# Organization, Information System and Distribution Modeling: An Integrated Approach

António Rito Silva[‡], Teresa Gonçalves[‡], Francisco Rosa[‡],
Arne-Jørgen Berre[§] *and* Jan Øyvind Aagedal[§]
[‡]*INESC/IST Technical University of Lisbon, Alves Redol nº 9, 1000 Lisboa, Portugal*
*{ars | tsg | fjar}@scallabis.inesc.pt*
[§]*SINTEF Telecom and Informatics, P.O.Box 124, Blindern, N-0314 Oslo, Norway*
*{Arne-Jorgen.Berre | Jan-Oyvind.Aagedal}@informatics.sintef.no*

## Abstract

*This paper introduces an object-oriented approach to the integrated modeling of Organizations, and their Information Systems in a Distributed context. The approach is based on the OOram role modeling methodology concepts and tool. In the proposed approach organization modeling is done at the enterprise level of abstraction and both reverse and forward engineering are consistently supported. Distribution is modeled, at both the organization and information system levels of abstraction, in an integrated way. Traceability is supported between all models.*

## 1. Introduction

Perceiving organizations in terms of their information systems is a common attitude. The information systems specification gives a partial description of the organization, which integrated with other such descriptions, is held to be the organization model. Using the information systems level of abstraction for perceiving organizations has been proven to be unsuitable to meet the new challenges faced by organizations: improvement and change in order to constantly adapt to new environment requirements. This approach does not offer a global view of organizations where changes can easily be applied. Thus, an approach at the organization level of abstraction is required. The information systems specification is the result and not the cause of the organization model. The organization model, defined independently of the information systems, permits a description of the organization, where management requests apply using the correct level of abstraction. Moreover, the organization model is the reference when integrating other information systems in the organization.

The design of information systems can take advantage of an organizational perspective. Once the organization model has been defined, new information systems should be modeled and integrated with it. However, integrating organizational models with information systems models brings the issue of models traceability. How are the concepts and entities of both models related? An approach to organization and information system modeling should present solutions to the traceability issue.

Organizations are intrinsically distributed, either structurally, defining departments with well established boundaries, or geographically, resulting from the geographic separation of people and services. So, an organization model must capture its distribution characteristics. Moreover, distribution is a key aspect of information systems modeling, distribution issues like partitioning, concurrency and failure have a large impact on information systems design and should be captured by information systems models. Distribution should be modeled and integrated with organization and information systems models such that these models are traceable.

Organization modeling can be either based on business roles or on business activities. Business roles define the responsibilities played by people inside the organization and the organization model describes how business roles interact and cooperate to fulfill organization goals. Business activities define the basic activities accomplished in the organization and the organization model describes how these activities should be carried to fulfill organization goals. Both perspectives are necessary, the former should be applied whenever an existing organization needs to be modeled (reverse engineering), while the latter ignores any organizational structure and focus on the organizational “chain values” (forward engineering). Any approach to organization modeling should support both perspectives.

From the above requirements it is clear that organization, information system and distribution modeling deal with different types of models, a large amount of information and require a consistent support on traceability. So, a tool with these characteristics should be used.

In this paper it is introduced a versatile object-oriented approach to the integration of organization, information system and distribution modeling, that is supported by a tool.

The rest of this paper is structured as follows. Section 2 describes the DASCo approach to distribution modeling. Section 3 describes the OOram concepts and tool that are used in the models construction and support. Section 4 describes the approach and illustrates it using an example. Section 5 discusses the advantages of the proposed approach while section 6 contains related work. Finally, in section 7 conclusions are presented.

## 2. DASCo Approach

DASCo is an approach to the development of distributed applications with separation of concerns (DASCo) initially described in [1].

DASCo approach distinguishes the problem space from the solution space in the lines of [2][3][4]. The entities at the problem space do not necessarily directly map to entities at the solution space, some kind of transformation is required. This distinction is extremely useful for distributed applications because the perception of the distributed application does not directly map to entities and constructs at the solution space. For instance, to be closer to the user's language the problem space description may use a declarative language instead of a procedural language.

Three levels of abstraction are considered by DASCo: model, policy and mechanism. Models describe users' expectations about the application or system behavior, e.g. the users expects his/her requests to be executed in isolation. Policies define algorithms to support application models, e.g. a pessimistic policy of concurrency control provides isolation of invocations to a resource. Mechanisms define functionality which is used by policies to implement their algorithms, e.g. a mutex is used to delay invocations to the resource.

Models specification is done at the problem space while policies and mechanisms are part of the solution space.

DASCo approach considers separation of concerns at both the problem and solution spaces. Separation of concerns, considered a key technique of software engineering [4], allow a “divide and conquer” strategy to development. Naturally, different kinds of concerns are considered for problem and solution spaces.

This paper emphasizes DASCo approach to distribution modeling at the problem space when modeling organizations and their information systems. So, distribution modeling will capture the user expectations about distribution from both organization and information system levels of abstraction.

At the problem space DASCo considers the following three concerns: partitioning, concurrency and failure:

- **Partitioning**. Partitioning is the problem of application functionality and structure separation across the network.
- **Concurrency**. Concurrency problem deals with the interaction and cooperation between different activities of the distributed application.
- **Failure**. The distributed application robustness is dealt by the failure concern.

The problem concerns have their own models and specification languages. For instance, sequential centralized systems offer a set of traditional models, called strict models, where activities and data are isolated. In these models users expect system reactions considering only his/her own inputs. From the user's point of view the model is the transparency of partitioning, concurrency and failures. However, developers are requesting particular non-strict models for computer supported cooperative work (CSCW) [5] where the user is aware, according to some criteria, of partitioning, concurrency and failure.

## 3. OOram Concepts and Tool

Object-Oriented Role Analysis and Modeling (Ooram) [6] is an object-oriented methodology first developed at SINTEF/Taskon and later refined and supported by tools [7] by Taskon.

The role model is the basic abstraction in OOram. It is an object-oriented model of an object structure and represents *a bounded part* of an interesting phenomena. One object might play many roles in its overall structure of collaborating objects, the role represents a part of the responsibility of an object. There are several different views from which one can study the role model. Each view is expressing certain aspects of the model, suppressing others which are not important in the context. Only a small subset of OOram views are used in this paper:

1. *Area of concern view*: A textual description of the phenomenon modeled by the role model.
2. *Semantic view*: A description of the meaning we attach to the roles and the associations between them.
3. *Scenario view*: A description of a specific, time ordered sequence of interaction between roles.

Role model synthesis is fundamental for the use of role models. This is done by the combination of multiple role models. Role models facilitate a separation of concern when doing analysis, supporting a focus on the fundamental roles instead of objects. This gives a better basis for reuse and flexible configuration, than the normal focus on objects. There are several objectives of synthesis:

- *Composition*. Composite role models are made through synthesis from multiple role models. Each of the role models focuses on one area of concern, and the creation of the composite model by synthesis is easier than focusing on the problem as one whole.
- *Level of Abstraction*. Synthesis can also be used to accommodate different abstraction levels. A role may be modeled into greater detail in a role model focusing on the one role only and creating a more detailed role model for that role.

The role models resulting from synthesis are called derived role models while the role models that are being composed are called base role models. Inverse synthesis is the process that constructs a base role model from a derived role model.

The OOram notation will be introduced as needed by the examples.

# 4. An Integrated Approach

This approach is based on the development of four types of models: Business, Organization, Distribution and Information System. The Business model is the initial model with the basic building blocks that are used in the construction of Organization, Distribution and Information System models.

The Business model describes business processes in terms of activities and manipulated objects independently of any organizational structure. The Organizational model describes business processes in terms of business roles and its interactions by mapping the previously identified activities with a specific enterprise organizational structure. The Distribution model describes the impact of distribution on the business processes. Information from the previous models may be used on this model development. The Information System model identifies tools for the support of identified activities and servers for the identified business objects along with its interactions.

For illustration purposes we will use the Travel Expense example from [6]. This example deals with the traveling process that begins with the request of travel authorization performed by an employee wanting to travel, followed by its correspondent authorization, the ticket acquisition, the request for travel expenses reimbursement and ends with the expenses payment.

## 4.1 Business Modeling

*Business Process Models* describe the business processes and the business objects they access and update. Fundamental for this description are the concepts of:

- *use case* - represents the responsibilities and externally visible actions between the system under discussion and its external actors
- *business process* - represents a set of activities coordinated to achieve a common perspective, constituting a "chain value" of the enterprise.
- *activity* - represents a logical step or piece of work from which processes are built.
- *business object* - represent data structures upon which activities operate.

Use cases are described informally, the external actors are identified and the stimulus'/responses described. Each business process is treated by OOram as a separate area of concern. The concept of activity is modeled as an OOram role and constitutes the basic building block for the definition of business processes. Business objects are modeled as OOram roles in separate role models.

Each business process is started by an external stimulus from a primary actor and it is described in terms of activities, related business policies and business objects being used in and exchanged between activities.

In the Travel Expense example we will focus on the following Area of Concern (AoC):

- *Travel authorization and reimbursement AoC* - deals with the travel permission request and travel expenses reimbursement.

For this AoC the stimulus is the message sent from the primary actor Traveler to the system requesting a travel authorization. The response from the system is the travel expenses reimbursement.

For this AoC the following activities were identified: *Request Travel Authorization, Evaluate Travel Request, Acknowledge Travel Authorization, Request Expense Payment, Check Travel Authorization, Evaluate Expense Report, Update Expense, Pay Expense*.

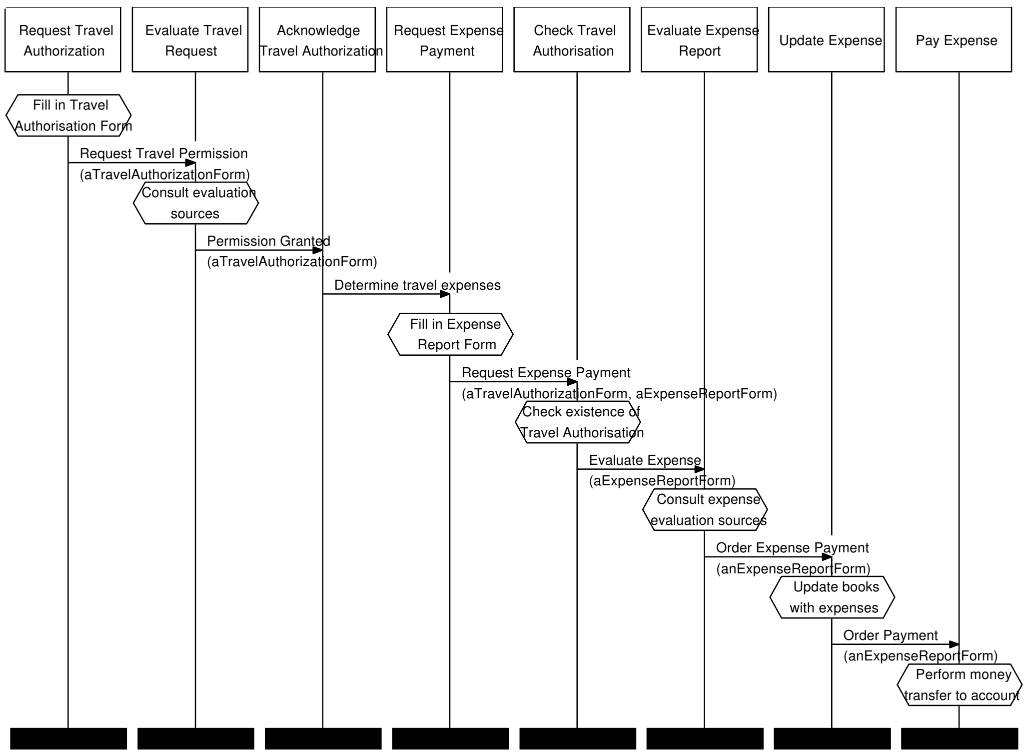


**Figure 1:Travel Authorization/Reimbursement Scenario View**

Figure 1 describes the business process for this AoC in terms of its activities using the OOram scenario view.

In the scenario view the rectangular boxes represent OOram roles, arrows between roles represent messages exchanges where from top to bottom a sequential order is established between messages, ellipsoidal boxes at columns represent actions taken in response to messages.

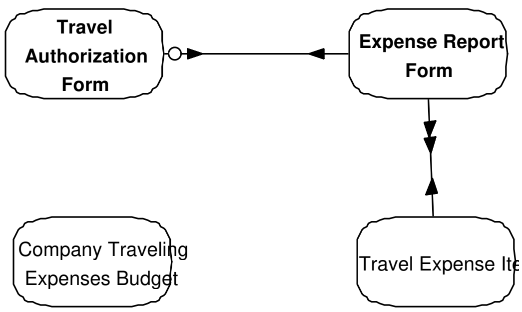


**Figure 2:Travel Authorization / Reimbursement Business Objects**

From this process description some business objects were identified as objects manipulated by the identified activities. Figure 2 shows the business objects identified for this AoC.

In the semantic view the rounded boxes represent OOram roles, lines between roles represent relationships between roles. Multiplicity in role relationship can be represented. A single arrow represents a one relationship, a double arrow represents a many relationship and an empty circle represents an optional relationship.

## 4.2 Organization Modeling

*Organization models* describe the business processes in the context of a particular organizational structure. Fundamental for this description is the concept of business role as a collection of attributes, qualifications and/or skills that can be assumed and performed by an organizational actor for the purpose of achieving an organizational objective.

The organizational structure can be defined by first identifying the existing business roles and by synthesizing this set of business roles with the business activities defined in the Business Modeling. The activities are mapped to their “rightful owner”. A business process, described in terms of activities, can be synthesized with different organizational structures.

For the Travel Authorization/Reimbursement AoC the following business roles were identified: *Traveler, Authorizer, Bookkeeper* and *Paymaster*.

Table A presents a possible mapping between the identified business roles and activities that is used in the synthesis:

| Activities | Business Role |
|---|---|
| Request Travel Authorization | Traveler |
| Evaluate Travel Request | Authorizer |
| Acknowledge Travel Authorization | Traveler |
| Request Expense Payment | Traveler |
| Check Travel Authorization | Authorizer |
| Evaluate Expense Report | Authorizer |
| Update Expense | Bookkeeper |
| Pay Expense | Paymaster |

**Table A: Mapping between business objects and activities**

According to the identified mapping, the interactions between the business roles can be identified. Figure 3 shows the process as seen from the organization viewpoint using the OOram scenario view after synthesizing the activities into the business roles:

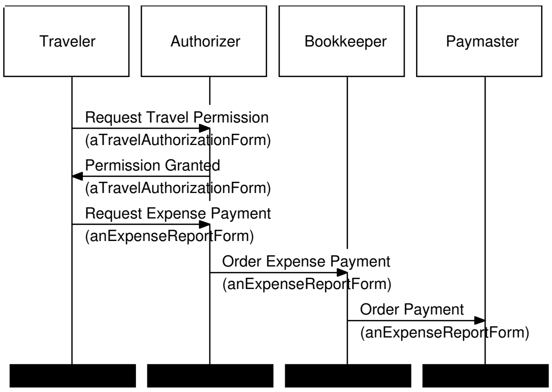


**Figure 3:Travel Authorization / Re-imbursement organization Scenario view**

Note that some of the messages in Figure 1 are now internal to the roles and do not appear in the scenario.

### 4.3 Distribution Modeling

*Distribution models* describe the impact of distribution issues in the business processes. It corresponds to DASCo models for distribution concerns at the problem space: partitioning, concurrency and failure.

DASCo considers two kinds of distribution requirements: explicit and implicit. The former are perceived by the user as associated with distribution while the latter have no direct correspondence with distribution. However, distribution consequences may be deducible from the latter.

For instance, organization structure and geographic deployment are explicit distribution requirements of partitioning while an implicit distribution requirement of partitioning would be the availability degree of a document, which may result on the use of a replication policy for the document.

Concerning business processes, a mapping between Business Roles and the identified units of distribution can be performed. Business roles can be synthesized onto the distribution units.

Distribution requirements, explicit and explicit, guide the identification of distribution units. So, distribution units are a consequence of the domain knowledge contained in requirements.

The OOram inverse synthesis is used to place business objects in the distribution units. The choice of which business objects should be placed in each unit is based on the business role/distribution unit mapping. If a business object is manipulated by a business role located in a distribution unit then this business object should be placed on this distribution unit.

From these models, distribution issues such as business objects replication and sharing are perceived and specified.

In the Travel Authorization/Reimbursement AoC three distribution units could be identified: Administrative Dept. unit, Financial Dept. Unit and Traveler unit. They are the explicit distribution requirements of partitioning driven by the organization structure.

Table B presents a possible mapping between the identified business roles and the distribution units:

| Administrative Dept. Unit | Financial Dept. Unit | Traveler Unit |
|---|---|---|
| | | Traveler |
| Authorizer | | |
| | Bookkeeper | |
| | Paymaster | |

**Table B: Placing of business roles into units of distribution**

According to the identified mapping, and using synthesis, the interactions between the distribution units can be identified. Figure 4 shows the process as seen from the distribution viewpoint using the OOram scenario view:

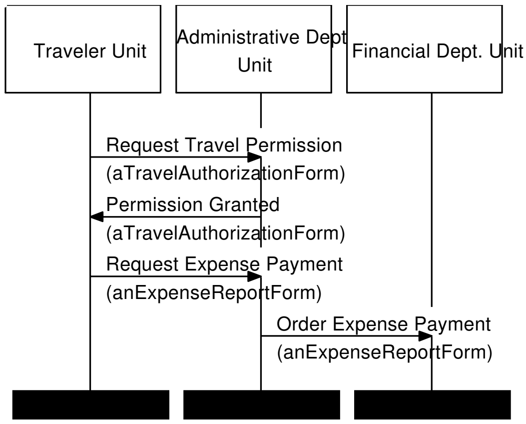


**Figure 4:Travel Authorization / Re-imbursement distribution Scenario View**

The previously identified business objects should then be placed onto the three units of distribution. Table C shows the placing of business objects:

| Administrative Dept. Unit | Financial Dept. Unit | Traveler Unit |
|---|---|---|
| Travel Authorization Form | | Travel Authorization Form |
| Expense Report Form | Expense Report Form | Expense Report Form |
| Travel Expense Item | Travel Expense Item | Travel Expense Item |
| | Company Traveling Expenses Budget | |

**Table C: Placing of business objects into units of distribution**

Other distribution requirements may be considered in the example:

- The Traveler Unit can always check the status of the business process, by observing the business objects in its unit, even if it does not get up-to-date information. This an implicit partitioning requirement because it may imply the replication of business objects according to some consistency criteria.
- Administrative and Financial Units always get the same information about the process status but it can be the case that the information is not available. This is an implicit concurrency requirement because it requires that accesses to objects in both units should be synchronized to support their isolation, and it also is an explicit failure requirement because the user is aware of system failure, the data is not available, such that a robustness criteria should be specified.

## 4.4 Information System Modeling

Information System Models describe a set of *tool and server models* that define the information system objects and its distribution requirements.

Two kind of tools can be identified: tools giving support for business roles and tools giving support for selected activities. While the former will provide roles interfaces, the latter will provide process activities interaction and cooperation.

Servers are identified by grouping of business objects. This way business processes at the Business Modeling are refined in terms of tool and server objects.

The process for the construction of information system models is the following:

- Identify user tools that can support the work of each business role. This user tools identification can proceed from the Organization Model which identified business roles and its corresponding activities.
- Identify activity tools that can support groupings of process activities according to their cohesiveness. This activity tools identification can proceed from the Business Model which identified activities.
- Identify business object servers for business objects and relevant computational services. Business objects are grouped according to the distribution requirements of partitioning and its semantic connection.
- Enrich the tool and server roles with the refinement of distribution requirements from the Distribution Model.

All these specified tools and servers models are then combined into the Information System model and collaboration diagrams identifying the interactions between them, using typical scenario diagrams, are developed.

In the example we can identify the following user tool roles:

- *Form Filling user tool*, supporting the Traveler business role work. This tool will provide the interface needed for the Travel Authorization and Expense Report Form filling.
- *Authorization user tool*, supporting the Authorizer business role work. This tool will provide the interface needed for consulting the information relevant to the authorization decisions and for issuing those decisions.
- *Accounting user tool*, supporting the Bookkeeper business role work. This tool will provide the interface needed for the bookkeeping activities.

- *Payment Issue user tool*, supporting the Paymaster business role work. This tool will provide the interface needed for the payment activities.

In the example we can identify the following activity tool roles which have a cohesion resulting from the data they manipulate:

- *Travel Authorization tool*, supporting all the activities concerning travel authorizations.
- *Travel Expense tool*, supporting all the activities concerning travel expenses.

In the example we can identify the following server roles driven by the organization partitioning:

- *Administrative Server*, contains administrative business objects including Travel Authorization Form, Expense Report Form and Travel Expense Item business objects.
- *Financial Server*, contains financial business objects including Company Traveling Expenses Budget.

Distribution requirements in the Distribution Model determine the distributed architecture and have impact on the tools and server modeling:

- The separation between Administrative Server and Financial Server is determined by the explicit organization partitioning.
- The Form Filling user tool may have replicas of business objects in order to satisfy availability distribution requirement associated with the Travel Unit. Moreover, replicas can be out of date according to a consistency criteria.
- The distribution requirements associated with Administrative and Financial Units are refined in the tools used by these Units which access the Administrative Server. These tools always get the same information from the server whether the final implementation uses a replication policy or not.

Note that Business object servers define a logical data base design which is independent of particular phsysical implementation, e.g. relational data base.

## 5. Discussion

Figure 5 shows the relationships between the different models.

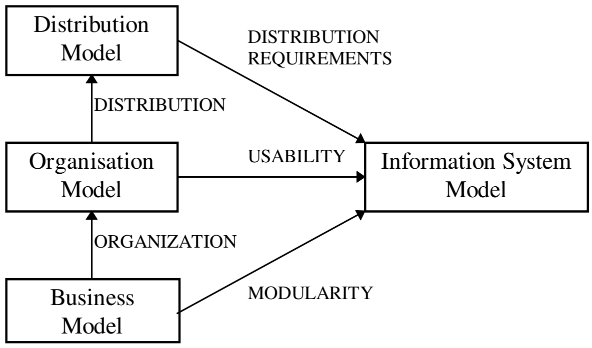


**Figure 5: The Overall Approach**

Organization issues determine the construction of the organization model from the business model while the distribution model is constructed from organization model considering the distribution concerns: partitioning, concurrency and failure.

The information system model specifies the requirements (problem space) that any implementation (solution space) should conform to. The definition of activity tools from the business models is driven by the modularity issues, where activities are associated according to their cohesiveness. The definition of user tools are driven by usability from an organization perspective. Finally, the server tools may be determined by organizational partitioning. Other distribution requirements are refined in the tools and servers of the information system model.

The proposed approach describes a set of models, a process and the use of a tool that answer the problems in section 1:

- *Modeling of business processes.* The specification of business processes in terms of activities constitutes an Ideal Model [8], which is orthogonal to organization and distribution structure. This model describes a "chain value" of the enterprise.
- *Modeling at the organization level of abstraction.* The organization model is independent of information system models. Moreover, several organization structures may be evaluated using synthesis from the business models.
- *Support of both reverse and forward engineering.* A forward engineering activity occurs whenever the organization model is constructed from the business model using synthesis. The approach also allows reverse engineering by creating the business model from the organization model by using inverse synthesis.
- *Modeling of distribution.* An enterprise distribution architecture is defined. This

architecture captures the distribution requirements which are explicit. Explicit distribution requirements are explicitly perceived by the user as associated with distribution. Implicit distribution requirements are also captured, e.g. associated with shared business objects. Refinement of distribution requirements in the information system model facilitates future decisions on distribution implementation.

- *Information system modeling from an organization perspective*. The construction of information system models is driven by the other three models. Information systems modeling conforms to the organization requirements and not the other way round.
- *Models traceability*. There is a clear traceability between the constructed models. Synthesis mechanism is used in the construction of all models except information system models. However, even if not supported by the tool the mapping of concepts between the models is clearly defined.

## 6. Related work

In [8] is described an approach for organization modeling. It considers both reverse engineering and forward engineering modeling. Reverse engineering modeling describes an existing organization while forward engineering describes an ideal model of the business and maps it afterwards in a organization structure. Our approach also focus on the definition of information system requirements from the organization model. The proposed approach supports both forward and reverse engineering using, respectively, synthesis and inverse synthesis between business and organization models.

OOram [6] also addresses organization modeling. It considers three models: enterprise, information and task/tool/service. The enterprise model describes how people work and interact to achieve a given goal. The information model describes the subject of the work detailed in the enterprise model. The task/tool/service models describes the tasks and the interfaces between the people and the information model. Our organization model is equivalent to OOram enterprise model, business model contains the business objects described in the OOram information model, and the information system model specifies the task/tool/service of OOram.

The ISO reference model for distributed processing ISO RM-ODP [9] describes an architecture which is based on five viewpoints: enterprise, which is concerned about the purpose, scope and policies of the enterprise; information, which is concerned with information modeling; computational, which is concerned about interaction patterns between the components of the system; engineering, which is concerned about the design of distribution aspects; and technology, which is concerned with the provision of an underlying infrastructure. The proposed approach complies with the RM-ODP enterprise and information viewpoints for distributed processing, and defines a specification, at the problem space, for the computational viewpoint.

Groupware focus on aspects - social, behavioral and computational - of group cooperation and cooperative work. Organizational models as well as information system models should describe these aspects whenever needed. Moreover, distributed applications are suitable for the support of groupware activities due to the inherent distribution, concurrency and sharing characteristics of such activities. An approach for the modeling of distribution should take in consideration the new requirements of Groupware activities [10][11]. Workflow systems are a groupware technology used in organization modeling. The Workflow Management Coalition [12] defined a glossary of concepts and terminology which unifies workflow concepts as workflow process and workflow process activity. The proposed concepts of activity and process modeled at the business model support these workflow concepts.

## 7. Conclusion

This paper describes an approach which integrates organization, information system and distribution modeling. The proposed approach defines four models: business model, which describes the business processes independently of any organizational structure; organization model, which synthesizes the business model into a organization structure; distribution model, which identifies the explicit and implicit distribution requirements from an organizational perspective; and information system model, which identifies the needed tools and servers as well as its distribution requirements. Model’s notation and construction is supported by the OOram methodology [6] and tool [7].

This approach supports an integrated approach where organization modeling is done at the enterprise level of abstraction and both, reverse and forward engineering are consistently supported. Distribution is also modeled, at both the organization and information system levels of abstraction, in an integrated way. Traceability of concepts exists between all the models.

In the proposed approach OOram organization modeling is enriched with the workflow concepts of activity and business process, and Jacobson’s work is enriched with the distribution issues from the DASCo method. The final result complies with the RM-ODP enterprise and information viewpoints for distributed processing, and defines a specification, at the problem space, for the computational viewpoint. OOram models enriched with DASCo distribution requirements are used for RM-ODP enterprise and information viewpoints.

A major limitation can be pointed out to this approach: scalability. Due to the number of existing organizational business processes the number of role models tend to be large. This fact requires the need of tool support, as provided by OOram, and the use of structuring abstractions. For the latter, OOram synthesis can also be used to accommodate different levels of abstraction.

This work is in the lines of previous work [13] for the design of distributed databases from an organizational perspective, which emphasizes requirements and solutions for replication. Currently, work is being done to fully integrate the approach with the OOram methodology [6] and tool [7] in the context of a methodology for distributed objects [14].

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