Support for exception handling through workflow management systems

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1 Introduction

Standardization of business processes is achieved by using workflow management systems (WMS). Generally, a business process executed by a WMS is well structured, however, there are scenarios where the corresponding process model does not support the efficient handling of the business process. Whenever the properties of the actual business process differ from the underlying assumptions of the business process model, an exception occurs. In short, an exception is the result of a gap between process definition and the requirements of a specific business case.

The result of the discussion on adaptive workflow are mechanisms and concepts aimed at increasing the flexibility of WMS (see e.g. [Pareschi et al. 96], [Sheth et al. 96]). In general terms, higher flexibility of WMS can be achieved by choice (between several process alternatives which are available in the process model) and by adaptation (of processes at run-time). Hence, workflow definition and workflow execution are the two crucial starting points when thinking of flexible WMS. In the following, the paper will provide a set of scenarios on how WMS can be improved in the future by focusing on these two issues.

The authors begin by developing a classification guideline for exceptions (section 2). The following section discusses concepts and functionalities that enable a flexible exception handling at both build-time and run-time. Section 4 deals with issues related to the management of exceptions. The results presented in this paper have been developed and tested in a research project financed by the German Ministry of Education, Science, Research and Technology. The official title of the project is as follows: "Improvement of business processes with flexible workflow management systems (MOVE)".

2 Classification scheme for exceptions

We basically differentiate between two classes of exceptions: "those known while modeling the process" and "those unknown until execution". The former class distinguishes itself by the fact that we know at build-time of a business process that a certain exception occurs periodically or occasionally. However, its exact character is not completely known and therefore the process can only be partially modeled (see below e.g. budget stop, escalation). Furthermore, the estimate for the cost of the modeling of a certain exception may give reason to leave it out of consideration. Cases in the latter group, however, can only be partially supported by the workflow application due to the lack of an adequate workflow model.

During the survey phase of the workflow modeling process we recognized that the users had developed individual criteria to identify exceptions. For example, one user could be confronted with a specific incident (e.g. a new customer requirement) and immediately gives rise to an exception. Another user, however, realizes that some information is missing, or that a set of objects or the case data is incomplete. Other users may identify an exception through the discovery that adequate rules for the case in hand are missing. An important result of our research was that different users may describe the same exception using different, possibly even an individual set of criteria. We also found that these criteria seldom apply to technical aspects of the WMS-implementation. We therefore distinguish exceptions not only by the aforementioned general classes, but also in accordance with user-oriented perspectives. Those perspectives support the communication between those persons modeling a process and those users, who are questioned during the survey. In the following we will introduce our classification of exceptions.

We have identified four major perspectives: *incompleteness, informal aspects, requirements for the distribution of work and the occurrence of incidents* (table 1). A more detailed description of the classification can be found in [Herrmann et al. 98, Vol. 2, p. 77-92].

It is important to recognize that those four perspectives are considered interwoven, overlapping and even incomplete by the means of one's personal point of view. Therefore each case of exception may correspond to more than one class at a time or even none, depending on the user's individual perspective or scheme of criteria. In our opinion, flexible WMS need to support each of those perspectives in order to supply an adequate working environment for the users of a workflow application.

	exceptions known while modeling a process			
excep-tions	**incompleteness**	**informal aspects**	**distribution of work**	**incidents**
un-known	concerning the conditions of the execution	divergence from signature regulations	delegation of sub-tasks	new customer requirements arise
until	concerning competencies and responsibility	requirements of the emergency handling	violating representation and power of attorney regulations	mistakes
exe-cution	of the set of objects (data)	violating of rules	omission of pre-defined process parts	turn of the year (periodically)
time	concerning the target definition or the company policy	ad-hoc communications	engaging additional experts	a budget stop may become effective
	....	....	....	....

table 1: Perspectives and examples for the identification of exceptions

Following we will concisely characterize these classes (e.g. incompleteness is known while modeling a process, incompleteness is known at execution stage of the process, ...) and illustrate them by a few scenarios. Within section 3 those scenarios will be picked up again to show how the handling of exceptions through WMS may be supported.

Incompleteness

The conditions of execution and responsibility can be unclear both at the time of modeling and at the processing stage. In this way, the sequence of steps or the number of tasks to be executed can be partially or completely open. In addition the position - in-house or not - or the specific person from a specific group of persons corresponding to this position (for example the one filling the post or co-operation partner) may be open. *Scenario 1*: (Facility management) In the field of facility management, maintenance tasks are to be distributed and the proper execution of these tasks are/have to be checked. It is not, however, possible to establish the best way to check this work in advance (for example, by means of supervising or by photo) or to decide whether to engage experts for these tasks or not.

Beside that it maybe impossible to plan in advance which data or information one will need (e.g. delivery notes or contracts etc.) or which information is available to complete one step of the process. *Scenario 2*: (Creditworthiness): in the case of investigating a customer's creditworthiness, or in the case of a foreign customer wishing to open an account, it might be necessary to consult more than the standard-used set of information and data. This then becomes an exception to the norm.

Some enterprises rather establish what the exceptions to the rules are. Such a catalogue only describes indirectly what a permissible case may look alike. That means that they have a "negative" catalogue of events which acts as the trigger to start a business process [Dourish et al. 96]. *Scenario 3*: (Negative catalogues): German Social Security Offices know which cases they are not allowed to deal with and to where such cases must be passed on and to whom instead.

Informal Aspects

Numerous examples of the significance of so-called informal procedures can be found in organizational research. By this we understand policies which diverge from the established and express regulations of an enterprise. These procedures often become necessary to solve emergency problems or to be able to preserve the chances of a lucrative business deal. *Scenario 4*: (Off-the-beaten-track) typical for this is the exchange of information without using the usual hierarchical channels; The divergence from signature regulations if, in urgent cases, the person normally authorized to sign is not available or the re-evaluation of an unofficial procedure to an official status because the procedure proves to be significant [Mambrey&Robinson 97] are examples often carried out in organizations.

Work distribution

The normal work distribution changes due to possible alterations to the classification of rights of those employed. An employee who is certain of the agreement of her superior can give permission for the start of a process although he/she is absolutely forbidden to do so. Similar exceptions are known of in the implementation of power of attorney regulations where one employee is standing in for another. In these cases employees are confronted with tasks which they would normally never come involved with because of their formal job description. *Scenario 5*: (Budget stop): A budget stop in public sector administration often requires a quick reaction; success is often, however, only possible through a certain breaking of rules.

Scenario 6: (Escalation): [Goesmann et al. 98a] describes the special process of escalation in the framework of the drawing up of a contract. Here, a sales representative has the opportunity to authorize through persons from the management, certain conditions which diverge from company policy. In advance, however, it is not known which person will first of all be involved, and which other persons will become involved later in the case still cannot be established.

Incidents

Other special factors can influence or cause an exception. Such factors can be ascertained explicitly (e.g. the turn of the year) or in a generalized form (e.g. budget stop). *Scenario* 7 (Law): The introduction of new laws or the emergence of new products on the market are events which can happen at any moment without warning. Saastamoinen, in a comprehensive investigation on handling exceptions, discovered reasons on different levels [Saastamoinen 95]. He therefore suggests differentiating between the causes of these exceptions. The exceptions he investigated referred to mistakes mostly. Thus, one can establish whether a mistake is technological, or due to employees' incompetence and carelessness, or due to miscalculations. This categorization is, above all, useful when one is dealing with the question of avoiding errors.

3 Workflow based support for exception handling in business processes

Goal of the former section was the presentation of a user-oriented classification of exceptions. It has been developed to support the survey phase of the workflow-life cycle [Unland 98], [Walter&Herrmann 98]. Following several techniques for the handling of exceptions using a WMS are discussed firstly for the modeling process and secondly for the process model execution stage. In our opinion, those techniques represent a kind of toolbox for WMS-user. We understand that one of the eight classes aforementioned may be supported by several techniques. Where as one technique may support the user to handle more than one class of exceptions.

For a concise paper we decided to use scenarios (1-7) as the linkage between sections 2 and 3. Those sections therefore do not share one structure. Part of our further work is the establishment of a checklist providing a relation scheme between techniques and exception classes aiming at the support of those involved in a WMS-implementation process.

3.1 Exception handling during process modeling

As we have discussed above, during process model build-time it is only possible to deal with exceptions that can be foreseen in advance - so-called predictable modifications [Deiters 93]. That means we assume that a standard business case exists and is defined by a process model. These business process models are usually strongly structured, i.e. all relations of the involved persons concerning co-operation, co-ordination and communication are defined. Thus, within the process model, the process model entities and the relationships between those entities are described [Picot&Reichwald 87].

What is the impact on process models that enables us to deal with exceptions? For all kind of exceptions one or more process model entity or the relations between process model entities are not determined. Thus, exceptions belong to the class of semi-structured processes[Lˆffeler et al. 98].

To deal with exceptions in business process models we therefore propose de-structuring business processes. That means, strongly structured processes are changed into semi-structured processes in order to adopt the normal case as well as the exception. The following scenario show possible de-structuring results:

- Scenario 2 (Creditworthiness):

Within this scenario it is not known which information is to be used to handle the exception. Here, an application of the pull-principle -a mechanism where the user has at his/her disposal a feature to request further required information objects from the WMS- could be reasonable.

- Scenario 3 (Negative catalogue):

Constraint based workflows [Dourish et al. 96] enforce that process parts that are not allowed or process parts that are ineffective must not be performed, whereas all other process paths can be performed by the user. Within their work [Nastansky&Hilpert 94] have also stated the necessity of introducing deviations from a pre-defined process definition.

- Scenario 4 (Off-the-beaten-track):

Particularly when dealing with all those informal aspects connected with exceptions, it can be very useful to integrate e-mail functionality into WMS. Furthermore, an integration of the internet/intranet allows informal communication.

- Scenario 5 (budget stop):

In order to deal with processes whose the definition is not completely known in advance (i.e. at build-time), late modeling techniques [Hagemeyer et al. 97], [Cla_en et al. 97] can be used in order to change or to extend process definitions during run-time.

- Scenario 6 (escalation):

For this kind of exception the appropriate kind of IT-support is the integration of a groupware system with a WMS performing the strongly structured process part under the control of the WMS, whereas the semi-structured process part is performed using the groupware system's functionality. An alternative support technique using intranet technology is described in [Goesmann et al. 98].

3.2 Exception handling during process model execution

In order to deal with predictable as well as unpredictable modifications during process model execution, the WMS supporting the business process has to be equipped with features for exception handling which allow us to deal with flexibility. Flexibility always means that the user of the system has to be able to make decisions during the process. Therefore, the system first has to encompass features to perform different process alternatives in a flexible way. Second, it should provide features empowering the user to make the right decisions. This, for example, could be achieved by collecting and storing experience gathered from earlier cases in an appropriate database, which could be used for further decisions.

3.2.1 Basic principles for dealing with exceptional cases during process execution

Different approaches for dealing with flexibility in business process execution have been proposed in the MOVE-project ([Lˆffeler et al. 98], [Just 96]). The following approaches have so far been distinguished:

- ***Basic build-ins*** for exception handling, like, for example, delegation, roll back or skipping of process steps (table 1: omission). These concepts can be a useful means for a user to react to certain situations. This is necessary, for example, in scenario 5 when the activity "require further offers" has to be skipped in the case of a budget stop.
- ***Late modeling*** of process parts means defining incomplete process models at build-time. Certain exceptional process parts are defined only at run-time when it is known due to the process state how to perform these process parts. This concept is useful in scenarios 1 and 4 above.
- ***Post modeling*** of process parts can be used when certain process parts are unknown at build-time and it is still unclear at run-time (before starting the corresponding part) how to perform the process part (see scenario 5). Using groupware techniques the user can still use CSCW support in the process. However, by recording the different actions the user performs, a process definition can be gained afterwards that can be used for further process instances.
- ***Model off-line execution*** can be a useful concept for those exceptions that cannot be performed according to the global, standard process model. In this situation, only those cases where a different treatment was applied should be recorded in a process database (scenario 7).

In order to strongly support these different concepts, communication processes should be organized and supported by appropriate IT-support that allows the exchange of experience in how to deal with exceptions. This could firstly be achieved by building up special databases (see below) where certain decisions are recorded, and secondly by building up certain co-ordination and voting means involving superiors and experts in the decision process concerning how to handle the exception.

3.2.2 Knowledge-based systems for exception handling

We have already indicated above that a flexible process execution always starts with a decision about how to perform a certain exception. Within this decision the user should be supported as much as possible. The following concepts give support within that decision process:

- identification of similar cases that have already occurred
- support of the communication process between different people (user, expert, superior) in order to make the decision
- information disposal during process execution

The different concepts for dealing with exceptions that have been indicated in the section above lead to different process versions, the definition of which should be recorded in an appropriate case repository. This repository contains information about all cases that have been performed or are currently being performed. It could be used as an experience database by the user in order to (at least) extract advice on how to behave while processing certain exceptional cases. However, this case repository should not only contain the core process information but rather should be enriched with as much context knowledge as possible. This context knowledge can, for example, contain information about the number of exceptions, the time when the exception occurred, reasons for taking certain decisions, errors that occurred, information taken into account for certain decisions, and much more. Some of this information can automatically be obtained from the WMS supporting the process. Other information of this kind can only be inserted into the case repository by the user.

With this kind of knowledge base algorithms should be implemented which allow the user to navigate through that knowledge to find support for his decision on how to handle a certain exception. Furthermore, there should be some kind of proactive support from the system proposing relevant information to the user. Case-based reasoning systems [Wargitsch et al. 98] could be an appropriate support in the latter kind of proactive usage of the knowledge base. Furthermore, concepts for detecting redundancy and contradictions in the knowledge base are needed.

The knowledge based case repository is one but, of course, no sufficient means to support the user in his decision on how to deal with exceptions in a process. Further support enabling a communication process between different people involved in the decision process is needed. This can be achieved by groupware systems (e.g. mail, newsgroups, videoconferencing). However, appropriate IT-support should also help to build up the needed communication. That means, for example, the system should help finding the right communication partner in a given process situation. This could also be achieved by storing and using know-how profiles of the different people involved in the process. These profiles could encompass information like: Who has performed a similar case, already? Who has already been consulted many times for advice or additional reports? Again, to a great extent this information could automatically be gained by producing case traces from the WMS.

Furthermore, within the process, information is often needed that is not described in the corresponding process model but can rather be found in various documents (e.g. ISO9000 definitions). These documents can be available from related document management systems, from the company's intranet or from other sources. If a WMS traces in which process states these documents have been accessed, it could pro-actively offer these documents to the user in other similar process states (for example in order to help deal with exceptions). For this reason uniform access is needed to the different information sources available in an organization. This leads to the concept of building up an organizational memory information system (OMIS). For a survey on OMIS see [K¸hn&Abecker 97]. For us an integration of OMIS and WMS seems to be an extremely interesting subject of research.

The knowledge management subject has already been under discussion for a couple of years. However, only little work has so far been done on using knowledge management techniques to deal with exceptional cases in process management. We are convinced that knowledge management techniques could contribute a lot to the building up of systems supporting flexible business processes. Some aspects of how to do so have been indicated in this section. A more elaborate discussion can be found in [Goesmann et al. 98b].

4 Conclusion: Systematic exception handling

In order to achieve the efficient handling of exceptions by WMS, a systematic approach should be followed. The approach should be based on the classification guideline provided in section 2 and the related workflow supported methods discussed in section 3. Figure 1 shows a cycle which allows to manage exceptions at run-time.

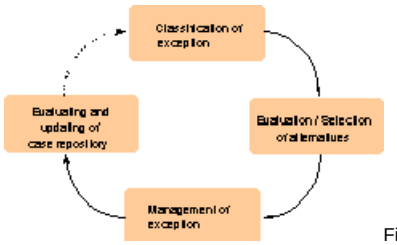

Figure 1: Steps for exception handling

With the occurrence of an exception during workflow execution, the first step lies in determining the nature of the exception. This task can be accomplished by using the classification guideline provided earlier (table 1). Once the circumstances of the occurrence of an exception have been established, alternative process paths can be suggested by the WMS. This task can be simplified by consulting the knowledge based case repository which contains problem solutions that have been executed before. The configuration of alternative process paths is also heavily influenced by the experience of the employees involved. This is because employees probably take into consideration alternatives external to the system. The selection of alternative processes can be evaluated for instance by comparing the expected goal fulfillment and related costs. Based on this evaluation the user can choose a specific process path. Then, further exception handling will utilize one or a combination of the workflow supported methods described in section 3. The management of an exception is concluded with an evaluation of the measures taken. The chosen problem solution is also included in a case repository, thus making it accessible for the next occurrence of an exception.

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