# Application Usage Mining to Improve Enterprise Workflows: ERP Systems SAP R/3 as Example

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## ABSTRACT

As a result of the users interaction with modern business application systems1, e.g. SAP R/3, users leave traces in the form of log, protocol and trace data. These data can be consulted and used as a main data source for a user behavior analysis. The main point of a user behavior analysis is to discover and analyze interesting patterns from these data. Application Usage Mining (AUM) uses the data Mining Methods to discover and evaluate these patterns. The results of the user behavior analysis should support and simplify the personalization2 of the system from the users point of view as well as enable the development of an As-Is Model as a basis to improve the Workflows of the Business Process of an enterprise regarding to the principles of Continuous Improvement.

## INTRODUCTION

The smallest level of detail of a Workflows are the tasks, which are regarded as logical working units. A task contains all work steps, which can be executed by resources at a work place. The scale of a task should be as small as possible and as large as necessary. A "Commit" is to store the task data in the database of the operational system as Logical unit OF Work (LUW). The storage must be made at the earliest possible time consistently and persistent [RS04]. The data are kept central e.g. in ERP systems. ERP systems focus on integration of distributed data. Application modules from deferent operational areas are integrated over a common consistent volume of data. The transaction characteristics are kept, which is made possible by the use of relational databases.

To implement an ERP systems the change to relational databases usually is necessary. Already existing Relational databases usually have to be migrated. The strict standardized structure of the data given by ERP system must be kept. The tasks must be executed under observance of transaction characteristics (ACID characteristics: Atomicity, Consistency, Isolation, Durability). A business transaction is a computer-assisted standardized task, which is executed by an employee at a certain time at a certain place. In order to ensure the observance of Atomicity transaction characteristics in ERP systems, work steps of a business transaction are either implemented together or not at all. Thus only business transaction is to be considered as the smallest measurable unit of a Workflow. Therefore task steps within a Business Transaction are hidden for Process Management. Nevertheless this condition does not mean a lack of the systems which support Process Managements, since the achievement analysis of Business Processes plays a substantial role in the context of the Business Process Reengineering (BPR). The competition takes place on the level of quality of the achievements and less on the level of the way, how the achievements are proceeded. Nevertheless improvements on Micro Level can lead to significant improvements of the efficiency of an organization.

Anyway the users work on the tasks with different effectiveness. This aspect is not considered in Workflow Management Systems (WFMS). The philosophy of the Workflow concept considers, that tasks are realized in the Workflow concept by one or more task steps and it is supposed that qualified employees are working on the task steps with the

optimum software. How a task is really worked on remains a black box for the Workflow Management, which is measurable by input and output values only. These values measure certain criteria of an activity, e.g. name of the employee, processing status, input data, output data and informations about the condition of the operational objects which are to be handled (Business Objects).

AUM uses the Data Mining methods for analysis and evaluation of different user behaviour in the system. Modern operational computer-aided systems such as ERP systems place detailed data, which describe the use of the respective system. SAP R/3 e.g. disposes of user trace data, which describe the interaction of users with the system exactly, so that a still finer degree of detail of the Workflow instances can be achieved up to the task steps of a Workflow. AUM uses the user trace data and pursues thereby the completion of the tasks from the user point of view and makes user behaviour analyses available. On the one hand the goal is the personalisation of the system, whereby a simplification of the use of the system can be achieved. On the other hand AUM can deliver a detailed Workflow-As-Is-Model, which is necessary for an Workflow analysis. As an example for the implementation of tasks and its steps the software product SAP R/3 is considered as a wide-spread ERP system.

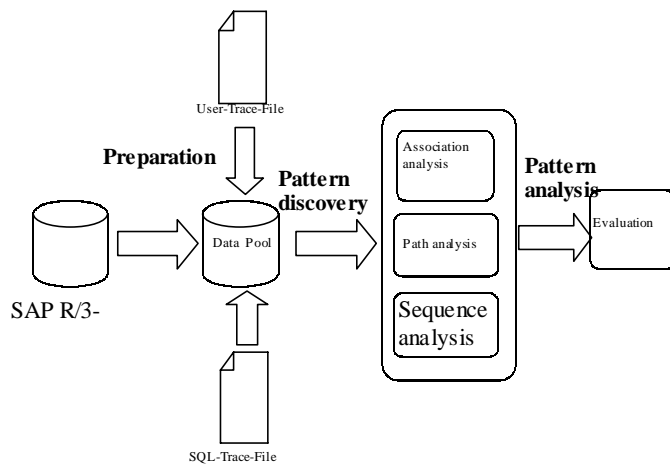## IMPLEMENTATION OF BUSINESS TASKS IN SAP R/3

A transaction in SAP terminology is an interactive program with one or more screen masks, which changes Data Objects in the Database in consistent way. An implemented Business Task in SAP R/3 is called Logical Unit of Work (LUW). LUW is a group of work steps within a transaction. All these steps must be accomplished correctly, before the LUW is terminated as part of the transaction (COMMIT). If an error arises during the execution of a transaction, all changes are rejected in the LUW (ROLL-BACK), not however in preceding LUW's of this transaction. The business task which can be implemented must be elementary. From the entering of a customer ordering up to the issue of the invoice one will divide the economical Business Process into parts of a Workflow which can be implemented logically separately, in order to then realize these parts by individual tasks (SAP LUW's) in the R/3-System. The evaluation, which is an "elementary" task, depends on the Workflow and its modelling. Screen masks in SAP R/3 represent therefore a task step within a LUW [Are99]. Conclusions can be drawn from the AUM process by observing the entered data as well as the screen elements operated by the user.

## APPLICATION USAGE MINING PROCESS

The Application Usage Mining process resembles the structure of the Web Usage Mining process, however with different tracking as well as the kind of the data which entered the process [KRM02]. The AUM process consists of three process phases based on the phase before (s. Fig. 1):

1. *the preparatory phase*: in the preparatory phase relevant data, which describe the interaction of the users, are extracted from

*Figure 1. Application Usage Mining Process*



*The AUM-Data-Base-Pattern*

Fig. 2 points the database schema as an Entity-Relationship-Model to describe the user interaction with a SAP R/3-System. The most important Entity-Types of the Metamodels are:

- **Mode:** During the users log-on to the system the system opens the first mode. An instance of a system window is called mode. In each window a mode is started, in which successively as many applications as desired can be executed. So the user can work in more than one application at the same time and let run off several modes parallely each in its own windows as a system surface.
- **Transaction:** By means of an application a determined problem definition and/or task is supported in the system. Applications are the functions in the respective program module. Each application is assigned an application code and a screen sequence. A transaction is regarded as execution of SAP-applications at run-time, like instance of a class or process of a program. It is marked as LUW of the actual application by the execution of a function, e.g. the application for user administration can create, change, indicate or delete users at run-time.
- **Screen:** Screens of an application are mainly dialog screens, with which the user communicates. In addition there are other kinds of screens such as system messages, reports or error-message-windows.
- **Screen Elements:** The main components of a dialog screen are screen elements, e.g. buttons, input fields etc..

The components and/or Entitiy types specified above are the basic elements for the implementation of the integrated data pool for the description of user interactions.

different sources, like user trace files and Databases of the SAP R/3. These then are stored in a separate central data base, the so-called data pool.
2. *the pattern discovery phase*: in the pattern discovery phase methods of Data Mining are used and coherent structures within the database pool, which are necessary for the analysis phase, are discovered.
3. *the pattern analysis*: this phase concludes the evaluation of discovered patterns and the presentation of results.

The AUM process should be a continuous process in the sense of the Continuous Improvement, which is to be started in regular time intervals and makes the results available to the Process Management.

**The Preparation Phase**

In Application Usage Mining data, which were produced by the use of the system, form the basis for the next phase of the AUM. These data are both operational and technical data. The filtering and derivation of operational and technical data take place in this phase. Both data types are integrated into a database, the so-called data pool, and prepared by it for the next phase of the AUM.

Technical data are data, which describe the interaction of the users and its activities with the system. Technical data only describe the way to the treatment of actual operational data. They are extracted from developer-trace-files of the SAP R/3-system and stored in the data pool of the AUM.

The operational data are data of all kinds, which were entered in the context of day trading in the SAP R/3-System. Before these data are integrated into the data pool of the AUM, they must be selected from the SAP databases and stored in the data pool. Technical data are integrated with the corresponding operational data in the data pool of the AUM. The data pool is based on a database schema, which illustrates and integrates the interaction of the users and the consequential results in the SAP R/3-database.

The allocation of the technical data to the operational data is carried out by comparing the SQL-Trace-Data with the User-Trace-Data and following integration of the operational data via BAPI-Interfaces3 into the data pool of the AUM. During the collection of the data into the data pool of the AUM the time factor has to be considered explicitly. Thus the Business Processes and their activities can be reconstructed in the analysis phase of the AUM and an As-Is-Model of the Workflows can be built.

**Pattern Discovery Phase**

In the following pattern discovery phase different methods of the Data Mining are used. The used methods are to help to uncover connections between the stored data in the AUM data pool. Here different techniques are used for different data connections:

- Path Analysis
- Association Analysis
- Sequence Analysis

In the *Analysis Phase* of the AUM the effectiveness of the use of the system is analyzed from economical view.  Effectiveness is defined as the "extent, in which planned activities are carried out and planned results are reached." (ISO 9000:0000). It is thus of higher priority to reach goals than to improve the way to it.

On the other hand it is the goal of an employee of an enterprise of settling given tasks expediently. A user transaction in this context (not to be confound with Database-transactions or SAP-transactions) contains the access path, the user action data due to it and the output resulting from it. In accordance with this fact the evaluation of the user transactions as success or failure depends on these results. Transactions, which are successfully executed, lead to changes of operational data in the database of the operational system. User transactions, which implement reading database transactions, are evaluated as successful, too, if they cause the output of data, e.g. deriving reports.

Input data of the users or actions, e.g. clicking with the mouse in the screens, are stored to the appropriate Dynpro elements into the data pool. The results of a LUW are stored by SQL-traces in the data pool and assigned to the access path, which causes the successful transaction.

Afterwards the Data Mining Methods are used in order to determine certain connections for the personalisation of the users in the system and the derivations of the As-Is-Model.

**Path Analysis:** With the path analysis one determines the used paths of the users by the system for clarifying for example the following questions:

*Figure 2. Data-Pool of a Data-Base-Schema*
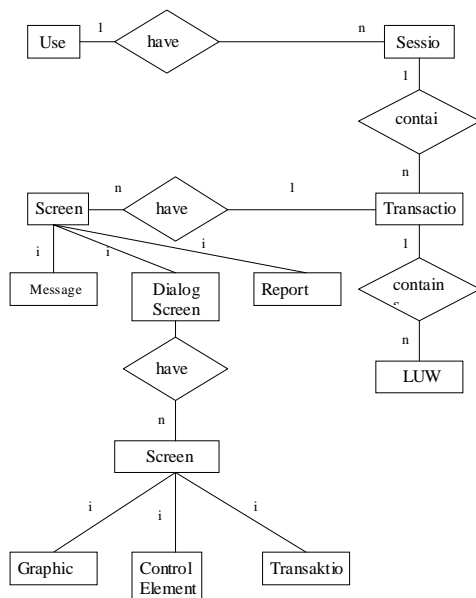


- In which places of same access paths of the users an error message appears?
- In which places of the users access paths the transactions are frequently broken off?
- In which places of the access paths there are dead ends?

**Association Analysis:** With the help of the association analysis the connection between events (e.g. input of data fields and manipulation of buttons) and the expiration of a screen sequence is to be determined. Here the customizing of the system is examined for its correctness. So e.g. the deviations of the user access paths are to be analyzed for the execution of the Business Processes by the ideal access path of this Business Process.

**Sequence Analysis:** With the sequence analysis time-related data are considered. Among other things the effectiveness of the users handling with the system is to be analyzed here:

- How fast are new users becoming acquainted with the system?
- How long does a user need to handle the task?
- Which text fields are occupied always with the same values and which values are concerned?
- Which screens of a transaction were not operated?
- From which transactions and from which screen other transactions are called?
- From which screen of a transaction aid programmes are used and which topic do they treat?

**Pattern Analysis:** This phase contains evaluations of discovered patterns and the presentation of results. The results of the pattern analysis phase drives activities for improvement system use as Personalisation of the system from the users point of view and on the other hand to build an As-Is Model containing Workflows, which should be improved.

*Personalisation of the System*
The Personalization concept cause changes of the operational application system.

Therefore it is mandatory necessary that the system supplies possibilities of modification in the form of services and tools to the execution of the personalisation concept. Changes in SAP R/3 are divided from technical point of view into the following categories:

- *Customizing* allows the user to select options and parameterize the system to adapt it regarding the requirements of an enterprise [Kel99]. For the setting of parameters the user does not need programming knowledge for the execution of the changes.
- *Modification* is the change for the individual customer at R/3-Repository objects. Modified R/3-Repository-Objects must be verified by SAP.
- *Extension*: With help of the R/3-extension concept the user can add its own functionality to SAP standard application without modifying the SAP originals [URL1].
- *Self-developments* are developments of functionalities, which do not exist in SAP-R/3.

*Personalisation of Navigation and Tasks in SAP R/3*
By customizing the administrator creates user menus, which offer the possibility of direct access to the functions relevant for the user. If the user logs on the system, he automatically receives the user menu typical for his daily work as well as the authorizations he needs for this work. Additionally the user can arrange his personal favourite list of the assigning functions. Via his favourites the user then starts its SAP-applications. Therefore "Personalization of Application" is one of the most important Customizing aspects of SAP R/3. The visible part of a transaction consists of one or more screens. Personalization of applications are made in SAP R/3 by a set of tools and services. The most important approach to Personalization of applications is the so-called "transaction/screen variant".

*Transaction/Screenvariants*
If a transaction is used for completion by different economical business transactions, it is frequently meaningful to adapt the flow of the transaction to the respective business transaction. Unimportant information is to be faded out, important information in contrast is to be presented better.

A transaction variant consists of a set of screen variants. The field values and field settings for each screen recorded in the transaction variant are filed in a screen variant. For each transaction as many variants as desired can be provided. If a transaction variant is created, the transaction runs in a special mode For each screen they specify, which elements are redundant or can be preallocated with values. If a whole screen is redundant, it can be deleted from a screen variant.

Transaction variants simplify transaction flows by:

- Inserting default values in fields
- Changing the ready for input status of fields
- Adjusting table control settings
- Fading out menu functions
- Hiding various screen elements and menu functions, or even entire screens

The new techniques and mechanisms of Personalization of modern operational application systems offer the user many possibilities and variants for Personalization. To adjust the individual Personalization profile the user usually needs external assistance by experienced co-workers and/or administrators to help as well as time-consuming reading of system on-line documentations.

Due to always changing and increasing requirements during daily working with the system, the Personalization profile has to be adapted consistantly. Many users are deterred by this complexity and valuable techniques and methods lie idle. A possible solution of the problem can be given with the help of the methods of Application Usage Mining (AUM). The goal of Personalisation by AUM is it to give the user selective and individual suggestions and recommendations in terms of

one or several personalisation profiles after observing and analysing the user's behaviour [KRM02].

## The Workflow-As-Is-Model

### Interactions of the Users with the SAP R/3-System

An interactive program is called transaction in the SAP terminology. Each SAP transaction can be called by the user over the transaction code. The visible part of the SAP transaction, e.g. the SAP Dialog program, are the screens. SAP R/3 transactions are a consequence of coherent interactive steps. An interactive step is represented in each case by a screen. The expiration of the transaction depends on the data entered by the user in the screens and the implemented actions (e.g. which button was pushed). Results of the transaction execution take place by updating in the data base as LUW's. The LUW's are to treat an operate-economical object (e.g. customer order, material, product etc..) and thus fulfil the business tasks. Successes or failures of the execution of transactions are communicated to the user by the system messages.

### Structure of the Minutes Entries in Developer Trace Files

Trace is a means, with which the expiration of a specific computer aided Processing can be regarded and reconstructed. A trace program is thus an application, which examines another program for it, in which sequence the program instructions was carried out and which results follow from it [URL2]. The trace files resulting from it are predominantly used within the range of the monitoring and the error tracing. Within the range of the operational application systems there is so far no standard format for the trace files of different software providers, so that this paper only deals with structure and format of the trace files in SAP R/3.

The user trace file describes the processing of SAP transactions and/or programs, which are implemented by the user. This description is noted to the so-called trace components on the basis of different criteria. On the other hand the trace file is always extended sequential during the user transactions by new units, the so-called work steps. A work step presents an interaction unit, which represents e.g. the change from a screen to the next. Each line in the trace files begins with the component abbreviation. As shown in table 1, this is the letter, which identifies the trace component.

In the context of this paper it is not dealt with components of the trace file and these will not be explained, in fact the interaction data necessary

Figure 3. Referring Trace File Data to Screen Elements
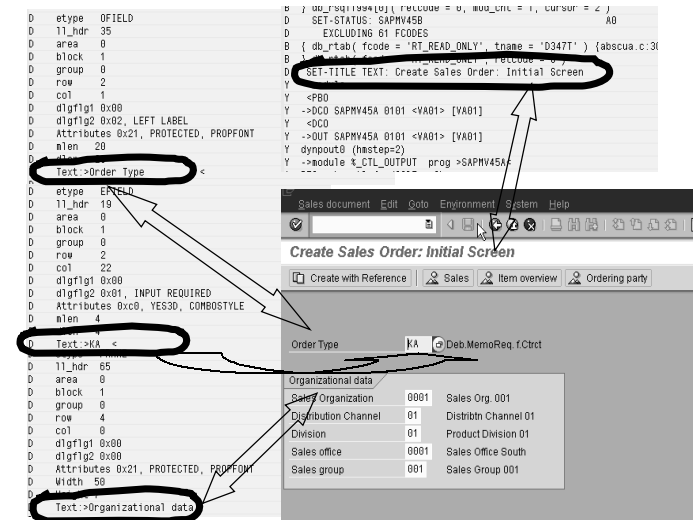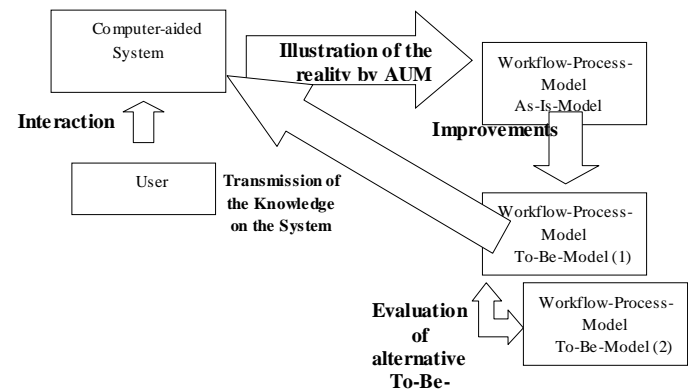


Figure 4. Workflow-Improvement Life Cycle



for the AUM are to be placed into the centre. The following interaction data are supplied in the user trace file to SAP R/3 system (s. Fig. 4):

- transaction code and/or program name
- time stamps with each work procedure
- screen title - screen elements with the respective values
- system messages

As-Is-models of the business processes can be illustrated by observing the user interactions, thus providing a real imagination about the real operational sequence of the processes in an enterprise.

Since the work steps, which are carried out by the interaction of the user with the system, can be logged by AUM, one can get an idea of the process data flow and derive the As-Is-Model of a Workflow.

### Improvement Life Circle of a Workflow

Fig 4 shows the development of an improvement life cycle of a Workflow. Starting point is the reality, which shows which work steps are used and how they are completed in the system during longer periods. AUM is to illustrate the Workflows, which exhibit improvement needs. On the basis of the Data-Mining-Methods this Workflows can be sought out in the discovery phase, be modelled in the analysis phase as an As-Is-Model and set up improvement suggestions as a To-Be-Model. Examples for this:

Table 1. Component Abbreviation in Trace File

| Component Abbreviation in Trace File | Component (Selection using SM50 or SM04) |
|---|---|
| M | Task handler |
| A | ABAP processor |
| Y | Screen processor |
| X | Extended memory |
| E | Lock management (enqueue) |
| I | IPC (inter process communication) |
| S | Print (spool) |
| N | Security |
| T | Debug system |
| L | Background |
| B | Database |
| C | Database (DBSL) |
| P | Paging |
| R | Rolling |
| D | Diag processor |

**Change of the Sequence:** Procedures can partly be improved by simply changing the working sequence within the transaction. An example is that one first examines, whether a customer is already present and thus already has a customer number, instead of first entering all customer data and then examining whether this customer is already existing in the system. Recordings of aborts of the transactions and possibly occurring error messages point at the pattern of the procedures.

**Omitting of Working Steps:** To deal with customer orders first the order type is selected and in addition due data are entered. If there is only one order type in the company, all fields of the starting screen can be reserved clearly according to the business transaction by the system. Since a manual input is no longer necessary, the screen can be faded out.

To be able to find out and improve such working routine, the values of the screen input data of a LUW are observed over a longer period of time during the discovery phase of the AUM. Screen input data, which exhibit the same values, refer to the necessity of the improvement of the task.

**Introduction of Conditions:** With the business transaction "Material Entrance" the size data of the materials and the assigned stocks are entered. Later it turns out that the materials do not fit into the indicated stock due to their size. The specialist corrects the allocation to another stock, which can take up materials of this size. The materials are transported and stored into the correct stock. On the basis of the employees interaction with the operational system AUM can discover also this case and mark it as an improvement requirement.

Further To-Be-Models can be compiled, which first must be examined each for itself for formal correctness. An evaluation of the To-Be-Model supplies decision-supporting proposals for solutions for qualitative improvements first of the models and thus also the Workflows themselves.

## VIEW AND SUMMARY

The examples specified above serve for illustrating business transactions. By the observation of the interaction of the users with the system as well as by the observation of results stored in the Operational Database, these business transactions can be improved. The AUM can make a substantial contribution to the improvement of the Workflows and therefore the Business Process through the refinement of the degree of detail of an Workflow instance up to the task step.

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[URL1] http://help.sap.com/

[URL2] http://www.ifi.unizh.ch/CL/Glossar/Trace.html

## ENDNOTES

[1]  Business application system means an installed software product, which serves the support of task settings in the business field.

[2]  Personalization means to adjust the System to meet the work requirements of specific users or user groups. Personalization is aimed at accelerating and simplifying the business transactions of the System processes.

[3]  Standardized programming interface enabling external applications to access business processes and data in the R/3 System.

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