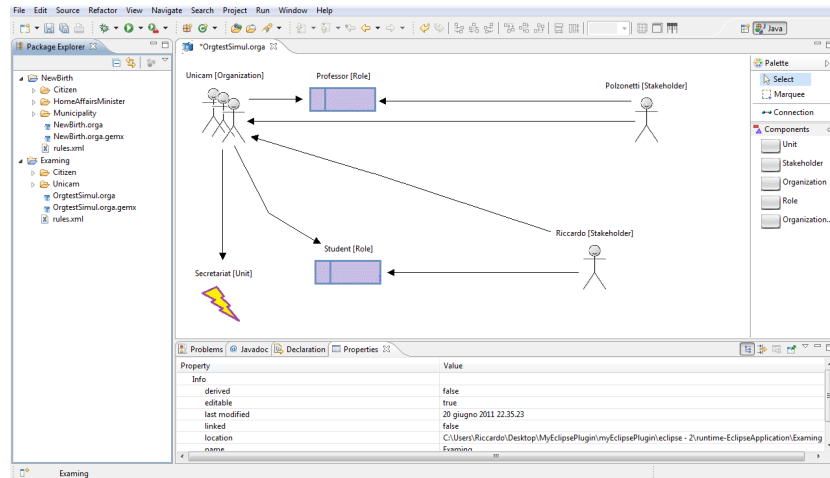
Organization meta-model permits to describe the structure of an organization. This can refer to a PA, group of citizen, schools, etc. The meta-model is composed by four different elements:

- *Organization* represents the organization (i.e. University of Camerino, Home Affairs Minister or Citizen);

- *Unit* represents the different units of the organization (i.e. personnel department or Warehouse);
- *Role* represents the role of Organizations (i.e. secretary and director);
- *Stakeholder* represents actors of the system as a person or an entity that can do something (i.e. Mario the director of the unit X).

These elements are related to each others through the following relationships:

- Each Organization is composed by Units;
- For each Organization, there is at least one Role, and each Role can be linked to at least a single Organization;
- For each Organization, there is at least a Stakeholder, but each Stakeholder can work in many Organizations;
- Each Stakeholder play at least a Role and each Role has to be played by at least one Stakeholder.



**Fig. 2.** Example of Organization Model

Figure 2 shows an example of Organization Model. In this case, there is only one Organization called *Unicam*. It has only one Unit, the *Secretariat*, and it includes two Roles, the *Student* and the *Professor*. Actors of the system are also two. There is *Riccardo* that is a *Student*, and *Polzonetti* that is a *Professor*.

Communication meta-models describes how actors interact with each other. For each Role/Lane it exists a Communication Diagram. Therefore, each actor has its Communication Model. This meta-model is composed by five different elements:

- *Receive Task* means that the actor receives a message from other actors;
- *Send Task* means that the actor send a message to other actors;

- *Pool* is referring to an organization in the Organization meta-model;
- *External Receive Task* is a Receive Task of an external actor; it means that this task is not executed by this actor;
- *External Send Task* is a Send Task of an external actor; it means that this actor does not execute this task.

These elements are related to each others through the following relationships:

- Each Pool can be link to zero or more External Send or External Receive tasks;
- Each External Send or External Receive task can be in only one Pool;
- Each Send Task can be linked to a single External Receive Task and each External Receive Task can be linked to a single Send Task;
- Each External Send Task can be linked to a single Receive Task and each Receive Task can be linked to a single External Send Task.

### 4.3 Business rules as meta-models links

Once all the different meta-models have been defined, we introduce a set of rules to link them. The main rules are as following.

- For each Role and for each Receive Task in a Process Model there is only one Receive Task in a Communication Model with the same *Name*.
- For each Role and for each Receive Task in a Communication Model there is only one Receive Task in a Process Model with the same *Name*.
- For each Role and for each Send Task in a Process Model there is only one Send Task in a Communication Model with the same *Name*.
- For each Role and for each Send Task in a Communication Model there is only one Send Task in a Process Model with the same *Name*.
- For each Organization in the Organization Model there is at most one Pool in each Communication Model with the same *Name*.
- For each Pool in each Communication Model there is an Organization in the Organization Model with the same *Name*.

The main element of XML rules file is *Rules* element. Inside *Rules* element there is at least a *Rule* element. A *Rule* element is composed by two simple elements.

- *Element* element: represents the related object and it has two attributes:
  - *Name*: contains name of the related object;
  - *File*: refers to the meta-model where the object can be found (it can be communication, organization or bpmn2).
- *Link* element: represents the object that is linked from Element. It has three attributes:
  - *Name*: contains the name of the linked object;
  - *File*: refers to the meta-model where the object can be found (it can be communication, organization or bpmn2).

- *Cardinality*: is the cardinality of the relation (i.e. if cardinality is 3, for each selected object in Element element exactly three linked elements must exist, or if cardinality is 1..\* at least a linked element must exist).

According to the rules, we can deduce the hierarchy of the models. The first model we need to create is the Organization Model. To do that we implement functionality that creates automatically the structure of the file system, from an Organization Model. It creates a folder for each Organization in an Organization Model and it creates a sub-folder for each role in an Organization with a BPMN2 Model and a Communication Model. There are many advantages in providing such folder structure. First, we can easily manage authorizations both in edit and view mode. For example, imagine that a Manager wants to modify a process of his stakeholders; in this case, we can easily implement the logic of permits that avoid the manager to modify something out of his Organization.

#### 4.4 Simulation

To define our simulator we have followed the approach proposed in [6] and tried to cover all the main aspects described in [21] and in [7]. As matter of fact we use sub-runs and statistics functions and we did not introduce animation in order to maintain the framework light.

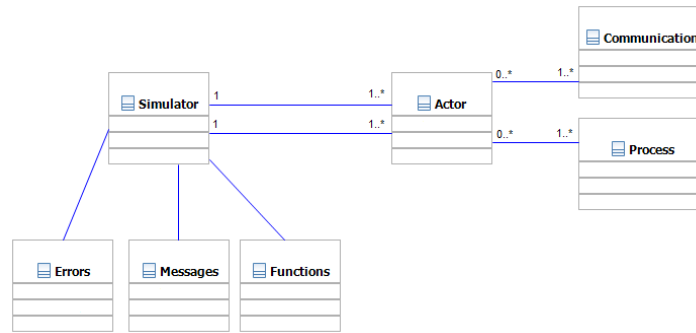
The approach is based on waterfall steps where the first is the definition of the problem. Input parameters are following proposed.

- *Organization, Process* and *Communication* models are defined according to the meta-models in eGaml;
- The *number of actors there is* in the simulation context as well as the *Role* they play;
- Information related *Actors*, like how long an actor work or how much time an actor spends for doing a specific Task, etc;
- *Path priorities* as the order of priorities for the routes in case of Gateway elements.

The outputs parameters we obtain are:

- Number of times that each actor completes his process;
- Time of execution for each actor;
- Number of times that each actor complete a Task;
- Statistical indexes (i.e. average waiting time, trend, variance, standard deviation, etc) for each Receive Task.

Figure 3 shows the conceptual model of our simulator. The core of the simulator is the class Simulator; it contains two sets of actors (class Actor). The first set contains actors with the given inputs parameters (given by user), and the second set contains actors defined during the simulation process. Every actor has at least a communication model and a process model (classes Communication and Process). There are three classes for doing various controls. They are



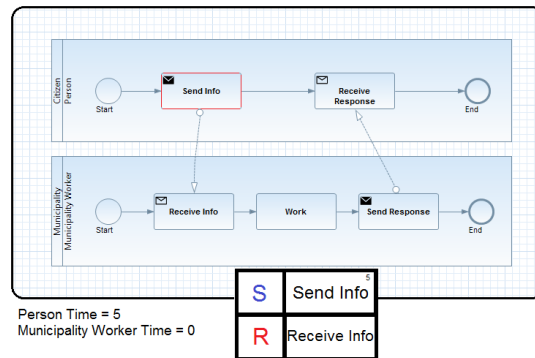
**Fig. 3.** Simulator model class diagram

Errors, Messages and Functions. Errors contains a set of error messages that are stamped when an error occurs. Messages contains a set of messages that are printed when something happen. Functions contains a set of generic functions (i.e. XML reader). Class description is following reported.

- *Simulator*:
  - *Messages Information*, tracks who send a message, who receive it and the time of send;
- *Actor*:
  - *Time Information*, that is the start time, the end time and the execution time of the actor;
  - *Task Information*, represents the information of Tasks (i.e. the time of execution of a task);
  - *Getaway Priority*, represents the priorities of Getaway elements;
- *Process*:
  - *Process Information*, is a simple XML file that describes the process;
- *Communication*:
  - *Communication Information*, is a simple XML file that describes the communication.

Based on this conceptual model we have realized the executable tool. There are a lot of tools created for executing simulation models, but we preferred to develop it from scratch, creating an algorithm from conceptual model, since available tools are too dispersed, they are designed for simulating general processes, and for example in our specific domain they lost some inputs parameters. Besides, they usually transform the system in a Petri-Net, and after that they do the simulation based on it.

In our case we define a simulation algorithm based on the concept of *actor time* and in a loop cycle that executes a single task for each actor in any time. For example image that we have the Process model in Figure 4. There are two different roles, Person and Municipality Worker. Suppose there is a single actor for each role that works from time 0 to time 100 (where time is a user defined time



**Fig. 4.** Simulation Example

unit), and each Task/Send Task has an execution time equal to 5 (all Receive Task has a variable time). The algorithm starts executing the first task of the first actor. In this case it starts from *Person's Send Info*. The execution's time of *Person* is now 5, he is waiting in *Send Info* and in the set of messages there is a message from *Send Info* to *Receive Info*. It is because when a Send Task is executed the algorithm adds a message in the set of messages, contrariwise when a Receive Task is executed a respective message is erased, if it exists. At this point the algorithm executes a Task of the other actor, *Municipality Worker*. The time of *Municipality Worker* is now set to 5 because the message that he attends is arrived at 5. Now it's up to *Person*. After that *Municipality Worker* does *Work Task*. And it sets his time to 10. Now it is *Person's* time. But he is still waiting for a message. So the situation does not change. The only action that we can do is *Send Response* of *Municipality Worker*. When the algorithm does *Send Response*, it adds a new message to the set of the messages and updates the time of *Municipality Worker* to 15. Finally *Receive Response* is unlocked at time 15 and *Person* can finish his process.

The Simulation results have to be interpreted by an analyst expert through graphs like histograms or through row textual data. They help us understand where the system can be improved.

- If the medium waiting time of a Receive Task is higher than the minimum waiting time, probably there is a block in the process with the respective Send Task.
- If the distribute indexes are high (i.e. Variance or Standard deviation), or if the difference between the maximum and the minimum waiting time is high, probably there is a block in the process with the respective Send Task.
- If a stakeholder ends his simulation before (i.e. final stakeholder's time is 10 and max stakeholder's time is 100), probably there is a slowdown in a linked processes.

- If the medium waiting time of Receive Task is similar to minimum and maximum waiting time, it means that probably there is not a slowdown in a linked processes.
- If each actor ends his process for the same times, probably there is not a slowdown in the system.

## 5 Conclusion

The paper presents a modeling and simulation framework. We face the modeling challenge considering standard languages such as UML 2.0 and BPMN 2.0. The approach is supported by a plug-in for Eclipse platform permitting to have an integrated environment in which to design and to simulate the information system. The plug-in makes easier and more effective the development of software system in order to provide better services to citizens.

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