# Automatic Knowledge Transfer-based Architecture towards Self-Service Business Intelligence

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***Abstract*—Enterprises use business intelligence systems to support their decision making process and give them the superiority against their competitors. However, business intelligence systems integrate data from internal and external resources and this in turn makes these systems more complex. The consequence behind such complexity is that business users cannot get the required information at the right time unless they get help from IT or professional (power) users. This is also conditional just in case that power users will have enough time to answer the questions of business users. In this paper, we present a new architecture for business intelligence systems to support the self-service functionalities that enable business users to get answers about their business questions at the right time. The main idea of the proposed architecture is to extract the knowledge of the power users and transfer this knowledge to the business users while they use business intelligence systems.**

***Keywords-Knowledge Transfer; Self-Services; Business Intelligence; Power User; Business User.***

## I. INTRODUCTION AND PROBLEM DEFINITION

In the last decade, business environments have changed to be more complex and dynamic. Enterprises should operate their business in a continuously changing environment, which is influenced by globalization, legal changes, volatile markets and technical progress [1]. Because of the rapid change in the internal and external conditions of current economic life, the demand for information as an important production factor is increased [1][2]. Therefore, enterprises adopt Business Intelligence (BI) systems that offer them solutions for these challenges. BI is defined as "an integrated, company-specific, IT-Based total-approach for managerial decision support" [1]. Therefore, the main goal of BI is the improvement of the decision making process by enabling business users to get the required information at the right time [3]. Based on Gartner research [4], the market share of BI systems and analytical applications is constantly growing. Gartner CIO's Survey 2013 showed that analytics and BI came on top of CIO's technology Priorities [5].

However, BI as an integrated system tries to integrate data from internal and external sources of the enterprise to one central point, which is the data warehouse. The goal of integrating data is to eliminate data redundancy and to have one single point of truth [6]. Consequently, this led to complexities in BI systems [7]. Moreover, even if a BI is a flexible and powerful system, it is still very complex for business users in the sense that they still face substantial difficulties while carrying out their ad-hoc analysis [3]. Furthermore, because of the high complexity and irrelevance of the provided information, less than 30% of target users could benefit from or use BI systems [8].

To avoid the confusing of the terms' usage, this work distinguishes between two types of BI users, business users and power users. Examples of business users include executives, managers and operation staffs. This kind of users tends more to be information consumers of easy-to-use BI tools like predefined reports or dashboards. Moreover, they lack the needed knowledge to use complex and more advanced BI tools like Online Analytical Processing (OLAP) and data mining. On the other hand, examples of power users include business analysts and IT professionals. They can use all kinds of BI tools with the different usage's complexities by generating the information based on their needs, as well as answering business questions of business users [9][10].

Therefore, in case that business user requires information for her/his decision process, and because of the complexity of BI tools and lack of knowledge to use such tools, business users must send a request to one of the power users to answer their business questions. However, these latter cannot answer in most cases at the right time due to their time limitations, the large amount of such requests and the few number of employed power users. Consequently, this will make the decision making process slower.

To conclude, the main goals of BI systems are eliminating guesswork and enabling enterprises to respond quickly to the market changes as well as customers' preferences. The aforementioned problems hinder BI systems from reaching these goals. Consequently, there is a need to develop a new BI solution, which empowers

 ISBN: 978-1-61208-408-4 

business users with the required knowledge to get the right information at the right time without the need to ask power users. This new approach is called Self-Service Business Intelligence (SSBI).

The Data Warehousing Institute (TDWI) defined SSBI as: “the facilities within the BI environment that enable BI users to become more self-reliant and less dependent on the IT organization. These facilities focus on four main objectives: easier access to source data for reporting and analysis, easier and improved support for data analysis features, faster deployment options such as appliances and cloud computing, and simpler, customizable, and collaborative end-user interfaces” [11]. The approach presented in this paper focuses on achieving the objective “easier and improved support for data analysis features” to enable SSBI functionalities. Unlike other material assets of enterprises, which are decreased by using them, the knowledge will always be increased while it is recalled. The sharing of knowledge will enrich its receiver [12][13]. Therefore, most businesses recognize their knowledge as a sustainable source of competitive advantage [13][14]. The main idea of the resulted architecture is to transfer the knowledge from power users to business users.

In the next section of this paper, the knowledge classification, conversion, and transfer will be explained. After that, the basic idea behind this work and the knowledge flow are illustrated. Section IV explains the resulted architecture and its component. It is then followed by the knowledge transfer model’s workflows. Section VI lists related work and finally this paper concludes with a short conclusion.

## II. KNOWLEDGE MANAGEMENT: CLASSIFICATION, CONVERSION AND TRANSFER

In the literature, there are many definitions of the term Knowledge Management (KM), most of them are focusing on the KM processes. Davenport and Ponzi defined KM as the process of capturing, distributing, and effectively using knowledge [14][15]. Bhatia and Mittal defined KM as an approach to discover, capture, and reuse both tacit (in people’s heads) and explicit (digital or paper based) knowledge as well as the cultural and technological means of enabling the KM process to be successful [16]. Dalkir claimed that KM is a collaborative and integrated approach to create, capture, organize, access and use an enterprise’s intellectual assets [17]. Therefore, KM is considered as a disciplined, holistic approach to effectively use the expertise for competitive advantage [18].

### A. Tacit Knowledge vs Explicit Knowledge

In the literature, there are different classifications of the knowledge. This work is focusing on the following two types of knowledge namely: the tacit and explicit knowledge [19][20]. Tacit knowledge is known as personal know-how and it resides in the head of knower. It is difficult to articulate and to put into words or text. Tacit knowledge that represents the expertise and know-how is the most valuable knowledge [17][21]. In contrast to tacit knowledge, explicit knowledge represents the knowledge that has been captured

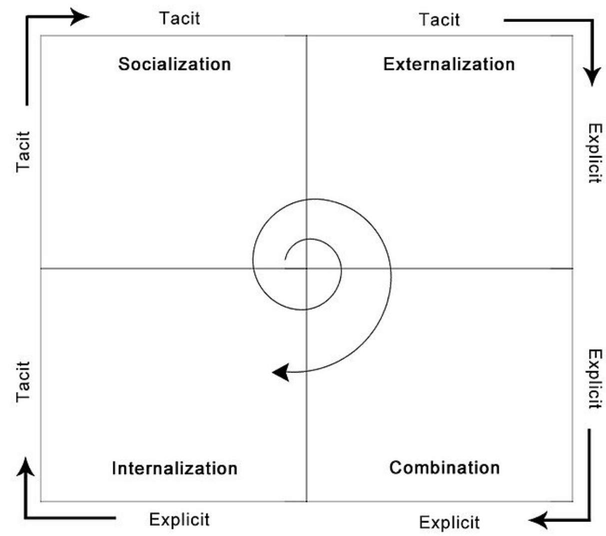


Figure 1. The SECI Process

in a tangible form like words, audio files and recording images [17].

Therefore, the processes of identifying, storing and retrieving explicit knowledge can be easily done by KM-system [22].

### B. The Modes of Knowledge Conversion

Most enterprises try to externalize or convert the knowledge from tacit to explicit knowledge, after that they store this knowledge in their intranet or portal. The efforts in this sense must be set to improve the sharing of the stored knowledge [23][17][19].

Nonaka et al. explained in their Socialization, Externalization, Combination and Internalization (SECI) model how to transform processes between tacit and explicit knowledge [23]. As seen in Figure 1, there are four modes of knowledge transformation:

*1) Socialization - Tacit to Tacit*

In this case, the knowledge is converted through shared experience such as spending time together or living in the same environment, or face-to-face meeting.

*2) Externalization - Tacit to Explicit*

This is a process of articulating tacit knowledge into explicit knowledge by transforming the knowledge of people’s minds into electronic forms like storing it in wikis, forums and collaborating systems.

*3) Combination - Explicit to Explicit*

The knowledge here is converted based on the desire of the user.

*4) Internalization - Explicit to Tacit*

The intranet of the enterprise allows the end users to access the information, which is stored in the knowledge repository. In this mode, explicit knowledge is used and learned from the user to extend her/his tacit knowledge and to become part of it. Internalization is related to the concept “Learning by doing”.

### C. Knowledge Transfer

Alavi and Leidner considered the knowledge transfer as an act of communication between source (the sender of the knowledge) and receiver (where the knowledge is transferred to). Both sides of the communication channel can be represented by a single person, as well as a team of people [18][24]. Knowledge transfer is the conveyance of knowledge from one place, person or ownership to another, and then this process can be considered as a successful process when it has a successful creation and application of the knowledge in the enterprise [25][26].

In the literature, the knowledge transfer process was described using models. Most of these models were focusing on the idea of collaboration and communication between the source and receiver of the knowledge [25]. Therefore, the basic knowledge transfer model consists of two main components namely: the source who share the knowledge and the receiver who acquire the knowledge. In addition, there are farther knowledge transfer modes, which describe different conversions between tacit and explicit knowledge (see the previous paragraph) [23][25].

## III. Basic Idea and knowledge flow

"A little knowledge that acts is worth infinitely more than much knowledge that is idle" - Khalil Gibran [13]. The incentive from this quotation is that we argue that the knowledge should not stay idle in a database or a portal of any enterprise. One of the advantages of the proposed solution is that the knowledge must be automatically transferred to the receiver (business user).

In this work, the focus is on two modes of SECI knowledge conversion, which are the externalization and internalization. The transfer of knowledge between the expert and novice or specifically in this work between power and business users can be represented as socialization. However, in our case, it is not possible to use the tacit to tacit knowledge conversion. It is difficult from time and organization perspectives to put the power and business users in the same environment. Therefore, our approach uses two conversion modes. Firstly, in the phase of capturing or extracting the power user's knowledge, it is tacit to explicit conversion - externalization. Secondly, in the phase of knowledge application or sharing it, it is internalization-explicit to tacit conversion.

Figure 2 depicts an abstraction process model of the knowledge transfer that is independent from the technical components, which will be illustrated later in section IV. As shown in Figure 2, the process is divided into two steps. In the first step, the power user's knowledge is captured and extracted. This step represents the externalization conversion mode based on Nonaka SECI model (tacit to explicit conversion). In the second step, the captured knowledge will be shared or applied to the business user. This step represents the internalization conversion mode (explicit to tacit conversion).

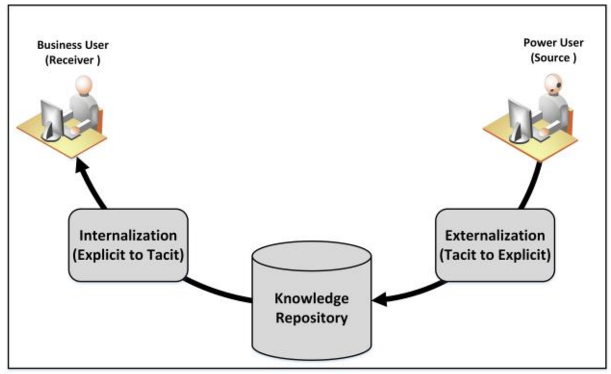


Figure 2. Knowledge Transfer Model

## IV. Knowledge Transfer-Based Architecture for Self-Service Business Intelligence

The proposed architecture is based on top of the traditional business intelligence architecture to enable self-service functionalities. It is illustrated in Figure 3. It depicts the components of the proposed architecture and the relationships between them. Therefore, the overall architecture consists of two sets of components.

The first set represents typical components of BI-System architecture including data sources, ETL process, data warehouse and frontend – applications (in gray color).

As for the second set of components, it includes tracking module, analysis module, recommendation engine and knowledge repository components (in blue color).

Data sources represent all kind of storage resources like Enterprise Resource planning (ERP), Customer Relationship Management (CRM), Supply Chain Management (SCM) and any other external resources that include all data coming from outside the enterprise.

ETL process is responsible of extracting, transforming and loading data into a data warehouse (DWH).

As for the frontend - applications component, it offers BI users the access to the information in different formats and flexibility in the analyzing this information. BI users use the Single Sign-On (SSO) service to access the frontend applications (portal).

In the following sections, the new components of the architecture and their functionalities will be explained in details.

### A. Tracking Module

This set includes three subcomponents:

*1) User Interactions Catalogue*

The catalogue includes all possible interactions between BI users and frontend - application components. The content of this catalogue comes from analyzing different frontend applications to consider all users' interactions that are filtered for the sake of knowledge extraction.

*2) Tracer*

This component traces the power user interactions that are previously defined in the user interactions catalogue. Then, it stores the trace log into the interactions database.

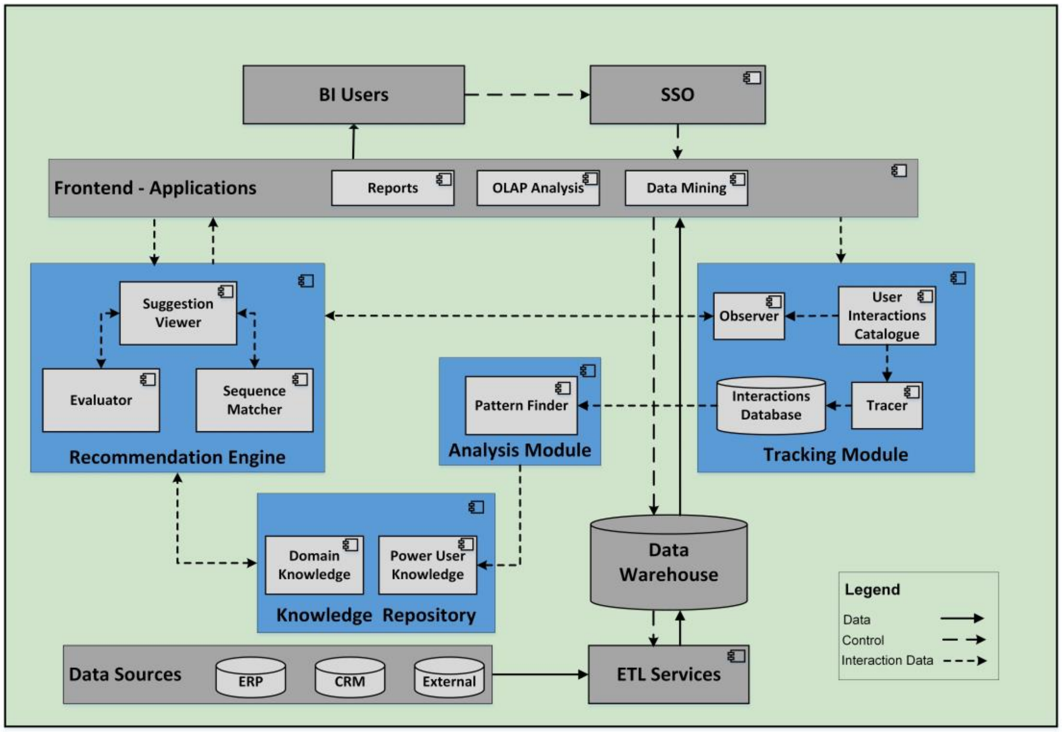


Figure 3. Automatic Knowledge Transfer Architecture for SSBI

*3) Observer*

This component is responsible of observing the interactions of business users while they use the BI frontend – application component in order to provide such log later to the recommendation engine.

*4) Interactions Database*

This database is merely responsible of storing the logs of power users' interactions. These logs can be stored either directly in the database or based on the power user's session, they will be stored in binary files.

### *B. Analysis Module*

This set includes just the pattern finder component.

*1) Pattern Finder*

This component gets the log files from the tracer component as an input and processes them to extract patterns from them to be provided to the recommendation engine via the knowledge repository. The extraction process is done based on sequential data mining algorithm. These patterns are called analysis paths and they represent the procedural knowledge of the power user.

### *C. Knowledge Repository*

This set has two components, the power user knowledge and the domain knowledge.

*1) Power User Knowledge*

This database stores the power user' analysis paths. It has a connection to the recommendation engine that uses these patterns to recommend similar paths to the business users.

*2) Domain Knowledge*

This database stores the typical knowledge harvested from the enterprise's data warehouse. Such knowledge includes several repetitive analyses of each enterprise's department.

### *D. Recommendation Engine*

This set is responsible of offering business users with appropriate suggestions extracted from power users' knowledge to ease the analysis process for them. This set includes three components namely sequence matcher, suggestion viewer and evaluator.

*1) Sequence Matcher*

The main functionality of this component resides in displaying or showing business users the paths of extracted suggestions.

*2) Suggestion Viewer*

The main functionality of this component resides in displaying or showing business users the paths of extracted suggestions.

*3) Evaluator*

In this component, business users are given the possibility to evaluate the displayed suggestions based on the relevance to their analyses. There are two ways to get the evaluation of business users. The first way is implicit and similar to the ranking system of the google search engine. The evaluator gives high weights to the analysis paths that are selected by business users. The second one is an explicit way that allows business users to evaluate the suggestions themselves.

 ISBN: 978-1-61208-408-4 

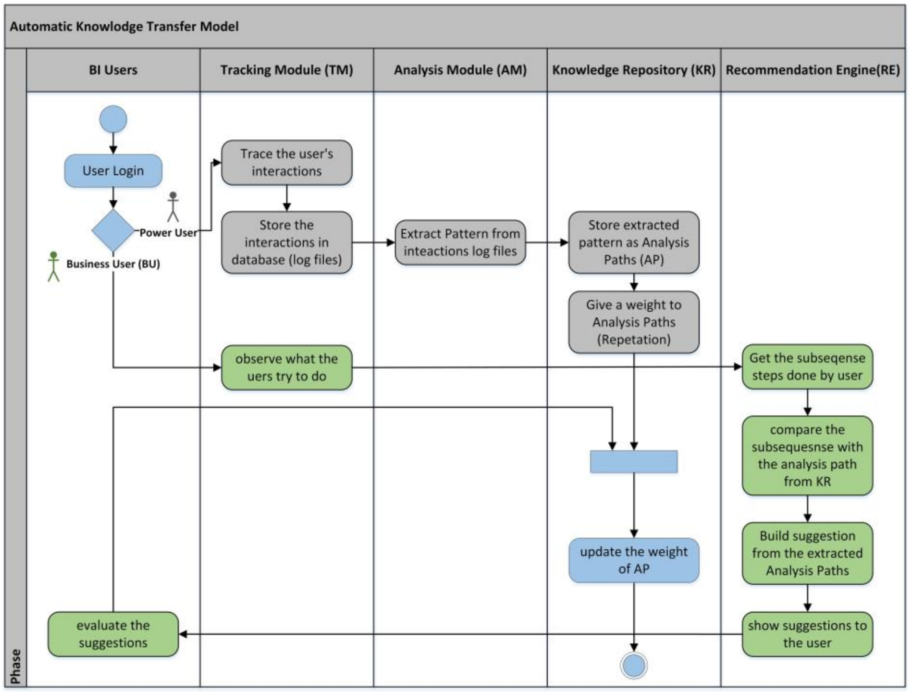


Figure 4. Knowledge Transfer Model Workflows

## V. KNOWLEDGE TRANSFER MODEL WORKFLOWS

In this section, the interactions between the architecture components are illustrated as activity diagram in Figure 4. The interactions are illustrated for both business and power users. As can be seen in that figure, the first step represents the login of a BI user to the BI-Application. Based on the login information, the system recognizes the user type, because the users are already predefined as power or business users. Based on the user type, the system's functions are executed either for power or business users.

### *A. Power User Knowledge Extraction*

This section explains the activities that are done to capture or extract power users' knowledge. After the system verifies that a user is a power user, the tracer component from the tracking module will trace all the interactions of this power user in a chronological manner. Then it stores its interactions into the interaction database or a log file. This log file will be then sent to the analysis module. The pattern finder applies a sequential pattern-mining algorithm to the log file or the interaction's database to extract a pattern from them. This pattern represents the analysis path of the power user. After that, the extracted analysis path will be stored in the knowledge repository. In this latter, every analysis path has a weight. This weight is a combination of its repetition in the interactions database and the evaluation of business users based on its relevance with business users' needs. Before storing an analysis path in the knowledge repository, there is a verification mechanism that checks whether an instance of this path is already stored in the repository or not. If an analysis path's instance exists in the knowledge repository, the repetition value of this path will be increased by one. Otherwise, a new instance will be stored in the knowledge repository.

### *B. Path Recommendation for Business Users*

The previous section explained how power user's knowledge could be extracted and stored. This section illustrates how such extracted knowledge can be transferred to business users.

After the system verifies that the logged-in user is a business user, the observer component of the tracking module will verify what the business user wants to do, i.e., to trace the steps when the user tries to perform an analysis. After that, the tracking module will communicate with the recommendation engine by sending it the subsequence of steps, which are performed by this business user. Next, the recommendation engine will compare such subsequence with the existing analysis paths in the knowledge repository. The result of the comparison can be more than one analysis path with different weights. Therefore, the sequence matcher sends the result to the suggestion viewer, which is responsible of showing the business user the recommendation result as a list of suggestions. The suggestions should be sorted based on their weights. The analysis path with the highest weight will be appeared on the top of the suggestions list.

As soon as the business user sees the suggestions list, she/he can evaluate them to choose an analysis path. The repetition of this process will enhance the functionality of the whole system. This evaluator component will then evaluate the business user's selection to increase the repetition of the selected analysis path to update its weight in the power user knowledge's database.

## VI. RELATED WORK

Two related works that have conceptual similarities to this work are to be explained here in this section. Mertens and Krahn had provided an approach of “Knowledge based business intelligence for business user information self-service” [3]. This approach is based on a semantic metadata layer, which is capable of modeling a semantic, machine readable and reasonable knowledge. This knowledge is imported and managed in the semantic metadata layer in form of domain ontology. It can be questions, analytics visualization or analysis results. However, the limitation lies in the issue that experts’ knowledge should be explicitly derived and modeled, and then imported to the analytical information system. In comparison with these two approaches, the proposed research in this paper will automatically extract the knowledge of power user.

Another approach was provided by Baars about how to distribute BI knowledge [27][28]. This approach focused on the idea that the analysis results and templates should be accessed from other users in the enterprise via the knowledge management system. Analysis results can be interesting to the users of the same segment with the same needed information. Moreover, analysis templates can be used from users who belong to other segments or departments. This approach has several challenges. It requires combining different interfaces and formats. Moreover, it lacks motivating users to explain and distribute their knowledge to the knowledge management system. The proposed architecture tries to address the limitations of this approach by providing suggestions to the business users based on their functional usage of BI tools.

## VII. CONCLUSION

This paper focused on presenting an extended BI architecture to enable self-service functionalities for business users. This architecture is based on a new knowledge transfer model that consists of two main processes. The capturing of the power user knowledge and sharing this extracted knowledge with the business users. Moreover, the functional components of this architecture have been explicated. Finally, two related works had been identified with their limitations to evaluate the strengths of the proposed approach. Future work will investigate the feasibility of this approach in the BI market.

## ACKNOWLEDGMENT

We gratefully acknowledge that this work is supported by fund coming from Lufthansa Industry Solutions.

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