# Development of a DEMO based workflow management system

E. Oren and J.L.G. Dietz

May 28, 2003

Workflow management (WFM) systems are software systems that support the enactment and management of operational business processes. Most WFM systems use an activity-based modeling methodology, which ignores the difference between coordination and production acts. DEMO is a methodology that does adhere to this notion; in addition, the use of DEMO also leads to a more precise definition of certain concepts in WFM theory. To demonstrate that it is feasible to design a WFM system based on DEMO, the design of such a system is introduced.

## Introduction

Workflow management (WFM) systems are software systems that support the management of workflow in an organization. A WFM system is based on a definition of the organization it is supporting. Most WFM systems use an activity-based modeling methodology [GEORG] in which the focus lies on modeling the work and activities that are performed in the business process. However, by focusing on the activities inside organizations, one ignores two things:

First, that it is important to distinguish between coordination and production activities, and the notion that it is only because of coordination acts that production tasks are performed. As production acts are always performed in reaction to some coordination acts the initial focus should be on modeling the coordination; this would then lead automatically to the production. After that one could, if needed, model the production activities to a greater detail.

Second, that it is important to note that all coordination in organizations follows the same universal pattern; by understanding this pattern it is easier to find the coordination (and the production) that takes place: by discovering some part of the coordination pattern, one knows the whole pattern must exist.

As DEMO is a methodology for modeling organizations that does adhere to this two notions, a DEMO model should be well-suited as a “process” definition for WFM systems. The goal of this paper is to present such a DEMO based WFM system.

To do this, we will first briefly introduce common ideas from present WFM theory. We will then describe WFM in terms of the DEMO theory, in which the two notions mentioned above are incorporated. This description is focused on the coordination and the coordination patterns (transactions) in organizations and gives a somewhat different view on workflow and the support that WFM systems should provide. Based on this view of workflow we will present a functional design of a WFM system. This WFM system provides a well-defined subset of the information requirements in the workflow management of the organization. Finally, we will discuss briefly the development of a research prototype.

## Workflow management systems

According to the Workflow Management Coalition [WFMC] workflow is defined as “the automation of a (part of a) business process, during which documents, information and tasks are passed from one participant to another for action according to a set of rules”. WFM systems provide this support by “defining, creating and managing the execution of

workflows by using software that is able to interpret the process definition, interact with participants and invoke external applications".

The Coalition presents a reference model describing the necessary components, interfaces and functionality of WFM systems. A WFM system consists of three functional components: a *definition tool* that is used to define business processes; a *worklist handler* through which interaction between users and their personal worklists is managed; and a *workflow engine*, that provides a runtime execution environment. The *workflow engine* interprets the process definition, manages different instances of the business process and allocates resources to tasks that are to be performed. The *workflow engine* should also provide an interface to invoke external applications (instead of human participants) to perform certain tasks, and an interface to external workflow engines, in order to cooperate in shared process execution while appearing to provide a single enactment service.

In [AALST] a more useful definition of WFM systems is given. First of all, a workflow is defined as a case-driven business process (no distinction is made between business processes and workflow), which has three dimensions: *process*, which consists of the definition of tasks and the sequence in which they are performed; *resource*, which consists of the people and machines that can perform the tasks; and *case*, which is a specific instance of the `thing' that is dealt with during the business process. A task that is performed on one specific case is called a workitem and a workitem that is performed by one specific resource is called an activity.

This is a more clear definition of the concepts involved in WFM systems. A workflow definition now consists of three aspects: the sequence and definition of all the tasks involved in the process, a collection of human and machine resources and the tasks that they are capable of performing, and a collection of cases that are handled during the business process. For the definition of workflows [AALST] suggests to use high-level Petri-nets. Tasks can be mapped onto transitions, and the resulting facts onto places. For the resource dimension it is suggested to use some kind of role assignment, and to define which tasks can be performed by which roles. For the case dimension it is suggested to map instances of cases onto (Petri-net) tokens with appropriate attributes.

By using this definition one could describe a WFM system as continuously performing the following loop of activities: determining all transitions that are enabled (based on their preconditions and the specific values of all tokens); selecting a resource for every enabled transition; and after the resource notifies the system of completion of his task, determining the value of all output tokens.

## DEMO theory

According to DEMO, an organization is a social system designed to deliver products (both tangible and intangible) to its environment [DIETZ]. The products are produced by social individuals (persons) playing certain actor roles. These actors (persons playing actor roles) communicate with one another to coordinate their production. Actors continuously repeat a predefined set of actions, constituting their 'life-cycle'. In this cycle of activities they enter into commitments, thereby coordinating their activities; to comply with these commitments, they perform production acts or perform coordination acts to have other actors perform production acts.

According to DEMO, an organization is also a discrete dynamic system. This means it consists of active components which are able to perform activities. Those activities

change the state of the system. The activities (and state-transitions) take place at discrete time-events. Actors are the only active components of an organization: only actors perform activities, thereby changing the state of the system. Actors perform both coordination acts and production acts. Production acts can be material or immaterial, and always contribute to the products (goods and/or services) the organization delivers to its environment. Performing production acts results in production facts; the state of the production world consists of the set of existing production facts. Coordination acts exist of a performer, an addressee, an intention and a proposition. By performing coordination acts the performer expresses some intention about a proposition to the addressee. This proposition is always a production fact; coordination is always in regard to production facts. Performing coordination acts results in coordination facts; the state of the coordination world consists of the set of existing coordination facts. The state of the complete social system (the organization) is the combination of the states of both the production and the coordination world.

Since actors are the only active components of an organization, the activities in their life-cycle constitute all activities in an organization. This actor-cycle consists of three parts: selecting an agendum, selecting an appropriate action rule and performing that action rule. The agenda of an actor is the set of all coordination facts to which this actor is committed to respond. The first step in the actor-cycle is selecting from his agenda one agendum upon which the actor wants to react. An actor role consists of a set action rules; each action rule defines a reaction to some agendum. The actor must therefore decide, in the second step of the actor-cycle, which of his action rules is appropriate in handling the selected agendum. Then, after selecting one action rule, the actor performs the described act(s) as a reaction to the selected agendum. These act(s) could be both coordination acts and production acts. Performing a coordination act would lead to an agendum for some (other) actor. The actor-cycle is repetitive, so after the last step the actor starts all over again and selects another agendum to react upon.

## Workflow in DEMO

A WFM system is a software system that supports automation of (a part of) business processes in some organization. In general, a WFM system does not handle task logic, but only process logic; the separation of process and task logic is the chief goal of a WFM system [MOHAN]. A WFM system is part of an information system that supports the operational management of the organization. The business system that is supported by this information system consists of the responsibilities and tasks involved in the operational management of an arbitrary organization. Since requirements of an information system is determined in the business system it is supporting, it is necessary to first describe this business system. Based on the information requirements of this business system it is then possible to determine the needed functionality of the WFM system, which fulfills in part of those requirements.

The description of the business system that should be supported by a WFM system can be deduced from the DEMO theory. Since WFM is about operational management of business processes, and this management consists of coordinating the work, it is necessary to distinguish between production and coordination acts. The production acts contribute to the products that are delivered to the environment; they are not part of but instead the subject of the coordination. The coordination that should be supported by a

WFM system consists only of the coordination acts. Since actors are the only active components in an organization, and the actor-cycle completely describes the operation of an actor, it is necessary and sufficient to model that part of the actor-cycle in which the coordination acts are performed and dealt with. The actor-cycle itself relies on certain concepts from DEMO theory that should be considered in modeling the actor-cycle. Those concepts are:

Role assignment: the actor-cycle does not describe how real-world organizations function, but only the actor roles inside those organizations. An actor role must however always be fulfilled by some person; actor roles are abstract concepts, they do not really exist. The fulfillment of an actor role by a person can be the result of three mechanisms for role assignment: authorization, delegation or propagation [DIETZ03]. Whereas propagation is an automatic role assignment, both authorization and delegation are explicit role assignment mechanisms, and are part of the business system that is being modeled.

Coordination: in DEMO coordination can be viewed at three levels of abstraction: performative, informative and formative. The distinction in those levels is important, because to perform a coordination act certain conditions must be met at all three levels. The formative condition implies that the information that is to be exchanged is expressed, transmitted and perceived without distortion. The informative condition implies that the addressee has understood the coordination act intellectually. The performative condition finally, implies that the addressee of the information feels socially responsible to respond to it. Only when the conditions in all three levels are met, does coordination take place.

Duration of production: scheduling of work is an important part of WFM system functionality. It consists of choosing a person to perform a certain task, in case multiple persons are able to perform this task. This scheduling can be done based on numerous factors; a possible scheduling could for instance be based on: the estimated duration of the task, the time available to all persons able to perform this task and the relative priority of this task compared to other tasks. To support this kind of scheduling, it is necessary to extend DEMO with some notion of the production world and the time schedule of employees. Because coordination acts are considered instantaneous [DIETZ], the duration of those acts is zero. Knowing the estimated duration of production acts is therefore necessary and sufficient to estimate the time needed to execute a transaction. Combined with knowledge of the availability of employees it is possible to compute which of the authorized employees is most suited to execute a transaction.

Inclusion of these three concepts leads to a business system definition, of which the model is shown in the figure below. The business system modeled in this figure is a generic description of WFM in an arbitrary organization: it describes WFM in for instance a bank, an insurance company or a factory. The behavior of certain actors in this model is limited by the model of the specific organization that is being supported. The DEMO model of that specific organization is available in the external fact banks EF1 -- EF5. The business system shown in this figure is generic; the contents of the external fact banks depends on the specific organization that is supported.

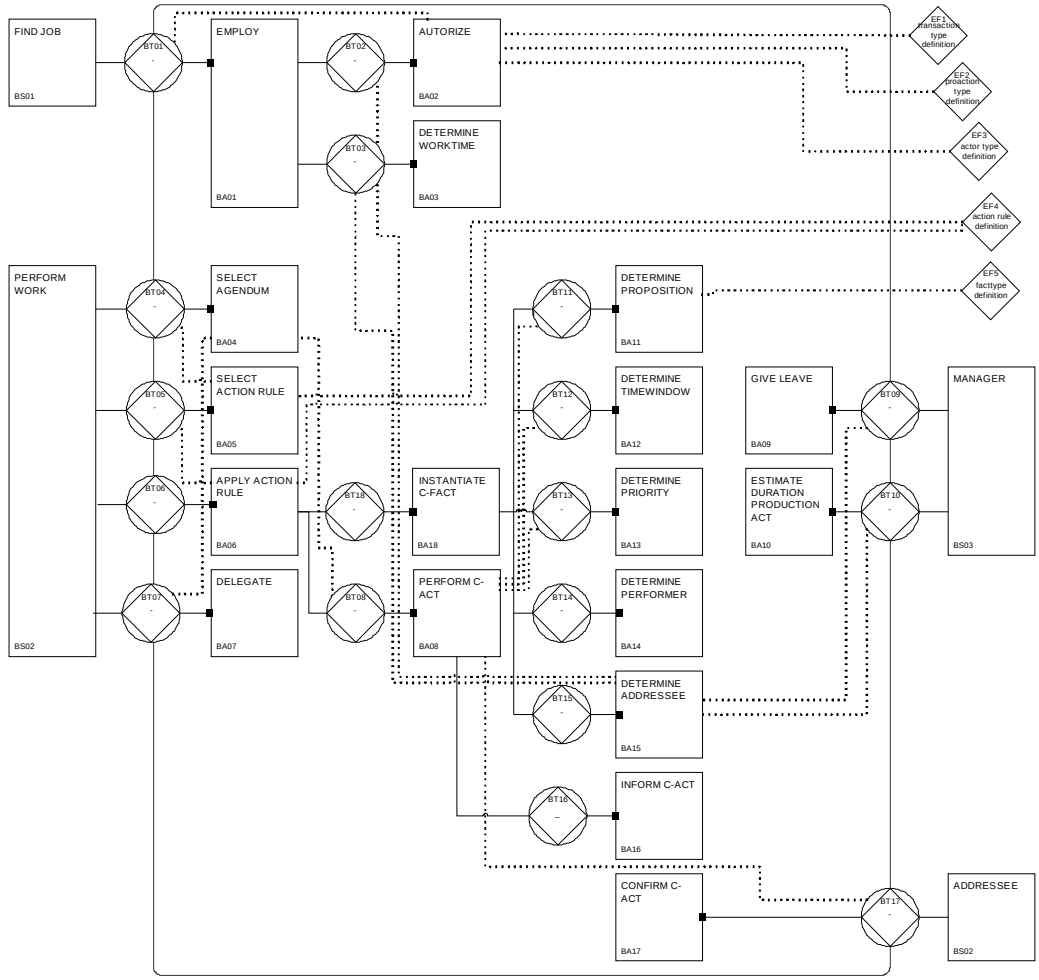
The model describes a generic actor, and the responsibilities inside him that are part of his actor-cycle. During his actor-cycle an actor selects an agendum and determines how to respond to it. His reaction can consist of performing a production act, which is not

modeled because it is by definition not part of the coordination. His reaction can also consist of performing one or more coordination acts, which leads to several responsibilities determining the content of those acts.

The responsibilities during the actor cycle form the basis of this model. Next, several actor roles are introduced (with their corresponding transactions) to accommodate the described concepts next to the actor cycle. To model the role assignment mechanisms actor roles *authorize* and *delegate* are introduced; the necessary transactions for employment of people are also introduced. The actor roles responsible for these transactions require information concerning the organization model. For instance, to authorize some employee for an actor role, it is necessary to know which actor roles exist in this specific organization.

The concept of the informative level of abstraction in coordination acts is modeled by explicitly demanding confirmation from the addressee of coordination acts. It is be possible to model the formative level of coordination as well, but that is not necessary for the purpose of this paper. The interstriction between actor role *perform c-act* and the transaction *confirm c-act* implies that the coordination act is not really performed until confirmed by the addressee.

The actor role *determine addressee* implements the scheduling mechanisms described above. The actor *determine addressee* chooses the addressee of a coordination act. In case there is only one employee that is authorized to fulfill the actor role to which the coordination act should be addressed, there is no choice to be made. In case several employees are authorized to fulfill this actor role, a choice for some addressee must be made based on the estimated duration of the production act, and the available time of all these employees.




## Functional design

An information system provides information to some business system. The task of an information system could be defined as: fulfilling the role of informational actors supporting some business system. The role of an informational actor exists of storing and retrieving information, at the request of some actor from the business system. The need for information storage can be derived from a need for information retrieval.

A WFM system is a software system that provides part of the required information to the business system that is concerned with the management of workflow. To design a WFM system for this business system, it is necessary to define what information the WFM system should provide. From this follows the information that needs to be stored by this WFM system: namely, all the information that should be supplied by, but is not known to, the information system. This information should be supplied to the WFM system by those actors that create this information: the producers of the transaction of which the resulting facts are needed.

In the table below the required functionality of the information system is shown; the ability to both store and return information for the business system. This functionality follows from the modeled interstriction in the business system: the need for information retrieval stems directly from the interstriction, the need to store information follows as described above. For a more elaborative deduction of these requirements, see [OREN].

| *Information system functionality:* | | *Stems from information requirement:* |
|---|---|---|
| IT01 | set employment | BA01 *keep* transaction results BT01 |
| IT02 | get employment | BA02 *give* all persons in the organization |
| IT03 | get transactions | BA02 *give* all transactions in the organization |
| IT04 | get proactions | BA02 *give* all proactions in the organization |
| IT05 | get actors | BA02 *give* all actor roles in the organization |
| IT06 | set authorization | BA02 *keep* transaction results BT02 |
| IT07 | set worktime determination | BA03 *keep* transaction results BT03 |
| IT08 | get agenda | BA04 *give* all agenda for an actor role *A* |
| IT09 | get exit points agendum | BA06 *give* exit-points of an agendum |
| IT10 | get proposition-types | BA11 *give* all proposition types in the organization |
| IT11 | set proposition | BA11 *keep* transaction results BT11 |
| IT12 | set timewindow | BA12 *keep* transaction results BT12 |
| IT13 | set priority | BA13 *keep* transaction results BT13 |
| IT14 | set leave | BA09 *keep* transaction results BT09 |
| IT15 | set production act estimation | BA10 *keep* transaction results BT10 |
| BT16 | perform coordination act | *executor BA08* |
| BT17 | determine addressee | *executor BA18* |
| IT18 | set confirmation | BA17 *keep* transaction results BT17 |
| IT19 | set delegation | BA07 *keep* transaction results BT07 |
| IT20 | get informed c-acts | BA16 *keep* transaction results BT16 |

## Implementation

The described functional design has been implemented in a research prototype. This prototype cooperates with a specific tool that supports the definition of DEMO models. The worklist handler is implemented as a dynamic webpage, so users can access their worklist and interact with the workflow engine from all around the world. The workflow engine executes the specified DEMO model, assigns tasks to people based on their availability and manages all coordination during the execution of the workflow. The prototype allows employees to perform coordination acts in reaction to their agenda. The employees are restricted to the coordination that is described in the specified DEMO model of their organization. The formative level of the coordination is fully supported by the prototype.

Comparing the functional design and the prototype with specifications of the Workflow Management Coalition shows [OREN] that firstly, both the *process definition tool* and the *worklist handler* are supported. Secondly, the ability of the workflow engine to interpret the process definition and to execute the workflow is implemented. The appointment of tasks to resources is also supported, however, a very rudimentary form of scheduling is being used. Two interfaces are missing: an interface with external applications and/or workflow engines, and an interface to control and manage the ongoing workflow. However, these interfaces could easily be added, as they do not form principal problems, but need only be built.

The most important parts of workflow management: specification of a workflow, the ability to execute this workflow, and to appoint people to tasks to be done, is supported by this prototype. The necessary interfaces with external applications and management capabilities should be added.

## Conclusion

A design is shown of a workflow management system that uses DEMO models as process definition. This design stems completely from the DEMO theory, and therefore takes an different approach to workflow management than most systems, and is yet compatible with specifications of the Workflow Management Coalition.

Developing a workflow management system based on DEMO shows that DEMO is not only usable as a method for business analysis and business process redesign, but also in operational management. This matches the claim of DEMO being a methodology for organization *engineering*, and not just for the organization *modeling*.

## References


[AALST] W.M.P. van der Aalst en K.M. van Hee. *Workflow Management: Models, Methods and Systems*. MIT Press, Cambridge, MA, 2002.

[DIETZ] J.L.G. Dietz. Generic recurrent patterns in business processes.

[DIETZ96] J.L.G. Dietz. *Introductie tot DEMO*. Samson Bedrijfsinformatie, Alphen a/d Rijn, 1996.

[DIETZ03] J.L.G. Dietz. The atoms, molecules and fibers of organization. *Data & Knowledge Engineering*, 2003.

[GEORG] D. Georgakopoulos, M. Hornick, and A. Sheth. An Overview of Workflow Management: From Process Modelling to Workflow Automation Infrastructure. *Distributed and Parallel Databases*, 3(2):119–153, April 1995.

[MOHAN] C. Mohan. Recent trends in workflow management products, standards and research.
In A. Dogac, L. Kalinichenko, T. Özsu, and A. Sheth, editors, *Workflow Management Systems and Interoperability*, volume 164 of *NATO ASI Series*. Springer-Verlag, 1997.

[OREN] E. Oren. *Van DEMO naar workflow management*. M.Sc. Thesis, Technical University Delft, 2003 (in Dutch).

[WFMC] WFMC. Workflow Management Coalition Terminology and Glossary. Technical Report (WFMC-TC-1011), Workflow Management Coalition, Brussels, 1999.