Extended Resource Perspective Support for BPMN and BPEL

Luis Jesús Ramón Stroppi¹, Omar Chiotti², and Pablo David Villarreal¹

¹ CIDISI, National Technological University Santa Fe Faculty, Lavaiise 610, S3004EWT, Santa Fe, Argentina, {lstroppi,pvillarr}@frsf.utn.edu.ar
² INGAR-CONICET, Avellaneda 3657, S3002GJC, Santa Fe, Argentina, chiotti@santafe-conicet.gov.ar

Abstract. This work provides support to the modeling and execution of the Resource Perspective of Business Processes with BPMN and BPEL. It is based on an extension developed to BPMN 2.0 in order to define and visualize the Resource Structure, Work Distribution and Authorization aspects of this perspective. This work proposes a mapping of extended BPMN process models to BPEL processes applying the BPEL4People and WS-HumanTask extensions. It also proposes the structure of people directories enabling BPEL4People and WS-HumanTask implementations to distribute work to the resources based on Resource Structure models defined by using the proposed BPMN extension.

Key words: BPMN, BPEL, BPEL4People, WS-HumanTask, Resource Perspective, Extension

1 Introduction

The Business Process Model and Notation (BPMN) [1] and the Business Process Execution Language (BPEL) [2] are two broadly accepted languages for the modeling and execution of business processes. BPMN provides a business-oriented way of visualizing XML languages designed for the execution of business processes. It also defines the way in which BPMN process definitions with some restrictions can be mapped into BPEL.

The Resource Perspective of business processes refers to the link between the activities defined in the processes and the entities that carry out the work related to them, which are called resources [3]. The way the work is distributed to the resources involved in a process is significant to its effectiveness and efficiency. A wide range of requirements may arise when integrating people in business processes. The Workflow Resource Patterns [4] were developed as an abstraction of a set of recurrent resource perspective requirements.

The metamodel defined in the second version of BPMN provides some elements supporting the Resource Perspective. Also, BPEL4People [5] is a BPEL extension based on the WS-HumanTask specification [6] that supports this perspective in BPEL processes. However, the modeling and execution of the Resource Perspective by means of BPMN and BPEL presents several problems.
The elements defined by the BPMN metamodel for the representation of this perspective provide support to a reduced set of Workflow Resource Patterns. Also, BPMN does not define a specific notation for the visualization of these elements in diagrams depicting processes. Although the BPMN specification foresees the mapping of BPMN User Tasks to BPEL4People elements, it does not define how it has to be performed.

In a previous work [7] a conceptual model of an extension to the BPMN metamodel was proposed for the definition of the Resource Perspective of business process models. Also, that work presented an extension to the BPMN notation to enable the visualization of the new elements introduced by the extension.

The goal of this work is to enable the generation of executable representations of the resource perspective of business processes from BPMN process models applying the aforementioned extension. This is accomplished by mapping extended BPMN process models into BPEL processes extended with the elements provided by BPEL4People and WS-HumanTask.

This work is structured as follows. Section 2 introduces the aspects considered by the extension proposed to define the resource perspective in BPMN. Then, it presents a representation of the extension by using a specific UML profile for defining BPMN extensions and introduces an example. Section 3 analyzes the way in which extended BPMN process models can be mapped to BPEL processes extended with BPEL4People and WS-HumanTask elements. Section 4 discusses related work. Finally, section 5 presents the conclusions and future work.

2 BPMN Extension to Define the Resource Perspective of Business Process Models

One of the aims of BPMN is to bridge the gap between the design and implementation of business processes. Business processes involving people are typically implemented by means of Workflow Management Systems (WfMS). These systems have common characteristics observable in different reference models [8, 9] and architectures [6]. A WfMS interprets a process definition and drives the flow of work by allocating the activities to the resources in the specified order. A software component known as Work Distribution Module [9] or Task Processor [6] performs the allocation of the activities based on the process definition. This may involve executing queries to data describing the resources stored in an organizational repository or available in the scope of the process. Finally, the resources access and complete the activities distributed to them by means of another software component called Worklist Handler [8] or Task Client [6].

In a previous work [7], the conceptual model of an extension was proposed to enable the definition and visualization of resource perspective aspects in BPMN process models. It enables the representation at design time of resource perspective concepts that need to be captured in process definitions to be interpreted by WfMSs. Section 2.1 describes the aspects considered by the extension. Section 2.2 presents the implementation of the extension by using the method and tool support presented in [10].
2.1 Resource Perspective Aspects Considered in the Extension

The extension considers three aspects to be defined in a process model in order to describe the Resource Perspective: Resource Structure, Work Distribution and Authorization.

The Resource Structure aspect is concerned with the characterization and classification of resources. The characterization is the description of the different features of the resources. The classification is the association of resources with a concept. The classification allows to reference the resources associated with a concept and to assign them sets of common properties.

The Work Distribution aspect deals with the advertisement and allocation of the work associated with process activities to specific resources for its execution [4]. The proposed extension adopts and extends the work distribution approach of BPMN based on the assignment of work distribution roles to resources.

The Authorization aspect is concerned with the definition of privileges that the resources own with regard to the execution of operations to see and progress the work distributed to them. Resource privileges depend on the resource structure and grant to the resources the execution of worklist operations to see the work offered or allocated to them. Task privileges depend on the task to be performed and the way the work is distributed. These privileges grant the execution of work item operations in order to progress the work of the task.

The proposed extension enables the definition of these aspects in two different models: a Resource Structure model and an Extended BPMN Process model. The Resource Structure model defines the Resource Structure aspect and the resource privileges. The Extended BPMN Process model contains a BPMN process definition extended with elements regarding the Work Distribution aspect and the task privileges. A Resource Structure model is imported by one or more Extended BPMN Process models defining the different processes of the organization by means of the Import BPMN element. The reuse of Resource Structure models is desirable to avoid redundant representations which may lead to inconsistencies [3].

The representation of the aforementioned aspects in BPMN enables generating specifications of processes involving people that can be processed by Workflow Management Systems based on well known reference models and architectures [8, 9, 6]. This is demonstrated by the development of the mapping of the resulting models to BPEL introduced in section 3.

2.2 Implementing the Extension by Using BPMN+X

In this work, the conceptual model of the extension proposed in [7] is implemented by using the BPMN+X UML Profile and the methodological guidelines developed in [10]. Figures 1 and 3 show the BPMN+X models defining the extensions proposed for the definition of Resource Structure and Extended BPMN Process models. The classes stereotyped as BPMNElement represent the standard elements defined in the BPMN metamodel. The classes stereotyped as ExtensionDefinition group the attributes and elements to be attached to the prede-
fined elements of BPMN. The classes stereotyped as *ExtensionElement* represent new types of elements defined in the context of the extension. Finally, the dependencies stereotyped as *ExtensionRelationship* document the BPMN element to be extended by an *ExtensionDefinition*. BPMN+X enables the graphical representation of BPMN extensions and the automatically generation of XML Schema documents describing them that can be processed by compliant BPMN tools. The BPMN+X models and the XML Schema documents defining the proposed extension are available at [http://code.google.com/p/bpmnx/downloads](http://code.google.com/p/bpmnx/downloads).

Figure 1 shows a BPMN+X model representing the extension proposed for the definition of Resource Structure models. It defines an extension to the *Resource* BPMN element. *ResourceBase* specifies the resourcePrivileges extension attribute that defines the privileges granted to the resources to execute worklist operations. *ResourceBase* has two subclasses: *ResourceClassifier* and *HumanResource*. *ResourceClassifier* addresses the resource classification introduced earlier and defines three extension attributes. The *population* attribute identifies the human resources grouped by the classifier. The *subsumedBy* attribute represents a relationship between a more general and a more specific resource classifier. The *references* attribute defines named associations between ResourceClassifier elements. The *HumanResource* extension definition represents a single person. It defines two extension attributes. The *resourceClassifications* attribute allows characterizing the human resource with the set of properties defined for zero or more resource classifiers. The *resourceParameterValues* attribute defines values for the properties characterizing the human resource.

Figure 2 depicts an example of a Resource Structure model of an insurance company. It has been represented by using the notation proposed in [7]. The Resource Structure model defines the Director, RegularStaff, Clerk and Supervisor resource classifiers. Tom is the human resource classified as the Director. Thus, all the resource privileges are granted to him. RegularStaff defines the hireDate resource parameter and a set of resource privileges. The Clerk and Supervisor

![Fig. 1. Resource Structure extension to BPMN 2.0.](image-url)
resource classifiers inherit these properties through their subsumption relationships with RegularStaff. Clerk defines an additional authorizedAmount resource parameter. John and Ann are human resources classified as Clerk. They possess the resource privileges defined by RegularStaff and define values for the hireDate and authorizedAmount resource parameters. Peter and Paul are human resources classified as Supervisor. They have the resourcePrivileges defined by RegularStaff and define values for the hireDate resource parameter.

![Sample Resource Structure Model](image)

**Fig. 2.** Sample Resource Structure Model.

The BPMN+X model of Figure 3 depicts the extension for the definition of Extended BPMN process models. The *WorkDistribution* ExtensionDefinition element specifies two extension attributes to the *UserTask* BPMNElement. The first one is *taskAllocation*. It defines how the work of the *UserTask* is distributed among the resources at the first time. The second one is *taskReallocation*. It specifies the redistribution of the task upon the occurrence of certain event.

The conceptual model of the extension proposed in [7] defines six work distribution attributes. They are specified in the BPMN+X model by the *WorkDistributionStrategy* ExtensionElement and the two ExtensionElements inheriting from it: *AllocationStrategy* and *ReallocationStrategy*.

The *roleRef* attribute references a *ResourceRole* element defining a predefined set of task privileges to be granted to the resources to which the task is assigned. The extension proposed enables defining three work distribution roles [7]: *PotentialOwner*, *Owner* and *Executor*.

The *resourceResolution* attribute defines the information evaluated to determine the set of resources that can perform the work related with the task. It complements the support provided to this requirement by the *ResourceRole* BPMN element. There are two kinds of resource resolution: *ResourceStructureBasedResolution* and *DataBasedResolution*. The *ResourceStructureBasedReso-
Fig. 3. Work Distribution extension to BPMN 2.0.

The `distributionAgent` extension attribute indicates whether the work distribution is performed by the system (SystemAgent) or by a resource (UserAgent). In case of specifying the UserAgent distribution agent, it is necessary to define the resource who will be responsible for the distribution of the task.

The `trigger` attribute specifies a reference to a BoundaryEvent attached to the distributed task. When defined by AllocationStrategy, it supports the Late...
Distribution Workflow Resource Pattern. It is mandatory for ReallocationStrategy and specifies the event causing the reallocation of the work distribution role.

Figure 4 shows an example of an extended BPMN process model. It uses the notation proposed in [7]. It depicts a work distribution requirement that could not be visualized by applying the convention based on the use of the Lane element provided by BPMN in order to partition the diagram elements based on different criteria. The process starts with a customer sending a claim request to the insurance company. Then, the Create Claim user task is activated and offered to the Clerks. For more flexibility, the PotentialOwner role is assigned to the Clerks so they are able to decide what instances of the Create Claim user task they will undertake based on their work load and knowledge about the customer. Once that the Claim is created, it has to be approved by a Supervisor. The Approve Claim user task is also offered to the supervisors who can decide when to undertake and complete the execution of the task. If nobody has completed the Approve Claim task after two days of its activation, then the Director will assign the task to one of the supervisors, who will have the responsibility to complete it. Finally, once that the supervisor approved the claim, a message is automatically sent to the customer in order to inform the result of the claim request.

3 Mapping of Extended BPMN Process Models to BPEL

The BPMN 2.0 specification [1] defines a mapping of BPMN models to BPEL that is required for claiming BPMN BPEL Process Execution Conformance and

![Fig. 4. Sample Work Distribution Model.](image-url)
BPMN Complete Conformance. It also foresees the mapping of additional BPMN constructs by using other capabilities not considered by the BPMN specification.

BPEL [2] focuses on business processes consisting of activities assumed to be interactions with Web services. It does not take into account aspects related to the participation of people in the execution of business processes. BPEL provides an extension mechanism. BPEL4People and WS-HumanTask [5, 6] are extensions defined by using that extension mechanism in order to address the Resource Perspective of Business Processes in BPEL.

Section 3.1 describes how the proposed Resource Structure models can be deployed into BPEL4People/WS-HumanTask implementations. Section 3.2 extends the mapping of BPMN elements to BPEL in order to enable representing BPMN process models with work distribution details as BPEL processes extended with BPEL4People and WS-HumanTask elements.

3.1 Deploying Resource Structure Models into BPEL

In BPEL4People and WS-HumanTask [5, 6] the assignment of tasks to people is frequently performed by executing queries on a people directory with certain organizational model. The WS-HumanTask specification defines the user and group elements representing the types of organizational entity that can be returned from the evaluation of these queries. However, the mechanism used by the implementations to evaluate people assignments and the structure of the data in the people directory is out of the scope of BPEL4People and WS-HumanTask.

The class diagram of Figure 5 depicts the structure proposed in this work for people directories. It is based on the extension shown in Figure 1. The HumanResource and ResourceClassifier classes shown in Figure 5 match with Resource BPMN elements applying the HumanResource and ResourceClassifier extension definitions depicted in Figure 1 (see [10] for more details on the meaning of BPMN+X models).

At runtime, the queries resulting in a ResourceClassifier are mapped to a group WS-HumanTask element. Instead, the queries resulting in HumanResource elements are mapped to user WS-HumanTask elements. The Resource Structure models defined with the proposed BPMN extension can be automatically deployed into people directories supporting it. Also, it is possible to apply model-driven development approaches to populate people directories supporting different metamodels. An XML Schema document defining the interchange format for people directories based on the metamodel of Figure 5 was also defined. The XML document depicting the sample resource structure introduced in the previous section has been omitted for reasons of space. Its nodes can be matched directly to the elements of the diagram depicted in Figure 2.

A particular comment needs to be done with regard to the definition of resource privileges which are aimed to restrict the set of work list operations granted to the resources. WS-HumanTask does not provide any mechanism to enforce resource privileges. In WS-HumanTask, when a task is created and activated, it is distributed to the resources to be claimed and completed. For that purpose, its architecture defines a component called Task Client. A Task Client
is an application which presents the tasks available to the resources. Then, they can claim tasks and work on them by means of the user interface provided by this application. WS-HumanTask specifies a Client API Port Type required for Task Clients to communicate with the Task Processor which is the component that manages the life cycle of the task. If the Task Client were able to obtain the privileges defined for a resource from the people directory supported by the Task Processor, then the Task Client would be able to enforce the resource privileges by restricting the work list operations available to the users. However, this would require to extend the standard WS-HumanTask Client API Port Type with an additional `getResourceParameters` operation.

### 3.2 Mapping Work Distribution Models

The integration of human beings in BPEL processes is supported by the `PeopleActivity` element provided by BPEL4People. BPEL4People depends on WS-HumanTask for the definition of work distribution requirements. `PeopleActivity` elements contain a WS-HumanTask `Task` element defining the way the work the task is distributed to the resources involved in the process. The class diagram of Figure 6 depicts the concepts introduced by BPEL4People and WS-HumanTask to enable the definition the Resource Perspective in BPEL processes.

The following paragraphs describe how a BPMN process model applying the proposed work distribution extension can be mapped to a BPEL process extended with the elements provided by BPEL4People and WS-HumanTask.

The `WorkDistribution` extension definition specifies two extension attributes: `taskAllocations` and `taskReallocations` (see Figure 3). The `AllocationStrategy` and `ReallocationStrategy` extension elements inherit from the `WorkDistributionStrategy` extension element. `WorkDistributionStrategy` defines five attributes.

The `roleRef` attribute enables identifying the role being distributed. The extension proposed [7] enables specifying the `PotentialOwner`, `Owner` and `Executor` work distribution roles. The `PotentialOwner` role is directly supported by WS-HumanTask. The `Owner` and `Executor` work distribution roles together match
Fig. 6. BPEL4People and WS-HumanTask elements regarding Work Distribution.

to the ActualOwner WS-HumanTask role. WS-HumanTask does not enable the definition of people assignments for the ActualOwner role. In the case that the people assignment defined for the PotentialOwner role results in a unique human resource, that resource is automatically assigned to the ActualOwner role.

The resourceResolution attribute defines the information to be evaluated in order to get the set of resources which can be allocated to the task being distributed. It complements the ResourceRole BPMN element which defines the resourceRef, resourceParameterBindings and resourceAssignmentExpression attributes to support this requirement. The resourceRef and resourceParameterBindings attributes of the ResourceRole BPMN element and the resourceModelExpression of the ResourceStructureBasedResolution extension element map to a from WS-HumanTask element within a generic human role assignment and defining the logicalPeopleGroup attribute and zero or more argument elements. The resourceAssignmentExpression attribute of the ResourceRole BPMN element maps to a from WS-HumanTask element defining the expressionLanguage attribute. The additional resourceParameterBindings and resourceAssignmentExpressions of the ResourceStructureBasedResolution and DataBasedResolution extension elements defined by ReallocationStrategy extension elements map to from elements within potential owner assignments of reassignment WS-HumanTask elements (see the mapping of the trigger attribute of ReallocationStrategy below).

The resolutionConstraint attribute defines restrictions to the set of resources that can be allocated to the role being distributed. With regard to the SelectResourceConstraint, WS-HumanTask enables the definition of the FourEyes and RetainFamiliar selection strategies by using the getActualOwner extension function for the assignment of the PotentialOwners and ExcludedOwners roles. It does not enable the definition of the remaining selection strategies. WS-HumanTask does not provide any element to be mapped with the SingleResourceConstraint resolution constraint. In order to provide full support to this
attribute, it would be necessary to extend the from WS-HumanTask element with an optional \textit{resolutionConstraint} attribute assuming the values \textit{singleResource} or \textit{selectedResource} and the addition of three new extension functions: \textit{random}, \textit{roundRobin} and \textit{sortestQueue}.

The \textit{taskPrivileges} attribute allows defining constraints to the set of task privileges assigned to the resources as result of the allocation of the distributed role. WS-HumanTask does not enable specifying the task privileges to be assigned to the resources on a task-by-task basis. It only enables granting these privileges to the resources by assigning them roles consisting of a fixed set of privileges which can not be constrained. Therefore, this attribute can not be mapped to any WS-HumanTask element. To support this requirement, it would be necessary to extend the WS-HumanTask \textit{task} element with a \textit{taskPrivileges} element in order to enable the specification of the task privileges that can be granted to the resources when distributing the task.

The \textit{distributionAgent} attribute enables specifying whether the task has to be distributed by the system or by a resource participating in the process. WS-HumanTask enables representing the semantics of the \textit{SystemAgent} extension element by means of the definition of \textit{peopleAssignments}. The semantics of \textit{User-Agent} is supported in WS-HumanTask by specifying an empty resource set for the potential owners role. The \textit{resourceRef} attribute of \textit{SystemAgent} is mapped to the assignment of the Business Administrator WS-HumanTask role.

The \textit{trigger} attribute is defined by both the \textit{AllocationStrategy} and \textit{ReallocationStrategy} extension elements. Although WS-HumanTask does not support the Late Distribution Workflow Resource Pattern \cite{11}, a similar behavior can be obtained by mapping the \textit{trigger} attribute of \textit{AllocationStrategy} extension elements to the \textit{deferActivation} element provided by the \textit{peopleActivity} BPEL4People element. The \textit{trigger} attribute of the \textit{ReallocationStrategy} extension element can be mapped to the \textit{for} or \textit{until} expression defined by \textit{deadline} WS-HumanTask elements. In this case, the \textit{resourceResolution} attribute of the \textit{ReallocationStrategy} extension element is mapped to the \textit{reassignment} element defined by the \textit{escalations} WS-HumanTask element in order to specify the resources to which the task has to be redistributed.

The BPEL process illustrated in Figure 7 depicts the way the extended BPMN process model of Figure 4 can be mapped into a BPEL process definition applying the BPEL4People and WS-HumanTask extensions. This BPEL process includes a BPEL4People \textit{humanInteractions} element. It contains a \textit{logicalPeopleGroups} element defining the Clerk, Supervisor and Director logical people groups that are used in the definition of tasks for specifying people assignments. The \textit{humanInteractions} element also contains the \textit{tasks} element specifying work distribution details defined for the Create Claim and Approve Claim user tasks depicted in Figure 4. The \textit{CreateClaimDefinition} and \textit{ApproveClaimDefinition} WS-HumanTask \textit{task} elements have been derived based on the mappings described above. The \textit{peopleAssignments} BPEL4People element assigns people to process-related generic human roles. Finally, the document defines a BPEL \textit{sequence} element specifying the order of the activities defined in the process. The
Receive Claim Request and Send Claim Response activities have been mapped following the guidelines defined in the BPMN specification [1]. The Create Claim and Approve Claim user tasks have been mapped to the CreateClaim and ApproveClaim peopleActivity elements. These elements reference the top-level definition of the tasks by means of localTask elements. This enables the same task to be reused within multiple people activities.

Fig. 7. Mapping of a Work Distribution Model into WS-HumanTask.

4 Related Work

There exist previous work covering the modeling and execution of the Resource Perspective of business processes. A UML Profile based on use case models was proposed in [12]. It also provides an approach for the generation WS-HumanTask specifications from the extended use case models. Compared to our
approach, it only enables representing the Resource Perspective in an isolated way. Our proposal extends the mapping of BPMN process models to BPEL and BPEL4People. Therefore it enables the generation of executable representations of the resource Perspective integrated with the Control Flow and Data perspectives. Also, our approach separates Resource Structure models from extended process models which enables their reuse.

Another work [13] provides a view-based modeling framework for the representation of the resource perspective at both conceptual and technology specific levels. It provides a transformation for the generation of BPEL4People process definitions from technology specific models. At the conceptual level, it only provides an abstract work distribution role. Therefore, most of the resource perspective requirements can not be supported without introducing platform-specific elements. The generation of BPEL4People process definitions is also supported by our proposal. In addition, our approach enables the representation of 38 Workflow Resource Patterns in platform independent models [7].

Other works [14, 15] provide support to the representation of the Resource Perspective on BPMN process models. They are based on BPMN 1 and the Business Process Definition Metamodel. Our proposal is based on the metamodel and extension mechanism provided by the second version of BPMN. The resulting models are portable between tools compliant with BPMN 2.0 as the elements defined by our extension can be serialized into XML documents defined according to the interchange format provided by the language.

5 Conclusions

This work proposed an approach that enables the implementation of resource perspective requirements defined in extended BPMN process models and Resource Structure models into BPEL process definitions applying the BPEL4People and WS-HumanTask extensions. The approach supports the modeling and execution of three aspects of the Resource Perspective: Resource Structure, Work Distribution and Authorization.

The proposed BPMN extension was implemented by means of the BPMN+X profile. This made it possible the automatically generation of the XML Schema documents representing the extension that can be processed by compliant BPMN tools. Therefore, the resulting extended BPMN process models can be interchanged between different-vendor tools.

The Resource Structure aspect is supported by the metamodel proposed for the definition of people directories. It is based on the BPMN extension proposed for the definition of Resource Structure models. Hence, the models represented in terms of this extension can be directly deployed into people directories supporting it and queried by BPEL4People and WS-HumanTask implementations.

The Work Distribution aspect is supported by means of the extension proposed for the mapping of BPMN process models to BPEL. It enables representing the most of the elements defined in the proposed BPMN extension in terms of BPEL4People and WS-HumanTask elements.
The Authorization aspect can be partially supported with BPEL4People and WS-HumanTask. WS-HumanTask does not provide any mechanism to enforce the resource privileges defined in Resource Structure models. Also, the task privileges can only be granted or revoked to the resources by assigning generic human roles. This work proposed a way in which WS-HumanTask can be extended to provide a complete support to the Authorization aspect based on extensions to the Client API Port Type and the task element defined by WS-HumanTask.

The development of tools enabling the automatically or semi-automatically generation of executable BPEL processes applying the BPEL4People and WS-HumanTask extensions from extended BPMN process models as well as the mapping of the proposed extension to other languages supporting the execution of processes involving people like YAWL is considered as future work.

References