Business Intelligence Systems in Support of University Strategy

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Abstract: - The Business Intelligence enables universities to measure, monitor and manage their performance more effectively. The paper presents a framework for developing a business intelligence solution for universities. The paper also presents how a university can use the BI to assess an e-learning platform. This paper briefly presents a dimensional data model to assess an e-learning platform from the viewpoint of usage. The choice of a dimensional data model was based on the need to analyze data at the scale of the entire university. The dashboards are the preferred method for delivering and displaying business intelligence to users. A university can use dashboards as main components of a BI solution. We can estimate: how often students have accessed the e-learning platform? Which resources are used more? Or which teachers are most active in terms of usage time?

Key-Words: - business intelligence, dimensional data model, data warehouse, dashboard, performance management, university management

1 Introduction

The Data-Warehousing Institute has defined Business Intelligence (BI) as “the tools, technologies and processes required to turn data into information and information into knowledge and plans that optimize business actions” [5]. The range of capabilities that can be defined as business intelligence is very broad. BI includes:
- BI tools (enterprise reporting tools, ad hoc query tools, statistical analysis tools, OLAP tools, spatial-OLAP analysis tools, data mining tools, text mining tools, dashboards, scorecards and predictive analytics/advanced analytics);
- Standalone analytical applications for a particular domain or business problem. For example, Financial Analytics, HR Analytics, Service Analytics, etc;
- Real-time BI/operational BI (BI embedded in operational applications and BI embedded in business process management);
- Performance Management has a number of names including: Corporate Performance Management (CPM), Business Performance Management, Enterprise Performance Management (EPM) and Strategic Enterprise Management (SEM-SAP) [11]. The Gartner, the information technology research company, has defined CPM as an “umbrella term covering the processes, methodologies, metrics and technologies for enterprise to measure, monitor and management business performance” [11]. CPM incorporates the following technologies: business process management (BPM), business rules management (BRM), business intelligence and data warehousing;
- SOA-based BI. Business Intelligence is made more powerful by the use of the SOA. Business Intelligence triggers changes in business processes and BPM invokes services. BPM and SOA work very well together because SOA abstracts individual tasks and activities as services. An SOA approach is generally considered from a technology/IT perspective, whereas BPM is treated as the domain of the business users and processes. Business users are consumers of the processes and services.

In the coming years, the emerging BI trends identified by Gartner include: mobile analytics, in-memory analytics, BI embedded in collaboration and social software and cloud-based BI. There are three cloud-computing services models: IaaS (infrastructure as a service), PaaS (platform as a service) and SaaS (software as a service). The benefits that cloud computing offers to BI are: lower
costs, pay per use, fast deployment, easy maintenance, etc.

The Business Intelligence (BI) can be vital for education institutions as well as for businesses. There are several factors that have to encourage university leadership to use BI such as: competition and expectations from students and employers. Using the BI, our universities should be able to analyze the unemployment rates of the school graduates and link to specializations that they had studied. Such analysis serves for strategic planning of the university and also can be used for comparing the quality of education in different universities.

Development and Deployment of a BI system is a challenge for Romanian universities. Universities need a framework that defines the layers and components that are to be integrated and aligned to deliver a strategic vision and plan for implementing BI system. Section 2 provides a framework that guides the implementation of a BI solution in universities.

The assessment is one of the most important activities in education. The next sections present how a university can use business intelligence to assess an e-learning platform. Section 3 briefly presents a dimensional data model to assess an e-learning platform from the viewpoint of usage. Section 4 presents how a university can use the dashboards to assess an e-learning platform.

2 A BI framework for universities

The available literature on BI is very broad, but there are few papers that focus on the BI maturity models. Most of the models are developed by BI consulting firms. Examples of BI maturity models are: TDWI BI maturity model, Gartner BI maturity model and AMR Research BI maturity model. The aspects covered by the TDWI BI model are: scope of BI initiative, business value and BI architecture. Also, the model focuses on data warehouse and BI system [4]. The aspects covered by the AMR Research model are: data, analytics, organization issues and culture. The model focuses on analytics and business performance management. The Gartner model defines “the people, processes and technologies that need to be integrated and aligned in order to bring a better defined strategic vision and plan for implementing business intelligence initiatives” [6]. The model includes three layers: people layer, processes layer and technology layer. The people layer includes three main groups of users: analysts, users and IT staff. The Gartner framework also recommends a business intelligence competency center (BICC /BI center of excellence).

The BICC combines business, IT and analytical skills and establishes a collaborative work environment. The Gartner framework identifies three groups of processes: business and decision processes, analytic processes and information infrastructure processes. This section presents a framework for developing a business intelligence solution for universities. The start point for this framework is the Gartner BI maturity model. Figure 1 presents this framework.

2.1 The University Strategy and KPI

One way of viewing BI in context of education environment is using BI for decision support of universities’ management. To use the BI in this way a set of appropriate metrics needs to be used. Identifying and monitoring key performance metrics is crucial for the university administration.

The university senate board manages the creation and definition of strategies and objectives. The performance measures need to be derived from the university strategies and from an analysis of the key business processes required to achieve those strategies and therefore this performance information must be presented to academic supervisor staff in a concise, intuitive format to support the university management processes. The basic function of performance metrics is to assist in determining how well a particular university or department/faculty has achieved its respective goals. Key Performance Indicators (KPI) must be established for each key business process. Monitoring key performance metrics is crucial for

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Fig. 1. A BI framework for universities
the university management. In addition to the KPI, a university should monitor a broad range of metrics

2.2. The people and the processes
A university has many users such as: university leadership, administrative staff, academic staff and students. The users will have different roles in analytic, business and decision processes. The users will also require different modes of analysis, different modes of delivery of information and different data. For instance, university leadership requires analysis facilities. Administrative staff requires reporting facilities and ad hoc query facilities. IT staff should have a detailed understanding of how users and analysts work and a detailed understanding of their roles in processes. IT staff should also have a detailed understanding of didactic processes and other related processes.

The key business processes are didactic processes. The key didactic processes are: defining curricula, registration, examination and completion of studies. The related processes are: student fees and other related processes (social department, library, etc).

A BICC for university will not be responsible for the creation of specific campus wide metrics, business processes, etc, but will become a knowledge base of BI activities across campus.

2.3. Information infrastructure
Information infrastructure addresses how the data architecture and data integration infrastructure ensure efficiency and agility to react to changing business requirements.

An information infrastructure includes: an enterprise data warehouse or/and a data mart or/and an operational data store (ODS) or a real-time data warehouse. A university needs a university data warehouse that provides a centralized source of information for the supervisory staff of the university and for the organizational and administrative structures. It also supplies the data necessary for reporting, analysis and developing the university strategic plan and supports the analytical activities regarding the three major components in the university context: didactics, research, and management. The university data warehouse is fed from various transactional data sources such as Human Resources, Finance, and Academic information system-SIMUR (student services, research management, resource allocation, e-learning, etc) external sources (other institutions performance data, workforce and employment data, etc).

2.4. BI technologies
The dashboards are the preferred method for delivering and displaying business intelligence to users. A university can use dashboards as main components of a BI solution.

Eckerson defined a dashboard as “a multilayer application built on a business intelligence and data integration infrastructure that enables organizations to measure, monitor, and manage business performance more effectively” [11].

From a decision maker’s perspective, the dashboards provide a useful way to view data and information. Outcomes displayed include metrics, graphical trend analysis, capacity gauges, geographical maps, percentage share, stoplights and variance comparisons.

In the coming years the dashboards will become essential in our universities. Dashboards will allow University leadership to monitor the contribution of the various activities in university.

The introduction of an e-learning environment at a university influences a variety of processes: registration of students for courses, the workload of teachers, how knowledge acquired during such a course is assessed, etc. The next sections present how a university can use the dashboards and a dimensional data model to assess an e-learning platform from the viewpoint of usage. Section 4 presents an example of dashboard. Using the dashboards we can estimate:
- How often students have accessed the e-learning platform?
- Which resources are used more?
- Which teachers are most active in terms of usage time?

3 The dimensional data model
In the traditional learning process, students are evaluated through tests, exams, etc. In distance learning, e-learning systems allow to evaluate student’s interaction with the e-learning environment. E-learning environments usually have a built-in student tracking tool that enables the teacher to view data such as a student’s first and last login, the number of accesses, etc.

BI allows universities to analyze and correlate teachers’ online activities with course evaluations and student results. For instance, we can identify who are the “risk” students. We can also analyze which tools are used depending on student age, gender and ethnicity. It is difficult to select suitable metrics and methods for the assessment of e-learning.
Over the past years many studies have focused on the assessment of the e-learning impact on the learning process and student’s evaluation. Lei proposed data mining analysis for evaluation of e-learning [5]. The log files were used as data sources. Sheard proposed statistical analysis [9]. The data sources were: Web logs, student demographics and survey results. There are few studies which proposed the use of data warehouse [8], [10].

Our university uses Moodle as e-learning platform. The University management is interested in an assessment of the distance learning. This section presents a dimensional data model for assessment of Moodle platform from the viewpoint of usage. The choice of a dimensional data model was based on the need to analyze data at the scale of the entire university.

Moodle is an Open Source Course Management System with a variety of communication tools, collaboration tools and evaluation tools. Moodle is used for distance learning in our university. The Moodle database has around 200 tables: a set of tables for each activity module (assignment, chat, choice, forum, lesson, etc); a set of tables for users, roles, role-capabilities, course, course category; a set of tables for logging system, etc [2]. Moodle keeps detailed logs of all activities that students perform on the e-learning platform. Each record in the log contains a time stamp and other fields that hold information about activity at that instant. Course logs show activity within the course. It allows teachers to see what resources are being used and when. For instance, the activity report lists how many times each course activity has been viewed and the last time it was viewed. But the Moodle statistics utility is somewhat limited. There are no drill-down or roll-up, it doesn’t use complex visual components as gauges or stoplights and compared to the dashboard technology it does not look appealing anymore. You can choose to display the logs on a page or download them in text or Excel format. All participants, all days, all activities and all actions for one course were selected and the logs were downloaded in Excel format. The Excel file was converted in CSV format. The CSV file was imported into an Oracle database. Many log file records can occur for a single action. Due to this problem, all records with the same IP address, same course, same tool, same hour, same day, same month and same year are a single activity. For instance, actions can be: assignment view, blog view, resource view, resource update, etc. The attribute Data is timestamp (for example 24-NOV-2010 04.11.32). The new attributes were defined. The attribute Start date of an activity is defined as: First_Value(Data) Over( Partition By name, Action, Information, Extract(Day From Data)|| Extract(Month From Data)|| Extract(Year From Data) Order By Data ).

For example, the start date for assignment view Tema 4 is 24-NOV-10 04.11.09

The duration (as interval) of an activity is defined as the difference between the first value and the last value of each partition: First_Value(Data) Over(Partition By name, Action, Information, Extract(Day From Data)|| Extract(Month From Data)|| Extract(Year From Data) Order By Data Desc )-First_Value(Data) Over(Partition By name, Action, Information, Extract(Day From Data)|| Extract(Month From Data)|| Extract(Year From Data) Order By Data )

The duration (as seconds) is defined as:EXTRACT (hour FROM duration) *3600+ EXTRACT (minute FROM duration)*60+ EXTRACT(second FROM duration)

For instance:

<table>
<thead>
<tr>
<th>Name</th>
<th>Action</th>
<th>Duration</th>
<th>Seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adina Cindea</td>
<td>assignment view</td>
<td>Tema 4</td>
<td>1447</td>
</tr>
</tbody>
</table>

The research data were collected with reference to only one course: Economic Informatics, Faculty of International Business and Economics, first semester of 2010-2011. Data can be obtained from three source systems: Moodle database, Moodle logs and the SIMUR database from which data about courses, people and study programs can be extracted. A dimensional data model is proposed for the storage of these data.

The dimensional data model is implemented in the Oracle RDBMS using a constellation schema (figure 2). The dimensional data model consists of three fact tables: Utilization Fact table, Activity Fact table and Grade Fact table. The measures of the Utilization Fact table are:

- Number of registered students. The registered students are users registered in Moodle as student.
- Number of Active students. The active students are registered students who have accessed a course at least once. These measures can be extracted from Moodle database.

The Activity Fact table includes information about student activities in Moodle platform. The measures of the Activity Fact table are: duration (in seconds) and type of action (view, add, update, delete, etc). These measures can be extracted from Moodle logs. The Grade Fact table includes information about student grades. The measures are: student grades for each Moodle course and average grade for all courses. The attribute Completed
describes whether a grade is satisfactory (completed=yes) or unsatisfactory (completed=no).

The dimensional data model also specifies the “granularity” (level of detail) for each measure. There are four dimensions: Time, Tool, Course and Person. Tool dimension contains information about Moodle resources (chat, forum, glossary, lesson, blog, assignment, test/quiz, survey, etc). The assignment tool allows students to upload digital content for grading. Each course has its own set of glossaries. Wiki can be a powerful tool for collaborative work. Each user has his own blog, which is non-course specific. Moodle has also two tools specifically designed for collecting feedback from students: surveys and choices. Course dimension contains information about courses. The attribute course category can have five values: DF - fundamental, DG-general, DS-specialized, DE-economic/management, DU-humanist. The attribute curricular category can have three values: DI-imposed, DO-optional and DL-free choice. Person dimension contains information about all course users. The attribute Role stores user roles, for instance, administrator, editing teacher (discipline coordinator), non-editing teacher (tutor), student and guest. User roles can be extracted from the Moodle database. We can also add Session dimension which contains information about IP address and type of session (home or school). The IP address allows for identification of the place where the e-learning platform was accessed (faculty, computer lab, etc.).

The hierarchies were created in dimensions to make it possible to analyze data at different levels. The Tool hierarchy consists of two levels: tool and category. Tools can be classified by category, for example, communication tools (chat, forum and blog), evaluation tools (test/quiz and assignment), feedback tools (survey and choice) and collaboration tools (wiki). The hierarchy of the Time dimension consists of four levels: start date, day, month, semester, study year. The hierarchy of the Course dimension can have, for instance, the following levels: course, curricular category, course category, license field and faculty.

4 Dashboards

The dashboards for assessment of e-learning should be classified into the following fundamental groups: top management, faculty, distance learning (ID) department and teacher. For top management the dashboards can provide information about: number of registered students per semester, number of active students per semester, number of active teachers per semester, number of registered students per semester and faculty, number of active students per semester and faculty, etc. For faculty the dashboards can provide information about: activity per course and person, activity per tool and person, activity of the most active teachers in tools (total time), etc. The ID department organizes the distance learning process and ensures quality. The ID department is interested in the way in which Moodle is used: the tools used more often, the final grades of students, monthly activity, etc. For teachers the dashboards can offer information about: activity of a particular student (time in minutes) with tools, activity among all students with course tools, etc. This section presents only an example of dashboard. The dashboard is developed using a free BI tool – Qlikview. The dashboard displays only one indicator: duration. You can view: activity per person, tool and course; total activity per semester, course and teacher; total activity per role and course; total activity per role, month and course; average duration per month; number of active students per month, etc. We selected: semester=1, month=12 (December), tool category=“communication”, course name=“Economic Informatics” and role=“student”. The figure 3 displays: activity (duration in minutes) per student.

![Fig. 2: The dimensional data model](image)
and tool, activity per student and communication tools category, total activity per communication tools category, and number of students which used the communication tools in December, semester 1.

Dynamically, you can change the semester, you can change month or day, you can change course, you can select a role (for example student), you can select all students or only a student and you can change the display from pivot table or straight table to a bar chart.

Fig. 3. An example of dashboard

5. Conclusion

This paper presented a framework for developing a BI solution for universities. The paper also presented how a university can use business intelligence to assess an e-learning platform. Section 3 briefly presented a dimensional data model to assess an e-learning platform from the viewpoint of usage. The paper also identified the potential data sources and methods for the extraction and integration of data. Section 4 presented how a university can use the dashboards to assess an e-learning platform. Dashboards will allow University leadership to monitor the contribution of the various activities in university. Dashboards will allow users to see multi-year trends, compare across departments, and see data from different viewpoints. But the infrastructure of the data warehouse must exist prior to developing dashboards for university management. A survey on quality assessment of e-learning can be used. The survey results can be analyzed together with the metrics which characterize an e-learning platform from the viewpoint of usage. This topic will be the subject of further research.

References: