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Development of a Decision Support System for University Administration: Integrating Business Process Management and Multidimensional Data Analysis

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Abstract

The paper provides an overview of decision support systems to demonstrate their role in supporting decision-making in university administration. Enhancing university performance and modernizing university administration must be top priorities for university leaders and decision-makers since quality is the foundation that supports innovation. Good decision-making is the first step towards efficiency and quality in the academic setting. The article's main topic is developing IT solutions to support decision-making business processes of student admission. By utilizing models of university business processes and applying business intelligence principles, with the support of multidimensional data analysis, it can be effectively introduced and integrated. The study attempts to provide selection criteria for selecting a development environment for creating a support system focused on university management based on data from the student information system database and the author's personal experience. The contributions include creating OLAP analytical models and a data warehouse model to support university managerial decisions.

Keywords: OLAP, Multidimensional Data Analysis, Business Process Management, Bus Matrix

Introduction

Higher education institutions will face challenges, from meeting educational quality standards to attracting the proper type of qualified candidates and managing financial difficulties. While these information systems, like the e-learning platform and study fee and student record management programs, are perfect for supporting university business processes, they usually lack management support regarding decision-making.

To support decision-making in university administration, managers need systems built on cutting-edge technology based on a holistic approach. These systems should offer prediction and analysis tools, provide relevant information, and offer an analytical perspective on the organization.

Universities are venues for fairs and creative and profitable data generation and delivery about financial, administrative, and social matters. Senior heads such as Rectors, Deans, experts, and different teammates help them achieve their pressing objectives. Data/information on the subject should be treated as part of possible decisions for actions and methodologies for review. (Ghisoiu et al., 2009)

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It is likewise crucial to include in an implementation evaluation the activities and skilled organization of educational institutions with instruments and tools, parts in state-of-the-art technological advancement (Bresfelean et al., 2009)

According to recent research (Tripathi et al., 2011), a problem arises when a system fails or does not perform as expected. However, problem-solving is not limited to addressing failures; it also encompasses identifying new opportunities. Problem-solving is one of the most critical functions within an organization. The process begins with decision-making, which serves as the foundation for resolving issues.

The decision-making process is initiated during the research phase, where potential problems and opportunities are identified and clearly defined. During this phase, alternative solutions are explored and developed. This leads to the selection phase, where the organization chooses a specific course of action. The implementation phase follows, during which the chosen solution is executed. Finally, in the monitoring phase, the implementation is evaluated to assess whether the intended outcomes have been achieved. If necessary, adjustments are made to improve the process and ensure success.

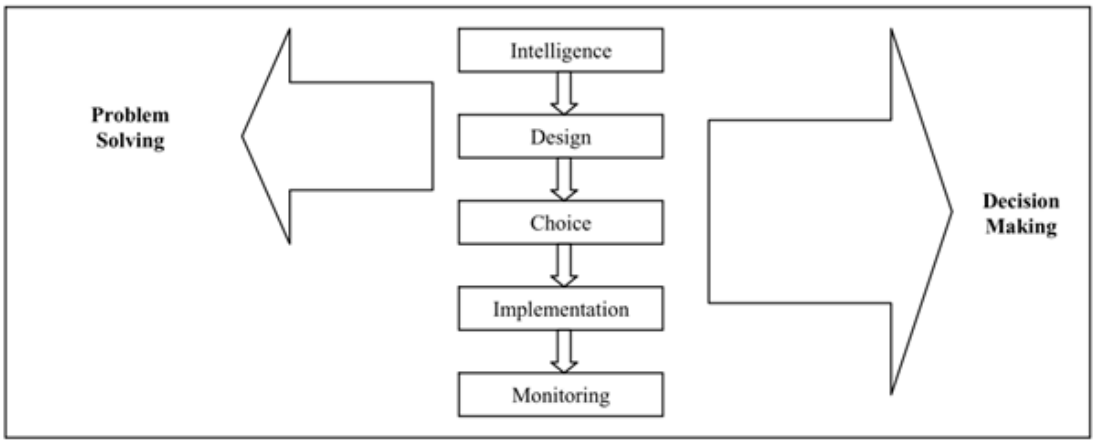

Fig. 1. Decision-Making and Problem-Solving Process (Tripathi, 2011)

While information systems that support university business processes, such as e-learning systems and study fee and student record processing programs, are welcome, they often fail to support management in their decision-making.

Managers within university administration need state-of-the-art technology-based systems to aid decision-making. Such systems should provide tools for forecasting and analysis, relevant information, and a business analytics perspective on the organization.

This research used comparative analysis and information gathering to highlight the characteristics of DSSs and their impact on university administration and provide guidelines for selecting a development environment.

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Applications that offer prediction, optimization, and charting based on OLAP and data mining tools are significant components of decision support systems. The technologies used for data processing and storage can be classified into three main categories.

- Data warehousing is an essential tool that is useful for centrally storing data from a variety of diverse sources.
- Data mining, which applies easily accessible data sources to discover previously unknown yet helpful information.
- Online analytical processing, or OLAP, transforms data into multidimensional structures called hypercubes and provides various functions suitable for performing advanced analysis on large datasets.

Transforming Transactional Data into Valuable Insights for Decision-Makers

The need to convert transactional data into actionable insights has become extremely important in making better decisions within all sectors of business. Making decisions is dependent on the amount and caliber of information at hand. The running of business operations, supported mainly by software systems, is the source of enormous volumes of raw data. However, transforming this raw information into decision-supportive information is somewhat complex and non-trivial. The key technical components of this process are data warehouses built on top of the operational system's data stores, technologies for Online Analytical Processing (OLAP), and data mining techniques. These elements allow for deriving value from the raw data and contribute to strategic and operational decision-making.

Bus Matrix for "NAEC Result" Output DB File

DB File Name: NAEC-Georgia (National Assessment and Examinations Center)

The "NAEC Result" file structure is in the bus matrix below. The "Students" table has been highlighted when organizing and evaluating student data for university management because it contains several important characteristics.

The table defines each attribute in detail, stating the source of data with constraints and type. This matrix went on to play a critical role in determining the completeness, accuracy, and reliability of data enshrined in any database.

The "Students" table contains a wide variety of personal and school-related information on each student in the "NAEC Result File" database. This information can be sourced from NAEC. NAEC's structure will effectively be used for business operations like registration, admissions, and more. The layout of the table is also designed to aid in strategic planning and data-driven decisions in the future beyond the immediate needs imposed.

Structure and Attributes

Table Name: Students

s_id

Type: int(10) NOT NULL

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Source: System

Comments: This is a unique identifier for each student, ensuring that each entry in the database can be distinctly recognized.

s_start_year

Type: varchar(10) NOT NULL

Source: System

Comments: Represents the year when the student commenced their studies. This is important for tracking the cohort and analyzing trends over different academic periods.

s_fac_id

Type: varchar(10) NOT NULL

Source: F(s_dir_id)

Comments: This attribute is derived from the directorate ID, linking students to their respective faculties, which helps in organizing data at the faculty level.

s_dir_id

Type: varchar(10) NOT NULL

Source: NAEC Result. Higher Educational Institution Info. Educational program code | IRO NAEC Recognition. Educational program

Comments: This ID is crucial for mapping students to specific educational programs and higher educational institutions, facilitating detailed analysis and reporting.

s_major

Type: varchar(30) NOT NULL

Source: System

Comments: Indicates the student's major or field of study. This is vital for academic tracking and resource allocation.

s_student_id

Type: char(8) NOT NULL

Source: F(s_fac_id, current_year)

Comments: A unique student identifier combining faculty ID and the current year, ensuring unique identification within a specific timeframe.

s_name_eng

Type: varchar(100) NOT NULL

Source: Student.Online form. Name En | IRO NAEC Recognition. Name En

Comments: Stores the student's name in English, which is essential for international records and communications.

s_surname_eng

Type: varchar(100) NOT NULL

Source: Student.Online form. Surname En | IRO NAEC Recognition. Surname En

Comments: Stores the student's surname in English, ensuring consistency in identification and communication.

s_name_ge

Type: varchar(100) NOT NULL

Source: NAEC Result. Personal Information. Name | IRO NAEC Recognition. Name Ka

Comments: Stores the student's name in Georgian, facilitating local administrative processes and compliance with local regulations.

s_surname_ge

Type: varchar(100) NOT NULL

Source: NAEC Result. Personal Information. Surname | IRO NAEC Recognition. Surname Ka

Comments: Stores the student's surname in

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Georgian, aiding in local documentation and identification.

s_citizenship

Type: varchar(200) NOT NULL

Source: (default Georgia) | Online form. Country | IRO NAEC Recognition. Country

Comments: Indicates the student's citizenship, which is crucial for demographic analysis and compliance with international student regulations.

s_gender

Type: varchar(6) NOT NULL

Source: Student. Online form. Gender | IRO NAEC Recognition. Gender

Comments: Records the student's gender, necessary for gender-based analysis and reporting.

s_passport_number

Type: varchar(50) NOT NULL

Source: NAEC Result. Personal Information. Personal ID (PID) | IRO NAEC Recognition. Personal ID (PID)

Comments: Stores the student's passport number or personal ID, important for identification and verification purposes.

s_email

Type: varchar(100) NOT NULL

Source: Student.Online form. Email | IRO NAEC Recognition. Email

Comments: Records the student's email address, which is essential for communication and notifications.

s_mobile_phone

Type: varchar(30) NOT NULL

Source: NAEC Result. Personal Information. Phone number (mobile) | IRO NAEC Recognition. Phone number (mobile)

Comments: Stores the student's mobile phone number, enabling direct contact for administrative and emergency purposes.

s_status

Type: int(3) NOT NULL

Source: System

Comments: Indicates the current status of the student (e.g., active, graduated), necessary for administrative tracking and reporting.

s_sector

Type: int(3) NOT NULL

Source: F(s_dir_id)

Comments: Derived from the directorate ID, it helps in categorizing students based on their academic sector.

s_type

Type: int(3) NOT NULL

Source: NAEC Result.

Comments: Indicates the type of student

s_level

Type: int(3) NOT NULL

Source: F(s_dir_id)

Comments: Derived from the directorate ID, it indicates the academic level of the student (e.g., undergraduate, postgraduate).

Olap Diagram

The work of (Kovacic et al., 2022) highlights the use of online analytical processing (OLAP) in business intelligence (BI) systems, enabling users to analyze multidimensional data from various perspectives. OLAP facilitates the

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examination of complex datasets through techniques such as querying with languages such as SQL or MDX, which offer flexibility in data retrieval. However, these queries can be time-consuming and cognitively demanding for many users. Alternative tools such as graphical OLAP clients, parameterized reports, and dashboards are available to overcome this challenge. These tools provide more user-friendly and comprehensive solutions for accessing and analyzing data in BI systems.

Data warehousing remains a fundamental component of modern business intelligence (BI) and analytics, providing a platform for integrated, clean, and consistent data that is appropriately structured for analysis. The predominant method for data representation within data warehouses is the multidimensional model. This model organizes key business events, or facts, within a multidimensional “cube,” aligning them along various dimensions that are hierarchically structured to offer varying levels of detail.

Multidimensional data models enable users to view data from different perspectives, leveraging online analytical processing (OLAP) to generate analytical queries on these cubes. Existing OLAP systems provide BI users with various tools for constructing such queries. While query languages like SQL or MDX offer a flexible and customizable means to query data warehouses, they are often time-intensive and cognitively demanding, as noted by (Allen & Parsons, 2010). To mitigate these challenges, alternative tools and interfaces are available to streamline the querying process.

It needs to define the fact table and dimension tables that will be part of this OLAP schema. In this case, since the data revolves around students, their attributes, and their educational details, we can structure it as follows:

Fact Table: Students

The fact table will contain measurable data about students. For this example, the key attributes from the provided list will be included in the fact table, and other related attributes will be organized into dimension tables.

Fact Table: Students

s_id: int(10) NOT NULL (Primary Key)

s_student_id: char(8) NOT NULL

s_start_year: varchar(10) NOT NULL

s_fac_id: varchar(10) NOT NULL

s_dir_id: varchar(10) NOT NULL

s_major: varchar(30) NOT NULL

s_status: int(3) NOT NULL

s_sector: int(3) NOT NULL

s_type: int(3) NOT NULL

s_level: int(3) NOT NULL

Dimension Tables

The dimension tables will contain descriptive attributes that provide context to the data in the fact table.

Dimension Table: Personal Information

s_id: int(10) NOT NULL (Foreign Key)

s_name_eng: varchar(100) NOT NULL

s_surname_eng: varchar(100) NOT NULL

s_name_ge: varchar(100) NOT NULL

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s_surname_ge: varchar(100) NOT NULL

s_citizenship: varchar(200) NOT NULL

s_gender: varchar(6) NOT NULL

s_passport_number: varchar(50) NOT NULL

Dimension Table: Contact Information

s_id: int(10) NOT NULL (Foreign Key)

s_email: varchar(100) NOT NULL

s_mobile_phone: varchar(30) NOT NULL

OLAP Diagram Structure

The OLAP diagram will have the “Students” fact table at the center, with links to the dimension tables “Personal Information” and “Contact Information.”

OLAP Schema Diagram

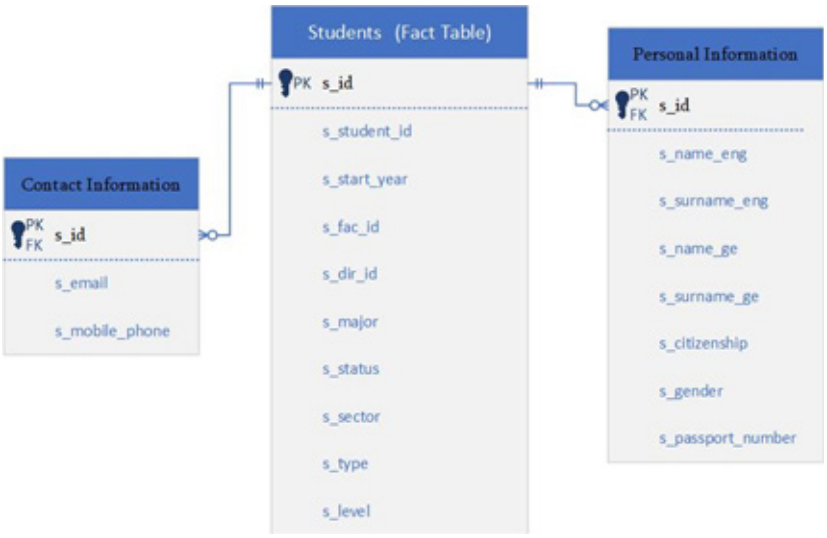

Fig. 2. Entity-Relationship Diagram of a Student Information System, illustrating the relationships between the ‘Students’ fact table and its associated ‘Contact Information’ and ‘Personal Information’ entities

Designing a Multidimensional Data Model for Student Analytics: Integration of Fact and Dimension Tables for Comprehensive Reporting

Fact Table (Students): This table contains primary quantitative data about students, such as their unique identifiers, start year, faculty ID, directorate ID, major, status, sector, type, and level.

Dimension Table (Personal Information): This table contains descriptive information about the students, including their names in English and Georgian, citizenship, gender, and passport numbers.

Dimension Table (Contact Information): This table contains the students’ contact details, such as email addresses and mobile phone numbers.

This structure allows for detailed analysis and reporting on various aspects of student data, leveraging the power of OLAP for multidimensional queries.

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Conclusion of Bus Matrix for "NAEC Result" Output DB File

The bus matrix for the output database file "NAEC Result" includes the "Students" table, representing a comprehensive and elaborate structure such that all necessary attributes are captured and sourced accurately. In this regard, it would be appropriate for data management and the facilitation of several university business processes such as admissions, registration, and advising. The matrix brings out the significance of each attribute, its type, and its source to ensure that the clarity and consistency of the data are handled and used. The sources, however, need to be further elucidated for accuracy and reliability.

Table 1. Data Dictionary for the 'Students' Table: Detailed Description of Attributes, Data Types, and Their Sources, analysis of its structure and the significance of each attribute

Table Name	Attribute Name	Attribute Type	Source
Students	s_id	int(10) NOT NULL	System "Unique identifier for each student"
Students	s_start_year	varchar(10) NOT NULL	The year the student started their studies
Students	s_fac_id	varchar(10) NOT NULL	F(s_dir_id)
Students	s_dir_id	varchar(10) NOT NULL	NAEC Result. Higher Educational Institution Info. Educational program code | IRO NAEC Recognition. Educational program
Students	s_major	varchar(30) NOT NULL	"Student's major or field of study"
Students	s_student_id	char(8) NOT NULL	F(s_fac_id, current_year)
Students	s_name_eng	varchar(100) NOT NULL	Online form. Name En | IRO NAEC Recognition. Name En
Students	s_surname_eng	varchar(100) NOT NULL	Online form. Surname En | IRO NAEC Recognition. Surname En
Students	s_name_ge	varchar(100) NOT NULL	NAEC Result. Personal Information. Name | IRO NAEC Recognition. Name Ka
Students	s_surname_ge	varchar(100) NOT NULL	NAEC Result. Personal Information. Surname | IRO NAEC Recognition. Surname Ka
Students	s_citizenship	varchar(200) NOT NULL	default Georgia | Online form. Country | IRO NAEC Recognition. Country
Students	s_gender	varchar(6) NOT NULL	Online form. Gender | IRO NAEC Recognition. Gender
Students	s_passport_number	varchar(50) NOT NULL	NAEC Result. Personal Information. Personal ID (PID) | IRO NAEC Recognition. Personal ID (PID)
Students	s_email	varchar(100) NOT NULL	Online form. Email | IRO NAEC Recognition. Email
Students	s_mobile_phone	varchar(30) NOT NULL	NAEC Result. Personal Information. Phone number (mobile) | IRO NAEC Recognition. Phone number (mobile)

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Students	s_status	int(3) NOT NULL	default 1 “Status of the student, with a default value of 1”
Students	s_sector	int(3) NOT NULL	F(s_dir_id)
Students	s_type	int(3) NOT NULL	default 1
Students	s_level	int(3) NOT NULL	F(s_dir_id)

Bus Matrix for Student Table Based on Admission and Registration Criteria

Table 2. Mapping of University Business Processes to Student Data Attributes: Admission and Registration Phases

University Business Processes	Student Table Attributes	Source
Admission	s_id	System
	s_start_year	The year the student started their studies.
	s_fac_id	F(s_dir_id)
	s_dir_id	NAEC Result. Higher Educational Institution Info. Educational program code | IRO NAEC Recognition. Educational program
	s_name_eng	Online form. Name En | IRO NAEC Recognition. Name En
	s_surname_eng	Online form. Surname En | IRO NAEC Recognition. Surname En
	s_name_ge	NAEC Result. Personal Information. Name | IRO NAEC Recognition. Name Ka
	s_surname_ge	NAEC Result. Personal Information. Surname | IRO NAEC Recognition. Surname Ka
	s_citizenship	default Georgia | Online form. Country | IRO NAEC Recognition. Country
	s_gender	Online form. Gender | IRO NAEC Recognition. Gender
	s_passport_number	NAEC Result. Personal Information. Personal ID (PID) | IRO NAEC Recognition. Personal ID (PID)
	s_email	Online form. Email | IRO NAEC Recognition. Email
	s_mobile_phone	NAEC Result. Personal Information. Phone number (mobile) | IRO NAEC Recognition. Phone number (mobile)
Registration	s_student_id	F(s_fac_id, current_year)
	s_major	
	s_status	default 1
	s_sector	F(s_dir_id)
	s_type	default 1
	s_level	F(s_dir_id)

Conclusion

Transactional systems that process student data are crucial to an institution’s day-to-day operations. However, they do not actively participate in decision-making. Decision-makers need support systems that provide accurate organizational insights and information that can be used alongside analysis and forecasting tools, leveraging different software analysis and development methods. These mechanisms are essential for strategic planning and well-informed decision-making in businesses.

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Rapid advances in the software industry, driven by significant investments in new technologies, have led to important developments in decision support systems (DSS). The competitive market environment has further intensified the development of these systems and increased their ability to support organizational decision-making processes. However, selecting an appropriate DSS is a complex process that requires careful consideration of several critical factors, including users' expertise, preferred platforms and technologies, and the organization's data management infrastructure. These elements are essential in ensuring that the DSS meets the organization's needs effectively.

OLAP and data warehouses are efficient for data analysis and can support managerial decision-making in the academic sector. These technologies provide thorough data analysis and actionable information, supporting effective and timely decision-making.

References

Kovacic, I., Schuetz, C. G., Neumayr, B., & Schrefl, M. (2022). OLAP Patterns: A pattern-based approach to multidimensional data analysis. Data and Knowledge Engineering, 138. https://doi.org/10.1016/j.datak.2021.101948

Tripathi, K. P. (2011). Decision Support System Is a Tool for Making Better Decisions in the Organization. Indian Journal of Computer Science and Engineering, 2(1), 112–117. http://www.ijcse.com/docs/IJCSE11-02-01-054.pdf

Bresfelean, V. P., Lacurezeanu, R., Ghisoiu, N., & Sitar-Taut, D. A. (2009). Developing a decision support system for university management. International Journal of Information Technology and Decision Making, 8(4), 611-632

Ghisoiu, N., Bresfelean, V. P., Lacurezeanu, R., & Sitar-Taut, D. A. (2009). Developing a decision support system for university management. International Journal of Information Technology and Decision Making, 8(4), 611-632

Allen, G., & Parsons, J. (2010). Is query reuse potentially harmful? Anchoring and adjustment in adapting existing database queries. Information Systems Research, 21(1), 56-77