

Workflow Management Systems for Healthcare Processes

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INTRODUCTION

Organizations achieve their goals by executing processes, which can be physical processes to produce goods (e.g., assembling components of a PC), information processes to manage information (e.g., to collect information about facts), or business processes (e.g., to produce goods, to provide services, and to manage information). Final goals are achieved by executing atomic work units (tasks), by coordinating them, by assigning them to executors (agents) that can be human or automatic ones.

A workflow management system (WfMS) is a software system that supports the execution of such processes inside organizations. A WfMS requires a formal description, known as schema or process model or workflow, for every process it has to manage: many instances (or cases) of a process can be executed at the same time, sharing the same schema, while each case has its specific data, like patient's name, insurance claim, and so on.

A WfMS has to manage a huge amount of data: to do that, it relies on a Database Management System (DBMS), which is mostly based on the relational data model. A WfMS is also tightly coupled to the Information Systems (IS) of the organization, and may be even more tightly coupled to the Decision Support System (DSS) of the same organization. In fact, the IS mainly focuses on data and data flows, without considering in detail the processes that produce/manage/consume data; the DSS, instead, helps the management to identify strategies for the organization, considering aggregated data possibly stored in a data warehouse.

At the early 2000s, the term of "scientific workflow" has also been introduced, mostly in the fields of bioinformatics and chemical informatics. However, scientific workflows do not refer to the specific context of processes and activities that can be suitably

managed by a traditional WfMS, as defined above: scientific workflows rather refer to the need for multiple interconnected tools to handle large quantities of data, like those coming from different monitoring systems, with multiple data formats, and for interoperability purposes.

BACKGROUND

A WfMS supporting the coordinated execution of tasks by agents requires (Grefen, Pernici, & Sanchez, 1999) a formal description of the process (process model), a formal description of the organization where the process is executed, and whose agents will be assigned for the execution of tasks (organizational model), and a formal description of the information related to every case (information model).

The workflow designer is responsible for the definition of the process model, generally performed via graphical design tools, producing the formal description in a Process Definition Language (PDL) format. Every WfMS features its own PDL. The Workflow Management Coalition – WfMC – (<http://wfmc.org>), which is a nonprofit organization involving producers, vendors, and consultants, as well as users of WfMSs, defined a standard process definition language, namely X-PDL, based on the XML format of documents: recently, some WfMSs and some Workflow Designer Tools have been released, declaring themselves to be X-PDL compliant.

The organizational model describes the structure of the organization where the process is executed, and considers agents available inside that organization. Typically, information stored for every agent, beyond traditional ones, relate to the skills of the agent (e.g., secretary, nurse, physician, head of the department, CEO), authorizations granted to the agent (e.g., respon-

sibility for a surgery intervention), localization of the agent (e.g., NIH at Bethesda, MD), working hours, and so on: these information are relevant for the scheduling and assignment of tasks to agents, balancing the workloads among available agents and maintaining constraints of tasks (e.g., deadlines for the completion of a task or the need of having two distinct executors for two tasks, like when one agent makes a proposal and a different ones approves or rejects).

The information model describes the data that are relevant for the process itself, like the patient's name, the patient's choices, the preferred food or diet (e.g., vegetarian) and so on: every case owns its data, which thus are case-specific. Data from the information model are also used to identify execution paths inside the process model. For example, if the patient suffers from diabetes, the task *PrepareSugarFreeMeal* will be executed; otherwise, the task *PrepareNormalMeal* will be executed. Data from the information model are stored by the underlying DBMS and, in some cases, can be shared with the IS and with the DSS.

The Architecture of a WfMS

In order to support the coordinated execution of tasks by different agents, the Scheduler of the WfMS, which is a software component inside the engine of the WfMS, reads from the process repository the process model of currently active cases, and identifies the current status

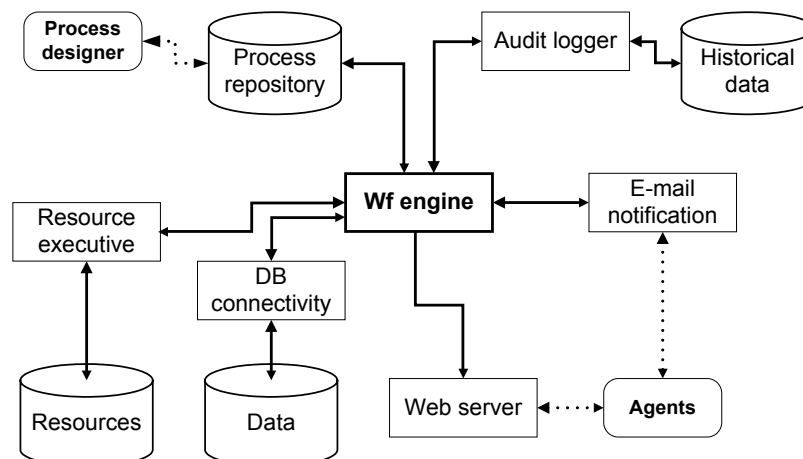
of execution and the next task(s) to be scheduled. The workflow engine asks the resource executive to read the organizational model and to identify the suitable agents to entrust for the execution of the task: the resource executive has to compare the skills and the authorizations of the selected agent with the minimum skills and authorizations required for the task, beyond providing workload balancing among the agents. The Scheduler also has to check for the completion of tasks within the prescribed deadlines, detecting and signaling possible anomalies and delays (Combi & Pozzi, 2003; Combi & Pozzi, 2004; Duftschmid, Miksch, & Gall, 2002).

Other components inside a WfMS are the e-mail feeder (to send and to receive e-mail messages and communications to/from agents), the Web server (to provide a html-based interface to the WfMS and to the worklists for every user), the DBMS connectivity (to access data related to current cases), and the Audit logger (to access historical data about past cases). Figure 1 depicts a general architecture for a WfMS.

WORKFLOW MANAGEMENT SYSTEMS FOR HEALTHCARE

WfMSs can be useful in coordinating any process that is "workflowable" (i.e., that can be suitably described by a process model). In order to be workflowable, a

Figure 1. A general architecture for a workflow management system (WfMS), highlighting the software components belonging to a WfMS; rectangles represent software programs; cylinders represent databases; rectangles with smoothed corners represent human executors.



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