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Modelling business processes with workflow systems: an evaluation of alternative approaches

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Abstract

Effective business process management necessitates a consistent information flow between the participants in the process, the smooth integration of the flow of work, the timely sharing of data and information during the planning and implementation phases and harmonious support for the collaborative aspects of work. The recent trends in the development of advanced workflow management systems and technologies seem to be of crucial importance for facilitating these tasks within the process management context. However, workflow management systems (WfMS) follow various approaches in modelling the flow of work and hence present varying functionalities when supporting enterprise processes. The present paper examines the ways in which workflow technology may facilitate the implementation of process management, reviews the pros and cons of adopting alternative workflow representation techniques in modelling business processes and provides guidance to managers as to the characteristics, the similarities and differences of the various workflow modelling schemes. © 2001 Elsevier Science Ltd. All rights reserved.

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1. Introduction

Today's dynamic business environment is driving a new extended organisation, which competes globally focusing on low prices and customer customisation of products and services. As a key

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success factor for effective competing one could identify the management of core business processes, which deliver value to their customers, suppliers and internal staff. Thus by focusing on automating, optimising, and continuously improving the core business processes, organisations can make commitments to those customers, employees, partners, and suppliers establishing a solid competitive advantage.

Since the 1980s, Information Technology has provided a wide range of applications supporting automation and management of the business process. Workflow management systems (WfMS) are the most evolved of those applications providing consistent information flow between the participants in the process, smooth integration of the flow of work, timely sharing of data and information during the planning and implementation phases and harmonious support for the collaborative aspects of work.

However, WfMS follow various approaches in modelling the flow of work and hence present varying functionalities when supporting enterprise processes. The implications of these approaches to the real-world management of processes and projects are not always clear and transparent to managers. As the different techniques match more or less to different types of processes, managers have to identify which approach to adopt.

The objectives of the present paper are: to examine the ways that workflow technology may facilitate the implementation of business processes; to review the pros and cons of adopting alternative workflow modelling techniques in modelling the processes; and to provide guidance to managers as to the similarities and differences of the various workflow modelling schemes and their characteristics.

This paper is organised in the following manner. Section 2 of the paper reviews current approaches in WfMS, while Section 3 outlines the alternative workflow modelling techniques. Section 4 illustrates a comparison of applying the two major workflow modelling techniques in a case-study. The case refers to the project management of a multi-annual European Union (EU) Operational Programme for Greece. Finally, Section 5 provides the conclusions and lists issues to be taken into consideration by managers when examining the adoption and use of one or the other workflow modelling system.

2. Workflow management systems

The workflow concept has evolved from the notion of the process in manufacturing and the office. Such processes have existed since industrialisation and are products of a search to increase efficiency by concentrating on the routine aspects of work activities. They typically separate work activities into well-defined tasks, roles, rules, and procedures, which regulate most of the work in manufacturing and the office; see also Georgakopoulos, Hornick, and Sleth (1995); Agostini, DeMichelis, Grasso, and Patriarca (1994); Mentzas (1993, 1999); Swenson, Maxwell, Matsumoto, Sahari, and Irwin (1994) and Dinkhoff, Gruhn, Sallmann, and Zielonka (1994).

A workflow can be defined as a collection of tasks organised to accomplish some business process (e.g. processing purchase orders over the phone, processing insurance claims). One or more software systems, one or a team of humans, or a combination of these can perform a task. Human tasks include interacting with computers closely (e.g. providing input commands) or loosely (e.g. using computers only to indicate task progress). Examples of tasks include updating a file or database, generating or mailing a bill. In addition to a collection of tasks, a workflow defines the order of task invocation or condition(s) under which tasks must be invoked, task synchronisation, and information flow.

Workflow technology allows an organisation to automate its business processes to better manage those processes, and therefore, better manage their outcomes, be they products or services. Workflow technology will deliver work items (things to do) to appropriate users, and help the users by invoking appropriate applications and utilities (how to accomplish the task). Further, it will allow management and employees to track the progress of the work item through the process and generate statistics on how well the different steps of the process are doing.

We should mention here the work of the workflow management coalition (WfMC) (see Hollinsworth, 1995) towards the facilitation of the use of workflow technologies across vendor products and the development of standard architectures for workflow specification to allow the interoperability by various WfMS.

3. Workflow modelling techniques

Workflow management involves: *process modelling*, that requires workflow models and techniques for capturing and describing a process; *process reengineering*, that requires techniques for optimising the process; and *workflow implementation and automation*, that requires methodologies and technologies for using information systems and human performers to implement, schedule, execute and control the workflow tasks as described by the workflow specification.

Performing process modelling involves workflow specification. A workflow specification captures a process abstraction into a workflow model. The latter typically includes a set of concepts that are useful to describe processes, their tasks, the dependencies among tasks, and the requirements (i.e. the skills of individuals or information systems) that can perform the tasks. Workflow specification is typically performed with a workflow specification language.

Such languages support the specification of the following:

- task structure (control flow) and information exchange between tasks (data flow) in a workflow, e.g., specifying that tasks can be executed in parallel, or that a task needs to wait for data from other tasks),
- exception handling, e.g., specifying what actions are necessary if a task fails or a workflow cannot be completed,
- task duration, e.g., specifying initiation and completion time of a task, and
- priority attributes, e.g., specifying priorities for task scheduling.

In rule- or constraint-based workflow specification languages, the workflow and data flow structure are typically specified by routing rules or constraints. Routing is often classified as conditional, rule-based, or parallel. Conditional routing involves scheduling a task based on data values. For example, "if item.cost > 1000 then contact Manager". Rule-based routing is more powerful than conditional routing and can involve arbitrarily complex rules stated in a rule-based language. Parallel routing allows one task to branch into multiple others that can execute in parallel. A few languages also explicitly support task rendezvous.

Graphical user-interfaces (GUIs) are provided for both graphical workflow specification and graphical task specification. Graphical workflow specification languages support the iconic representation of workflow tasks and the ability to sequence those tasks graphically by connecting arrows and decision icons among tasks. Many WfMS use graphical specification to automatically generate code or set up rules for a workflow implementation and execution.

There are three basic categories of workflow specification languages and related techniques:

- *Communication-based techniques*, which mainly stem from work on the "Conversation with Action model"; see Winograd and Flores (1987). This technique assumes that the objective of business process reengineering is to improve customer satisfaction. It reduces every action in a workflow to four phases based on communication between a customer and a performer: preparation; negotiation; performance and acceptance.
- *Activity-based techniques*, which focus on modelling the work instead of modelling the commitments among humans. Such methodologies model the tasks involved in a process and their dependencies. It should be noted that the activity-based approach is consistent with object-orientation; see e.g. McCarthy and Sarin (1993) and the object-oriented workflow system Oz in Ben-Shaul, and Kaiser (1995).
- *Hybrid techniques*, which can be considered as a combination of the communication-based and the activity-based techniques; see Georgakopoulos and Rusinkiewicz (1997).

3.1. Communication-based workflow modelling

A representative example of a communication-based methodology is the action workflow analysis (AWA) Method. At the heart of the AWA method is a loop, a visual metaphor that greatly simplifies the task of representing how work is performed in a business process. The loop represents a unit of work, or "workflow" within the process, and defines several parameters of the work to be done, the participants involved, i.e. the "customer" and the "performer"—and the requirements for successfully completing the work by ultimately satisfying the customer.

Linking the workflow loops specifies the flow of the process. As other workflows are specified and linked, a graphical map of the process emerges as a network of workflows. There is always an identified *customer* and a *performer*, and the workflow deals with a particular action the performer agrees to complete to the satisfaction of the customer. The words customer and performer apply to people within a single organisation, as well as across organisational boundaries. In addition to the customer and performer roles, a workflow may have an observer, who monitors or supervises the work that is being co-ordinated.

The workflow loop also divides work into phases (see also Fig. 1):

- *Preparation*: where the customer requests (or the performer offers) completion of a particular action, according to some stated conditions of satisfaction.
- *Negotiation*: where the two parties come to a mutual agreement on the conditions of satisfaction, including the times by which further steps will be taken.
- *Performance*: in which work is done to produce and deliver agreed results, and
- *Acceptance*: in which the customer reports satisfaction (or dissatisfaction) with the work. This final phase is often discounted, but is essential for assuring that the quality is achieved.

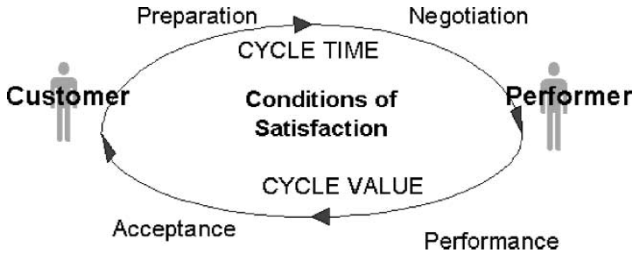

Fig. 1. Communication-based workflow loop.

The entire map—a model of the business process—is built upon the central idea of customer satisfaction, and shows how each element of the process—including where it begins, who is involved, the sequence of events, and how different workflows interact—contributes to this goal.

The integrity of every process map can be checked with a consistency checking function that is based on the respective methodology. The consistency check reviews the maps and automatically identifies logical errors—such as erroneous links, inconsistent time allocations, or even missing participants—so that they can be corrected. Finally, the map can be reviewed for areas requiring improvement—such as duplicate workflows, or workflows performed in sequence when parallel work is possible.

3.2. Activity-based workflow modelling

The activity-based technique is a more classical way of representing a process. Unlike communication-based techniques, activity-based ones do not capture process objectives such as customer satisfaction.

Activity-based workflow models consist of the following elements:

- *workflows*: a partial or total order of a set of tasks,
- *tasks*: a partial or total order of operations, descriptions for human actions, or other tasks,
- *manipulated objects*: documents, data records, images, phones, fax machines, printers etc.,
- *roles*: a placeholder for a human skill or an information system service required to perform a particular task,
- *agents*: humans or information systems that fill roles, perform tasks and interact during workflow execution

The workflow participants are identified by ensuring that the organisational data needed to define workflow actors are available (either in hard copy or electronic data repository) and defining the role sets and roles to be used by the business process represented by each workflow. Organisational data are used to determine the names, e-mail addresses and signing authority of workflow actors.

Each workflow uses one role set, and roles belonging to that set are assigned to individual workflow tasks. Roles are used as a valuable abstraction of organisational data into generic roles, or positions that people hold (Fig. 2).

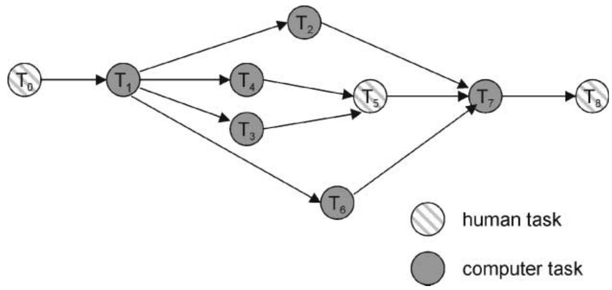

Fig. 2. Activity-based workflow model.

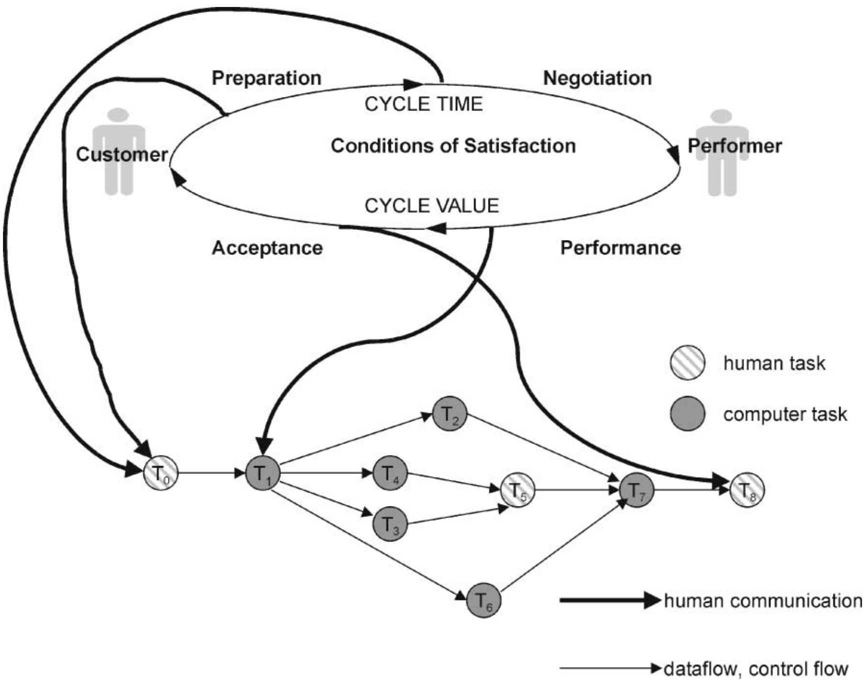

Fig. 3. Hybrid workflow model.

3.3. Hybrid workflow modelling

The communication-based and activity-based workflow models can be combined when process objectives are compatible with both models (e.g. satisfy the customer by minimising workflow tasks and human roles) (Fig. 3).

However, it should be noticed that the design and development of WfMS that follow a hybrid approach are still at the research and development phase; no commercially available tools have been reported that manage to link both approaches in a consistent way.

Hence, in the following sections we limit the analysis to the communication-based and activity-based techniques.

4. Modelling processes with workflow techniques

In order to proceed to an analysis of the advantages and disadvantages of adopting communication-based or activity-based workflow representation techniques when using workflow systems in the management of a process, this section proceeds with the presentation of applying both techniques in a case study. The case involves the management of a multi-annual EU-funded programme for Greece, the EU Operational Programme for the Energy Sector.

4.1. The case: EU Operational Programme for the Energy Sector

Towards the EU, one of the key parameters to cope with is the convergence of the member states economies. To this effect the European Commission (EC) established the Support Frameworks, aiming at the increase of the growth rate in the less developed countries. The concept of the Support Frameworks consists of a 6-year umbrella-programme financing activities, which serve development strategies, pre-agreed between the EC and the state-member.

In this context, the Second Support Framework for Greece was established in 1994 with a total budget of 13.98 billion ECU, for the years 1994–2000. The Greek Framework is divided into 13 Regional Operational Programmes implemented each in one of the 13 administrative regions of Greece and 11 Sectoral Operational Programmes implemented countrywide.

The life cycle of a typical Operational Programme consists of four major operations, which are designing and planning, programme breakdown to projects, implementation and evaluation. Those operations are executed by a network of actors either from the EC or Greece, comprising the Management System of the Programme. Such a typical Management System includes:

- the Steering Committee, which is responsible for the overall implementation of the programme,
- the Secretariat of the Steering Committee, responsible for the everyday management of the programme,
- the Ministry of National Economy mainly contributing to strategic and accounting aspects of the implementation,
- the Project Manager (usually a consulting company), who supports the above entities in the overall management of the programme,
- the Programme Evaluator (usually a consulting company), who periodically evaluates the progress of the programme.

In this paper, we focus on the Operational Programme for the Energy Sector, which subsidises the construction of new electricity plants, energy saving investments in the industry, the promotion and use of Energy Renewable Sources and geo-technical research activities, with a total budget of 946.5 million ECU for the years 1994–1999.

The major functions of the Programme's Management System include programme planning, programme breakdown to projects, progress monitoring, financial management and programme evaluation.

In order to evaluate the alternative workflow specification techniques we have modelled a significant number (36 in total) of project management processes of the Operational Programme for the Energy Sector using both communication-based and activity-based workflow representation techniques.

For the purposes of the present paper, we limit the presentation to the modelling of a specific process: the Subsidy Payment process. This process involves five roles, the Secretariat of the Steering Committee, the Ministry of National Economy, the Project Manager, the Bank of Greece and the Beneficiary. A brief overview of the process follows.

The process starts with the submission by the beneficiary of the trimester project progress report, which is then elaborated by the Secretariat of the Steering Committee and the Project Manager using the MIS of the Programme. If the progress of the project fulfills the conditions for the next subsidy payment, the Beneficiary is added to the payment list sent to the Ministry of National Economy. The latter is responsible for the management of the overall support's framework fund and the deposit of the adequate amounts to each programme's account. Since the programme's fund includes both EU and Greek resources, the Ministry of National Economy has to inform the EU about the progress of the programme in order to receive the EU contribution to the programme's fund.

When the payment list is sent to the Ministry of National Economy the Secretariat of the Steering Committee checks the balance of the programme's account and sends a copy of the list to the National Bank of Greece. Finally, the National Bank of Greece transfers the subsidy to the beneficiary account and informs the Secretariat of the Steering Committee.

4.2. Modelling processes with the activity-based technique

The process described above is modelled as shown in Fig. 4. The activities are divided into two levels—tasks represented by the large boxes and concluding actions represented by the smaller ones. Six tasks and 11 actions are related in order to reproduce the whole process. For each task the organisational role, which performs the related activities, is presented at the bottom of the task box. These roles derive from the key actors of the Programme's Management System. Finally, the reminders set are presented within each task box and the deadlines in the action boxes.

In this context, the process under discussion starts with the task "Progress Report" performed by the beneficiary and submitted within the first 6 days of the following trimester. The action "Submission" triggers the "Evaluation" Task, which has to be completed within 3 days, otherwise a reminder shall occur every 2 days. If completed, the report is forwarded to the Project Manager otherwise the report is rejected by the Secretariat of the Steering Committee and has to be resubmitted by the beneficiary. Since the trimester report is forwarded to the Project Manager, he elaborates the data and prepares within 7 days an integrated report presenting the progress of the programme.

This report is then submitted to the Secretariat of the Steering Committee, which after checking the balance of the programme's account sends payment orders to the National Bank and, if necessary, submits a request for funding to the Ministry of National Economy. After receiving the funding request the Ministry of National Economy evaluates the request and issues within 15 days a deposit order forwarded to the National Bank of Greece. At the same time it informs EU entities

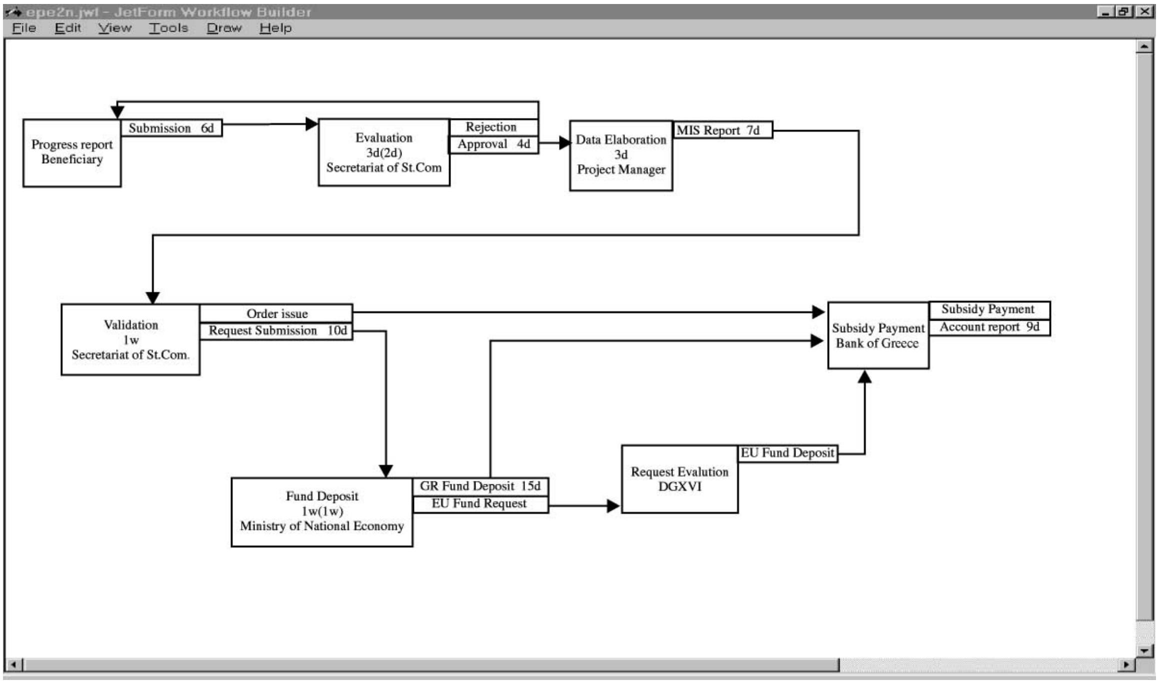

Fig. 4. Activity-based workflow map for subsidy payment process.

requesting the EU contribution. This request includes the progress of all the Second Framework Programmes and is evaluated by the relevant EU General Directions.

According to the evaluated progress EU proceeds to the deposit of an adequate contribution. Finally, the beneficiary is invited by the National Bank to collect the subsidy and the Bank prepares an account report which is sent to the Secretary of the Steering Committee.

4.3. Modelling processes with the communication-based technique

Fig. 5 shows the same process modelled with a communication-based workflow system. In this case, the primary workflow "Subsidy Payment" is broken down to secondary workflows representing the parts of the process.

The preparation stage of the primary workflow is analysed to three secondary workflows, "Trimester progress report", "MIS report", and "Fun Deposit". Between the second and the third secondary workflow a conditional symbol interpolates providing two routes. If the payment(s) does not exceed the account balance of the programme, then the preparation stage is completed; if not, the third secondary workflow is activated. This workflow includes at the performance stage two workflows performed in parallel, "EU Fund Deposit", and "GR Fund Deposit" aiming at the deposit of the needed resources.

All the consequent phases of the primary workflow are analysed in one secondary workflow presenting the action taken during the respective phase.

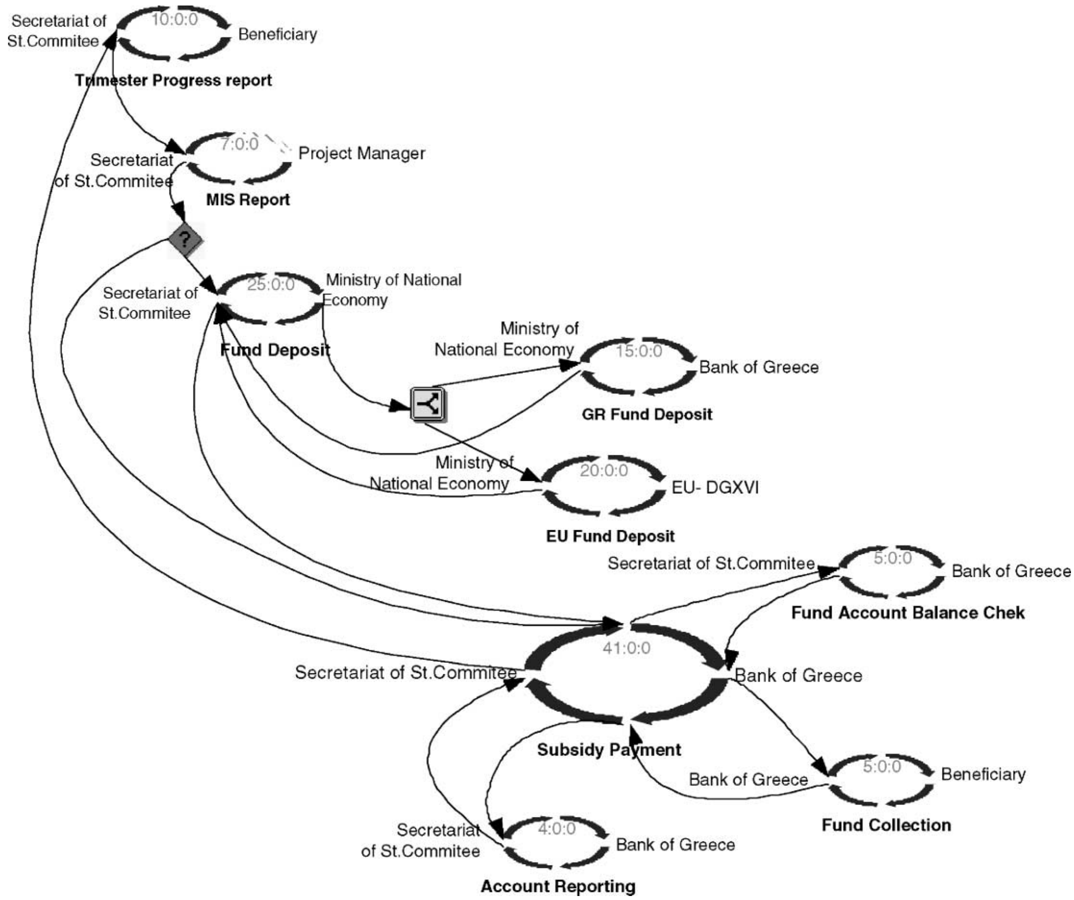

Fig. 5. Communication-based workflow map for subsidy payment process.

Thus, the second phase of the primary workflow, corresponding to the negotiation phase, consists of the "Fund Account Balance Check" secondary workflow. There, the Secretariat of the Steering Committee controls the availability of funding resources, remaining from previous stages of the project. Such a control is performed by the Bank of Greece.

Following the same logic the performance phase is further analysed by a secondary workflow labelled "Fund Collection". This transaction refers to the appropriate funding that the Beneficiary should receive from the Bank of Greece. The logic behind the appearance of the Beneficiary as the performer of the transaction, lies in the fact that the participant receiving (in other words collecting),the money from the Bank of Greece, is the Beneficiary.

Finally, the secondary workflow representing the acceptance phase of the "Subsidy Payment" workflow, is the "Accounting Report" requested by the Secretariat of the Steering Committee and written (composed) by the Bank of Greece. Such a report aims to verify the appropriate and expected evolution of the project. Inside each workflow the duration of the workflow is presented in days.

5. Discussion and concluding remarks

The analysis so far has shown that the two approaches usually applied in workflow management systems, i.e. the activity- and the communication-based, can provide adequate vehicles for process modelling when the aim is an effort to reengineer and/or streamline these processes aiming for operational improvement.

None of the two approaches falls behind the other concerning the scope and wealth of information provided.

Specifically, they both provide:

- ample information concerning the tasks to be modelled (separating them into either phases, or tasks and activities),
- rich information for the time duration of processes and the cost incurred for the execution of the processes, and
- constructs for modelling issues such as parallelism and if–then–else mechanisms.

However, the two approaches present a number of differences concerning the "philosophy" of modelling which should be taken explicitly into account and are strongly related to the limitations that, in general, the workflow systems have.

Below we list the basic ones, observed throughout the modelling procedure, which constitute the main scope of the paper:

- the methodological rigour implied by each approach, i.e. the possibility of formally specifying (using provable mathematical constructs) the correctness of each approach. At that point, we can clearly differentiate the two approaches given the different philosophies underlying them. The communication-based approach is implicitly using an underlying model (the one described thoroughly by Winograd and Flores, 1987), but the activity-based one seems to lack a strong mathematical construct. However, this observation relates to a general limitation of workflow modelling: the lack of rigorous modelling. Such efforts to present workflows analytically took place recently, using either meta-graphs or distributed computational modelling techniques (see Weske, 1998; Basu & Blanning, 1998). The concluding remark is that obviously the activity-based approach can be more easily formalised in the context of these two analytical essays, since they both are activity-oriented analytical techniques.
- The simplicity/complexity in applying the approaches, especially with regard to the flow of communication and the interdependence of tasks. Both methods are highly dependent on the type of the process. The key issue, though, is that the activity-based approach enables us to observe possible interdependencies of tasks but does not provide much information about the flow of communication among processing entities (Weske, 1998). On the contrary, that is being brought to an end successfully by the communication-based approach, which, in turn, due to its structure, cannot represent a large number of interdependent tasks.
- The ease of applying the approaches to well defined repetitive processes. It is very hard, for different reasons in each approach, to model exceptional tasks or processes. Therefore, such tasks should be excluded, due to the uncertainty either in time or in the processing entities involved.

- The ability and ease of each approach for handling client-orientation. The activity-based approach is more convenient for automating internal tasks of organisation, while the communication-based one strongly focuses on the relationship with the customer, reminding at each single step who the client is and what he is expecting from the task.
- The managerial implications concerning the expertise required by each approach. The activity-based techniques seem to be less structured and hence require some process modelling expertise by the project management team. On the other hand, the communication-based technique is more structured and guides to an adequate degree (at least conceptually) the model designer throughout the whole modelling procedure. However, the latter can also be a disadvantage, because it restricts the degrees of freedom that the design team has. Such a case does not exist in the activity-based approach, which enables the modelling of even complex models.

In addition to the above-mentioned issues, two remarks about the use of workflow modelling point to possible future research directions.

First, the workflow representation techniques do not include uncertainty handling in their modelling. We should recall that in the process implementation, uncertainty drives big delays; see e.g. Adler, Mandelbaum, Nguyen, and Schwerer (1995). Time duration is usually represented in a deterministic way, without enabling or involving possible knowledge about the uncertainty. It would be very interesting to incorporate such probabilistic views which would couple very well with the "if–then–else" properties of the workflow systems, directing the flow of information to the appropriate processes.

Second, the resource allocation mechanisms are not sufficiently covered by workflow representation techniques. Of course, the assigning of roles to different processing entities is, somehow, a resource allocation procedure. However, there is no clear representation of a resource allocation map as in most management software tools. Further extending and improving the resource handling issues of workflow modelling techniques could facilitate their adoption and use in business processes automation.

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