A Learning Architecture for Complex Organization

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Abstract: Modern organizations are challenged to understand and put in action latest procedures and rules in order to constantly improve their service quality while coping with quickly changing contexts and decreasing resources. Such are defined by means of several kind of models that are in general quite interrelated. In this paper, we propose a Learning Architecture using Zachman Framework that allows us to define relations among these models and permits us to handle with huge amount of informations and resources in an organized way. Furthermore, the architecture enables process-driven learning and improvement through enriched models with contextual knowledge in terms of documentation and resources.

1 INTRODUCTION

In the public service domain it is increasingly demanded greater effort in terms of quality and efficiency in the services provided by civil servants to citizens. To ensure this efficiency and this quality is necessary that employees with expertise in a given task (process) can to share their experience. To facilitate both the knowledge elicitation and the learning process, a wide variety of models, tools and techniques have to be provided and integrated. All these artifacts at the same time may confuse organisations, because it is not very obvious which one to choose or which purpose is served. Moreover, all the process and its sub-processes have to be developed and managed independently from other domains processes. Integrated models are needed, which put the various approaches into perspective. Such integration is meant to improve the speed of working, improve quality of documentation, products and processes, reduce costs, enhance responsiveness to customer needs and handle the overall system inherent complexity.

In this paper we propose an architecture conceived to provide a learning experience in which learner acquires knowledge while serving real requests, supporting "learn while doing" approach. For being effective, the architecture must provide the requirements for a modelling notation which describe the learners level, the acquired competencies and knowledge to perform a procedure described by means of a business process. With this approach the learner can access and study these enriched models and operate within a simulated environment reproducing real requests through the promulgation of a process and monitoring activities in order to provide feedbacks for the evaluation of learners, business processes, and associated learning contents. To fulfill the need of share knowledge, manage and improve the processes in enterprise, the Learning Architecture *LA* provide a machine-processable model that exploit the correlation among the activities and/or concerns in order to provide enriched informations to the organization. The Zachman Framework (Zachman, 2012) is used to describe all the interrelations, that provides a logic structure for classifying and organizing the knowledge about business activity of an organization in different dimensions, and each dimension can be perceived in different perspectives with respect to the Enterprise Architecture.

Structure of the Paper. The paper is organized as follows. Next section illustrates a motivating example related to a Public Administration. In Section 3 we present an analysis of the required informations in order to design a LA; in Section 4, we outline how are integrate all the artifacts involved in learning in complex organizations using the Zachman Framework. Related work is discussed in Section 5 and finally, in Section 6 we draw some conclusions and future work.

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2 MOTIVATING EXAMPLE

In this section, we present an example where an organization submits a project to the European Union (EU). To do that, the organization have to be aware of the environment complexity in which it is working because the ability to deal with this complexity is critical for the success of the project proposal. They must be able to handle in different ways a process as well as use different tools, models, reporting documentation etc. Moreover, to successfully participate in a project proposal and to support administrative reporting activities, for a complex organization, like the Public Administration, is required to involve a unit of administrative personal. For this reason, and also due to the typical public employees high mobility, the availability of an electronic learning platform is therefore highly desired.

In order to better understand how complex is managing public administrative procedures, a real world scenario is presented. Such scenario reference the administrative offices of an Italian public research body and is related to his participation to an European Project Budget Reporting (EPBR) (Barbara Re,). We will start from the University organization structure description to the detail of the Business Process under analysis. Figure 1 denotes a fragment of the University organization in which there is an administration and different schools (e.g. the Computer Science Division). In turn, an administration may have several employees, each one with its own role.

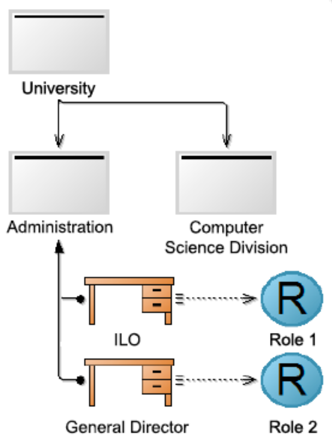

Figure 1: Organization Model: University organization (partial).

This scenario engages different partners in the definition of models and documentation for a Business Process and will permit to assess applicability of the proposed solution within real working contexts.

For the sake of clarity, we are going to explain only a portion of the entire process and, after a first analysis of the domain, the Grant Management BP has been selected as reference point. It includes some sub-process, such as: Periodic Report, Final Report, Manage Payment and eventually Manage Amendment.

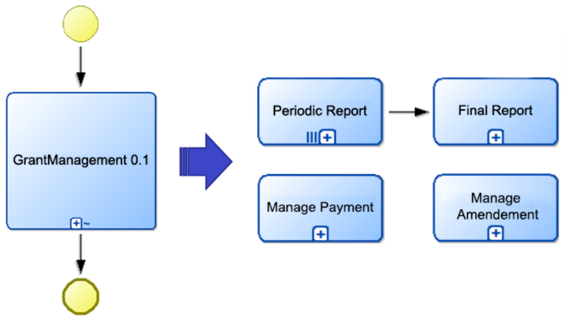

Figure 2: Grant Management Different Level of Detail.

Without going into the details of each of the sub-processes involved in the scenario (this is not the purpose of our work) we consider the **Periodic Report** as motivating example. It is the data object representing the periodic report written by each partner participating to the project. In this process are involved different participants such as the officer, the coordinator (one pool), the grant beneficiary (multiple in parallel) and optionally the third part. Figure 3 describes how the coordinator organizes the process of periodic reports with respect to all the involved stakeholders.

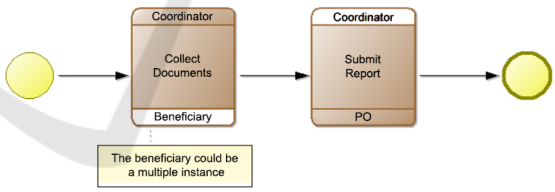

Figure 3: Periodic Report - Choreography Diagram.

Moreover, each Public Officer (PO) according to her experience, might have her own view of the process for the production of her private periodic report (Figure 4 shows an example of a private process done by an EU public officer). In this way, different versions of the same process could be created, so we may have different diagrams for the same process and all of these should also have documentation so we need other models for this purpose.

In its turn, a documentation have to describe, textually and graphically, the state of the data-object. In particular, Figure 5 shows as the Periodic Report is composed by a set of data-objects.

Focusing on the role of Coordinator, they can be determined specific data-object: Amendment Tem-

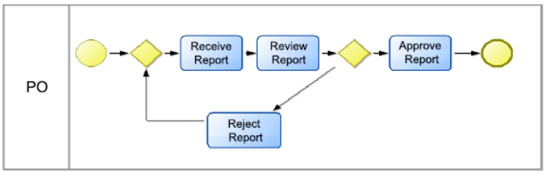

Figure 4: Periodic Report - Private Process of EU Officer.

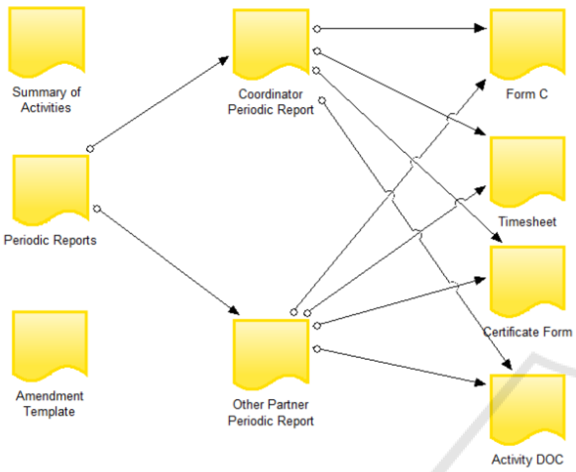

Figure 5: Document Model: Periodic Report.

plate, Summary of Activities and Periodic Reports.

Finally, Figure 6 shows the private process of the Coordinator in relation to these documents.

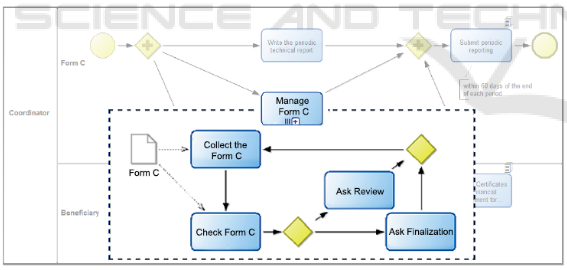

Figure 6: Periodic Report - Private Process of Coordinator Relationship with documents.

This scenario shows the use of a wide variety of models and diagrams (i.e. organization model, choreography diagram, collaboration diagram, Document Model, etc.) at different levels of detail both in term of modelling and learning (i.e. according to the learner skill you should focus on different abstraction level regarding how to deal with reporting).

The disadvantage in using all these models is represented by the increase of the complexity of the entire process and the problem of integration of all these artifacts together in a proper way. In the next section, we will show how the complexity emerged in this scenario is handled and the integration is done.

3 LEARNING ARCHITECTURE

As illustrated in (Hinkelmann et al., 2010), in complex organisations there are many information resources that represents the complete set of activities consumed to perform missions, goals, and objectives. The knowledge must be systematically formalized, organized and consistently categorized in order to support effectiveness in learning. The architecture proposed in this paper supports:

- *informative learning* by which the learner can access and study the enriched BP model and related material with additional descriptive contents and,
- *procedural learning*, by which the learner operate within a simulated environment reproducing real requests through the enactment of a process and monitoring activities. Such environment allows us to capture useful feedback for the evaluation of: *i)* learners, *ii)* business processes, and *iii)* associated learning contents.

The above strategies, are *off-line* because the learner acquire such knowledge before serving real requests. However the typical complexity of processes defeats the human capacity to acquire a full knowledge on any aspect just through informative and procedural approaches. It is necessary that learner can retrieve and process useful and context-dependent information while she is working on real cases. The architecture therefore, must provide learning experience with *on-line* strategies in which learner acquires knowledge while serving real requests, supporting *"training on the job"* or *"learn while doing"* approach. To this end, it is of crucial relevance to be able to provide the user with contextually selected task and user-specific background knowledge (Alfonso Pierantonio, b). In particular, the learner should be able to access the required knowledge in an optimal manner. This can be achieved by coupling the process (formal or informal) description with the descriptive units about the kind of data and document type being considered by the process. Ideally, the notion of context provided by the process permits users to know:

- what to do,
- who does what, and
- what to do after the task.

In such a way the users engaged in their daily work have not to spend much time and effort in knowledge, information retrieval and management activities further than their operative ones.

Within complex enterprises, knowledge includes factual, conceptual, procedural and meta-cognitive artifacts represented by means of metamodels and

model. Starting from metamodeling architecture in (Pierantonio et al., 2015), this section briefly illustrate the main models involved in organizations able to represent knowledge needed for learning.
These models, as shown in Figure 7, are obtained with an in-depth analysis of a) three business processes in the domain of the Italian Public Administration (the family reunion, the grant citizenship, and the bouncer registration); and b) a number of relevant modeling notations (Alfonso Pierantonio, b). The business modelling language, defined to provide a process notation that could be easily understood by all business stakeholders is BPMN 2.0 (BPM, 2011) as represented in Figure 7(a). BPMN is a standard for modeling processes described as a predefined sequences of activities with decisions (gateways) to direct the sequence along alternative paths or for iterations, flow of activities. Unfortunately, its semantic, as discussed in (Alfonso Pierantonio, b), is limited, and it is not useful for some organizational aspects as for instance when the activities in a process

- can occur in any order and/or in any frequency,
- are not predefined, repeatable and knowledge intensive,
- depend on evolving circumstances and ad-hoc decisions by knowledge workers regarding a particular situation.

The standard notation CMMN (CMM, 2013) as depicted in Figure 7(b), allows us to deal with the aforementioned limits. As discussed in (Yu et al., 2006), the importance to introduce intentional modeling in enterprise architecture entails potential benefits and pitfalls. In learning context, it is of crucial relevance to model intentionality providing a scheme for developing, communicating and managing business plans in an organized manner. The BMM (BMM, 2014) focuses on that. It has been proposed as a standard under the Object Management Group (OMG) and provides elements and relationships of intentional modeling as depicted in Figure 7(c). Central elements include *Means*, *Ends*, *Influencer*, *Potential Impact* and *Assessments* that are specialized into more detailed elements as discussed in (Pierantonio et al., 2015). The learning architecture must provide a modelling notation able to describe the learners level, acquired competency and learning progress respect to a business process or procedure in organizations. In Figure 7(d), the Competency model unlike the other models is not defined in specific standard leaving to the modeller the responsibility to define such aspects. The implementation we take into account is defined in (Alfonso Pierantonio, a) and it is partly based on the framework the European Committee for standardisation, CEN WS-LT LTSO (Learning Technology Standards Observatory)[1]. To achieve their means and ends, organizations are structured (often hierarchically) in units where each one has a set of job functions or tasks assigned to a group of people belonging to the organization. Therefore, an organization structure is composed of units, each encompassing the relevant people who work to achieve the mission of the organization (Oh and Sandhu, 2002). The need to keep track of "who does what, how and when" is demanded to in Organizational model as depicted in Figure 7(e) whose implementations is provided in (Alfonso Pierantonio, a). About the management of knowledge and documentation, instead of using the BPMN 2.0 data object element for modeling information/documents used in a process, e.g. as input or output for an activity, we use a separate model, as shown in Figure 7(f). This allows to define a data object (and its meta data), and adding more details, e.g. providing references to operative templates or guidelines, knowledge products or resources, which are utilized in the processes (input, output to activities etc.).

4 LEARNING USING THE ZACHMAN FRAMEWORK

The huge amount of informations and resources gathered from models in Section 3 is not independent. To fulfill the need of learning in enterprise, the *Learning Architecture* provides a machine-processable model that exploits the correlation among the activities and/or concerns in order to provide enriched informations to the organization. In the following we use the Zachman (Zachman, 2012) framework to describe:

- the interrelations of above mentioned models,
- the logic structure for classifying and organizing the knowledge about business activity of an organization in different dimensions and perspectives with respect to the Enterprise Architecture.

Figure 8 outlines how the models can be structured by Zachman's matrix (Zachman, 2012). Rows in Figure 8, take into consideration all the participants involved in the organization's Information Systems (Inmon et al., 1997) in different perspective, starting from an high level abstraction layer to the final product, ie:

- *Scope* (Planner's Perspective), the planner defines the catalogue of services which describe concrete information about a specific organisation, the context of learning, and business scope. The specifi-

[1]2EN WS-LT Learning Technology Standards Observatory. URL: http://www.cen-ltso.net/Main.aspx. Main contact: University of Vigo 36213 SPAIN

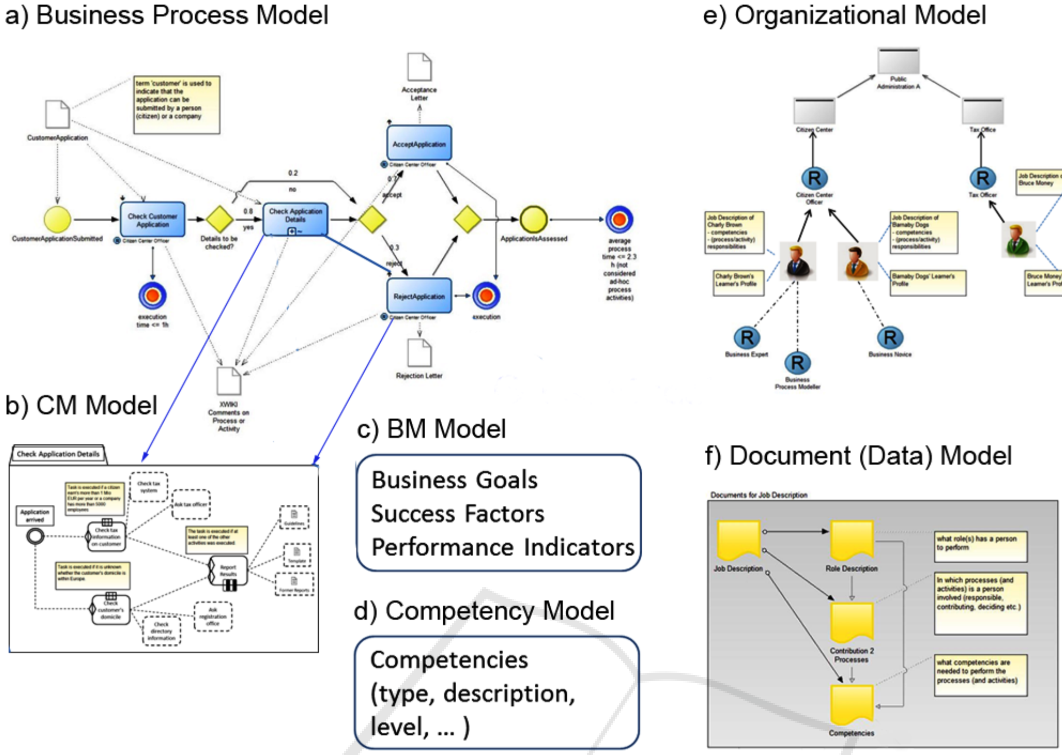

Figure 7: Models involved in learning.

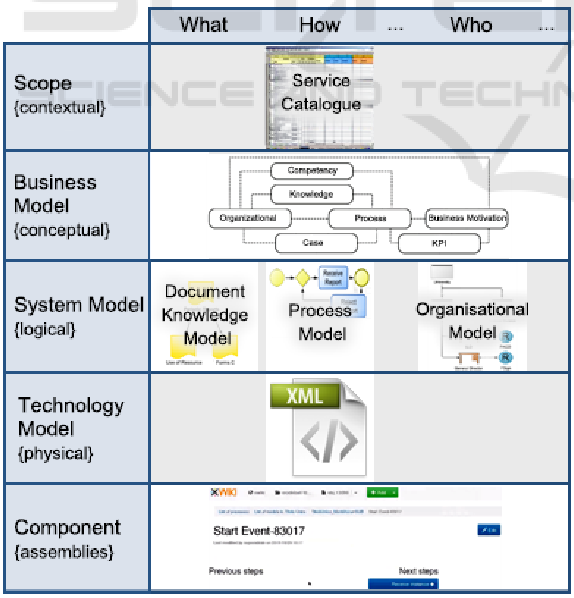

Figure 8: The learning architecture structured by Zachman's matrix.

cation is written in natural languages and structured by means of a table that gather the aforementioned information;

- *Business Model* (Owner's Perspective), the owner is interested in modelling, at conceptual level, the services defined in the *Scope*. The relevant data involved in a learning architecture consists of a number of component metamodels illustrated in Figure 9. Among them, the following have been defined by adapting current industrial standards:

– business motivation (BMM) (BMM, 2014);

– business process management and notation (BPMN) (BPM, 2011); and

– case management and notation (CMMN) (CMM, 2013).

The remaining metamodels have been defined from scratch and are described in (Pierantonio et al., 2015)

– competency metamodel (CM);

– document and knowledge metamodel (DKM);

– key performance indicator metamodel (KPI), and

– organization metamodel (OM).

The relations, are implicit and hence, a process defined in a service catalogue (Scope Concepts level), may occur in the process description on the Business Concepts level but that relation is not formalized and therefore hard to trace;

- *System Model* (Designer's Perspective) the designer works with the specifications defined above, instantiating all elements involved in business organization to ensure that it will, in fact, fulfill the owner's expectations. The problem about tracing the relation between a process model on the System Logic Layer and the process description (at conceptual level), holds true;
- *Technology Model* (Builder's Perspective) the builder manages the process of define the language and functionalities able to satisfies the requirement of the learning platform. To this respect, the model set defined in *System Model* must be transformed in a standard exchange format, eg. XMI, in order to be machine readable;
- *Component* (Learning platform's Perspective) the learning architecture takes the instance models provided by the *Technology Model* and enables process-driven learning, fostering the cooperation and knowledge sharing among the learners.

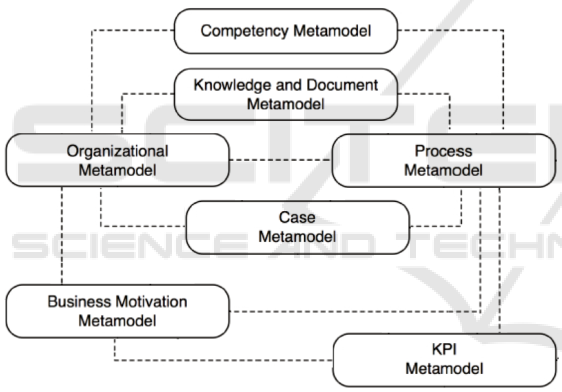

Figure 9: The conceptual model.

While the horizontal dimension in the Zachman Framework describe the participants involved in the learning architecture, the columns provide a focus on each dimension (Hay, 1997): What, How, Where, Who, When, Why. The architecture exploit a subset of them as following:
- Data (What?), in this column, "Document and Knowledge" concepts are defined. In particular, about the perspectives *Business Model*, *System Model*, and *Component*, the enterprise's informations about knowledge and resources used for business activity;
- Function (How?), the process of the organization are defined in several abstraction level. Starting from a service catalogue, the models are refined and enriched with structured information. In such way, learner can retrieve and process useful and context-dependent information while she is working on real cases;
- People (Who?) The latest column describes who is involved in activities, assigning them to business or IT perspective and classifying them w.r.t. to several aspects.

The matrix structure of the LA, allow us to perform an in depth analysis on some intrinsic characteristics:

- *horizontal relations*: bridging the various modeling notations (and their representation formats) between considered Business Objects;
- *vertical relations*: factorizing part of the transformation chaining in order to produce artifact needed for learning;
- enhance relevant quality factors, eg maintenance, extendibility, etc.

4.1 Horizontal Relations

As already discussed in Section 3 there are many information resources in an enterprise that serve several purposes and that usually reside in different information systems. The separation of concerns in software system modeling avoids the construction of large and monolithic models which could be difficult to handle, maintain and reuse. At the same time, having different models (each one describing a certain concern) requires their integration into a final model representing the entire domain (Reiter et al., 2005). The integration in the LA is made through horizontal relations in Zachman Framework and, for the sake of clarity, only relations between models on the *System Model* layer will be discussed in this paper (see the related row in Figure 8). To make these relations explicit and machine processable we provided the specification in terms of weaving models for defining correspondences between modeling elements belonging to different metamodels[2]. Although there is no accepted definition, in (Bézivin, 2005) it is considered as:
- the operation for setting fine-grained relationships between models or metamodels, and
- executing operations on them based on the semantics of the weaving associations specifically defined for the considered application domain.

In the following, each weaving is given by means of a weaving metaclass denoting the correspondences between two or more metaclasses in different metamodels. Each weaving definition can encompass one or

[2]Implemented metamodel resources can be found in the repository: https://github.com/LearnPAd/learnpad/tree/master/lp-collaborative-workspace/ lp-cw-bridge/lp-cw-bridge-transformer/resources/metamodels

more associations. The weaving models are given according to the component metamodels defined in (Pierantonio et al., 2015):

- Business Process Modelling Notation (BPMN 2.0)[3]: several kinds of weaving are defined; the link with Document Knowledge Model permit to have the resources used as input (Figure 10) and/or output (Figure 11) in a process or activity. The lack of a specific semantic in the BPMN specification for the Lane concept required the definition of the Lane-weaving (Figure 12). Such interconnection links a Lane in BPMN, with respectively *i)* OrganizationalUnit, *ii)* the Perfomer, and *iii)* the Role in Organisational Model. Finally, the Activity-weaving interconnects information linked to a given activity in accordance with the Figure 13. In particular, given an activity, it denotes: *i)* the competencies needed for realizing it; *ii)* the criteria used for evaluating its performance; *iii)* the organizational unit, which has been assigned the responsibility and who is performing that.

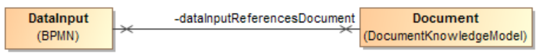

Figure 10: The DataInput weaving.

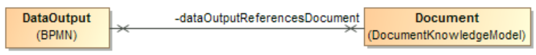

Figure 11: The DataOutput weaving.

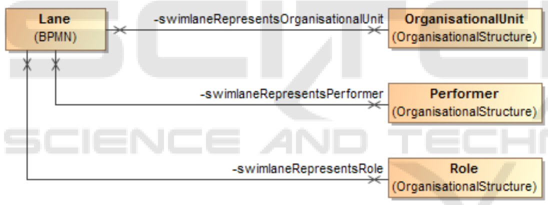

Figure 12: The Swimlane-lane weaving.

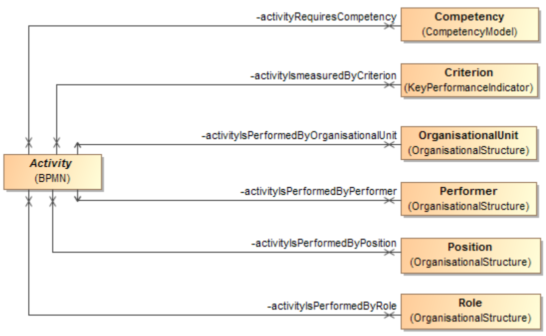

Figure 13: The Activity weaving.

- Case Management and Notation (CMMN)[4]: the ProcessTask-weaving denotes the reference to an activity (regular task) to be invoked by the process task (Figure 14).

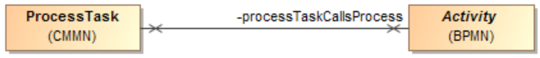

Figure 14: The Process Task weaving.

- Organization Model: the Position-weaving links the position described or reported in a resource in a Document and Knowledge Model, e.g., a job description (**Figure** 15).

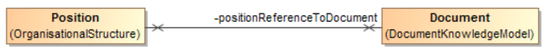

Figure 15: The Process Task weaving.

The above relations are just only a subset of all possible ones, according to motivating scenario in Section 2. A more in depth analysis, and other kind of relationship tailored for learning in Public Administrations are discussed in (Alfonso Pierantonio, a).

4.2 Vertical Relations

The LA exploits models in order to have informative specifications *i)* for the learners and *ii)* at the same time informations able to simulate e monitor the processes in organisations. As said, models in the Zachman matrix are organized using different abstraction levels therefore, the learning contents that describe multiple aspects of processes in organizations, should rely on adequate means that automatically relate and trace over the multiple views. The generation of e-learning artifacts out of specified business processes will be performed by means of vertical model transformations chain as depicted in Figure 16[5]. In order to enhance the automation in finding model transformation chains, we use the proposed process of deriving model transformation chaining depicted in (Basciani et al., 2014). Moreover, there is the need of techniques introducing automation in the management of artifacts that have to be kept consistent to

[3]http://www.omg.org/spec/BPMN/2.0/

[4]http://www.omg.org/spec/CMMN/

[5]Implemented transformation resources can be found in the repository: https://github.com/LearnPAd/learnpad/tree/master/lp-collaborative-workspace/ lp-cw-bridge/lp-cw-bridge-transformer/resources/transformation

each other. Therefore, model transformations play a central role since they represent the glue between the several levels of abstraction and enable the generation of: *i)* different artifacts for learning purposes using ATL [6] in *Model2Model* (see Figure 16(a)) transformation languages and *ii)* the generation of implementation code (Bézivin, 2005) by means of Acceleo [7] in *Model2Code* transformation (see Figure 16(b)).

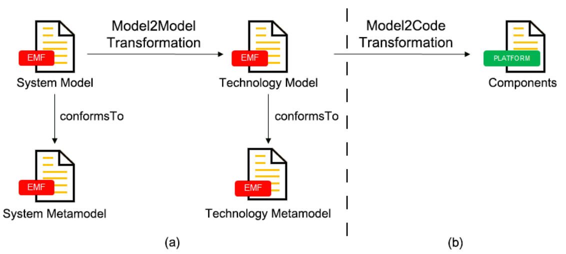

Figure 16: The vertical Zachman transformation chain.

5 RELATED WORK

Many efforts have been done in order to support the integration of models, tools and techniques used to describe various aspects of a complex organization.

(Lankhorst, 2004) tackle the issue of integration of all the concepts and modelling techniques used by architects to describe their architectural domains, presenting an enterprise modelling approach. In this approach several abstract layers are integrated combining several existing languages. Unlike the work presented in this paper, they propose a workbench for enterprise architecture that supports the integration of models in existing modelling languages and the integration of existing modelling tools. We choose to perform a similar integration using the Zachman Framework mainly because we are aware that the communication is important.

Indeed, thanks to the Framework's perspective, which allows us to answer the *what*, *how*, *where*, *who*, *when*, and *why* questions, we are able to create different descriptive representations (i.e., models), which translate from higher to lower perspective. This guidance is both clear and complete and as result these perspectives, in relation with these questions, determine a communication matrix. Furthermore, the Zachman Framework permits us to understand where completeness lies, and how to asses when we've achieved it. Indeed, "*Zachman's framework suggests that an architecture can be considered a complete architecture only when every cell in that architecture is complete. A cell is complete when it contains sufficient artifacts to fully define the system for one specific player looking at one specific descriptive focus*" (Tupper, 2011).

Although we do not use the tools which they have defined, we still followed the method defined in (Pereira and Sousa, 2004). In the article, in fact, they propose a method to achieve an Enterprise Architecture Framework based on the Zachman Framework Business. Furthermore, the authors identify a new concept related to this framework defined as "anchor cell" that defines the semantic relationships existing between cells on any of the framework's perspectives. In our work, we developed this "anchor cells" that represents vertical relationships with model transformations that transform a model in a perspectives in another model in another perspective. Moreover we have horizontal relationships through the rows (dimensions) using the weaving model (Didonet Del Fabro et al., 2005).

6 CONCLUSION

In this paper, we presented a learning architecture able to supports both an *informative* learning approach based on enriched Business Process Models and a *procedural* learning approach based on simulation and monitoring learning-by-doing. In order to manage such information, it is important to organize knowledge archives exploiting the usage of BPs in a context-giving structure. In particular, learner should be able to access the required knowledge in an optimal manner. This can be achieved by coupling the process model with the descriptive units about various aspects including the kind of data and document type being considered by the process, the organizational structure, the indicators for measuring both the performance and how far the learning goals are achieved. The learning architecture is implemented as described in Section 4.1 and Section 4.2. A discussion about its advantages and disadvantages will be part of future plans together with its evaluation.

Furthermore, we intend to tackle the problem by conceiving advanced model-driven techniques able to keep aligned different views (i.e., models specified at the same level of abstraction) and to manage multi-scale models (i.e., models in which parts of the system are specified at different level of detail) by means of bidirectional transformations (Czarnecki et al., 2009) and uncertainty management (Eramo et al., 2015). However, these approaches testify the benefits and advantages of applying theory and results from MDE on learning (Laforcade and Choquet, 2006).

[6]https://eclipse.org/atl/
[7]https://eclipse.org/acceleo/

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