Integration of a DAU-System in Workflow Management Systems

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Abstract

The integration of a document analysis and understanding (DAU) system in workflow management systems (WFMS) allows to bridge the gap between paper documents and workflow management enabled business processes. With this integration it will be possible to assign the incoming business letters to the correct workflow instance, to support the data capturing by clerks, and to integrate the paper based part of the business processes in the workflow management concept of an organization. This paper describes the concept of a generic integration of the systems and the benefits which arise from the cooperation.

1 Introduction

Document analysis and understanding deals with transforming paper-documents in machine readable information and providing the semantic of the document. The research has reached a point where the achieved innovations can be applied to real-world scenarios. It is obvious to choose those domains with high accumulation of (paper-) documents and associated business processes to improve the information flow and to handle the immense work rate, for instance in domains like insurance (e.g. contracts, claims), bank (e.g. bank drafts, cheques) or administrations (e.g. purchasing). These domains distinguish themselves by having structured business processes whereby workflow management systems come to business.

The DAU-system *OfficeMAID* [BHD+97] demonstrates the benefits that DAU can obtain by using knowledge available in business processes. As a continuation the project *VirtualOffice*[1] from which this paper is motivated, focuses on commercial WFMS and follows the goal to provide a generic integration of DAU and WFMS to achieve and use the synergetic effects.

This paper describes the integration of a further enhanced DAU-system in WFMS. In the following chapter a short introduction to DAU is given. Chapter 3 provides a description of the integration and in chapter 4 the application scenario and an example is presented to understand the use. A conclusion completes the paper.

2 DAU

As mentioned above DAU aims at extracting information from paper sources and translating it into a structured representation. By this the information and semantics contained in the documents are gained in order to support the human in filtering, sorting, and extraction of relevant information, thus achieving improvements in document-based business processes.

DAU can be divided into three steps: First the *structure analysis* which starts from a scanned document and produces a layout structure and logical objects like sender (address field). Structure analysis subsumes different processing steps like image filtering, skew elimination, and page segmentation which have distinct tasks. For example in the image filtering step any background noise (e.g. in faxes) will be detected and deleted from the image, thus achieving a better identification of the character images. The layout structure provided by the structure analysis forms the input for *text recognition*. In this step the OCR (Optical Character Recognition) transfers the binary image data into machine readable ASCII text. This is the basic step, but more sophisticated post-processing steps can be applied. As an example consider a dictionary look-up to compare the word hypotheses delivered by the OCR with (domain-specific) vocabulary to select the best fit in order to achieve better results.

The produced text is input for *information extraction* which also consists of different steps like morphological text-analysis (reducing inflected words to their word stems), message type classification, parsing, and pattern matching. These steps are applied to retrieve the document's information. For example pattern matching recognizes text phrases and formulations typically for distinct message types in order to classify the document and to extract the contained information. A more detailed description of the steps is given in [BHD+97].

All these steps are handled in VirtualOffice by so-called *DAU-specialists*. A specialist has a specific task, input and output data. The coordination of the specialists will be shown in the next chapter.

3 Integration

The overall goal of the DAU-system developed in VirtualOffice is to assign incoming business letters to the correct workflow instances, extract required data, and provide requested information. The decision to which workflow instance a document belongs to is based on the actual requirements of all workflow instances waiting for particular documents. More accurate: a workflow activity waiting for a document states in a so-called *expectation* all known information about the

[1] The project is funded by the German federal ministry of education, science, research and technology under contract number 01 IW 807.

expected document. The expectation is a record with different information: the message type of the expected document (e.g. invoice, delivery note), administrative data to identify the waiting workflow activity and furthermore all available knowledge about the document itself like sender (company name), order number, references to related documents (e.g. the order belonging to an invoice), etc. In addition any further required data is determined, like the amount stated in the invoice. This is done by specifying a *DAU-task* (e.g. GetInvoiceAmount).

All this information is used by the DAU-system to allow an assignment to the respective workflow instance and to further increase the recognition rate of the DAU.

Expectations are determined in the design phase of a workflow and enriched during runtime by a workflow user and/or automatically by using arising information from the workflow instance.

All expectations are kept in a database. Using the expectation database the DAU-system determines which documents may arrive, what type they are, their possible contents, and what information has to be additionally retrieved. With this knowledge the system plans the analysis of an incoming document and uses the DAU-specialists efficiently. Planning is done by the *reactive planner.* 'Reactive' because the planner is always in control and is able to replan in case more information is available after a specialist's run.

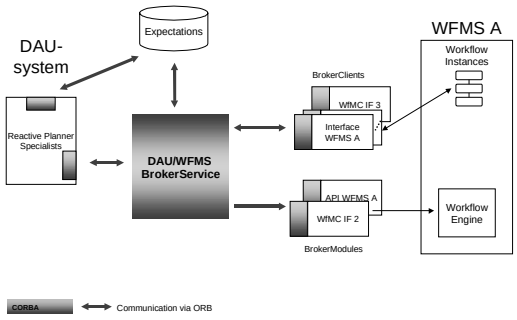
As an example for a plan suppose the expectations state that most of the workflow instances are waiting for an invoice but from different companies. Therefore the planner would invoke first the logo recognition specialist because the specialist is fast and limits the search for a matching expectation to a specific company. If the logo is known the company can be inferred, hence the corresponding expectation. With that the waiting workflow activity can be directly identified without running through the whole document analysis. Notice that the document will be verified in the workflow, so that a wrong assignment would be detected, but for most cases such a fast decision will be sufficient. If there are still more possible expectations the planner will collect information until only one matching expectation is left.

The plan assembly by the planner and the used preferences (e.g. speed versus accuracy) can be individually set. The planner will be realised using techniques from the areas of constraint satisfaction and configuration (for details see [BMM+97]).

Whenever a document arrives that doesn't match to an expectation a default workflow definition will be instantiated and the document will be assigned. The instructions which definition has to be instantiated are given in *default expectations*. Suppose the workflow *ProcessAdvert* routes an advertisement to a specific clerk then a default expectation for the message type *advertisement* with workflow *ProcessAdvert* would be added to the expectations.

Interaction between DAU and WFMS

For the coordination of the interaction between DAU-system and WFMS the *DAU/WFMS BrokerService* is responsible (see picture 1). This service acts as a broker between the workflow activities and the reactive planner. Two additional components assist the broker: First the BrokerClient which will be invoked by a workflow activity in order to communicate and exchange data with the BrokerService. Secondly the BrokerModule which is located at the workflow engine [WfMC 96] and responsible to realize the BrokerService's actions in the WFMS. All interaction of the components with the WFMS will be defined in generic interfaces and encapsulated in modules in the respective components. These modules are responsible for the realization of the interfaces for a specific WFMS by using their specific application programming interface. Additionally the (pre-) proposed standard interfaces of the WfMC (Workflow Management Coalition, Interfaces 2 and 3 [WfMC 94]) will be taken into account to investigate the applicability of the standard and to ensure a generic system.



Picture 1 : DAU/WFMS - Broker architecture

The communication between the components will be realized by using the OMG (Object Management Group) standard CORBA (Common Object Request Broker Architecture). With CORBA the gap between the participating heterogeneous operating systems, applications, and programming languages can be bridged. The standard also offers the possibility to propose the DAU-system as a Vertical Domain Facility in CORBA. Furthermore there is an interesting development by the OMG: providing workflow management functionality to all applications taking part in CORBA by introducing the Workflow Management Facility [SBM 98].

corporate and document knowledge

In an organization many different sources of information are available, e.g. customer lists, business addresses, product lists or archived business letters from business processes. This knowledge is important for a business process. Because of this, VirtualOffice points out, how the usage of the corporate knowledge in DAU and WFMS can increase the benefit in the overall

system by providing the DAU-system access to the corporate knowledge. For instance an interface to the company's address database to compare analysed addresses.
A further knowledge source is the information about the structure of the business documents of the different companies. The DAU-system uses knowledge about the common structure of business letters like the existence of an invoice-number in invoices as well as company-specific knowledge about business letters like the location of the logo of company XY in the lower left corner of their invoice. Such kind of information is stored in the *document knowledge*. In addition new documents types arrived will be learned and inserted in the document knowledge. This ensures that in future the new document structure will be known by the specialists and thus increase the recognition rate.

Implementation

A first prototype with a simple integration of our DAU specialists in a WFMS (namely CSE WorkFlow, CSE Systems) has been implemented. The prototype shows the possibilities and limits of getting information from the WFMS and the problems we have to face when we will develop a generic system. For instance accessing the data of the business processes handled by the WFMS.
The presented system will be implemented by using the WFMS Staffware 97 from Staffware plc. and COSA Workflow from Software Ley.

4 Application Scenario

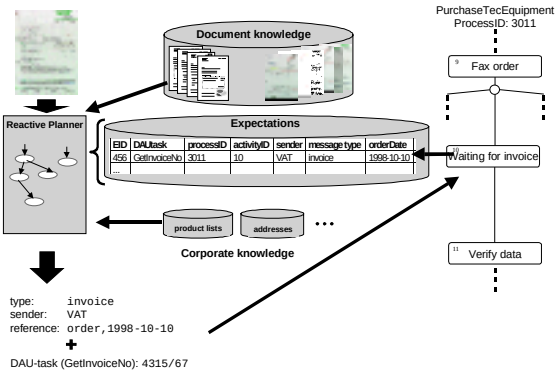
To clarify the concept, the application scenario used in VirtualOffice will be introduced now. The scenario is the purchasing process in the purchasing department of the university of Kaiserslautern/ Germany. This process is a good example to establish both a workflow management system and a DAU-system, because the process is well structured, many paper documents are involved, and the information need is very high. The process is determined via statutes describing the practice of purchasing, e.g. it is stated for a demands announcement that requests for offers must be sent to several sellers, their offers have to be collected and after a certain time limit the best offer has to be chosen. The documents involved in the overall process are forms, offers, requests, invoices, delivery notes, reminders, etc.
In the next sections let us look in detail at a simple purchasing process handled by a WFMS.

Expectation

The workflow is started by the arrival of a demands announcement from a university department ordering a computer and a monitor. For simplicity assume the workflow is now in the order phase. In a preceding activity an order has been faxed to a company (e.g. VAT, date: 1998-10-10) and now the workflow is waiting for the confirmation of order, the arrival of a delivery note, and an invoice. The documents will arrive in a different, in advance unknown order. To cope with these circumstances the workflow is modelled by parallel activities, each waiting for a different document. To inform the DAU-system for which document a workflow activity is waiting an expectation has to be set. Picture 2 shows the expectation set by the workflow activity waiting for the invoice. In a subsequent activity the invoice number will be processed, therefore the DAU-task *GetInvoiceNo* is added.

Assignment and Verification

Whenever a scanned document arrives in the office in-tray, the in-tray-server starts a reactive planner instance with the document image and an unique document ID (e.g. retrieved from the Document Management System) as input. Now the planner instance uses the current expectations to determine a plan for analysing the document. With this plan the instance starts the designated specialists with their required input data and parts of the expectations relevant to the specialist's task.
If the reactive planner is able to decide upon the results produced by the specialists which expectation is satisfied by a document, the analysis can be stopped. In our example the company VAT is identified as sender, the message type is invoice, and the pattern matcher found the phrase '*with reference to your order from 1998-10-10*'. With this information the expectation mentioned above is matched and the specified DAU-task is executed. The planner instance contacts the BrokerService with the request to assign the document and the data to the workflow activity designated in the expectation. The BrokerService connects via BrokerModule the workflow engine to contact the waiting workflow activity.



Picture 2: Example Scenario

In the next step a verification tool is started by the workflow. The user obtains the document image, the expectation assigned, and all needed information from the workflow instance to ensure that he can decide if the document is the one expected. After that the user has to verify any additionally requested data by comparing the extracted results with the document image. This has to be done although the document analysis delivers

good recognition rates, but there are still some false results which could cause worse problems in the business process. So in fact the human cannot be replaced but there's a immense assistance in delivering the documents to the right business process and providing any required data. Furthermore in general no data capturing by the clerks is needed, because the required data is requested by specifying DAU-tasks. Last but not least a tight integration of the paper work in the WFMS is accomplished.
After the results are verified the document and the data (in case additional data was requested) are transferred to the workflow instance and can be processed. But if the document is assigned to the wrong workflow instance, there are two possibilities: First the user can assign it to the correct workflow instance. The user will be assisted by the presentation of the expectations on which he has a special view convenient for his needs. Second if the user isn't able to make a decision, the document is given back to the BrokerService. The service instantiates a default workflow definition and assigns the document to the newly created instance. The only task of this instance is to assign the document to the respective workflow instance. The assignment has to be done by a clerk. If the message type of the document is already known, e.g. invoice, an employee of the accounting department would get this work item on his worklist.

DAU-Tasks

Beside stating an expectation the DAU-system allows a workflow activity to request one or more DAU activities in a DAU-task. Such a request could be 'extract the product list of the invoice'. A DAU-task for a specific document will be assigned to the planner instance belonging to that document by the DAU/WFMS BrokerService. To do this the workflow activity starts a BrokerClient and hands over the DAU-task and the unique ID of the document. The BrokerClient connects to the BrokerService which invokes the corresponding planner instance in case the document reached the WFMS via the DAU-system. Otherwise a new planner instance will be created.
Because of retaining intermediary results after analysis and assignment of an incoming document, it is possible to response directly to consecutive DAU-tasks in case the required results are already extracted. Furthermore to guarantee a very fast response time in case the analysis can be started on the intermediary results computed. A further advantage of this approach is that there is no need to analyse the whole document at the beginning, thus reducing compute time and resources and avoiding bottlenecks in peak loads. But there is still remaining enough flexibility to serve subsequent requests.

That means a planner instance exists until a *DAUEndSignal* for the assigned document is invoked by the workflow instance. The signal is indicating that no further request will arrive and therefore the planner instance is no longer needed. In this case all data concerning the planner instance and the document analysis for the document is removed. For example such a DAUEndSignal can be invoked after an invoice is archived. In case all required data was requested with the expectation by the specification of a DAU-task, the signal can be sent directly after the verification of the assignment.

5 Conclusion

The paper started with the claim that the integration of a DAU-system into a WFMS would bring advantages. Then explained the concepts of the integration, showed the use by an example process, and pointed out the synergetic effects.
With the concept shown it is possible to integrate the paper based part of a business process into a WFMS. In addition the DAU will be supported by data retrieved from the WFMS because the specialists know what is very likely to arrive by the information retrieved from the expectations. Furthermore the specialists will have background knowledge available about the expected results, thus increasing recognition rates. Moreover the planner can adjust the plan according to new information, thus effectively using specialists and resources. And as shown in the example it is possible to assign documents to the respective business processes and to support and automate data capturing by the users.

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