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A Process Model to Integrate Data Warehouses and Enable Business Intelligence: An Applicability Check within the Airline Sector

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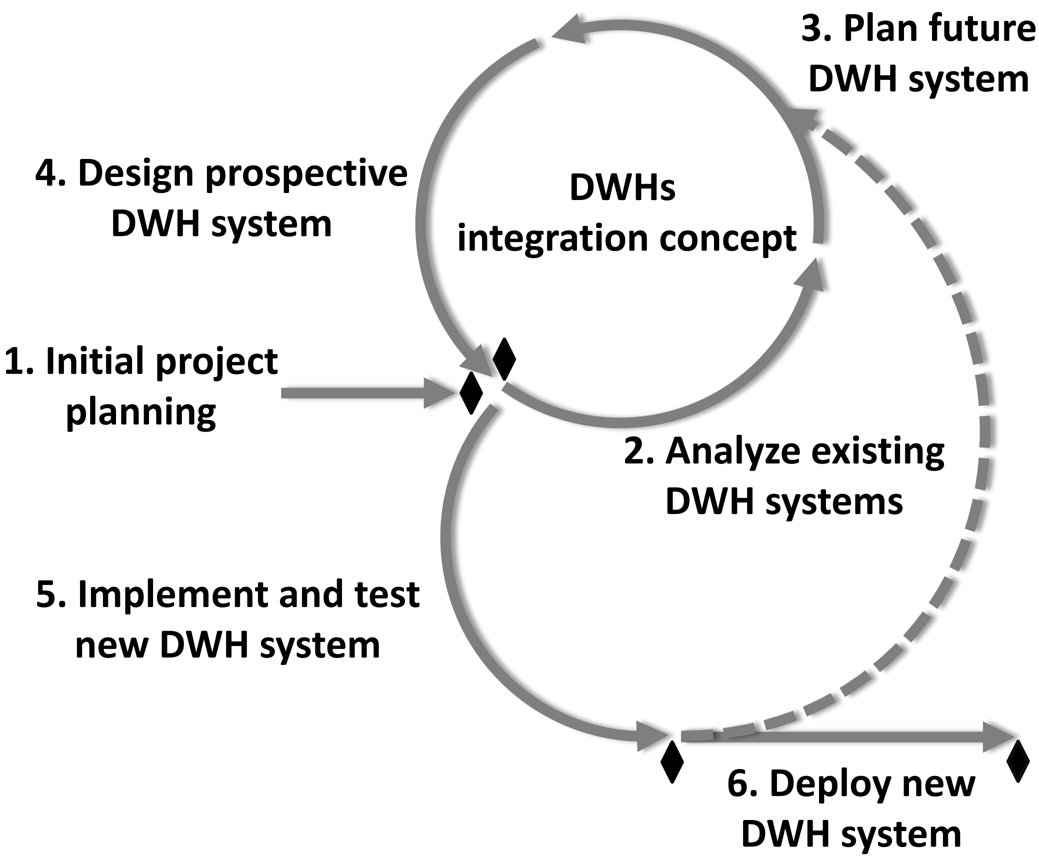

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Abstract

Since the data warehouse allows the extraction of needed information for organizational decision making processes, it has received great attention by many companies. However, companies often face the problem that many heterogeneous data warehouses accumulated over the past. Executives and business users are often unaware of the existence of accurate information. To receive a unique overview and, consequently, having consistent shared data, an integration of independent data warehouses must be realized. This can help to improve decision support, business intelligence, and even knowledge management. Therefore, we constructed and introduce an iterative data warehouses integration process model (DWH-IPM) as a first approach. Our process model is divided in to six main phases including several activities to achieve a successful integration outcome. Within a globally operating flight company, we check to what extent the applicability of the designed research artifact can be assumed.

Keywords

data warehouse, business intelligence, process model, integration

1 Introduction

The topics Business Intelligence (BI) and Data Warehousing (DW) receive great attention by many companies and their business information management. Especially in today's hypercompetitive market, many executives use diverse BI applications to make strategic decisions. For this purpose, companies often implement the Data Warehouse (DWH) as their main BI instrument to analyze a large amount of operational data. More specifically, the DWH allows the extraction of needed information for organizational decision making processes [18]. However, companies often face the problem that many heterogeneous DWHs accumulated over the past. Executives and business users are often unaware of the existence of accurate information, which are necessary to achieve organizational goals. Without a consistent view on the corporate performance, executives have fewer possibilities in making correct decisions.

Furthermore, many DWH systems often lead to data redundancy. These redundant, not integrated analytical systems are often wasteful and may increase the DW costs rapidly. Numerous companies have the main objective to minimize their analytic systems landscape trough a successful integration project. The problem in this context is that integrating the heterogeneous DWH systems is often very complex. Integration projects face two major challenges. The first challenge is to make an efficient decision on the prospective DWH integration strategy, which defines the procedure of restoring and integrating the heterogeneous data into one core database. The second challenge involves cultural and established structures of distributed power. Solution approaches regarding technology competencies and corporation wide measures, structures, and responsibilities must be identified [2]. This leads to the research question:

How can Data Warehouses be integrated to enable Business Intelligence?

Based on a practical problem of a globally operating airline group, the main objective of this work is to design a process model for DWHs integration. Although, such practical issues often exist, where executives need to obtain a unique overview of their company through an integrated DWH system, the research on this topic has received little attention [18]. The complexity of this task requires a well-structured and systematic approach. As proposed by Gregor and Hevner [9], the structure of this work is as follows: After this introduction, the theoretical foundations and related work are addressed. Afterwards, the research design is presented. Then the designed iterative DWHs integration process model is illustrated and each related phase is explained in further detail. The developed model is evaluated within the airline group. A discussion on the results and observations follows, and the identified limitations and further research are drawn. Finally, the work ends with a conclusion and outlook.

2 Theoretical Foundations and Related Work

2.1 Business Intelligence and Data Warehouse

In the last few years, the term BI became an important topic for many companies. Especially for numerous CIO's, BI has been a top strategic priority in the past decade [27]. Even the latest Gartner [7] research predicts that in 2014 the top investment priority will be in BI and other analysis applications. The origins of BI emerged from decision support systems (DSS), which were first mentioned in the early 1970s, when business managers used computer applications that supported business decisions [27]. In the late 1980s, Gartner has generated the BI term including tools and technologies such as DWHs and reporting queries [29]. Today, there is a variety of BI definitions in the scholarly literature. Yet, in every definition, applications and processes are mentioned that gather, store, access, and analyze organizational data so strategic competitive decisions can be made [27], [29]. BI is more than just a collection of software and visualization tools. The real added value comes from the processes that deliver credible knowledge value to the users, the processes for acting upon that knowledge gain, and the people, which are willing to take action. Most BI tools do not achieve any business value without the right people and processes [14].

The DWH was first mentioned in the early 1990s, when companies used information to achieve effective planning and decision making. The DWH has established itself as one of the most successful and powerful DSS during the last decade [21]. Although the DWH was introduced several years ago, the DWH market is experiencing continuous growth because it becomes more and more of a powerful tool [23]. According to Watson [25] the DWH is "a collection of data created to support decision making. Users and applications access the warehouse for the data that they need. […] It eliminates a reason for the failure of many decision support applications." Users access the DWH through queries to support their process of making decisions [12]. The DWH answers and supports important business questions, which require analytics such as aggregation, drill-downs, roll ups, pivoting etc. [21]. Data is extracted from the source systems, transformed, and cleaned to be loaded in to the data stores, which is generally known as the ETL process [28]. To present and analyze the data, the DWH uses a multidimensional data model including dimensions and measures. This supports the views of a user in relation to the measures. A dimension is a domain of real world entities named members. The measures are used to represent the factual data [4] and are often arithmetically calculated through the use of facts, which are numerical variables that are also termed as the basic measures [16].

Since today's companies often face the challenge in extracting the high amount of internal and external data, CIO's often struggle to deliver consistent data quality that provides a single version of truth (SVOT) [5]. The SVOT allows managers and users to have the same precise, centralized, consistent, and integrated view on the data base at a certain time [26]. Many companies tend to use a central DWH, which is also known as the enterprise data warehouse (EDW). According to Winsemann et al. [26] an EDW supports all decisions and activities concerning every organizational business area since it collects and distributes the data from multiple heterogeneous source systems to departmental data marts (DM). These DMs have the same characteristics as a DWH, however, it is narrower in scope than a DWH and usually satisfies the information needs of a specific department or independent group [21].

2.2 Critical Success Factors for BI and DWH Projects

Implementing or changing a BI and DWH environment can be a complex process that requires considerable resources [30]. Many BI and DWH projects are unsuccessful as they are too expensive and time consuming. However, some companies such as Continental Airlines were able to produce a tremendous ROI of more than 1000% [13] due to their concentration on the BI and DWH implementation success factors.

Critical success factors (CSFs) enable BI stakeholders to optimize their few resources and commitment by concentrating on the critical aspects that are required to achieve a successful BI and DWH project [30]. Yeoh and Koronios [30] present critical BI and DWH success factors which are outlined in the following. *Committed management support and sponsorship* is the most important factor for every BI implementation and DW success [17], [28] and since it allows to receive the required operating resources such as human skills, funding or other essential requirements. According to Mungree et al. [17] *clear vision and well-established business case* is important to align such projects with the strategic business vision to achieve the needed outcome of the DWH. A *business-centric championship and balanced team composition* is needed to support and promote the project by providing material, information, resources as well as political support [28]. While a champion needs a strategic and organizational perspective on the BI system [30], [27], the BI project team must have highly competent members that have specific knowledge, technical, and interpersonal skills [30], [27], [17]. A *business driven and iterative development approach* with a first well-defined and communicated scope, realistic expected outcomes, timelines, and adequate budget help to guarantee a consistent understanding of the project goal [30]. An incremental instead of a big bang approach manages risks and provides specific outcomes, which facilitates knowledge transfer and effective change management for a sustainable solution. *User-oriented change management* with business user participation through assigned project roles and tasks leads to a better communication of wishes and needs [17], [30] – especially in case of unclear architecture, applications, dimensions, and business rules [28]. The proposed *business-driven, scalable and flexible technical framework* for a BI or DWH project has to be flexible and adjustable in the change of any business requirements [30]. *Sustainable data quality and integrity* is essential since the quality and integrity of the data, especially in the source system, has a crucial influence on the success of the DWH system [30], [17].

2.3 Data Warehouses Integration

DWHs integration will play a very critical role for companies in the near future [20]. The main objective of an EDW is making information broadly accessible through a SVOT, but companies often face the challenge that such an EDW is often just a vision. In reality, a high amount of different analytic systems accumulated over the past years [5] because business departments and functional groups often work independently and decentralized. As a consequence, different operational and analytic systems are built because differences in technical, financial, or security requirements occur. These independent systems complicate the obtainment of a unique overview on the entire company. To receive a unique overview and, therefore, having consistent shared data distributed internally or externally, an integration of independent analytic systems with its overlapping subject areas must be realized. Olaru [18] defines DWHs integration as "[…] the process of combining strategic information from two or more heterogeneous DWHs with the aim of providing users a unified view of the entire available information." DWHs integration is not the same as data integration into a DWH. The data integration process is characterized by integrating data from data sources into a unique data repository. Whereas, DWHs integration considers the integration of existing multidimensional information from several heterogeneous data repositories into one single data store [18]. It is essential to make an efficient decision on the DWH integration strategy. The DW literature distinguishes between two major approaches, which are known as either integrating (known as fork-lift) an existing DWH into another DWH or redesigning a new unified DWH architecture [18], [2].

To practically integrate DWHs, Eckerson [5] created an integration plan that considers essential steps for successfully integrating analytic systems. Eckerson does not particularly address the integration of a DWH system, moreover he gives practical advice and best practice from integrating diverse analytic data systems. The integration plan represents an important basis for our research.

3 Research Design

Our research design consists of two main phases. The first phase focuses on the design of a research artifact. Our research was conducted by using the design science research (DSR) guidelines to address relevance and increase the quality of the research artifact and design process. More specifically, the recommendations proposed by Hevner et al. [10] and March and Smith [15] and the advices from Peffers et al. [19] regarding to the research process were used in this context.

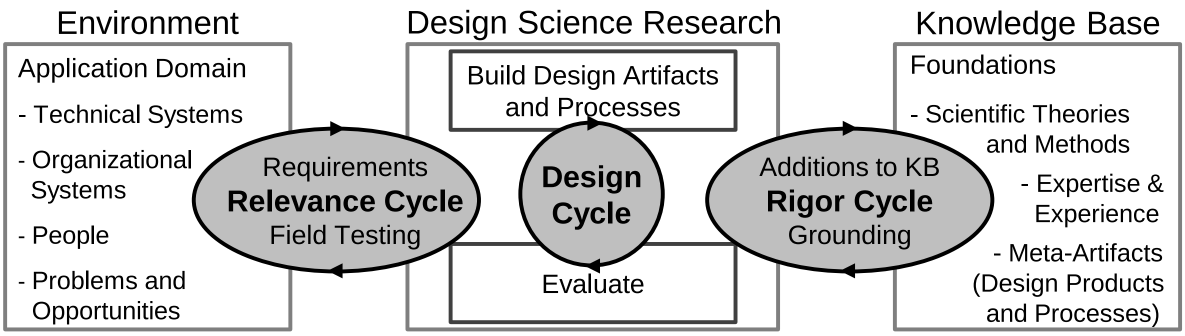

Fig. 1. Design Science Research (adapted from Hevner [11])

According to Hevner [11], the research design consists of three inherent cycles (see Figure 1). First, the research process is initiated by the relevance cycle that provides the requirements and acceptance criteria of the environmental context. Here, practical investigation in the globally operating TUIfly airline gave rise and input for new research. Second, to enhance methodological rigor, appropriate foundational theories, frameworks, and models must be reviewed and applied from the existing body of literature [10]. Therefore, we conducted a comprehensive literature review within the BI and DW domain. The identified scientific and practical literature is used to construct and evaluate the artifact through the design cycle. This cycle is a constant interaction of constructing an artifact, evaluating it, and receiving subsequently feedback to further refine it [11]. Based on this, we constructed together with the reviewed foundations the final research artifact: the iterative DWHs integration process model.

The second phase of our research design consists of an empirical evaluation of the research artifact. We therefore used the applicability check from Rosemann and Vessey [22], which provides a framework to analyze the practical importance, accessibility, and suitability of the artifact. The TUIfly airline served as a case company in this context. During two months, we were regularly present at the IT department and mainly used two data sources (company documents, opened-ended interviews) to empirically investigate the current state problem and a possible solution. We created, presented, and evaluated the artifact at the airline and organized interviews with two subsequent round table discussions that lasted between 60 and 90 minutes. The eight participants included the CIO, Head of IT, Senior IT Manager, two Application Managers, IT Security Manager, IT Project Manager, and an IT intern. We first presented our artifact and gave the participants the possibility to ask questions of understanding. Then the guided round table discussions were used to discuss and debate the artifact and its presentation, importance, accessibility, and suitability. Once both group interviews were conducted, we gathered and analyzed the participant's observations, statements, and recommendations, and used these inputs to finalize the research artifact.

4 DWHs Integration Process Model

In today's era of increasing heterogeneous data volumes, a successful approach to conduct homogenous data analysis is required [20]. Although many companies have implemented analytical systems, not many of them developed an organizational wide DWH (EDW) approach. Based on the theoretical foundations described in chapter 2 and our empirical data, the resulting iterative DWHs integration process model (DWH-IPM) describes the activities to integrate heterogeneous DWH systems, see Figure 2.

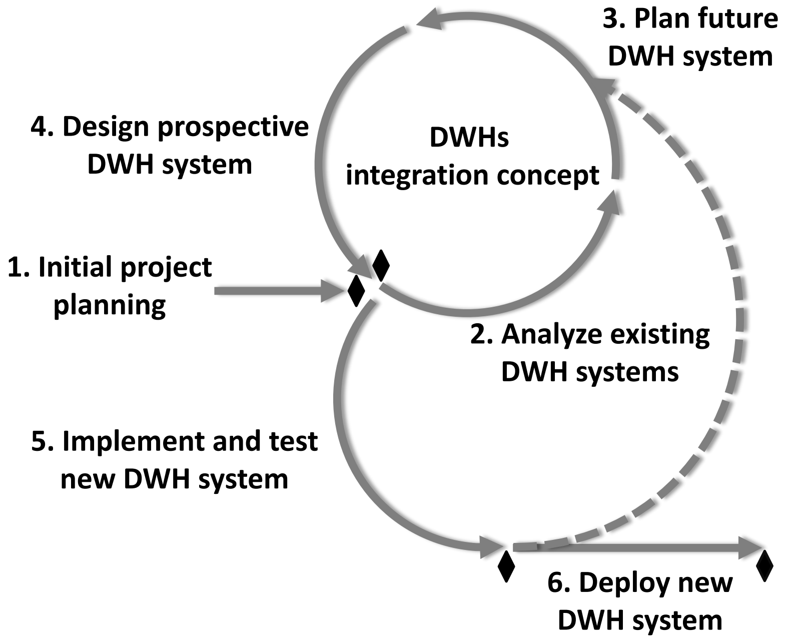

Fig. 2. The iterative Data Warehouses Integration Process Model

The DWH-IPM is divided into six phases. These phases are now outlined briefly and then explained in detail within the following subchapters. The process model begins with the initial project planning. This phase clarifies the fundamentals for a DWHs integration project. The second phase is characterized by analyzing the existing DWH systems from a technical/qualitative and monetary point of view. This phase is the beginning of an iterative cycle, since one of the CSF for BI and DWH projects is the use of an iterative development approach. The main advantage of such an iterative process is that each phase can easily react to required changes [2]. Within the iterative cycle, the theoretical DWHs integration concept is developed. The third phase plans the future DWH system. It identifies the potential integrated DWH, defines the target architecture, and considers issues involved in the integration process. The fourth phase, which is the last phase of the iterative cycle, concentrates on the design of the prospective DWH system. This includes, besides standardizing definitions, the design of the new DWH schema and ETL process. Once all iterative phases are completed and the project team has identified all required information, the implementation and testing of the new DWH can begin. If the testing was successful and data quality can be assured, the DWH system is deployed to its business users. If the testing was unsuccessful, the integration concept has to be revised and the iterative cycle needs to be run through once more. The DWH-IPM has four milestones that have to be completed to keep the integration project successful: after the initial planning phase, once the complete integration concept is designed, when the implementation and testing phase was successful, and after the new DWH system is successfully deployed.

4.1 Initial Project Planning

The initial planning phase focuses on the required organizational requirements for integrating heterogeneous DWHs. The first important activities are to identify a project team and gaining top level management support [5]. However, the early stage of the project should firstly be run with a small core project team. This core team should be managed by a competent project supervisor, who has a high reputation and strong commitment in the company. The same applies for a top level management supporter. Often, departments and employees who have used established DWHs do not want to separate themselves from the existing technology. Individuals with a great reputation and commitment are more likely to influence and convince such employees [2].

As soon as an organizational supporter has been identified, the composition of the first project scope can be realized. This includes a rough overview of all the processes and activities that are required to complete the project successfully, available budget and resources, the primary monetary and qualitative objectives, and expected deadlines. The exact monetary and qualitative objectives can only be determined after the analysis phase has been finished. The initial planning phase also includes a feasibility study which examines in which way the project leads to organizational benefits and side effects and whether the project is technically and economically feasible [2].

The next step is to identify the overall integration project team. Since a DWH integration project is rather complex, a high level of expertise is required [1]. The project team should consist of an integration committee, which is composed of the potential executive sponsors; a project supervisor, who is usually an IT manager, and diverse BI and DWH specialists. Further, business users should support the team in analyzing and planning the requirements and needs of the DWHs integration project.

4.2 Analyze Existing DWH Systems

After the first milestone is reached, the second phase is the analysis of the existing DWH systems, which is the first phase within the iterative cycle. This phase is a starting point for the planning phase since any identified problems can be used for potential improvements. An overview of the ongoing current or planned BI and DWH projects is required before analyzing the existing DWH landscape, since current or ongoing projects might have similar objectives and can be taken into consideration.

From a technical point of view, the analysis of existing DWH systems can be divided into two aspects. On the one side, it should be analyzed in which way the DWH systems technically cover the business requirements in order to identify a potential leading DWH system. On the other side, it is necessary to identify the existing and overlapping subject areas of the DWH systems. This includes the identification of the business processes, data granularity, dimensions, facts, etc. In addition, it is important to analyze in which way the source systems are still needed for analysis purposes [2].

To receive a detailed overview of the technical DWHs structures, Ballard et al. [1] suggest the use of an analysis report. The report includes nine assessment points, which help to keep track on the analysis phase. These points are identifying the existing analytic structures such as DWHs, DMs, etc.; analyzing the data quality and consistency of the analytic structures; identifying any redundant information; assessing the various source systems involved; analyzing the business and technical metadata; identifying every reporting tool, other BI tools and hardware or software inventories. These assessment points are mainly used to analyze the DWH systems from a qualitative perspective. The objective of such an analysis is to identify the quality level and technical issues of each system, and then to create the functional integration concept.

The analysis of the existing DWH systems can only be realized in cooperation with the affected departments since they have the knowledge about used measures (e.g. master data, transactions data, market data, etc.) and BI applications. Users and developers have to be deeply involved in the analysis of the DWH landscape. It must be examined, e.g. with an analysis tool, which information and BI applications are currently used or needed for future usage. However, a major issue is that the analysis of a DWH system is a complex task, which often demands exhaustive manual investigation and includes numerous interviews as well as comprehensive analysis activities.

The next step is to determine the annual cost for every system. It is vital to identify all relevant annual costs metrics to compare the DWH systems. Therefore, every system has to be analyzed by a list of cost drivers such as operational, maintenance, and support costs. When analyzing the heterogeneous DWH systems, it is useful to subdivide the costs into different types of costs to make the comparison easier.

4.3 Plan Future DWH System

The next phase focusses on a detailed project plan, which is based on the project scope from the initial planning phase, and defines the construction of a new integrated DWH system. This includes the objective of the approach; the risks and concerns; the effort needed to clean, integrate, and standardize the data; and the team members.

Based on the findings from the previous phase, an appropriate integration strategy has to be determined and a decision on the potential to be integrated systems has to be made [1]. The team has to decide whether the use of an existing DWH as a leading DWH or the redesign of a new DWH is more appropriate. In both cases, the interfaces between the existing DWHs and the operational data sources play a decisive role. A decision on the needed operational systems and their data must be made [2]. The integration strategy is important since building a new DWH system can cause high integration costs [5]. However, many companies often constrain their decision on monetary and qualitative objectives. It is necessary to verify if the planned DWH system is an improvement compared to the current DWHs landscape. Findings from the qualitative and monetary analysis should be compared with the planned DWH system.

Further, the project team should keep attention on how the prospective DWH architecture should be constructed. It is important to understand the underlying structures and procedures of the company since these characteristics determine the DWH architecture. If the company has many autonomous departments, which are independent in relation to their business processes, a global architecture should be chosen. In this case, every department would have its own DM for data analysis. However, if the departments are dependent, the company should use a local DWH architecture.

Business users need to be deeply involved in the planning phase because of their knowledge and understanding of future requirements of the new DWH. In reality, however, this is often disregarded because technical specialists do not see the necessity in involving the users [2]. As a consequence, the prospective DWH system struggles with the user acceptance. Wixom et al. [27] highly suggest that business users should gain broad technical skills to develop some solutions by themselves.

While planning the future DWH system, the project team should also pay attention on consolidating other BI tools. It is necessary to decide whether some tools are still needed after the integration project. This includes for example the ETL tools, data modeling tools, or specific operating systems [1]. Further, the current reporting environment requires attention. Each DWH system usually has its own reporting environment, so that each system is connected to a report server, security measures, development tools, and other IT [1]. When integrating DWHs, it is essential to look at every system that the DWH is connected to.

4.4 Design Prospective DWH System

The next and last phase of the iterative concept cycle is the design of the prospective DWH. This phase determines a technical design and how the identified requirements should be implemented. The main activity is the design of the future data base schema. Integrating heterogeneous DWHs may involve small or high level changes of the schema [1]. Since the company has to decide whether to design a new DWH or use an existing DWH as the leading one, the integration strategy plays a decisive role. The project team has to first focus on standardizing the business definitions and rules and clarifying what common definitions are used within the DWH landscape [1].

Second, in both integration approaches, the business and technical metadata also have to be standardized. The business metadata are used to transform the technical systems into a business language. This includes the terms and definitions of the tables, columns, reports, and the data in the DWH. Whereas, the technical metadata addresses the technical definitions of the physical tables and column names, data mapping, foreign keys, etc. Furthermore, the ETL execution metadata has to be equally defined.

Now the design of the new schema can begin. Designing or integrating a new schema from the existing schemata is a complex challenge because there are several schema conflicts that appear between heterogeneous DWHs. This occurs when diverse DWHs contain the same information but it is differently structured or represented by other values [18]. Berger and Schrefl [3] distinguish between five schema conflicts: schema instance conflict, naming conflict, aggregation hierarchy conflict, fact table conflict, and dimensionality conflict. Designing the new schema for the prospective DWH requires a lot of work since these conflicts have to be eliminated first. Although these conflicts are common throughout the scholarly literature, there is not a broadly accepted solution to eliminate such conflicts from the beginning. Most solutions only name these conflicts or provide ad-hoc solutions to eliminate them [18].

The next activity is to identify which dimensions and facts can be conformed. Ballard et al. [1] suggest to identify the data in different tables that have equal structures and are captured from the same source systems by using the primary keys. Matching two or more dimensions means that two dimensions are conform if they share one or more attributes that are captured from the same sources. Fact matching means to name two or more facts the same if they exist in two different fact tables [1]. However, matching dimensions or facts is often more difficult than expected due to matching conflicts. When trying to match the dimensions with their attributes, according to Preis and Seitz [20], the following conflicts appear: Naming conflict, granularity conflict, data type conflict, and data representation conflict. Fact conflicts often occur when the calculated measures have inconsistent values for the same measures or a difference in the scale exists between the measures [24]. Further, a new ETL process design has to be developed. The process that leads from the current source systems to the DWH has to be changed to the new sources and the prospective DWH.

Since the design phase is the last phase within the iterative cycle, it is essential to review if the DWHs integration concept is completed. The project team has to verify if additional technical or business requirements emerged before integrating the DWHs. If so, another iterative cycle has to be performed to find a successful solution.

4.5 Implement and Test New DWH System

The next phase aims to implement and test the new DWH system. The first activity of this phase is to construct the previously designed target schema. Torlone [24] proposes that once the to-be integrated dimensions and facts are identified, a dissolution of the common conflicts has to be realized. When these conflicts are eliminated, the dimensions and facts can be integrated to achieve the desired level of interoperability [24]. The process of eliminating the conflicts and integrating the dimensions and facts often takes place in between the design and the implementation phase. The reason is that the design of a schema assumes that all conflicts are eliminated.

The second activity is the construction of the ETL process. Based on the previous ETL process, the project group has to construct the dataflow from the source systems to the implemented DWH. This effort is often underestimated, although it is known that the ETL design claims 60-70% of the total effort. This is due to the definition, administration, and maintenance of the data flow process concerning the data quality since the integrity is mainly achieved through the completion of the ETL process [2].

The third activity of the implementation phase is to modify or construct the end user reports. Based on the integration approach and the previous determined user requirements, a redesign of the existing reports may have to be realized [1]. It must be considered if the reporting environment should be slimed down based on the planning phase and the decision whether certain reporting and BI tools are still needed [1].

The testing of the new DWH system now follows. DWH testing distinguishes itself from generic software or transactional systems tests, since a DWH test lays its attention on the data, information, and outcome retrieved from the system [8]. The testing phase validates the data quality through checking the correctness of the data loaded by the ETL procedures and accessed by the data presentation level [8]. The DWH is validated by performing several acceptance tests, which mainly implies to verify whether the user requirements are well covered by the new system [8], [1]. Testing the implemented DWH plays a very important role to keep the integration costs as low as possible. Yet, there are two factors that can increase these costs critically. First, incorrect reports may lead to incorrect business decisions. Since the DWH provides information for strategic decision making, errors in the data transformation may impact upon drawing the wrong conclusions. Second, a mistake in the data loading process may lead to further data migrations or a reload of the entire data pool [2].

The test management of a DWH project must still have activities such as planning the test, defining the test objectives, etc. Before beginning a DWH test, specific test cases have to be created. These test cases are then performed, documented, and evaluated. It is important to perform several tests throughout the entire DWH architecture, including testing the architecture elements such as the source systems, ETL procedures, analysis tools, etc. [2]. However, DWH testing never ends, since it is almost impossible to predict or identify all types of errors, which will mostly occur when the system is in operational use [8]. When the implementation/testing milestone has been reached, the deployment can be begin.

4.6 Deploy New DWH System

The deployment phase is the final step in the DWHs integration. It is required to document the new DWH environment so all users will know how the new system works and which information can be gained. Further, it is also necessary to educate and train the users with the new system. These steps are vital for gaining acceptance and having a project success through the new DWH system [1]. However, education and training should first be executed with a small pilot project in which the system is presented to a selected group of people only. According to Bauer [2], small pilot projects cannot only be used for receiving feedback on the new DWH system, but also to observe the system while it is partially used for operational processes. The experiences retrieved from the pilot project can be used to readjust the system before the final roll-out.

When the new system is successfully deployed and fully integrated, it can be used for business operations. All the business gaps must be filled with information and knowledge for being absorbed in decision making procedures. This is when the value proposition is being realized and the company receives greatly business improvements [12]. The last milestone is reached.

5 Applicability Check and Evaluation

To test the practical applicability of the designed DWH-IPM, an applicability check was performed at the TUIfly airline. Further details of the research method and background are described in chapter 3. This chapter presents the results of the applicability check with regard to the dimensions proposed by Rosemann and Vessey [22].

Importance Importance addresses the practical relevance of an artifact by meeting a real world problem and providing an eventual solution. TUIfly and TUI airlines use diverse analytic systems, so the problem of having several DWHs exists:

> *"Such DWHs constellation exists within the TUI group. For this reason, the iterative DWHs integration process model can be practically used for integrating the systems."* (Senior IT Manager)

A major challenge of organizational-wide projects is selling the value of the project to all departments. Some participants mentioned that DWHs integration projects might fail because some employees and executives are not following the integrated vision:

"It is indeed nowadays often the case that several DWHs exist within the company. Yet, the problem is to convince the departments to consolidate their DWHs. The process model forms a practical solution for consolidation projects." (CIO)

In general, the DWH-IPM was considered as a good approach, which is relevant to integrate heterogeneous DWHs within an organizational environment.

Accessibility The accessibility dimension encompasses whether the presentation of the artifact is understandable for practitioners and focuses on the results rather than on the research process. Research papers use scientific terms and descriptions, which can be a barrier without the required academic knowledge [22]. Our artifact was presented with some theoretical foundations, but the main focus lay on describing each phase in detail. This aspect was rated by all participants as positive:

"The presentation is easy to understand. The main focus surely is on a successful outcome of the transformation." (Application Manager)

Most participants had existing knowledge related to the BI and DWH topic. Some interviewers noted that the main issue here is the complexity. It requires high business and technical competences, therefore the presentation might not easy to understand:

"The presentation is understandable; however it might be too theoretical for somebody who does not have any kind of BI or DWH knowledge." (Head of IT)

Since TUIfly is currently implementing a DWH system, it made it easier to find appropriate contact persons, who were able to understand the complex DWH-IPM. Consequently, there were not any problems with the accessibility of the artifact.

Suitability Suitability encompasses whether the artifact and solution meets the practical needs [22]. Most statements above already indicated that the DWH-IPM is practically suitable and relevant. The CSF for BI and DWH projects also found great attention by the participants. Particularly, the organizational and top level management support plays a critical role in such time-consuming, cost-intensive projects:

"The process model meets the practical needs […] important is the acceptance among all stakeholders, especially throughout all TUI airlines." (Head of IT)

Especially the iterative process was acknowledged by most of the interviewers. Every participant agreed they have experienced that a "big bang" solution is not feasible:

"[…] the iteration of the DWHs integration process makes the process realistic and applicable." (CIO)

Within the context of the airline company, the applicability of the artifact was shown. However, some recommendations were given during the investigation. Management support was rated as the most important CSF since the executive is finally the person who can influence the entire project, sets out the vision, and allocates resources.

6 Discussion, Limitations and Recommendations

With regard to the identified research gap and our research question, we constructed and evaluated the iterative DWH-IPM as a process model for companies to integrate heterogeneous DWH systems. We used DSR to create and evaluate the artifact and further performed an applicability check at an airline company. CSFs for BI and DWH projects and a DWHs integration approach [5] were important foundations to this end. The process model includes six main phases which were described in great detail including several activities to achieve a successful integration outcome.

DWHs integration can be considered as simply integrating heterogeneous data bases, where developers can use previous research to fully integrate the analytic systems in a short period of time. However, as it was demonstrated in this work, combining DWH systems from a business and not only from a technical perspective requires more than just integrating the data and automatically matching terms. Although the technical integration has been studied in the scholarly literature, an overall DWHs integration process model has, to our best knowledge, never received attention.

Therefore, we introduce the DWH-IPM as a first approach. In terms of accessibility, this DWH integration project guideline serves for practitioners as an easily understandable approach, which was further supported by practitioners from an airline company.

Several researchers have developed technical solutions to overcome DWHs integration problems. Yet, these technical solutions tend to forget the human being as one of the most important factors. A well-defined integration strategy is inevitable [20]. Further, the user involvement and acceptance influences the success of a DWH project heavily, which also includes commitment and involvement from other important employees such as top level management, project supervisor, and DWH specialists. Most DWHs integration intentions can be technically realized; however, if important stakeholders do not share the integration vision, the project will presumably fail.

A disadvantage of integrating heterogeneous DWHs into one central DWH/EDW can be the overall performance of the core DWH system. According to Gartner, approximately 70% of today's EDWs experience performance issues. These typically arise because of the high workloads, growing integration of BI, and operational applications [6]. Therefore, the first limitation of our model refers to the decision on integrating the DWHs into an EDW. Although, factors such as data quality, cost reduction, etc. are a major advantage, it is necessary to analyze if it is better to implement, for instance, two core DWHs so the performance risks can be diversified.

Further limitations deal with the practical applicability of the DWH-IPM. We presented the model as a first approach, which needs further empirical validation. Although the participants from TUIfly found the process model as a good approach, it is necessary to employ and evaluate the model in other companies.

Based on the presented process model, further research must be conducted and the DWH-IPM can be refined. Especially the above mentioned second limitation concerning the empirical validation should be addressed. If employed in other companies, more empirical evidence and best practice knowledge can be generated. A more precise examination of each phase could be made, where each individual step is described and visualized in more detail. Although, every company has individual characteristics of its environment, culture, and strategies, the process model outlines how to successfully accomplish DWHs integration. Thus, the integration objectives such as the SVOT, cost reductions, flexibility improvements, and so on can be achieved.

7 Conclusion and Outlook

Starting with a review on DWHs integration research within the IS domain, this work focuses on how to integrate heterogeneous DWH. BI and DWH projects must receive attention from organizational, technical and process-oriented levels. Based on CSF for BI and DWH projects and related literature, we presented a practical, iterative DWH integration process model called DWH-IPM. The model describes in further detail the phases and activities that an integration project should follow to successfully integrate DWH systems. The model was constructed and evaluated according to the DSR principles and its practical applicability was then initially checked at the TUIfly airline.

Integrating heterogeneous DWHs requires a great deal of work. Although DWHs integration accomplishes many benefits, companies often face the challenge that these projects require high technical and functional knowledge. Especially long implementation periods and high funding can lead to project failure. Therefore, it is important that an organizational culture and attitude towards the integration purposes is developed. This requires top level management support, commitment of business users on delivering consistent data, and a continual investment of time and budget. Based on this, the DWH-IPM can be used to slim down the organizational DWH landscape.

In today's interconnected world, companies tend to use cloud computing services. Corporate data can be stored in a virtual cloud and can be accessed through the internet. The cloud can save hardware and software costs and it also enables worldwide data access and sharing possibilities. Future research should address the integration of heterogeneous DWHs in a cloud environment.

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