WORKFLOW ACCESS CONTROL FROM A BUSINESS PERSPECTIVE

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Abstract: Workflow management systems are increasingly being used to support business processes. Methodologies have been proposed in order to derive workflow process definitions from business models. However, these methodologies do not comprise access control aspects.
In this paper we propose an extension to the Work Analysis Refinement Modelling (WARM) methodology, which also enables to determine workflow access control information from the business process model. This is done by identifying useful information from business process models and showing how it can be refined to derive access control information.
Our approach reduces the effort required to define the workflow access control, ensures that authorization rules are directly related to the business and aligns access control with the information system architecture that implements the business process.

1 INTRODUCTION

Business models help us to better understand the actual business and its goals, process (activities), resources (such as people, machines and material) and rules, providing a good basis for identifying the correct requirements of information systems that support the business.

Several approaches (Eriksson & Penker, 2000; Sharp & McDermott, 2002) use business models to determine information systems requirements by identifying system use cases (Bittner et al., 2002) directly from business process models. Although workflow management systems (WfMSs) are increasingly being used to support business processes, this strategy cannot be applied to workflow applications because, that way, important human intervention information captured during business modelling is lost.

In (Vieira & Rito-Silva, 2003), the authors propose the Work Analysis Refinement Modelling (WARM) methodology, a first approach to derive workflow process definitions by using business process models. They introduce an intermediate step between business modelling and system modelling, whose main purpose is to classify process activities as manual activities, accomplished by human workers, or automatic activities, executed by information systems. As a result of this step, they get a lower level description of the business process model (a WARM model), which can be executed by a WfMS. However, the WARM methodology focuses on functional aspects, neglecting non-functional aspects, such as access control. Indeed, we can observe that, while we can find in the literature a good amount of work defining access control models and mechanisms for workflow (Bertino et al., 1999; Casati et al., 1999; Kang et al., 2001; Miller et al., 1999; Botha & Eloff, 2001b; Thomas & Sandhu, 1997; Kandala & Sandhu, 2001; Atluri & Huang, 1996), there is no work on how workflow access control information can be determined from business models.

In this paper we propose a methodology to determine workflow role-based access control information from business process models. We extend the WARM methodology with access control concepts; we identify the information provided by the business process model and by the WARM model that could be useful from an access control perspective and we refine it to derive authorization rules. Additionally, we also show how our methodology can be used to derive authorization rules for the information systems that support the business process.

Our approach reduces the effort required to define the workflow access control, ensures that

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authorization rules are directly related to the business, aligns access control with the information system architecture that implements the business process and guarantees the least privileged principle by ensuring that each role has the needed authorizations to perform its functions and no more.

The remainder of this paper is structured as follows: in the next section we introduce business modelling, emphasizing business process models. The WARM methodology is overviewed in section 3 and our approach to derive workflow access control information from business process models is described in section 4. Considering that the WARM methodology can also be useful to determine use cases of information systems that support business processes, in section 5 we show how their authorization rules can be derived, as well. Section 6 summarizes some implementation issues and, finally, the last section presents some conclusions and provides a brief look of our future work. We illustrate our approach with an example of a loan workflow application.

2 BUSINESS MODELS

A business model is an abstraction of a complex reality that captures the core functions of the business. It provides a simplified view of the business structure that can be used to better understand the key mechanisms of a business, to radically change the business or to identify new business opportunities (Eriksson & Penker, 2000).

In this section we introduce the main concepts of business modelling, emphasizing business process models since they are used as the starting point of the WARM methodology.

Although each business has specific goals and internal structures, they use similar concepts to describe concepts. According to (Eriksson & Penker, 2000), the concepts used to define a business are:

Process: a collection of steps performed within the business during which the state of business resources changes. Processes describe how the work is done within the business and are governed by rules;

Step: a piece of work to be done within the context of a business process;

Goal: the purpose of the business or the outcome the business is trying to achieve. A goal can be broken down in sub-goals and allocated to individual parts of the business;

Event: some happening that triggers the business process execution and that can be generated within the process;

Resource: the objects within the business, such as people, material, information, and products, which are used or produced in the business;

Rule: a statement that either defines or constrains some aspect of the business. Rules govern how the business should be run.

All of these concepts are related to each other: a rule can affect the way some resources are structured; a resource is allocated to a specific process; a goal is associated with the execution of a specific process. The goal of business modelling is to define these concepts and show the relationships and interactions among them. A simplified meta-model describing the concepts used in business modelling and their relationships is shown in Figure1.

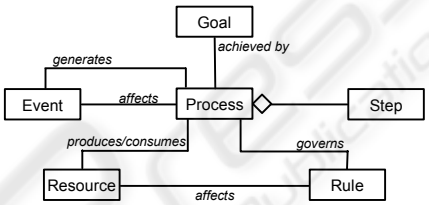

Figure1: A simplified meta-model of business modelling concepts

Business models can be described according to several formats. In this paper we adopt the Eriksson_Penker Business Extensions to Unified Modelling Language (UML) (Eriksson & Penker, 2000). They propose a set of UML extensions to accommodate business concepts. Considering the focus of our work, we concentrate our business model overview on business process models.

Business process models describe the steps performed within the business, their logical flow, and the value created and consumed by each one. Within Eriksson_Penker Business Extensions, they are represented with UML activity diagrams. These extensions define a set of new tagged-values that could contain additional information about the process. One of them is:

Process actors: a textual value that defines the actors needed to run the process. Typically, their skill levels are described.

Additionally, resource objects can be used to define the resources involved in the process. One type of these objects is:

Supplying objects: are used to define who is involved in performing steps, i.e., the resources that participate in the process. These objects are drawn below the process with a dependency (a dashed line) from the object to the process. The dependency is stereotyped to «supply».

Process models can also include swimlanes. Swimlanes are a technique used to insert information about where a specific process or step belongs.

Normally, swimlanes are used to describe where the step is performed in terms of the organization of the business (i.e., in which division or department of the company). Moreover, a swimlane can show objects other than the organization to illustrate which object is responsible for a specific step or process. It could, for example, show which resource is responsible for performing a specific step.

According to the Eriksson_Penker Business Extension, business rules are specified using the Object Constraint Language (OCL).

Figure 2 illustrates a simplified business process model represented with a UML activity diagram, which will be used to exemplify the WARM methodology. Firstly, a clerk receives the loan request and produces a document with the request information. Then, the score is determined and is added to the request information. Based on this information, if the requestor is a bank client, an account manager evaluates the loan and produces an answer; otherwise, this activity is done by a bank manager. Finally, the requestor is informed about the answer. As stated before, using Eriksson_Penker Business Extensions, information about which resources can perform each process step can be shown using different types of techniques. Figure 2 illustrates the use of supply objects to define who is involved in performing steps. This example also illustrates the use of OCL to define constraints on supply objects.

In summary, business process models provide extensive information about steps performed within the business, which can be used to derive low-level workflow process definitions, as shown by (Vieira & Rito-Silva, 2003) and described in the next section. Moreover, they also provide information about who is involved in performing these steps. Although this information is not modelled within a security perspective, we explain in section 0 how it can also be useful to derive workflow access control information.

3 WORK ANALYSIS REFINEMENT MODELLING

The WARM methodology uses business process models to derive workflow process definitions described in a lower level language suitable to be executed by a WfMS. WARM refines business process concepts and creates an intermediate step between business and workflow modelling.

Business process concepts are refined within the WARM methodology in the following way:

Process: a collection of steps performed within the business during which the state of business resources changes. Processes describe how the work is done within the business; they are governed by rules. This definition was inherited from former business modelling concepts.

Step: an activity performed within a business process which may involve the execution of several tasks;

Task: unit of work which cannot be further decomposed;

Human Task: a specific type of task representing the smallest piece of work that may be performed by a human worker without IT support;

Tool Task: a specific type of task representing the smallest piece of work that may be performed by a human worker assisted by a system tool.

System Task: unit of work which cannot be further decomposed. A system task is completely automated by a software system and consequently does not need any kind of human intervention.

Message: type of business resource which represents the information that flows across the entire business process and that is produced and consumed by tasks.

Figure 3 illustrates the WARM concepts meta-model, which extends the business concepts meta-model according to the concepts introduced previously.

To derive workflow process definitions from business process models, the WARM methodology introduces an intermediate step between business modelling and workflow modelling. Incrementally,

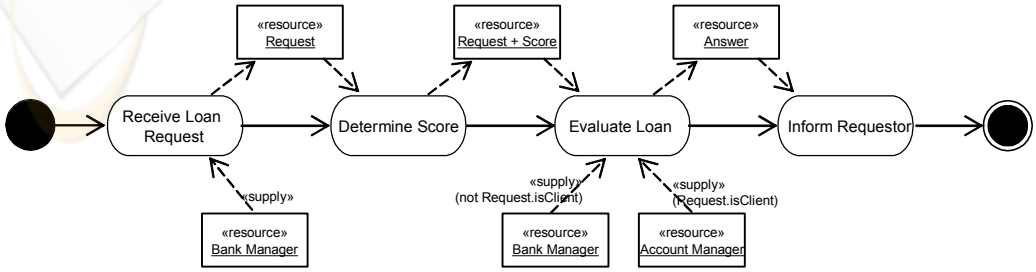

Figure 2: Loan request business process model with supply objects

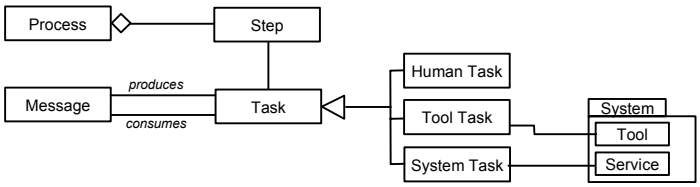

Figure 3: Work analysis refinement modelling meta-model

this intermediate step refines business concepts by supplying additional information to the WARM concepts described above, as follows:

- Steps are decomposed into smaller units of work, named tasks;
- Tasks are classified as human task, tool task or system task.
- Input and output messages are defined as data resources.

In the following, we exemplify the use of the WARM methodology, applying it to the loan request business process model shown in Figure 2.

Within our example, firstly, we decompose each step into tasks. Then we classify the *Determine Score* and the *Inform Requestor* tasks as system tasks, and the others as tool tasks. Finally, input and output messages are defined. At last, we obtain the WARM model presented in Figure 4.

As stated in (Vieira & Rito-Silva, 2003), the lower level model obtained by the WARM methodology is used to generate a workflow process definition, which can be executed by a WfMS.

In the next section we propose an extension to the WARM methodology, which also uses business process model information to derive workflow access control information.

4 WORKFLOW ACCESS CONTROL

In this section we explain how we refine business model process information, through an extension of the WARM methodology, in order to get workflow role-based access control information.

Role based access control models (Sandhu et al., 1996) have been widely applied to both commercial and research workflow systems (Casati et al., 1999) in order to meet workflow access control requirements. The central notion of RBAC models is that permissions are associated with roles rather than individual users. Users are assigned to roles and acquire permissions by being members of roles. The main advantage of the role concept is the simplification of the administration of permissions.

Within WfMSs, permissions are interpreted as authorizations to execute tasks. A typical workflow RBAC authorization rule is represented as a tuple (*r, t, execute, p*) and states that a user *u* playing role *r* can execute task *t* if the predicate *p* holds true (where *p* is optional).

Roles can be defined statically, by enumerating the users that belong to a role, or dynamically, as an expression on user attributes.

Therefore, we need to relate business process model information to workflow authorization rules. To accomplish this, we base our approach on the WARM methodology. Firstly, we extend the WARM methodology with four new concepts, which refine business process concepts, as follows:

User: type of business resource, a human being that can act in the process.

Role: type of business abstract resource, which can be organizational units, human jobs, organizational positions or workflow functions (Botha & Eloff, 2001a). Within workflows, a role associates users to a collection of workflow tasks.

Authorization Rule: type of business rule, which relates a role with a task, stating that a user playing this role can execute this task, if the predicate holds true. Predicates of authorization rules can be defined using the Object Constraints Language (OCL). Predicates can use any of the following attributes:

- Attributes of the system, such as time and location of access;
- Attributes of the user, for instance, his age;
- Attributes of the task, such as execution time;
- Process execution history, i.e., information about tasks already executed, such as the username of the executor; and
- Values of resources used as input data of tasks.

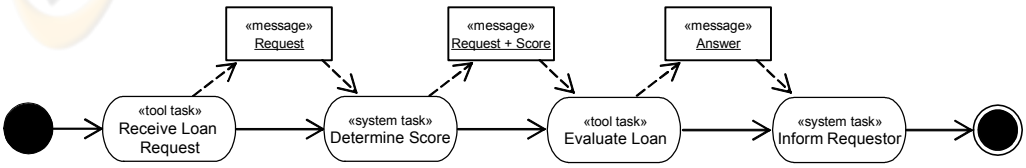

Figure 4: Loan request WARM model

Assignment Rule: type of business rule, which relates users to roles by defining which users can play given roles.

Additionally, we also take into account that system tasks and tool tasks invoke information systems and, within these information systems, invocations might need to be authenticated in order to be authorized. By this way, system tasks and tool tasks can be enriched with information for authentication purposes:

Authentication Info: information used to authenticate (identify) tool tasks or system tasks when they invoke information systems.

Figure 5 represents the WARM meta-model extended with these concepts.

In the following, we explain how we use business process model and WARM model information to derive workflow access control information.

To define authorization rules, firstly we identify the tasks that need these rules: human and tool tasks. Both these type of tasks are performed by human workers, which have to own the needed authorizations so they can perform them.

Then, we have to identify the roles that can perform each of these tasks. In business process models, swimlanes and supplying objects can be used to define resources that are responsible for performing steps. So, we analyse swimlanes and supplying objects to identify if they are being used with this semantic and we use them to derive roles and, consequently, authorization rules by mapping steps into their corresponding refined WARM tasks.

Additionally, business rules can also provide information about who can perform steps. This information is also analysed to identify and refine authorization rules.

According to the type of roles we identify (organizational units, humans job, organizational positions or workflow functions), we derive role assignment rules. To derive these rules we also use descriptions of actor skill levels that we can find in the tagged-value process actor.

Finally, we define authentication information for tool tasks and system tasks. It includes:

- User identification,
- Information to authenticate the user (for instance, a password or a certificate), and
- Information about the roles the user will assume when the information system will be invoked (optional).

The user, whose identification is used to invoke the information system, can be:

- The workflow, or
- A workflow user (for instance, considering a tool task, the workflow user that is performing it).

Considering our illustrative example, we define authorization rules for both WARM tool tasks: *Receive Loan Request* and *Evaluate Loan*. Analysing the process model presented by Figure 2, we determine three roles: *Clerk*, *Bank Manager* and *Account Manager*. As we can see in this figure, *Clerk* can perform the step *Receive Loan Request*, which is refined on the tool task *Receive Loan Request*, using the WARM methodology. A similar mapping can be done for the other step.

To exemplify how we can define authentication information, we suppose that the system task *Inform Requestor* invokes a tool of the *Mail Information System*, which implements user-based access control. On the other hand, the system task *Determine Score* and the tool tasks invoke tools of the *Evaluate Loan Information System*, which implements role-based access control.

Therefore, within the loan workflow application, the authentication information can be defined as follows:

- Tool tasks invoke information system tools using the identification of the users that are performing them and their corresponding roles;
- The system task *Determine Score* invokes an information system tool using a specific user identification (*LoanWfApp*) and assuming the role *ScoreCalculator*; and
- The system task *Inform Requestor* also invokes an information system tools using a specific user identification (*LoanWfApp*).

In Figure 6 we present the loan request WARM model extended with role information (information about which roles can perform WARM tasks) and authentication information, which is showed between parentheses.

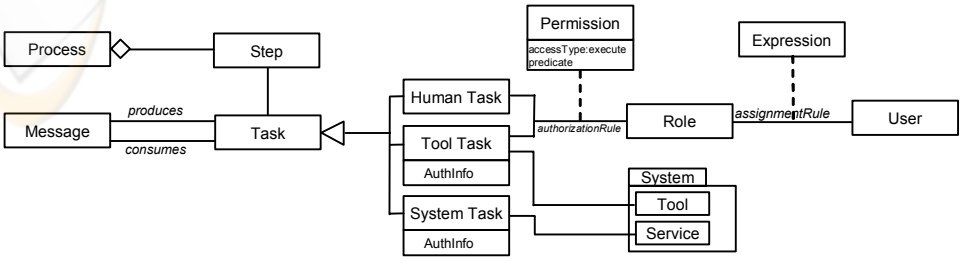

Figure 5: WARM meta-model extended with access control concepts

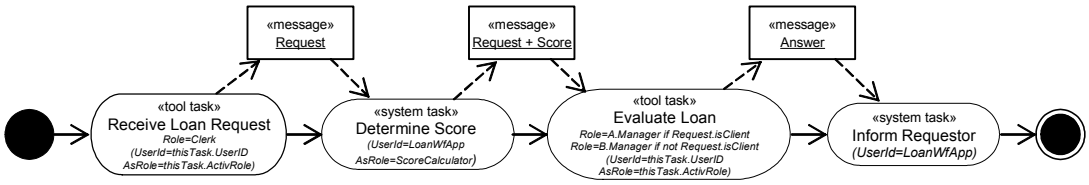

Figure 6: Loan request extended WARM model

Considering this information, we generate the following workflow authorization rules:

(Clerk, Receive Loan Request, execute)
(Account Manager, Evaluate Loan, execute, Request.isClient)
(Bank Manager, Evaluate Loan, execute, not Request.isClient)

Figure 7: Loan request workflow authorization rules

As we explain in the next section, authentication information can be used to derive authorization rules for information system.

Within this approach, we show how business process model information can be used to derive workflow authorization rules and we guarantee that all roles have their needed authorizations so they can perform their tasks and no more than their tasks.

5 USE CASES

As we show in the previous section, our WARM methodology extension can be used to derive authorization rules for workflow tasks (tool and human). Additionally, considering that the WARM methodology can also be used to find system use cases, we explain how authorization rules for information systems that implement these use cases can be generated, as well.

Indeed, in (Vieira & Rito-Silva, 2003), the authors also explain how WARM models can be used to find system use cases of the components that will implement the work logic of the business process. The classification of tasks as human, tool and system tasks enables the system modeller to clearly distinguish in the WARM model different kinds of system use cases: purely human tasks, tool use cases and system services use cases.

Regarding human tasks, they represent tasks that are performed by human workers without any information system support. Therefore, they do not have any link to system use cases and they are mapped into the WfMS architecture as work items.

Tool use cases are identified in the WARM model as tool tasks, which represent pieces of work to be performed by humans assisted by a system tool, while system services use cases are identified in the WARM model as system service tasks and represent functionality required to an information system.

The actors of tool use cases and system services use cases are determined using the authentication information defined in their corresponding tasks. If tasks include information about the roles the user will assume when the information system will be invoked, this role information is used to derive the use case actors, as exemplified in Figure 8. Within this picture, we point out that use case *Evaluate Loan* can be done by one of the roles: *Bank Manager* or *Account Manager*.

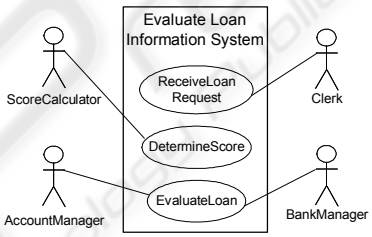

Figure 8: Three use cases of evaluate loan information system

Otherwise, if tasks do not include role information, the user identification is used to derive use case actors, as illustrated in Figure 9.

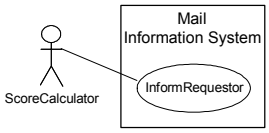

Figure 9: Inform requestor use case diagram

Based on the method proposed in (Fernandez & Hawkins, 1997), we can determine the needed authorizations for the information systems that support business process from the use cases that we obtain using the WARM methodology.

Considering our illustrative example, we derive the following role based authorization rules for the *Evaluate Loan Information System*:

(Clerk, Receive Loan Request, execute)
(ScoreCalculator, Determine Score, execute)
(Account Manager, Evaluate Loan, execute)
(Bank Manager, Evaluate Loan, execute)

Figure 10: Authorization rules for the evaluate loan information system

Additionally, considering that the *Mail Information System* uses a user-based access control

model, we derive the following authorization rule for it:

(LoanWfApp, Inform Requestor, execute)

Figure 11: Authorization rules for the mail information system

In summary, with our approach, we show how business process model information can be used to derive not only workflow authorization rules but also authorization rules of information systems that support the business, while ensuring that all roles have their needed authorizations so they can perform their work, and no more. Additionally, we point out that, during the workflow execution, the workflow assumes different roles according to the task that it is executing.

6 ENFORCING WORKFLOW ACCESS CONTROL

The Workflow with Separation of Concerns (WorkSCo) project is being developed based on the new workflow architecture presented in (Manolescu, 2001) designated by micro-workflow. The WorkSCo framework was developed using techniques specific to object systems and compositional software reuse. It targets software developers and provides the type of workflow functionality necessary in object-oriented applications. WorkSCo has a lightweight kernel that provides basic workflow functionalities and offers advanced workflow features as components that can be added to the kernel. Software developers select the features they need and add the corresponding components to the kernel through composition.

Access control information is added to the core classes using the property pattern (Foote & Yoder, 1998) and authorizations are saved using access control lists mechanism. This access control information is generated by the described WARM extension methodology and saved in two access control files using the eXtensible Markup Language (XML). One file saves roles definitions, while authorizations rules are saved in another one. Figure 12 presents, in XML, the workflow authorization rules generated within our request loan illustrative example.

```
<ACWorkflowPolicy>
  <ACWorkflowActPolicy ActivityID="ReceiveLoanRequest">
      <ACRule>
          <Operations>execute</Operations>
          <Roles>Clerk</Roles>
      </ACRule>
  </ACWorkflowActivityPolicy>
  <ACWorkflowActivityPolicy ActivityID="EvaluateLoan">
      <ACRule>
          <Operations>execute</Operations>
          <Roles>AccountManager</Roles>
          <Constraint>request.isClient</Constraint>
      </ACRule>
      <ACRule>
          <Operations>execute</Operations>
          <Roles>BankManager</Roles>
          <Constraint>not request.isClient</Constraint>
      </ACRule>
  </ACWorkflowActPolicy>
</ACWorkflowPolicy>
```

Figure 12: Workflow authorization rules

7 RELATED WORK

In (Fernandez and Hawkins, 1997), the authors propose a method to determine the needed authorizations for roles in a system by considering use cases and sequences of use cases. They extend use cases using security stereotypes to indicate access constraints. Since use cases represents all the possible functions of the system, with this approach we can determine all the needed role authorizations by considering the methods that need to be invoked by corresponding actors. This approach cannot fulfil all workflow access control requirements, since, for instance, use cases do not represent workflow human intervention. Moreover, our methodology takes a step forward by ensuring that access control information is directly related to the business.

Transaction based business process models are used by Holbein et al. (Holbein et al., 1996a; Holbein et al., 1996b) to derive role based access control for workflow data, i.e., information exchanged during the process execution. Their approach has been used in the MobiMed project (Nitsche et al., 1998), which aims to provide access control to data in a clinical environment. However, their work focuses on workflow data access control while we approach the workflow service perspective.

8 CONCLUSIONS AND FUTURE WORK

WfMSs are increasingly being used to support business process. Considering that business models provide a good understand of the business and, consequently, a good basis to identify information system requirements correctly, the WARM methodology shows how they can be used to derive low level workflow process definitions. However, this methodology restricts its applicability to functional aspects.

In this paper we extend the WARM

methodology to derive workflow access control information from business process models. Additionally, we show how this methodology can also be used to derive authorization rules for information systems that support the business.

Our approach reduces the effort required to define the workflow access control because it can be derived from business process and WARM models, which are not developed, but only used with access control purposes. Therefore, we ensure that workflow authorization rules are directly related to the business, instead of being added to the workflow as an afterthought based on the application perspective. Similarly, authorization rules for information systems that implement business process are related to the workflow process definition and, consequently, to the business. Finally, our approach also guarantees the least privileged principle by ensuring that each role has the needed authorizations to perform its functions and no more.

We are evaluating and developing a prototype implementation of our methodology in the context of the COMBINE (COMponent-Based Interoperable Enterprise system development) project funded by the V Framework IST-1999-20893, where it is being tested in more real situations.

REFERENCES

Atluri, V., & Huang, W. (1996). An authorization Model for workflows. In Proceedings of the 5th European symposium on research in computer security. Rome, Italy, pp 44-64.

Bertino, E., Ferrari. E., & Atluri, V. (1999). The specification and enforcement of authorization constraint in workflow management systems. ACM Transactions on Information and System Security, vol. 2, nº1, pp. 65-104.

Bittner, K., Spence, I., & Jacobson, I. (2002). Use Case Modeling. Addison Wesley Professional.

Botha, R.A., & Eloff, J.H.P. (2001a). Designing Role Hierarchies for Access Control In Workflow Systems. In Proceedings of the 25th Annual International Computer Software and Applications Conference (COMPSAC'01), Chicago, Illinois.

Botha, R.A., & Eloff, J.H.P. (2001b). Separation of Duties for Access Control in Workflow Environments. IBM Systems Journal. vol. 40, no. 3, pp. 666-682.

Casati, F., Castano, S. & Fugini, M. (1999). Managing Workflow Authorization Constraints through Active Database Technology. Information Systems Frontiers, 3, 3.

Eriksson, H., & Penker, M. (2000). Business Modeling with UML, Business Patterns at Work. John Wiley & Sons.

Fernandez, E.B., & Hawkins, J.C. (November 1997). Determining role rights from use cases. In Proceedings of the 2nd ACM Workshop on Role-Based Access Control, pp. 121-125.

Foote, B., & Yoder, J. (August 1998). Metadata and Active Objects-Models. In Proceedings of the Fifth Conference on Pattern Languages of Programs (PLOP 98). Illinois, USA.

Holbein, R., Teufel, S., & Bauknecht, K. (1996a). A Formal Security Design Approach for Information Exchange in Organisations. In proceedings of the 9th annual IFIP TC11 WG11.3 working conference on Database security IX : status and prospects. 267-285.

Holbein, R., Teufel, S., & Bauknecht, K. (1996b). The use of business process models for security design in organisations. In Proceedings of 20th International Conference on Information Security (IFIP SEC96 TC 11), Samos, Greece, Chapman & Hall, London, UK, 13-22.

Hollingsworth, D. (1995). The Workflow Reference Model. Document Number TC-00-1003. Issue 1.1.

Kandala, S., & Sandhu, R. (2001). Secure Role-Based Workflow Models. In Proceedings of the 15th Annual IFIP WG 11.3. Canada.

Kang, M., Park, J. & Froscher, J. (2001). Access Control Mechanisms for Inter-Organizational Workflow. In Proceedings of the 6th ACM Symposium on Access Control Models and Technologies, Chantilly, VA, 66–74.

Manolescu, D. (2001). Micro-workflow: a workflow architecture supporting compositional object-oriented software development. PhD Thesis. University of Illinois at Urbana-Champaign.

Miller, J., Fan, M., Wu, S., Arpinar, I., Sheth, A. & Kochut, K. (1999). Security for the METEOR Workflow Management System. Technical Report #UGA-CS-LSDIS-TR-99-010, University of Georgia, 33 pages.

Nitsche, U., Holbein, R., Morger, O., & Teufel, S. (1998). Realization of a Context-Dependent Access Control Mechanism on a Commercial Platform. In Proceedings of the 14th Int. Information Security Conf. IFIP/Sec'98, part of the 15th IFIP World Computer Congress, pp 160-170.

Sandhu, R., Coyne, E., Feinstein, H. & Youman, C. (1996). 'Role-Based Access Control Models'. IEEE Computer, vol. 29, no. 2.

Sharp, A., & McDermott, P. (2002). Workflow Modeling: Tools for Process Improvement and Application Development. Artech House.

Thomas, R., & Sandhu, R. (1997). Task-based Authorization Controls (TBAC): A Family of Models for Active and Enterprise-oriented Authorization Management. In proceedings of the IFIP WG11.3 Workshop on Database Security, Lake Tahoe, California.

Vieira, P., & Rito-Silva, A. (2003). Work Analysis Refinement Modeling. INESC-ID Technical Report.