BUSINESS INTELLIGENCE IN HIGHER EDUCATION – A UNIFIED METADATA APPROACH

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TÓM TẮT

Việc sử dụng tri thức nghiệp vụ (business intelligence - BI) đang được nhìn nhận như một giải pháp tiềm năng hỗ trợ quản lý hiệu quả các nguồn tài nguyên cũng như các hoạt động trong những tổ chức giáo dục đào tạo. Tuy nhiên, ngày nay, các viện và trường đại học vẫn còn gặp nhiều thách thức trong thu thập và tích hợp những lượng rất lớn dữ liệu đào tạo từ nhiều nguồn đa tạp và phân tán. Trong bối cảnh đó, bài báo này trình bày một giải pháp BI dựa trên siêu dữ liệu, hướng đến định nghĩa và phát triển kiến trúc BI trong môi trường giáo dục đại học. Trong đó, cơ sở siêu dữ liệu và các bộ từ khóa được điều khiển sẽ thiết lập nền tảng ngữ nghĩa cho quá trình tích hợp những thông tin thuộc và không thuộc các cơ sở dữ liệu. Đồng thời, cổng thông tin Intranet với các công cụ hỗ trợ quản lý đóng vai trò là thành phần trung tâm, hỗ trợ tích hợp và chuyển đổi dữ liệu từ nhiều nguồn phân tán thành các thông tin nghiệp vụ. Bên cạnh đó, hệ thống BI được triển khai và phát triển tại Đại học Huế cũng sẽ được giới thiệu, nêu bật tiềm năng của hướng tiếp cận trong hỗ trợ các tổ chức đào tạo thu thập, truy cập và phân tích các nguồn dữ liệu tổng hợp, đảm bảo khả năng lập kế hoạch và ra quyết định chính xác, kịp thời.

Từ khóa: *Hệ thống thông tin đại học, Tri thức nghiệp vụ, Intranet, Siêu dữ liệu, Tích hợp dữ liệu.*

ABSTRACT

Nowadays, the utilization of business intelligence (BI) in educational environments can be seen as a potential solution to foster educational data for better planning academic resources and performance. However, at no time in the past have educational institutions and universities faced so many challenges in gathering and integrating huge amounts of educational data from multiple, distributed and heterogeneous sources. In this context, this paper presents a metadata-based BI solution, aimed at defining and developing a BI architecture for academic domain. In our approach, a bridging metadata base and well-defined controlled vocabularies found a semantic basis for the integration of both database and non-database information. Moreover, corporate Intranet, with its accompanying management support functionalities, has been developed, playing the key role in transforming just-integrated information into business information crucial for the understanding of the academic environment and its future needs. Furthermore, a prototype of developed BI system in Hue University will be introduced, further emphasizing the potential of our approach in allowing educational organizations to gather, access and analyze corporate data sources for academic planning and decision-making.

Keywords: *University System, Business Intelligence, Intranet, Metadata, Data Integration.*

I. INTRODUCTION

To make sound decisions and cope with pressures to improve productivity, universities must establish a solid data foundation, combining both current and historical data values from disparate operational systems, and be able to identify trends and future outcomes [10]. In this context, University Information Systems (UISs) rely on transactional systems such as the financial management system (FMS), human resource management systems (HRMS), student information system (SIS), and course management system (CMS). However, without the completely academic picture, it is difficult to make valid and dependable decisions. That is because good decision-making requires a complete and accurate view of data [12] and it has become more important than

ever to access, integrate data throughout the whole university and generate valuable knowledge and shareable information among authorized users.

From this perspective, recent developments both in the business and in the technological domain have led to a significant increase in demand for Business Intelligence (BI) [5, 14] infrastructures that can find ways of bringing together and make sense of the vast amounts of data flowing within and across the UIS in minor frames. With its set of methodologies and technologies, BI has been described as a promising technology that tends to help universities in transforming their legacy systems towards integrated, user-centric information systems required for the support of improvement academic operation effectiveness and of management/decision making process [14].

However, the usage of information technology at typical universities is characterized by historically grown system platforms and an incomplete support of business processes in the university administration [10]. Since in most cases, due to the fact that in the past not much effort was spent on integration, these components are rarely integrated and often do not provide means to communicate among each other. Therefore, in UISs, while BI remains a high priority, the need for better accessibility, maintenance, and preservation for managing these repositories has turned to be an urgent requirement [2]. Especially, a more broadly approach is required, including consideration of how users navigate, and communicate knowledge embodied in computer-based vocabularies and metadata classification schemes [11].

Within the scope of this paper, a metadata based BI solution has been developed, supporting the wider use of data and services that are typically available through various non-integrated and legacy university subsystems. Founded on Dublin Core standard [1] and semantic technologies, the proposed architecture is introduced, in which the data integration processes, by means of XML and Web Services technologies, play a crucial role in providing reliable, timely, accurate and integrated data from distributed sources. Moreover, a university Intranet, with analysis and decision support modules that store, retrieve, manipulate, analyze and produce reports from integrated, is implemented, enabling authorized users to understand the information within the data, making decisions, and taking actions based on this gained insight. Furthermore, the system can be linked directly to the university's information portal, supporting the dissemination of value-added information to all members of the community.

The rest of this writing is organized as follows: section 2 introduces some approaches related to our work; section 3 gives a brief introduction of BI and the motivation for developing BI in education; in section 4, the proposed BI solution is presented with its core components and semantic mechanisms, especially highlighting the metadata-based data integration and the University Intranet; in section 5, a prototype of our approach, developed in the environment of Hue University will be described in detail. At last, section 6 gives a summary of what have been achieved and future works.

II. RELATED WORKS

The characters of the proposed approach can be rooted in several research areas of BI, including the trends and concept of BI solutions, the combined use of metadata and semantic technologies in supporting BI, as well as the utilization of BI in higher education.

With the amount of data generated in an enterprise increasing continuously, delivering the right and sufficient amount of information at the right time to the right business users has become more complicated and critical [7]. More and more enterprise solutions and platforms for Business Intelligence have been developed, such as IBM DB2 with Business Intelligence Tools, Microsoft SQL Server, Teradata Warehouse, SAS, iData Analyzer, Oracle, Cognos, Business Objects, etc. [13], have been developed aim to empower businesses by providing direct access to information used to make decisions, create more effective plans and respond more quickly to problems and

opportunities [12]. Meanwhile, there are many studies as well as projects applying metadata and semantic technologies in enabling BI solutions to solve the structural heterogeneity and semantic heterogeneity between multiple disparate data sources [11]. Thus, this approach effectively and efficiently leverages the data resources to satisfy their requirements for analysis, reporting and decision making process.

Considered as one of the most complex environments, UISs are typically large and decentralized and data at multiple information resources tends to be formatted in various, complex, changing and incompatible ways [2, 8]. In this context, an increasing number of universities are developing institutional BIs to leverage information assets in administrative systems for strategic and management decision making [2, 3, 9]. Furthermore, this trend is supported by many BI solutions especially developed for higher education, e.g. Microsoft Institutional Reporting and Business Intelligence, SAP for Higher Education & Research, Oracle's PeopleSoft Campus Solutions … [10]. However, almost all existing tools only operate on analyzing and presenting structured data and do not seriously taking into account aspects of semi-structured and unstructured data [9].

In this context, this paper focuses on using metadata and semantic techniques in improving the data integration of database and non-database information resources together with their accompanying management support functionalities (navigation, retrieval, and analysis). In this BI solution, the corporate Intranet, supported by the integrated data repository as well as various data analysis and decision support tools, provide efficient ways of obtaining valuable information and knowledge. Thus, the utilization of BI in universities provides a feasible and effective method to improve the speed of reporting, analysis, and information delivery for faster operational decision-making and action-taking in universities, thus enabling them to react rapidly to business problems and satisfy new requirements.

III. APPLYING BUSINESS INTELLIGENCE SOLUTIONS IN HIGHER EDUCATION

In today's competitive, fast-evolving world, the effective management, processing, analyzing huge amounts of data and turning it into profits represent both the greatest opportunity and the most difficult challenge for most organizations [14]. In these cases, BI is presented, as a potential approach offering the means to efficiently extract oceans of data to useful business information and derive knowledge through analytical tools to support decision making. This section presents an overview of BI concept, methodology along with its main components, and then some views of BI in higher education will be introduced, responding to the challenges for improving decision making capabilities in higher education institutions.

1. Business Intelligence

Business Intelligence by today is never a new technology instead of an integrated solution for companies, within which the business requirement is definitely the key factor that drives technology innovation [5, 13]. Specifically, BI focuses on gathering, management and analysis of data from a wide range of sources to provide useful information to people throughout the organization as a support for their decision making, strategic thinking and acting [14].

BI systems may be analyzed from different perspectives. From data analysis perspective, BI is the process of gathering meaningful information to help authorized users on all levels of management (depicted in figure 1) analyze information or draw conclusion, make prediction [13]. On the strategic level, BI makes it possible to perform different comparative reports, e.g. on historical results, effectiveness of distribution channels along with forecasting future results. On the tactical level, BI systems may provide some basis for decision making within marketing, finance, capital management, etc. The systems allow for optimizing future actions and for modifying organizational or technological aspects of company performance appropriately in order to help enterprises realize their strategic objectives more effectively. Additionally, from knowledge

perspective, BI is the process of transforming data into information, and through discovery, transforming that into knowledge [5].

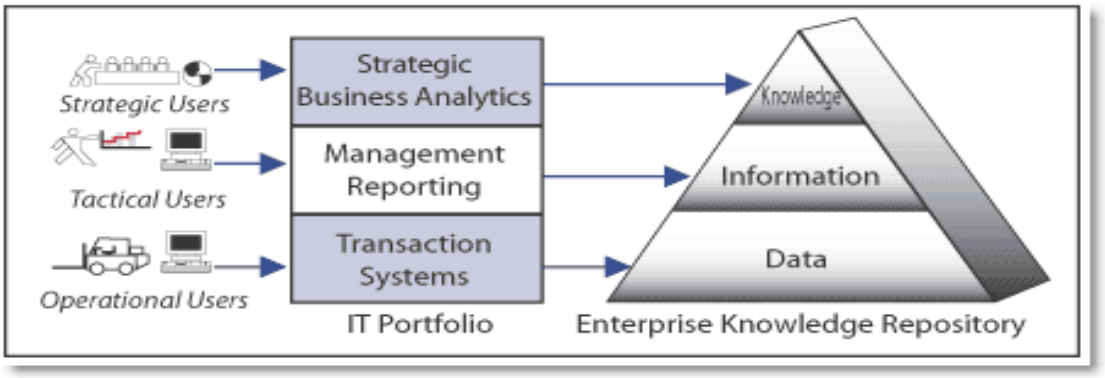

Figure 1. *Role of BI in the Enterprise [12]*

Meanwhile, from a technical perspective, BI systems offer an integrated set of tools, technologies and software products used to collect heterogeneous data from disparate sources in order to integrate and analyze data [14]. In this approach, the successful application of BI in an enterprise should consider the following two points. The first is correct, valid, integrated, and in-time data, and another is the means which will transform the data into decision information [14]. As a result, BI tasks implicate a technological structure of the BI systems, shown in following figure 2 with its common components.

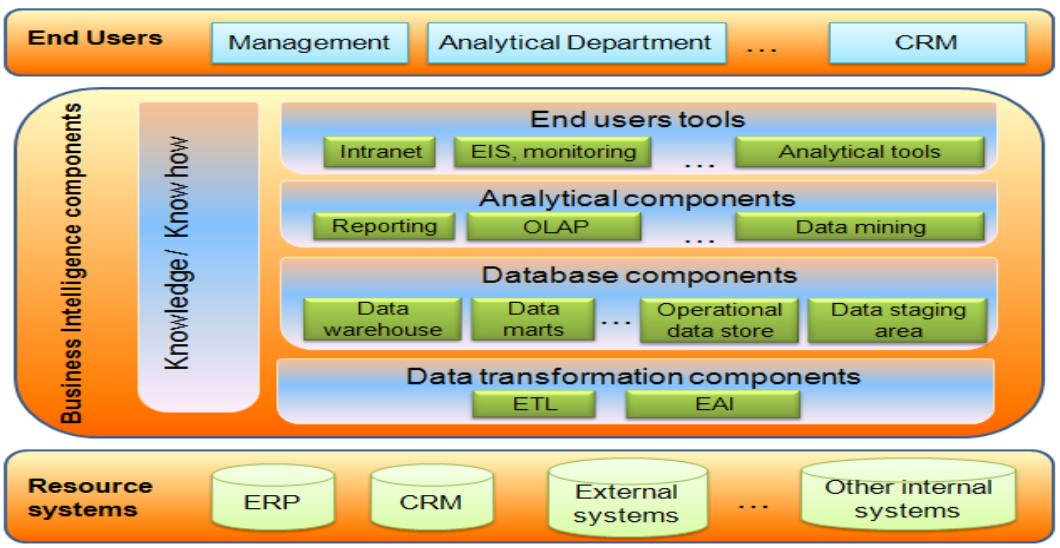

Figure 2. *Common components of a typical BI solution [3]*

As a way of improving business performance by providing actionable information at hand as well as integrated and customized data analysis to all side of organization, along with powerful assists for different mangers at different level in decision making process [12], BI system gives an organization's employees, partners, and suppliers easy access to the information they need , and the ability to analyze and easily share this information. Moreover, today's technology further ensures the capability of BI tool in allowing for multi level of information delivery across an enterprise [14].

2. Bridging the Business Intelligence Gap in Higher Education

To adapt to new challenges in increasingly dynamic and complex environment, higher education institutions have to face increasing demands for timely and relevant information needed to support administrative, academic, planning, regulatory, legislative, research and operational interests [2, 10]. In this context, many academic administrators now have recognized the importance of having accurate and accessible data in order to support the decisions that improve day-to-day operations, as well as long-range strategic planning [4].

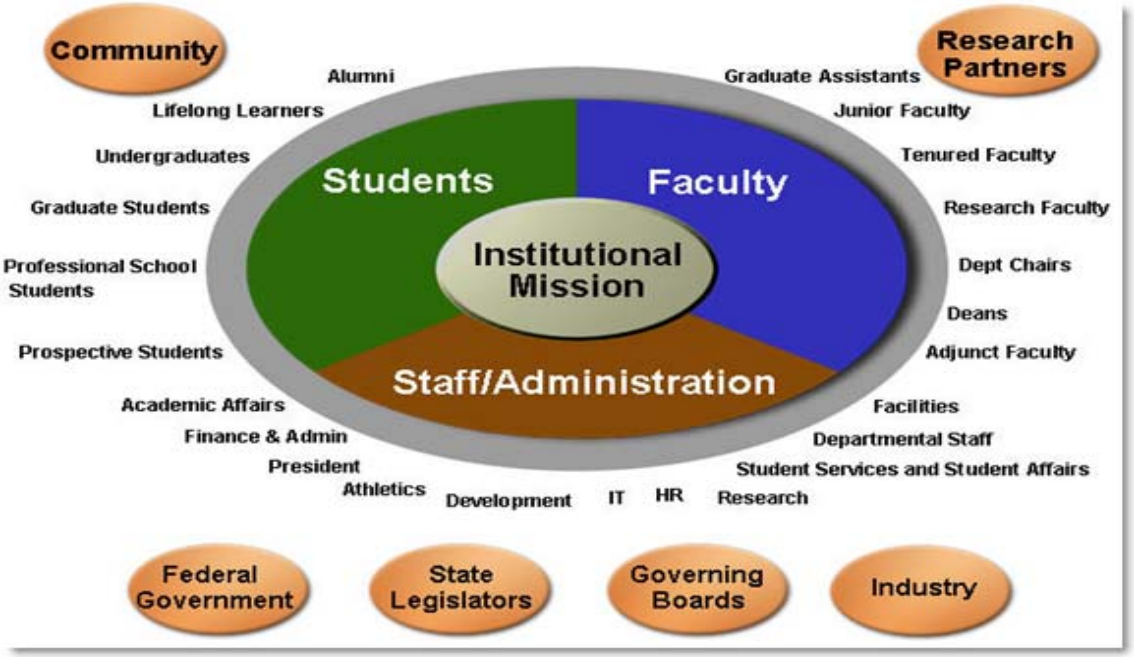

Figure 3. *Complex landscape of higher education [2]*

However, IT environments in colleges and universities are typically large and decentralized with disparate internal and external sources, including administrative systems, library, and research systems, etc [2]. Undergoing institutional processes happening around the universities have inevitable made UISs highly heterogeneous, with disintegrated applications, overlapping sets of data, and disperse points (in location and time) of data collection and processing [9]. Moreover, data at multiple information resources tends to be formatted in various, changing and incompatible ways [10]. Hence, using BI technologies is a common approach to assure a consistent, exact, timely and efficient support to decision makers in such heterogeneous and dispersed environment.

Provided with data driven decision making capabilities by means of BI systems, higher education administrators and staff can now more accurately aligning multiple processes with strategic objectives through integrated performance management and analysis [10]. These advanced decision making capabilities benefit an institution not only with respect to long-term planning, but also in assisting routine fact-based decision making that can add up to tremendous performance improvements over time [2]. As a result, BI in higher education becomes a crucial technology in support of strategic goals of gaining a competitive advantage and securing good prospects for the future.

IV. AN INTEGRATED METADATA-BASED SOLUTION TOWARDS BI

This section will introduce a BI architecture in university based on Dublin Core metadata and describe its mechanisms, supporting the gathering and providing access to analyze structured, semi-structured, as well as unstructured data [9, 11]. Especially, sets of controlled vocabularies will be

defined as both a medium of domain knowledge representation and a navigable structure, establishing the semantic foundation for the architecture. Moreover, University Intranet plays the key role in supporting the information dissemination, collaboration, and real-time sharing of corporate information to enhance organizational effectiveness across functional boundaries and organizational levels [5].

As in a typical UIS, the proposed architecture is conceived as a distributed system comprised a number of interconnected operational nodes, including student information system, finance and accounting system, human resources management system, etc. Providing a standardized core of metadata elements as well as a standardized set of key words, the solution focuses on facilitating interoperability among metadata databases. Hereafter, the Dublin Core metadata and defined controlled vocabularies provide the basic glue for semantic interoperability among operational data sources and among system layers/components.

On the basis of a common Dublin Core standard, each operational node can be accessed by end users through web-based or other local client tools for query, navigation, and analysis. Specifically, metadata from the nodes can be collected into the integrated metadata repository both automatically and intellectually by information providers, aiming to provide abilities for interoperability searching and data integration among university information resources [9]. In this approach, the most important component of our architecture is the data integration services which are used to pull structured, semi-structured, and unstructured data from different Dublin Core data sources together into the integrated data repository and delivering an information infrastructure that will meet strategic BI initiatives.

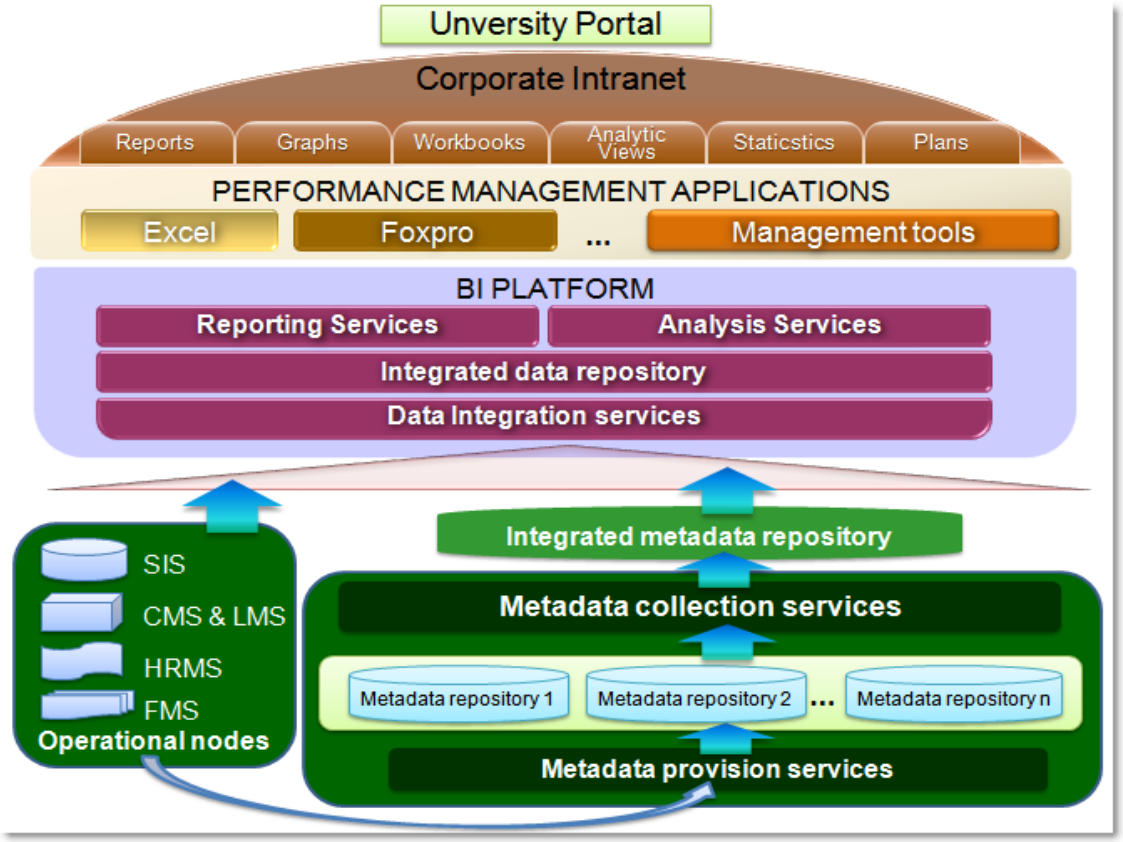

Figure 2. *Conceptual architecture of metadata-based BI solution*

All decisions must be made as quickly as possible based on the historical and current data through the implementation of the up-to-date tools that store, retrieve, manipulate, analyze

and produce reports [10]. Based on Dublin Core metadata bases and integrated data repository, university corporate Intranet with web-based reporting and analysis modules fulfills many reporting needs on university environment, providing a platform to change data into information and helping users maintain control over report logic, formatting, and data selection. As a result, the BI system can be used across a whole university, between different unit, feeding on multiple information systems and servicing multi type of information delivery such as reporting, data analysis, decision support and performance measurement that supports timely and efficient decision-making in a secure and customizable manner [5].

Moreover, by means of well-defined mechanisms linking developed Intranet directly to university portal, information providers can transform reports and data analysis view into information objects up to Dublin Core standard and publish these objects to all members of the community with a single gateway. Furthermore, the reports and analysis view generated will also be collected, classified, and then well archived into integrated repositories. Thus, our BI solution can support varying constituents at all levels with dynamic views of information and on-demand, comprehensive, customized analysis capabilities to make better informed strategic and day-to-day decisions.

V. EXPERIMENTAL RESULTS – A CASE STUDY IN HUE UNIVERSITY

In Hue University (HU), although operational information resources provide invaluable information to the top management for planning, forecasting, and implementing the academic business, HU administrators and staff have to face many challenges in seeking synthesized and analyzed information to better devise and implement strategic planning as well as manage available resources. In this context, the proposed metadata-based BI and integration solution have been implemented enabling decision-makers to study ways of optimizing the business and to respond quickly and effectively to arising issues.

In this BI system, the automatic procedures have been defined to extract metadata, e.g. field descriptions and constraints, out of the source database systems up to Dublin Core standard. Moreover, in case of document bases, information providers can non-automatically input descriptions, explanations, and usage hints or restrictions for any information objects they generate, also up to Dublin Core standard.

Figure 3. *Management Module of Research Resource*

With the both the integrated data and integrated metadata repositories, corporate Intranet supported by the analysis and decision support modules can be seen as a decision-support reporting environment, allowing users to interrogate and explore the resources and modeling process used to

generate reports. Moreover, the Intranet also provides authorized users with modular and easy-to-use web interface to tailor reporting requirements for their needs and generate academic reports. Such modular and flexible reporting system will also enable more automated, cost effective and responsive reporting appropriate users.

Linked with the university portal, the developed BI system provides authoring tools, standards and procedures for the report publishers produce the reports and disseminate the information accordingly to the various types of users in the community. Thus, the proposed solution can provide Hue University the opportunity to shorten lead time on being responsive to critical demands, improving key decision making process, enhance their information management practice and gain intelligence information about HU as whole.

Figure 4. *Comprehensive data analysis in graph view*

VI. CONCLUSIONS AND FUTURE WORKS

As the process of turning data into information and then into knowledge, the concept of Business Intelligence has been emerging as a potential solution to open new perspectives and areas for improvement of higher education processes and operations. In this paper, a metadata and semantic-based BI solution, with the integrated repositories and corporate Intranet as the central components, has been introduced to support universities' administrators and staff makes better business decisions. Moreover, the proposed has been implemented in Hue University, integrating large amounts of data, analyzing that data, and presenting a high-level set of reports, enabling management to make fundamental daily business decisions [2].

In the near future, the pursuit of semantic technologies will be used to enhance the efficiency and agility of our BI solution. Moreover, data mining algorithms will be adapted for multidimensional

analysis of integrated data from heterogeneous sources in university environment. Thus, the proposed BI tools can provide improved analytic capabilities for the multi levels of information delivery across an enterprise, which would help the university to be better informed about its performance and increase its visibility about strategic decisions.

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