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Rabuzin, Kornelije; Konecki, Mario; Šestak, Martina

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# LEARNING ABOUT BUSINESS INTELLIGENCE – CHALLENGES OF THE VISUALLY IMPAIRED

<sup>1</sup>KORNELIJE RABUZIN, <sup>2</sup>MARIO KONECKI, <sup>3</sup>MARTINA SESTAK

<sup>1,2,3</sup>Faculty of Organization and Informatics, Varaždin, Croatia  
E-mail: <sup>1</sup>krabuzin@foi.hr, <sup>2</sup>mario.konecki@foi.hr, <sup>3</sup>msestak2@foi.hr

**Abstract-** Modern business systems, especially those of middle and large size, generate a large amount of different data. This data is important for proper analysis, prediction of future trends or in other words for making various business decisions. The large amount of data that can be found in many different formats and in different technology can be stored on multiple locations that all refer to the same business system. Education about technology, such as various business organizations' business intelligence systems and data warehouses is important part of many higher education curriculums. However, since many business intelligence tools rely on various graphical representations of data they are not suitable for visually impaired students. In this paper a discussion about challenges that visually impaired students encounter when trying to learn about business intelligence is given along with directions for future research.

**Keywords-** Business intelligence, Data warehouses, Visually impaired, Learning.

## I. INTRODUCTION

There are many visually impaired students that enroll higher education studies every year. The desire of visually impaired to learn about information technology and to make a professional career in information technology industry is present and concurrent. Visually impaired have been included in computer industry from the first time it began to attract wider categories of users.

The usage of computers was made possible for visually impaired by using appropriate aiding technology which comprised of various text-to-speech synthesizers [6; 8]. This aiding technology enabled visually impaired to read various texts and find different information which was beneficial in the terms of their professional careers and in the terms of their education.

Visually impaired have also had successful programming careers. However, graphical user interfaces that have emerged at one point have made using computers much more challenging for visually impaired and a whole new set of requirement for developers of aiding solutions have emerged. All these problems have occurred in the area of professional work and learning simultaneously.

Visual nature of user interfaces has created problems in learning about different development and business systems, for example learning about various programming development environments and programming languages.

Existing text-to-speech synthesizers encountered many problems in trying to describe the graphical elements on the screen or the context of the screen. To address mentioned problems a number of aiding solution for learning programming have been proposed and developed, such as [4; 9;10; 11;12]:

- GUIDL (Graphical User Interface Description Language)
- APL (Audio based Programming Language)

- SODBeans (the Sonified Omniscient Debugger in Netbeans)
- WAD (Wicked Audio Debugger)
- Javaspeak tool

Some higher institutions provide different aiding tools to their students with disabilities that are aimed at making students' learning process easier [5]. However, there is still a number of education institutions that lack proper support for visually impaired students.

In the same manner as problems affect visually impaired students when trying to learn how to use programming development environments and to create user interfaces problems also affect visually impaired students in other areas of learning.

One of these areas is learning about business intelligence and about using various business intelligence tools. In this paper a discussion about different challenges that affect visually impaired students in this area of learning are given and discussed.

## II. DATA WAREHOUSES AND BUSINESS INTELLIGENCE

To put it as simple as possible, databases are here to store the data. In order to build a database, some database management system (DBMS) has to be used, like Oracle, Microsoft Access, PostgreSQL, etc. By using one such DBMS one can implement one or more databases and in such a way one can store the data in an organized manner and with a controlled amount of redundancy.

Usually when one talks about database management systems one thinks about relational database management systems that store data into relations, or tables as they are usually called. Table consists of rows and columns and such data organization has several advantages that are

responsible for the fact that the relational data model is still so popular after many years of its usage.

In recent years many companies started to experience problems due to incompatible and heterogeneous data sources that made it difficult to write reports in order to make decisions. Namely, over time many partial applications were built that supported just one aspect of business and only some business processes, and now this fact started to become problem rather than the advantage.

All these applications are built in different programming languages (programming technologies) and it is also possible that data is stored differently as well; some data can be found in files, some in Excel, some in databases, some in XML, some in NoSQL databases, etc. But to support business and in order to make business decisions, it is often the case that all the data has to be placed on a single report which is in most cases a difficult task. Due to the heterogeneous data sources, data cannot be used in its current form and complex reports remain only a wish.

As a solution data warehousing technology emerged. The data warehouse [3; 7] is a database as well, but the data it contains is usually extracted, integrated and cleaned (ETL - Extract, Transform and Load) [2] before it is loaded into the data warehouse. Of course, the ETL procedure is by no means easy and many hours have to be spent to improve the quality of data. But once the data warehouse is built, it can be a real gold mine and it can provide interesting information. In order to transform the data various manipulations can be performed such as merging, splitting, sorting, translating, etc.

Usually the main structure that is used to store data in the data warehouse is called a star schema, although a snowflake schema is also frequently used. A single star schema consists of several dimension tables and one fact table (Fig. 1). Dimension tables are used to express criteria in queries, while a fact table usually contains numbers that are used to evaluate the business processes.

In order to analyze the data in the data warehouse, front end business intelligence tools are used. Most popular tools today include Tableau, QlikView, Qlik Sense, Cognos, Pentaho, etc. Such tools can be used to produce queries and reports, to visualize the data, to analyze the data in different ways (drill down, roll up, slice, dice...), for data mining purposes, etc. The main goal of these systems is to provide an adequate support for making different decision in various organizations [1].

To sum it up, business intelligence systems comprise of different components that can be implemented in one software solution or can be implemented modularly as different tools. For example there can be a separate tool that provides data

warehouse and ETL components and separate tool that provides the options to perform advanced queries, analysis, reports and visualizations of data (this kind of tools belong to the category of OLAP tools – Online Analytical Processing).

Providing well-organized and aggregated information that would be well suited for management purposes is a challenging and complex task. Different challenges are present in every single component of architecture presented in Fig. 1. These challenges include the following:

- Data sources – data sources are heterogeneous and each source requires a different approach to analyze the data. It is convenient when relational databases are used to store data, as SQL can be used to retrieve them. But many times files in various formats can be found in different places (servers, personal computers) and one has to inspect them in order to determine their structure and purpose. In both cases documentation is not always present which makes the job even harder.
- ETL – it represents a challenge as one has to extract, transform and load the (anomalous) data. In order to extract the data, one has to take into consideration that each source can be specific and that it can require specialized knowledge. Sometimes those sources can be quite old and there is no one to help as people might have left the company many years ago. The transformation part could represent a real challenge. Namely, inconsistent values have to be corrected, missing values have to be filled, duplicate values have to be resolved, records have to be merged or split, etc. The load part should be the easy one, after all the problems have been resolved.
- Data warehouse – this component would not represent such a problem as data warehousing models for different scenarios are the same (more or less). However, each problem domain is specific and some model changes could occur.
- Business intelligence – it represents a challenge since many different tools can be used to perform the analysis and each one is specific. In either case, one could build simple queries and reports, complex queries and reports, perform the OLAP analysis on data, use data mining techniques, etc. How to customize all of mentioned procedures for visually impaired remains a challenge

As can be seen, business intelligence is a complex field of study that can be challenging for all students and especially for students with visual impairment.

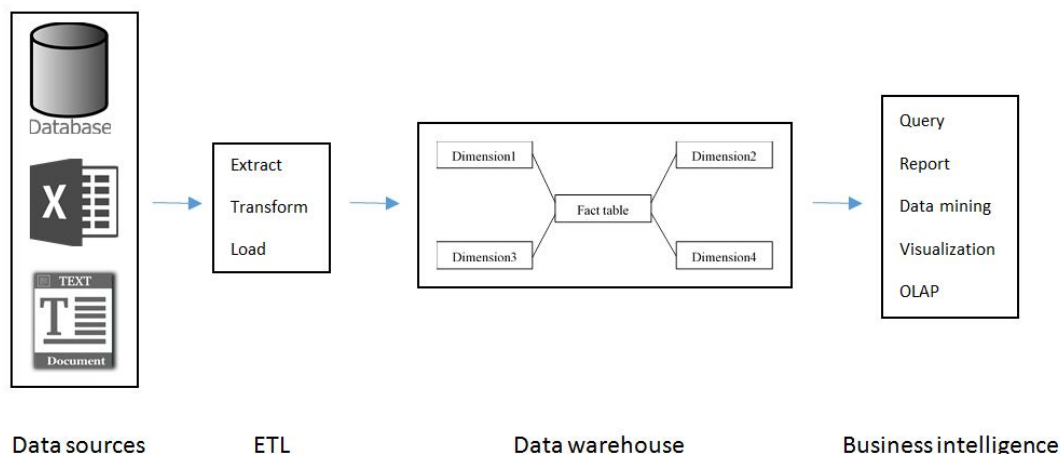


Fig. 1. Data warehousing architecture

### III. CHALLENGES OF VISUALLY IMPAIRED IN BUSINESS INTELLIGENCE EDUCATION

In order to teach students about business intelligence many different elements have to be included, such as:

- Organizational structure and management
- Decision making process
- Collecting data
- Analyzing data
- Aggregating data
- Understanding data
- Working with business intelligence systems

The biggest problem in learning and teaching business intelligence to visually impaired students refers to working with data and with business intelligence systems. Theoretical knowledge about business intelligence can be taught and learned by visually impaired students by using text-to-speech synthesizers and audio lectures, but many challenges appear when these students try to learn how to implement this theoretical knowledge through the usage of various tools, which are not only graphical in their nature but also include graphical representations of data and large amount of data that needs to be comprehended.

The main challenges of visually impaired students regarding learning business intelligence include:

- How to cope with large amount of data (how to perceive the data and how to navigate through the data)
- How to perform data analysis
- How to perceive various query results and aggregated data which are in many cases represented graphically
- How to work with business intelligence system environments that are graphically oriented

In order to be able to understand the basics of business intelligence tools visually impaired students have to understand the following:

- Data Warehouses

- Extract, Transform and Load (ETL)
- Online Analytical Processing (OLAP)

Each of mentioned elements includes a special set of challenges for visually impaired students.

In order to understand data warehouses visually impaired students have to be able to understand the concept of data formats and be able to perceive a large amount of data. The biggest challenge lies in the fact that data, in the case of relational model, is presented in a table that can have a large number of columns representing different attributes. In order to work with the data visually impaired have to be able to remember rather large number of attributes at time and they have to be able to perceive the data and to navigate through the data.

All mentioned actions are quite challenging for visually impaired since existing aiding technology can only represent a piece of data at the time. Also, to navigate and work with the data a proper aiding solution is required, which is not something that is supported by text-to-speech synthesizers.

In order to understand ETL visually impaired students have to be able to perceive multiple data sources and multiple data formats. In order to do this, they again have to be able to navigate through different data sources, which is yet another challenge for them that requires an appropriate aiding solution. Furthermore, (anomalous) data detection could also cause problems and it presents additional challenge for visually impaired.

In the case of OLAP, along with already mentioned challenges, there is a challenge of being able to aggregate the data, which requires one to be able to perceive and remember the data and different attributes in order to perform valid queries. In the end another posed challenge is the fact that many reports and analysis are graphically represented and that the business intelligent environments are also visually oriented.

Possible solutions for mentioned problems include aiding technology that would enable visually impaired to interpret images and data in a tactile way,

aiding technology that would enable voice control of business intelligence systems and aiding technology that would enable textual and audio based presentation, filtering and analysis of data.

## CONCLUSIONS

Business systems are getting more and more complex and the amount of data that is required to manage these systems is getting larger. With increased complexity of business systems a number of different data sources that are needed to analyze business trends and make a valid business decisions increases. In order to provide a usable solution for this situation data warehouses and business intelligence systems have been developed as a viable part of successful business management.

Based on this it can be said that business intelligence has become important part of academic programs and learning how to work with business intelligence systems has become an important part of students' education.

Teaching and learning business intelligence is not an easy task for none of students and it is much harder for students with visual impairment. Visually impaired students face a number of challenges when trying to learn business intelligence, such as how to perceive large amount of data or how to aggregate and interpret aggregated data.

In this paper a discussion about challenges that visually impaired students face when learning business intelligence has been given along with an overview of business intelligence components.

Further research about aiding technology and other solutions that can support the learning process of visually impaired students regarding learning about business intelligence will be a part of future work.

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