

## Enhancing User Profile Personalization in Enterprise Systems: A Conceptual Framework Leveraging Application Usage Mining Methods

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**Abstract.** Facilitating seamless business transactions and intricate processes within contemporary enterprise systems often demands a proficient and well-trained workforce. This paper is dedicated to presenting a groundbreaking conceptual framework aimed at fostering dynamic, standardized personalization within these systems. The proposed framework emerges from an in-depth analysis of individual user behaviors, leveraging cutting-edge Application Usage Mining (AUM) techniques to glean invaluable insights and knowledge from user-system interactions. Such an approach promises to revolutionize end-user efficiency and streamline the utilization of enterprise systems, including but not limited to ERP, SCMS, and CRMS platforms.

To validate the efficacy of this framework, a real-world scenario involving SAP ERP will serve as a compelling case study. Furthermore, the results of implementing the framework in this context will be vividly portrayed using graphical tools, offering a visual representation of the access pathways crucial in the execution of workflows.

**Keywords:** User profile personalization; Application usage mining. Enterprise system

## **1. Introduction**

The concept of "Application Usage Mining (AUM)" has gained significant prominence in the broader context of Web Mining (WM) (Etzioni, 1996), with a primary focus on enhancing personalization and optimizing web applications by extracting valuable insights from server log files. These log files serve as invaluable data repositories, capturing user interactions with web servers, and have been extensively explored in the literature (Facca & Lanzi, 2003; Aartsen et al., 2020). Over the years, a substantial body of research has emerged, particularly since the 1990s, underscoring the importance of web-based application usage mining in the context of the World Wide Web.

While web application usage mining has garnered considerable attention, our research ventures into a relatively unexplored territory within Enterprise Systems as "Application Usage Mining". Surprisingly, this domain has received limited research attention. Our motivation for this exploration is rooted in the pressing need to alleviate the complexities associated with business processes facilitated by enterprise systems, such as Enterprise Resource Planning (ERP) systems. ERP systems as standardized software solutions offer functionalities that seamlessly integrate and automate enterprise's business processes. These systems rely on a common data model that spans across various enterprise functional areas and extends their reach to encompass multiple departments of an enterprise (Abts & Mülder, 2017; Al-Sawa'ei et al., 2015). To operate effectively within this ERP ecosystem, users, especially newcomers, typically need to undergo extensive training programs. Enterprise systems offer a multitude of transactions and transaction variants, diverse navigation tools, interactive documentation, and support tools. While implementing ERP systems promises to support a substantial portion of an organization's current business processes and prepares for possible future process adaptations, this proliferation of functionalities inevitably leads to complex system navigation and a steeper learning curve.

Recognizing this, the need for advanced personalization in the context of Enterprise Resource Planning (ERP) systems becomes evident. Personalization not only streamlines complexities but also holds the key to optimizing the usability of these enterprise systems, thereby improving the efficiency and effectiveness of end-users. Furthermore, personalization, with a focus on enhancing the simplicity of enterprise system usage, has emerged as a burgeoning area of research, offering innovative technologies that are increasingly vital in the modern business landscape.

In this research article, we conduct a literature review to investigate various forms and objectives of personalization related to Enterprise systems and E-commerce applications. We provide an overview of the main mechanisms and approaches employed to implement personalization concepts, using the SAP ERP system as a case study throughout the paper and based on this, we present a novel conceptual model for implicit personalization in the context of Enterprise systems. This research aims to offer practical solutions that not only reduce complexity but also enhance the usability of enterprise systems, thus contributing to the evolving landscape of personalized and efficient enterprise system usage.

Our pursuit of these research objectives will unfold through a structured progression:

- The next section will offer a comprehensive literature review, addressing related works.
- Section 3 will provide an extensive description of the methodology used.
- The fourth section will include result visualization and discussion.
- The work will be concluded in the last section.

## **2. Literature Review**

This chapter presents the main personalization concepts, methods, and techniques currently used in the area of business applications in form of a literature review.

### **2.1. Insights into Personalization**

This section explains personalization in general. First, we provide a definition aiming to find a common

basic understanding of personalization. Then, the purpose of personalization will be investigated and analyzed. Personalization started in the area of web applications. Since 1995/1996, Information Systems personalization within the areas "Adaptive Hypermedia Systems" (Bry& Heinzel, 2002). and "Web Usage Mining" "E-commerce" (Spiliopoulou, 2000., Srivastava et al., 2000) has been investigated. E-learning is another important application field of personalization (Bry.& Heinzel, 2005). .

"Personalization" as a concept is still foggy in the literature because this term is used in very different contexts. Several disciplines are interested in personalization, adapting products to customer requirements (including customization), software configuration (user settings), adapting web pages to customers or visitors, etc. From the application/user perspective, Rosenberg limits personalization as an application that processes result and thereby modifies actively the interaction with the end user (Schackmann, 2003). In another publication, Rosenberg defines personalization in this context as a computer-aided application that delivers one or more recommendations and provides the end user with contents in runtime based on precisely defined inputs by the user. Bry & Henze promote this definition; they declare that: Ideally, personalized software should appear as were developed to meet the personal needs and requirements of the end users directly (Bry.& Heinzel, 2005). The purposes of personalization depend on its application fields. For example, in the Web area, personalization "offers the users more control over their web. The target here is to promote repeated visits, user loyalty, and ultimately the financial performance of the enterprise" (Richard, 2001). In the field of enterprise systems, personalization aims to accelerate and simplify processes and transactions while working on the system.

The usage mining tools and methods are intensively used for personalization, especially in Web-related areas like (Bharti & Raval, 2019), which focuses on using web usage mining and web context mining for web page access prediction which is applied for the Personalization of web pages for specific users or group of users. Similarly (Rathi & Singh, 2019) focused on usage mining methods for investigating the user behavior for personalization of web pages. In line with applying usage mining methods presented a framework for improving using usage of website structuring (Kapusta et al., 2018). Also (El Azab et al., 2018) focused on how web usage mining techniques and applications across industries can be supported. It is Clear to experience that many research works handled with personalization and usage mining especially in web-related areas but near to no research focused on using usage mining for personalization in enterprise system applications. This paper focuses on explaining the scientific contribution of this research.

## **2.2. Methods of personalization in Web area**

Generally, all different methods of personalization run to adapt the user profile with corresponding sub-areas of a web page, dynamically based on modeled content categories. According to Schackmann, the most commonly used methods are (Schackmann, 2003):

- Electronic Catalogs: Offer choice lists with specified search criteria that are actively selected by the user.
- Configuration options: Allow the user to preset his preferences and automated adjustments of the offered information.
- Contextual inference: Gives the department's employees the opportunity to set rules to provide users with such content based on their profiles.
- Collaborative filtering: customer segments are determined based on similarity of interests. This is done either by explicit inquiry of sample users or by automatic alignments of the user behavior and extraction of exemplary user profiles.
- Data Mining: analyze user log files, user click streams, as well as demographic data of a user to find out user behavior patterns and predictions about the relevant content.

The differences between the methods lie in the ability to process offline and online, the intrusion into the privacy of customers, and the accuracy of the personalization results that can

be evaluated (Schackmann, 2003). According to (Instone, 2000), a personalization system is: any piece of software that applies business rules to users' profiles and their content to provide a variable set of user interfaces. Personalization is presented as a two-dimensional construct based on user involvement (explicit vs. implicit) and what is profiled (user interface vs. content) (Instone, 2000). Furthermore (Treiblmaier et al., 2004) have examined the user-initiated customization (explicit) and system-driven personalization (implicit). The different methods show that there are differences in the extraction of information about the user. Therefore, it must be distinguished within the personalization process based on the type of information gathering:

- **Explicit information retrieval:** This requires that the user provides the system actively with information. This can be done through a survey, by filling out forms, or by directly editing the user profile. The advantage of this approach is the ease of implementation and its transparency to the user regarding disclosures of personal information. Disadvantages could be caused, for example, by possible time limitation of the user, his confusion about the appearing survey site, and switching (changing) his attention could lead the user to release incorrect or insufficient information about himself.
- **Implicit information retrieval:** Here, information about the user is gathered through observation and analysis of user behavior. The role of the user here is passive during the processing of his profile. The advantage of this type of information gathering is, for example, that other external data can be integrated by information extraction, so that the quality of personalization can be further improved. Another advantage is the cognitive discharge of the user. The disadvantage of this method is that a system with adaptive properties is a precondition for this kind of implementation. In addition, the user loses control of the user-related information determined by the system.<sup>1</sup>

The obtained information about the user must be evaluated in a further step and included in the user profile. This process essentially depends on the purpose of personalization. If, for example, the user of the system is a customer, then the user profile should include information about consumer preferences. However, if the user is an end user of an enterprise system like an ERP system, information should be stored in the user profile resulting in more employment facilitation. The newly gained information in the user profile should then be used for system adaptation. Information gathering, evaluation, and adjustment of the system within the personalization are an ongoing process due to the continuous changes in the intra- and inter-individual user characteristics.

### **2.3. Personalized Enterprise systems**

In contrast to the web area, the correctness of transactions that the user processes during his navigation through an enterprise system stands in the limelight, not the users themselves. Thus, personalization is defined in the enterprise systems area as an "adaptation of the system considering organizational and business requirements of specific user groups or specific users" (Kassem & Rautenstrauch, 2005). The aim of personalization here is to accelerate and simplify the transactions to be easily processed by the user. Therefore, an enterprise system has to be technically able to offer personalization of information and user interfaces according to the roles and profiles of employees.

#### **Personalized Information**

From the informational point of view "personalized information" stands for information access, which is personalized according to the needs of the employee of a company. User models are an important step towards a "meaningful full-automation" of information processing. By helping the "understanding of

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<sup>1</sup> Data privacy should be noted. In particular, national laws and regulations should be taken into consideration.

computers and humans", personalization, in this case, increases the acceptance of application systems (Mertens et al., 2004) [. In accordance with the defined roles, authorization concept, and user profile, every employee has access to exactly the data and functions that are needed for daily tasks.

### **Navigation and Customization of User Interfaces**

Through user interfaces, data and functions of an application are provided. Personalization of user interfaces has the goal of accelerating the processing of business transactions by the system. This can be achieved through efficient navigation and simplification of the user interface.

Navigation within a business application is "a change by the user from one screen to another or from an application to another". Navigation through the system is the basis for carrying out the actual interaction tasks and not the tasks itself (Balaguer & Mangili, 1991). The personalization of navigation options should provide the user with as much decision support as possible when changing screens or applications.

Business processes are usually based on a variety of programs and applications that implement enterprise business transactions or tasks. By using enterprise systems, a task in a business sense appears to users as a series of logically connected dialog steps (screen or images) and ends with an update (data changes) of the database. Personalization should help the users with the execution of a task through simplification and acceleration of the presentation of the user interface. Standard Enterprise systems provide applications with the corresponding pre-standard user interfaces that could be personalized. Examples of possible techniques to personalize the user tasks include:

- Hide in-/output field elements and images
- Provide fields with default values
- Move fields
- Create or modify input ranges of values (domain) from fields
- Modify properties for representation of tabular objects or hide specific columns
  - Hide menu functions
  - Add and change text
  - Add help element to field (F1 and/or F4 for example)
  - Add new screen elements (e.g. checkboxes, buttons, graphics and documentation)

### **3. Research methodology**

This paper presents a conceptual model for a dynamic user profile personalization in modern enterprise systems. The basis of this research is inductive research method based on observations and knowledge gained by conducting a systematic literature review and an inductive case study (SAP ERP). The conceptual model leads to changes in the standard enterprise system. Therefore, it is necessary that the system offers change options in the form of services and tools to design the personalization concept.

Changes to personalization in SAP ERP from a technical point of view should be regarded according to the following categories.

- Customization: Allows users to select and parameterize the appropriate functionality of the desired processes, based on own objectives and requirements, from a wide range of functions and processes (Teufel, 2004). Setting of parameters is the keyword in the customization. Here, users do not need programming skills to perform the changes.
- Modification: Customized changes to SAP ERP Repository Objects which is the Central repository for SAP ERP. Modified Repository Objects have to be checked and adjusted in case of change by SAP.
- Extension: Using the SAP ERP-extension concept, users can add their own functionality to the SAP standard applications, without altering the original objects of SAP.

- Development: In-house development is the generation of customer-specific objects.
- Client add-on: GuiXT is a tool for system-wide or user-specific customization of the SAP GUI standards. The modification of the layout occurs via a script that is placed on the front end. The GuiXT process interprets the script and modifies the image layout. The application logic remains intact.

### **3.1. Personalized Information in SAP ERP**

SAP uses roles and authorization concepts to personalize the information in SAP ERP, these roles include collections of activities of a specific job in a company.

The roles allow the user to participate in one or more business scenarios of a company. There is also the option for the user to create their own specific roles in order to use them. Access to the applications assigned to the roles is possible via user menus. Users' menus should contain only the functions that are typical for the daily work of a particular user.

The integrity of business data is ensured through the assignment of roles. According to the activities in the roles, authorization profiles are created limiting the activities of users in the SAP system. The changes made by the roles and authorization profiles are done in SAP ERP by customization.

### **3.2. Personalization of Navigation and Tasks in SAP ERP**

To create possibly direct access to the relevant functions of the system, a system administrator needs to customize user menus for the user. If the user logs into the system, he automatically receives his typical user menu and the permissions needed for his work. In addition, he can create his personal list of favorites of functions. Through the favorite list or tree menu structure, the user then starts his SAP or internet/ intranet applications.

Tasks in SAP are realized through one or more applications. Therefore, in SAP it is called "personalization of application". The visible part of an application (an application is in SAP terminology also called a transaction) consists of one or several screens. Personalization approaches of applications are done in SAP ERP by a series of tools and services. The most important approach to application personalization is "transaction /screen variants".

### **3.3. Transaction - / Screen variants**

If a transaction is used to process various business transaction scenarios, it is often useful to adjust the expiration of the transaction to the respective part of the business scenario. Irrelevant information should be hidden. Important information should be better placed. A transaction variant is composed of a set of screen variants. The field values and settings for each in the transaction screen are stored as screen variant. For each transaction, many variants can be created. When one creates a transaction variants, the transaction is processed in a special mode. For each screen, one specifies which items are unnecessary or can be put with default values. Even some whole screens can be hidden and skipped. With Transaction variants transaction processes can be simplified by:

- Pre-assignment of fields with default values
- Hiding and changing the input readiness of fields
- Hiding and changing properties of table control columns
- Hiding menu functions
- Hiding whole images
- Transaction variants are carried out through customization.

### **3.4. Personalization and Application Usage Mining**

The new techniques and mechanisms for personalization of enterprise systems provide the user with many options and variations on personalization. So, it is hard for the user to determine an ideal

personalization variant that covers all his needs. Usually, the user needs external help (experienced staff or administrators) and time-consuming reading of the system and online documentation to personalize his individual profile. With the continuous changes and growing demands of business processes, this profile should be adjusted repeatedly. For this reason, many users ignore the use of personalization and discern valuable techniques and methods provided by the system for personalizing as unusable. A possible solution to the problem can be given by using the methods of application usage mining.

Through the use of standardized enterprise systems, the application usage mining process extracts knowledge in three aspects: system, user, and process. Knowledge about the system can be in the form of obtaining information about system settings (customization) and/or the effectively used modules/transactions of the system. This information will assist in the review of system correctness related to customization and/or system sizing.

On the other hand, extraction information about user behavior<sup>2</sup> helps to personalize the system for a user or a user group as well as to clarify the efficiency of system use by the user during the execution of their tasks: for example, the extents to which users are familiar with the system and whether certain users need training. Process knowledge clarifies how processes are actually run in the system by the user. It can even help to improve a company's business processes and system settings (Kassem, 2007).

By observing and analyzing user behavior, it is possible to generate individual suggestions and recommendations in the form of one or more personalization profiles. With application usage mining methods the goal can be reached in a similar way as with the fourth method of personalization in the web application area. This is done by using implicit information retrieval as shown previously in chapter 3. Application usage mining uses the approaches and methods of data mining for the analysis of user behavior (Kassem et al., 2003).

Figure 1 shows a conceptual model for a dynamic user profile personalization in modern enterprise systems like an ERP system. The conceptual model presented as a life cycle model summarized in four phases:

- In the preparation phase, interaction data from various sources of the Enterprise system will be integrated into a database. This is mainly to trace data, which records the user interaction with the system over time and describes meta-interaction data, the trace data, and their interrelationships. In addition, workflow-description data that define the information in the system imbedded workflows.
- In the pattern discovery phase, different patterns can be discovered at different levels of target analysis. For workflow analysis, data is detected via the executed workflow instances of a workflow type based on specific mining algorithms that use information collected in the phase before. A workflow instance shows the sequence of the running system functions of a workflow type. On the other hand, click-stream patterns are grouped by users for personalization purposes and provided as a "click-stream protocol" analysis for personalization.

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<sup>2</sup> Data mining methods such as sequence, bath and association analysis can be used for user behaviour analysis.

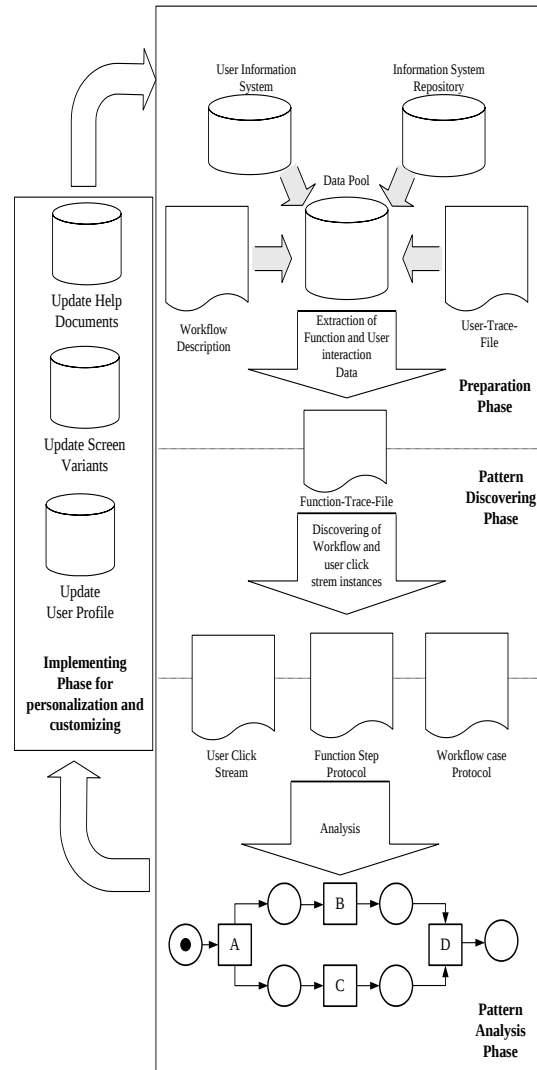


Fig.1: Conceptual model for a dynamic user profile personalization in modern Enterprise

- In the pattern analysis phase, the workflow instances, detected in the pattern discovery phase, are analyzed with the workflow mining algorithms and graphically shown as actual workflow models for workflow instances executed in a certain time in the past. For the personalization, data from the "click-stream protocol" and "Function Step Protocol" will be used for personalization purposes, in order to graphically represent and analyze the most frequently performed paths by a user or user groups.
- In the implementation phase, new information and knowledge from the analysis phase is used to adjust or customize the setting or personalization of the system. The gained information and knowledge can also be used outside the system to undertake certain measures for service improvement. Examples include a change of error-prone materials or Training of employees etc.

This paper's focus is the analysis phase of the personalization. The visualization of access paths in the execution of the workflow plays a central role.

#### 4. Results and Discussion

Here a use case scenario will be demonstrated for visualization of user access paths by using SAP ERP as an example for an enterprise system. This demo is used for evaluating the framework. For the visualization of user access paths, the "click-stream protocol" from the pattern analysis phase can be used to describe the course of the workflows processed by the user. The "click-stream protocol" consists

of entries, where each entry describes executed interaction elements such as transaction code, screen titles, involved business object, and system message. The order of rows in the access path file is sorted according to the time of execution of the interaction elements. For the visualization of user access paths, the following components are used:

- SQL database: mysql
- "Click-stream protocol"
- Perl script to read the "click-stream protocol" and to store the data in the database
- Grouping and analysis with SQL
- Visualization with uDrawGraph

The basic idea for the visualization of user access paths (see Fig. 2) is based on the separation of the "click-stream protocol" entries according to individual users or user groups. Then, information from the individual rows is written with a Perl script in a database table with respect to node type (SAP transaction code, screen titles, business objects, and messages) as well as node value. It is successively always assumed that the next node is the successor. An additional table records nodes grouped by their values.

Initially, a node list and an edge list are then calculated, where the edges are grouped according to node value through a four-fold (equal to the number of node's types in this case study) joins of both tables and then outputted as a GML file (Graph Markup Language). Except for nodes and edges, a third parameter is calculated which represents the measured frequency of an edge. Other parts of the script deal with the formatting of a GML file. GML is a simple description language for graphs.

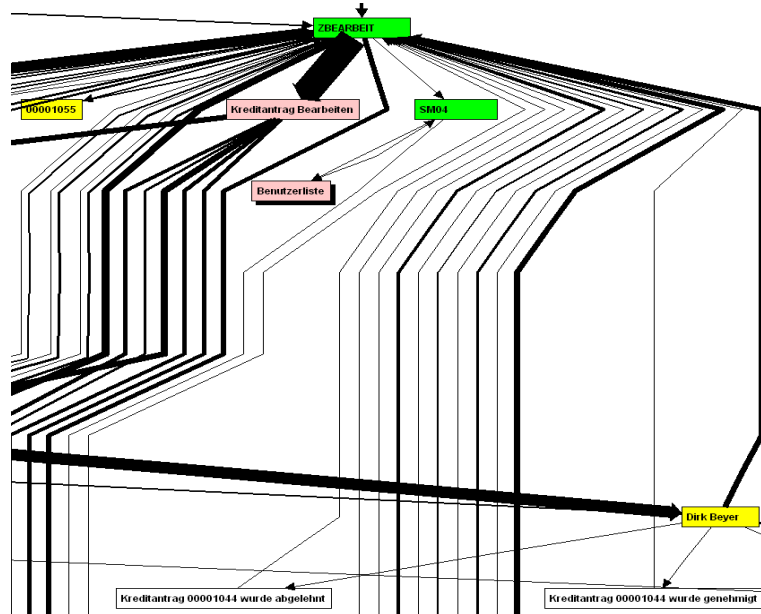


Fig.2: Graph-excerpt visualization of access paths in the execution of the workflow 'approval of an application for credit'

For visualization of GML, there are tools like "Graplet" (University of Passau). However, in the context of this work, the tool uDrawGraph (University of Bremen) was chosen because it can be purchased for free and installed easily. uDrawGraph has its own file format (UDG). GML files can be converted in UDG format with a provided tool gml2udg. With UDrawGraph, the UDG file for the visualization of the user's access paths can be opened. The generated graph can be regarded and may be exported as graphics. Part of the graph is shown in Fig2. Here, each node type is mapped as a rectangle with its own color. The text of a node indicates its value. The edges between the nodes and their direction are represented by arrows. The thickness of an arrow indicates how often it has been used.

The gained knowledge and information from the analysis can help to improve personalization. Through the visualization of user access paths, certain relationships can be made more clear and transparent for the system analysts and administrators. The gained knowledge and information from the analysis can be used to improve the personalization by integrating it into the AUM approach in the implementation phase and based on customizing the system accordingly.

The main added value of this work comparing with the related work to AUM and personalization is the provided framework which has been adapted based on the related works for personalization of one of very important business application systems which is enterprise system to increase the performance based on previous user behavior and the result has been evaluated through using visualization tool showing the user or user group paths using SAP ERP as case study.

## **5. Conclusion and Future Work**

Personalization in enterprise systems can occur in many different forms. This ranges from simple system sets up of a system to complete changes of the user profiles and roles with respect to the execution of complex business transactions. Personalization processes, which use implicit information retrieval that is successfully applied in the web application area, can even be adapted and used in the field of enterprise systems. This adaption is necessary because the way users handle transactions and not the personal preferences of users is an important aspect of this kind of personalization. Then, implementation of the gained information can be done by adapting user profiles and roles in the system, currently, this step could be only performed manually.

This paper presented an four phases conceptual model as a life cycle model for a dynamic user profile personalization in modern enterprise systems like an ERP system. The included phases in this model are : preparation phase, pattern discovery phase, pattern analysis phase and implementation phase. An visualization tool has been used for evaluating the validation of the targeted conceptual model.

The future research in this area is the further development of AUM tools to ensure automatic or semi-automatic adaptation of user profiles, roles, and system support documentation.

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