

# CRISTAL: Collection of Resource-centrIc Supporting Tools And Languages\*

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**Abstract.** In this demo, we introduce CRISTAL (Collection of Resource-centrIc Supporting Tools And Languages), a tool suite aimed at improving the human resource management capabilities of current Business Process Management Systems (BPMSs), covering the design and enactment phases of the business process (BP) life cycle. The central element is Resource Assignment Language (RAL), a Domain Specific Language (DSL) for specifying resource assignments in process models. RAL's strong analysis capabilities enable the automated resolution of resource assignment expressions both (i) at design time, serving for post-design analysis to find and correct potential problems prior to execution, and (ii) at run time, in order to execute the BP in an existing BPMS considering the RAL assignments for resource allocation. The resource assignments can be directly modelled in a Business Process Modelling Notation (BPMN) diagram, or specified by means of a RACI matrix. In the latter case, CRISTAL can take all the RACI information automatically and introduce it into a resource-unaware BPMN model at any moment, resulting in a RACI-aware BP model (and, thus, a resource-aware BP model).

## 1 Background. RAL and RACI matrices

RAL is a DSL specifically developed to express resource assignments for the activities of a BP [1]. The language was designed to bridge the gap between BP models and organizational models, and to exceed the scope of existing approaches. RAL expressions cover from simple assignments based on specific members of the company, to complex assignments containing access-control constraints (e.g. Segregation of Duty -SoD-) between activities, as well as compound expressions. As can be seen in the following examples, its syntax is close to natural language, which increases its understandability:

RAL 1: IS Samuel

RAL 2: NOT (IS PERSON WHO DID ACTIVITY CreateResolutionProposal)

RAL 3: (HAS ROLE DocumentWriter) OR (HAS POSITION ACDocumentSigner)

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We provided RAL with formal semantics based on Description Logics (DLs) in order to be able to automatically solve RAL expressions. It also enabled us to benefit from operations implemented in DL reasoners to analyse BPs in terms of how resources are being managed. RAL’s semantics now cover both the design time [2] and the run time phases of the BP life cycle [3], meaning that:

- RAL assignments can be automatically solved at design time. Accuracy is not possible for those expressions requiring run-time information though, since some data are missing (e.g. the expressions related to the person who did a certain activity). Besides, the design-time resource-related analysis of RAL expressions automates the answering of questions such as (i) who are the potential performers of each BP activity?; or (ii) what is the potential set of activities each person of an organization can be allocated at run time?
- Regarding run time, resource assignments defined with RAL can be automatically solved during execution to obtain the *real* potential performers of an activity given the specific run-time information. The allocation method then depends on the support provided by the Business Process Management System (BPMS) in which the process is executed.

As explained in [1], RAL can be easily used in conjunction with BPMN 2.0 because it can be directly integrated into it by using the resource assignment mechanisms provided by the standard [4]. Nonetheless, it could also be integrated into other workflow (WF) modelling notations, provided that they offered a flexible way to define resource assignments in a BP model.

Furthermore, RAL can also be used together with RACI matrices to specify resource assignments in a BP model. RACI matrices constitute an alternative for enhancing the management of human resources in an organization, providing detailed information about the degree of involvement of the members of the company in the activities carried out within it [5]. This degree of involvement is specified by means of the so-called RACI roles, which usually are: Responsible (R), Accountable (A), Consulted (C) and Informed (I). This extends the traditional notion of resource assignments in BP models which only defines the resource that is in charge of the activity.

## 2 CRISTAL’s Overview. Demonstration Guideline

CRISTAL is composed of several tools, to be named RACI2BPMN, DT RAL Solver and RT RAL Solver, which facilitate the definition and analysis of resources in BP models. These tools can be used separately or sequentially. Figure 1 provides an overview of the system, in which the tools are represented in rounded rectangles, their inputs and outputs are represented by documents linked with dashed arrows, and the possible interconnection between tools is done by using solid arrows. One possible way to use CRISTAL’s tools is the following.

We can use Oryx [6] or any other process editor supporting BPMN to build a resource-unaware BPMN model, i.e. a process model that does not contain

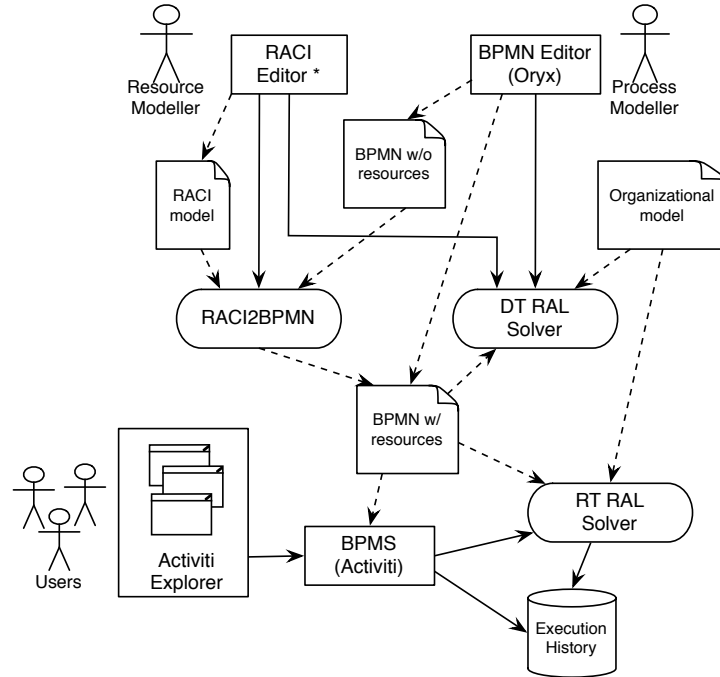


Fig. 1: Overview of CRISTAL

any resource assignments. Then, with CRISTAL’s RACI Editor we can build a RACI matrix with the responsibility assignments we aim to apply to the process activities. In order to generate accurate resource assignments for the process, the RACI matrix may need to be extended with some *binding information*. CRISTAL’s RACI Editor is a Web application that allows the definition of both the RACI matrix and the binding information. It is currently under development.

With these inputs, the RACI2BPMN tool can automatically turn the resource-unaware process model into a RACI-aware BPMN model, i.e. it contains the assignments from the RACI matrix and the binding information. The resource-related information in the model is expressed with RAL. The resulting BP model can be opened in any editor that supports BPMN 2.0 (e.g. Oryx), so both the process model and the resource assignments can be modified as desired.

The next tool to be executed may be DT RAL Solver, which allows us to automatically analyse the RAL expressions associated to the activities of a RAL-aware BP model. Among other operations, this tool automatically calculates the set of potential performers for each activity in the process model. To do so, the tool must receive the OWL description of an organizational model together with the RAL-aware BP model.

Finally, RAL-aware BP models can also be opened in an open-source BPMS called Activiti<sup>1</sup>, in which we have previously integrated the RT RAL Solver tool. The goal of this tool is to automatically solve the RAL expressions at run time. Then, the proper activities are automatically offered to the potential performers resulting from the assignments at run time, to proceed with the allocation of the tasks to specific resources. The execution history is stored in execution logs.

The low-level description of CRISTAL's architecture can be found at [www.isa.us.es/cristal/](http://www.isa.us.es/cristal/).

### 3 Maturity and Significance to the BPM Field

The DT RAL Solver tool was developed in 2011, as a prototype to demonstrate how DL reasoners could be used to automatically solve RAL expressions at design time [2]. Driven by research results, it was then extended to be provided with the proper implementation to solve them considering run-time data as well. In the current version, RT RAL Solver is still a prototype.

The RACI2BPMN tool has been recently developed from research results on how to combine BPs and RACI matrices, given that the resource-related information provided by the matrices is greater than the information that today's BP modelling notations allow to specify [7]. The main features currently provided by CRISTAL are the following:

1. **Automated generation of a BP model with complete information about the RACI roles involved in the BP.** The model can be opened and modified in any modelling tool supporting BPMN, since it is BPMN-compliant. In addition, it is prepared to be directly executed in a BPMS.
2. **Design-time automated resolution of all the RAL expressions defined in [1].** As a result, the potential performers of the activities of a BP model can be automatically inferred from their RAL expressions at design time. The design-time features are available as a plug-in for Oryx [6].
3. **Run-time automated resolution of most of the RAL expressions defined in [1].** Only those assignments related to information coming from data objects of the process are not yet implemented, since the mechanism to access data is ad-hoc to the BPMS in which the process is run, and thus we did not consider this a fundamental feature to include in the prototype. Run-time implementation is delivered as a library for Activiti, a light-weight open-source WF and BPMS.
4. **Flexibility in the organizational model** against which RAL expressions are solved. The only requirement is that the model must comply with the organizational meta model used by RAL [1].
5. **Usability.** In order for module RACI2BPMN to be executed, the user must fill in the RACI matrix, and configure the binding information according to his/her needs. The rest of the procedure is automatic. As for RAL Solver, the use of both the plug-in for Oryx and the code for Activiti is straightforward.

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<sup>1</sup> <http://activiti.org/>

For the former, a few instructions can be found at <http://www.isa.us.es/cristal/>. The latter is totally transparent to the user of the BPMS.

6. **Extensibility capabilities.** More analysis operations over RAL assignments can be easily added by composing operations already implemented by current DL reasoners (e.g. Hermit, or Pellet), as stated in [2].
7. **Re-usability.** The core of the RAL Solver tool (i.e. RAL Analyser) can be used in other platforms, since it provides a simple and well-defined interface.

However, CRISTAL has also some limitations. The efficiency of complex and/or compound resource assignments may not be good enough due to the inference operations the DL reasoner has to perform.

### 3.1 Significance to the BPM Field

CRISTAL offers innovative features with respect to the (human) resource management capabilities provided by current BPM notations and systems.

First, to the best of our knowledge, RACI2BPMN is the first tool focused on the automated introduction of RACI information in a process model, generating RACI-aware BP models that can be executed with no need of changes.

Second, regarding RAL, the RAL Solver tool provides BP modelling languages with a more expressive mechanism to assign resources to tasks. Furthermore, as far as we know, RAL is the first resource assignment language that offers automated analysis capabilities at design time that are built in the language itself. As for run time, it is a fact that most of the BPMSs existing at present have resource assignment mechanisms based basically on assigning users or groups of users (sometimes also roles) to the BP activities (e.g. Activiti, jBPM, Intalio—BPMS). Other tools such as YAWL are more expressive because they are supported by a more powerful organizational meta model. However, YAWL does not rely on a specific language for resource assignments, and uses ad-hoc mechanisms to assign resources and resolve the assignments instead. Therefore, we believe RAL outperforms the current scope, both at design time and at run time.

## 4 Availability

Further information about RAL, the descriptions of the tools, user instructions, and downloadable example files can be found at <http://www.isa.us.es/cristal>. The source code and executable files are available on demand.

## 5 Future Work

CRISTAL can be extended in different directions referring to resource management in BPs. Some future work consists of adding the proper functionality to detect at design time potential allocation problems that can arise at run time,

and which are derived from the control flow of the process, e.g. empty sets of potential performers due to the definition of a Binding of Duties (BoD) constraint between two activities that belong to different branches of an XOR gateway.

Another possible line to extend the tool is about dealing with data together with resources, e.g. to automatically generate Access Control Lists (ACLs) from a resource and data-aware BP model.

The optimization of RAL Analyser is also part of planned work.

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