ISSN 2350-1022

International Journal of Recent Research in Mathematics Computer Science and Information Technology
Vol. 4, Issue 2, pp: (1-13), Month: October 2017 – March 2018, Available at: www.paperpublications.org

Data Warehousing As a Decision Support Tool for Effective University Governance

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Abstract: **This paper addressed the problem of the inability of University management to take correct and effective decisions bothering on day to day running of the institution.**
Information is generated from daily transactions carried out at the various sub units of the institution. This information exists in different data formats in computer applications stored at each sub unit. Obtaining a coherent, consistent and accurate information for decision making because of this heterogeneous existence of data in different locations, becomes difficult for management. This difficulty is avoided by building a centralized and integrated information repository using a single format for quicker analysis, trends and patterns discovery.
An SQL Server 2008 database management system (containing integration services, analysis services and reporting services), is used to carry out the data Extraction, Transformation and Loading (ETL) processes to build the data warehouse.
This data warehouse enables online analytical processing (OLAP), trends and patterns discovery for decision making.

Keywords: **Data warehouse, Decision making, ETL, OLAP, Patterns, Trends.**

I. INTRODUCTION

Decision Support System (DSS) in Universities:

There are various forms of decisions that are taken on daily basis by a University management on internal routine matters that include academics(planning, etc.), financial services, monitoring fixed and variable overheads, capital and recurrent expenditure, allocation of resources, staffing (salaries, allowances, welfare, promotion, etc.), medical services, infrastructure provision and maintenance, general administration, campus security, accreditation issues, students welfare(Canteen services, hostel and security), human and material resources, funding, expansion, infrastructures, stock and inventory, discipline, quality control, among others.

Decisions can also involve external issues pertaining to those involving the governments, the surrounding community, related academic institutions, parents forum, University national and regional accrediting bodies such as Nigeria University Commission (NUC) and African Universities accreditors, the University proprietors, students alumni and other emerging externalities.

A decision support tool, apart from its usefulness on routine matters is also an instrument that guides an institution in taking critical decisions on complex matters that are non-routine. Such include University expansion, emergency funding for shortfalls, among others.

Utilizing decision support tool can bring forth benefits such as improved internal control, identification of internal/external strength and weaknesses, improvement on quality of decision, quicker response to unexpected changes in the environment, enables increased knowledge acquisition in the institution strategy and tactical management.

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Any DSS tool is mostly useful to the University top management comprising the board of trustees, the university council and the vice chancellor. These top groups formulate strategies of long term goal of the vision and mission of the university board of trustees to produce responsible graduates and ensure the University continuity.

The University middle management comprises the Vice chancellor,the deputy vice chancellors, the registrars ,the deans,chief security officer, head of departments, the bursar and directors of units. These groups could be regarded as tactical managers that translate and provide tactical management on the strategies laid out by the university top management. They can be aided with other ICT tools like the Management Information system(MIS), Expert System, Executive Support System(ESS). See figure 1. They formulate middle term goals.

The last of the University management is the group whose tasks are on daily routine activities based on implementing the formulations of the tactical University middle management. The members of the group comprise both senior and low level academic and non-academic staff within the University. They are the lecturers, the campus security staff, the university medical staff, the canteen maintenance staff, the students' hostel porters and wardens, the drivers, secretaries and others within the system.They perform their functions on daily and hourly basis. They cannot be found wanting at any moment. This group constitutes the operational management and can be aided with any form of transaction processing system, medical devices, security tools, canteen utensils, etc. See figure 1.

There are many other functions being carried out in the university system apart from the major functions of training and producing qualified graduates.

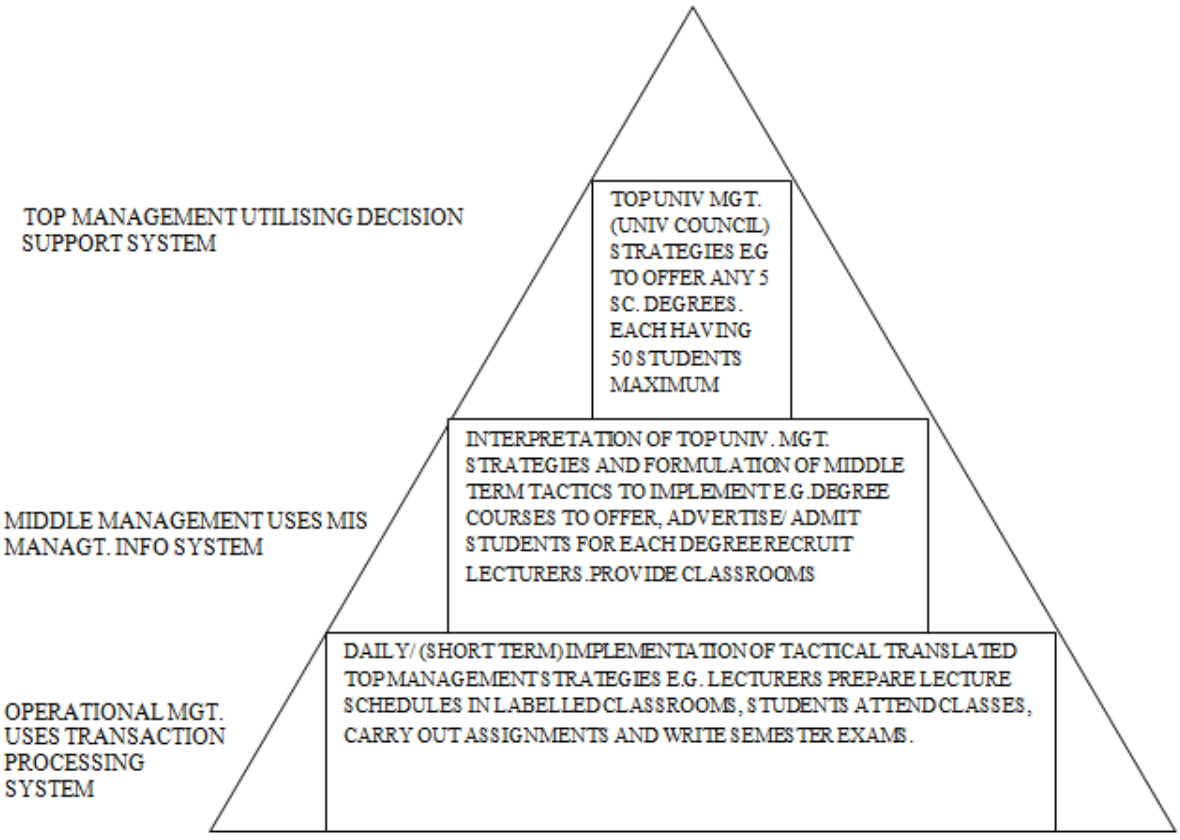

Fig. 1. Pyramid illustration of a University Management structure

Problems of University information flow and access:

One of the major p**roblems of information flow and access** faced by decision makers of institutions of higher learning is that the corporate University data resides in many different operational systems. Such data is held in many different formats and on a variety of platforms and sometimes with different names or different attributes. A simple example is the different ways that student identity can be treated in different systems.

Also, University management can presently obtain vital information from operational units by calling or visiting the individual operators of such units. Such information could be duplicated and inconsistent.

A solution to the problems of inadequate information access is to put user-oriented reporting and analysis tools in the hands of the users thus assisting the decision making process and enables the realization more of the potential benefits of information systems to achieve the University goals.

University management can presently obtain vital information from operational units by calling or visiting the individual operators of such units. Such information could be duplicated and inconsistent.

University corporate data is not presently accessible via end-user tools.

Present mode of decision making:

The present data processing at individual operating unit has traditionally had an operational focus, rather than a decision and analysis support focus. Information is being made available to executives via irregular management reports and no unified approach to placing analysis tools and supporting data in the hands of these decision makers.

Data Warehousing is seen as the technology that attempts to address this problem. The objective for a Decision Support system is to develop and maintain a central University database for analysis and effective decision making.

Providing end user data access as a concept of the Data Warehouse would make it easy to navigate, use the Data Warehouse and routinely populate it from existing data sources. While individual operating units would continue their regular data processing, the data warehouse design can be optimized to support the needs of decision makers and knowledge workers. The integration would make this data warehouse easy for user to navigate metadata. A metadata is a subset of the data warehouse belonging and managed by individual operating units. All data definitions, sources and refresh details will be held in the metadata, with procedures for maintaining them on regular basis.

A data warehouse is different from an operational database in four important ways:

i. A data warehouse is subject oriented while operational database is application oriented

ii. A data warehouse is integrated from heterogeneous sources and operational database is of multiple independent diverse sources

iii. A data warehouse can be analysed multi-dimensionally through an online analytical processing (OLAP)whereas an operational database can only be analysed uni-dimensionally through an online transactional processing(OLTP)

iv. A data warehouse is time-variant whereas an operational database is real-time and current

v. A data warehouse is nonvolatile but an operational database is updateable

vi. A data warehouse is designed to support strategic decision making. An operational database is designed primarily to support day to day operations.

A data warehouse is not a product that can be purchased from a vendor. It is a model of an establishment's data, put together in such a way that it answers the establishment's business questions.

II. LITERATURE REVIEW

The paper, Developing a Data Warehouse for a University Decision Support System by Türkmen, G.M.S.(2007) describes Data warehouse as an important contemporary issue for many organizations and is relatively a new field in the realm of information technology but little research has been done regarding the characteristics of academic data and the complexity of analyzing such data. Educational institutions measure success very differently from business-oriented organizations and the analyses that are meaningful in such environments pose unique problems in data warehousing. Hence the paper identifies a decision support system that will query the data taken from an existing Student Information System and generate reports as outputs in order to help administrative decision-making

A Decision Support System Based Data Warehouse(DSSBDW) enables knowledge workers to make strategic and tactical business decisions based on factual data stored in a business intelligence data warehouse. DSS must allow users to

intuitively, quickly, and flexibly manipulate data using familiar terms, in order to provide analytical insight. DSSBDW are implementations of an informational database used to store sharable data sourced from an operational database-of-record. They are typically a subject database that allows users to tap into a company's vast store of operational data to track business trends, facilitate forecasting and data mining,respond to data patterns, aid planning efforts, and measure performance against strategic goals—all with the goal of aiding and supporting decision making. Bao,Y., & Zhang,L.(2014)

Data warehouse and data mining algorithms for deducting rules, patterns and knowledge have been applied interactively as the basic resource in the decision making process of students services in academic institutions. Data Warehouse offers a flexible solution to the user on information and knowledge retrieval by using tools, like Excel, with user-defined queries to explore the database more efficiently in comparison to all other tools from the OLTP environment.The user does not need to possess knowledge concerning the relational model and the complex query languages.

Using this approach in data analysis enables OLTP systems to get optimized for their purpose and to transfer data analysis to OLAP systems. Suknović,Čupić, & Martić(2005)

Wang,Y., & Ta-HuaKuo(2010) in their work on Financial Assets and Liabilities Management Support System, describe the design and implementation of a decision support system through an integrated data warehouse on which Online Analytical Processing (OLAP) technique is applied to analyze daily transaction data of an enterprise resource planning system guided by the enterprise management goal. Through the analysis, latest and timely information of financial asset and liability positions in each company within the enterprise enables a clear decision support in fund dispatching.

A new paradigm for computing that is human-centered with a novel and observation-oriented approach to data modeling was proposed by Beynon,M.,et al (2002) to solve the problem of an effective use of decision support systems (DSS) by improving the quality of interaction between humans and computers

III. METHODOLOGY

In a typical relatively young University, operational systems include the library, exams and records, and ICT Resource center as major units in the university. The library keeps tracks of book collections, reference works, technical reports etc. The exams and records stores student data including past exam questions, answer booklet and marking schemes. Others are bursary, departments and colleges, school of postgraduate and part time studies, chaplaincy, security, works and services, students affairs, university farm and ventures, sports, quality control and academic planning, university clinic, hostel and canteen services, entrepreneurship unit, JUPEG, and the University Cooperative. All of these systems could be integrated.

An integrated information system contains information from all the operational units in a single repository such as a data warehouse that can be accessed. Information integration enables queries and analysis of the data warehouse by management to discover trends and patterns of events. Since the data warehouse holds archival data of several years, discovered trends and patterns can reveal knowledge valuable for effective decision making.

The University top and middle management referred to as users, are those considered only suitable in this paper to use the integrated information contained in the constructed data warehouse and its associated desktop/laptop tools for its various decision making tasks on daily basis.

This group of management meets on schedules and as when necessary for tactical and operational policies and procedures, as well as strategic planning and long term goal setting of the University. It is supported by other management and advisory committees.

Building the Data warehouse:

Data warehouse building is started from the smallest segment of data mart and developed bigger and bigger through iteration and refinement as the needs arise.

To start with, the users referred to earlier are carried along from the commencement of the warehouse project in order to be relevant to the viability of the data warehouse. A data warehouse committee that can discuss and actualise the needs of the users is appointed. The committee regularly interacts with individual operating units of the institution and also reports,

recommends to and makes useful demand from management whenever necessary, on the successful implementation of the project. The data warehouse committee appointed should consist of technical personnel in the domain and would be responsible for documentation of the data descriptions and meanings with their attributes that include data sources that may change from time to time. It would also design the logic for translating data from various sources into an integrated data base through the construction of relevant tables and schemas.

The access mechanisms for retrieving data from the operational units' data sources are identified.

Having completed the initial tasks mentioned, the data extraction, transformation and loading (ETL) processes are commenced. The data refreshing/updating process would be done regularly during the lifetime of the data warehouse.

Data is extracted from the various sources by writing codes or applying a suitable data base management systems (DBMS) package agreed to by management to handle the ETL processes carried out in a staging area before loading into the data warehouse. The transformation process here includes the data cleaning that removes errors and inconsistencies.

The procedures to handle the scheduling, management and maintenance of the data warehouse are outlined.

Finally, is the documentation of the definition of data elements in the data warehouse and in the data sources, and the transformation rules that relate with them. This documentation is referred to as 'metadata'. A metadata is the data dictionary of the data warehouse through which the end-users find and understand the data in the warehouse. It is also useful whenever an update to the warehouse data is desired because different components of the warehouse may require updates at different times, some at regular intervals such as weekly or monthly, and some on specified dates, done automatically or by manual process. Figure 2 summarizes the tasks.

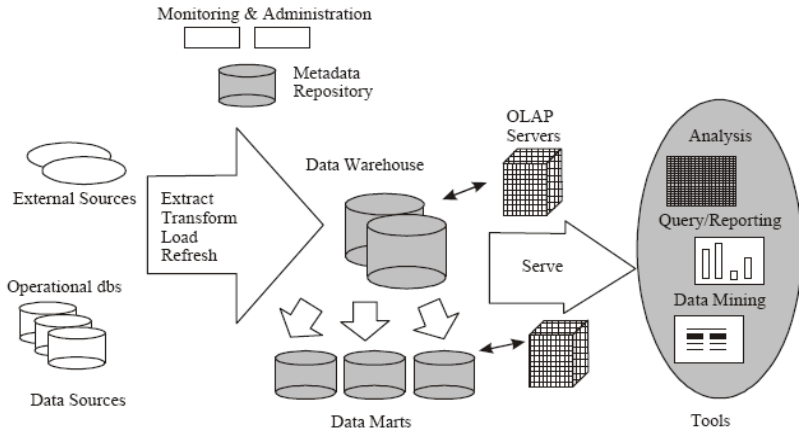

Fig. 2. Archicteture of data warehouse building processes

Decision Support processes:

An individual database in the data warehouse resides in a server made available for the OLAP or OLTP tasks. The diagram above refers to such server as an OLAP server.

i. Data Enquiry: This entails basic query and reporting carried out using relevant SQL query tools. Since the concern is to obtain statistical properties and characteristics of data that cut across several years in the data warehouse, an online analytical processing (OLAP) is carried out. This is quite different from an online transactional processing (OLTP) that uses current operational database. The choice of the type of query is dependent on the desire of the user management. Generally, the query provides statistical models for forecasting and trend analysis.

ii. Multi-dimensional Analysis: This basically uses the data warehouse that contains heterogeneous and multidimensional data- The analysis provides a multi-dimensional view of data presented in an aggregated form to demonstrate the interrelationships of different dimensions.

iii. Information Discovery: This is a data mining process whose goal is to discover previously unknown information through trends and patterns obtained by examining the large amount of data in the data warehouse.

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There are several computer packages from different vendors that can be utilised for the processes explained in i, ii and iii above. Examples of such include Microsoft SQL Server editions and MySQL.

IV. IMPLEMENTATION

Identification and collection of Data Sources:

The following data sources are considered and selected to build the data warehouse.

Assets Data Collection: Asset name, Asset type, Location, Asset value, Date acquired

Student data collection: Name, Matriculation Number, Birth Date, Address, Date enrolled, Course Enrolled, Requirements fulfilled?, Department, Head of Dept, Course level adviser,

College Data Collection: Staff Name, Gender, Address, Birth date, Employment Date, Committee memberships , Date of last leave, Highest qualification, ,Last promotion date

General Ledger Data Collection: Account Name, Account Number, Fiscal year, Fiscal month, Budget actual, budgets estimate, Year to date GL balance,

Salary Management Data Collection: Employee name, Employee number/ID, Job status, Post held, Department, Salary grade level, Name of bank,

Admissions Data Collection: Applicant name, Applicant Number/ID, Gender, Date of birth, Program Applied for, JAMB score, UTME score, Last school attended,

iv. University Clinic Data Collection: Student Name, Home address, Parents' Phone Number, Gender, Ailment Type, Date of diagnosis, Prescribed drug, Hostel Number, Fitness Date

v. University Canteen: Canteen Name, Location on Campus, Breakfast Type, Lunch Type, Dinner Type, Breakfast Average Price, Lunch Average Price, Dinner Average Price, Meal Day

TABLE 1: Student Table

Input Variables	Data Type	Content Type Usage
Name	Alphabetic	Discrete
Matric Number	Numeric	Discrete
Birth Date	Alphanumeric	Discrete
Address	Alphanumeric	Discrete
Date Enrolled	Alphanumeric	Discrete
Course Enrolled	Alphanumeric	Discrete
Requirements fulfilled	Alphabetic	Discrete
Department	Alphabetic	Discrete
Head of Dept.	Alphabetic	Discrete
Course Level Adviser	Alphabetic	Discrete

TABLE 2: College Table

Input Variables	Data Type	Content Type Usage
Name	Alphabetic	Discrete
Gender	Alphabetic	Discrete
Address	Alphanumeric	Discrete
Birth Date	Alphanumeric	Discrete
Employment Date	Alphanumeri	Discrete
Committee Membership	Alphabetic	Discrete
Date of last Leave	Alphanumeric	Discrete
Highest Qualification	Alphabetic	Discrete
Last promotion Date	Alphanumeric	Discrete

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TABLE 3:General Ledger Table

Input Variables	Data Type	Content Type Usage
Account Name	Alphabetic	Discrete
Account Number	Alphanumeric	Discrete
Fiscal Year	Alphanumeric	Discrete
Fiscal Month	Alphanumeric	Discrete
Budget Actual	Currency	Continuous
Budget Estimate	Currency	Continuous
Year to date Balance	Currency	Continuous
Journal Entries	Currency	Continuous

TABLE 4:Salary Table

Input Variables	Data Type	Content Type Usage
Employee Name	Alphabetic	Discrete
Employee Number/ID	Numeric	Discrete
Employment Category	Alphabetic	Discrete
Post held	Alphabetic	Discrete
Department	Alphabetic	Discrete
Salary Grade Level	Alphanumeric	Discrete
Bank Name	Alphabetic	Discrete

TABLE 5:Admissions Table

Input Variables	Data Type	Content Type Usage
Applicant's Name	Alphabetic	Discrete
Applicant Number/ID	Numeric	Discrete
Gender	Alphabetic	Discrete
Date of Birth	Alphanumeric	Discrete
Program Applied for	Alphabetic	Discrete
JAMB Score	Numeric	Discrete
UTME Score	Numeric	Discrete
Last School Attended	Alphabetic	Discrete

TABLE 6:Asset Table

Input Variables	Data Type	Content Type Usage
Asset Name	Alphabetic	Discrete
Asset Type	Alphanumeric	Discrete
Asset code	Alphanumeric	Discrete
Asset Location	Alphanumeric	Discrete
Asset Value	Currency	Continuous
Date Acquired	Alphanumeric	Discrete

TABLE 7:Clinic Diagnosis And Prescription Table

Input Variables	Data Type	ContentType	Usage
Student's Name	Alphabetic	Discrete	
Home Address	Alphabetic	Discrete	
Parents' Phone Number	Numeric	Discrete	
Gender	Alphabetic	Discrete	
Ailment Type	Alphanumeric	Discrete	
Date of Diagnosis	Alphanumeric	Discrete	
Prescribed Drug	Alphabetic	Discrete	
Hostel Number	Alphanumeric	Discrete	
Fitness Date	Alphanumeric	Discrete	

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TABLE 8:Canteen Table

Input Variables	Data Type	Content Type Usage
Canteen Name	Alphabetic	Discrete
Location on Campus	Alphabetic	Discrete
Breakfast Type	Alphabetic	Discrete
Dinner Type	Alphabetic	Discrete
Breakfast Average Price	Currency	Continuous
Lunch Average Price	Currency	Continuous
Dinner Average Price	Currency	Continuous
Meal Day	Alphabetic	Discrete

The Warehouse is organized by subject areas by data collections and tables from various collections are joined together to provide integrated information about the University.

Microsoft Visual Studio is an IDE (Integrated Development Environment) for developing windows and web based software applications proprietary to Microsoft Corporation. The visual studio dot net Integration Development Environment (IDE), has a number of programming languages and these are: C#.net (called C Zap.net), VB.net, and J#.net (called J zap dot net). VB.net is used to implement this tool because of its flexibility, simplicity and interoperability. The Visual Studio IDE is used because multiple operating units are involved and they need to connect to the data warehouse server.

The database was created in Microsoft SQL Server, This is because, Microsoft SQL Server is highly secured and highly scalable database system.

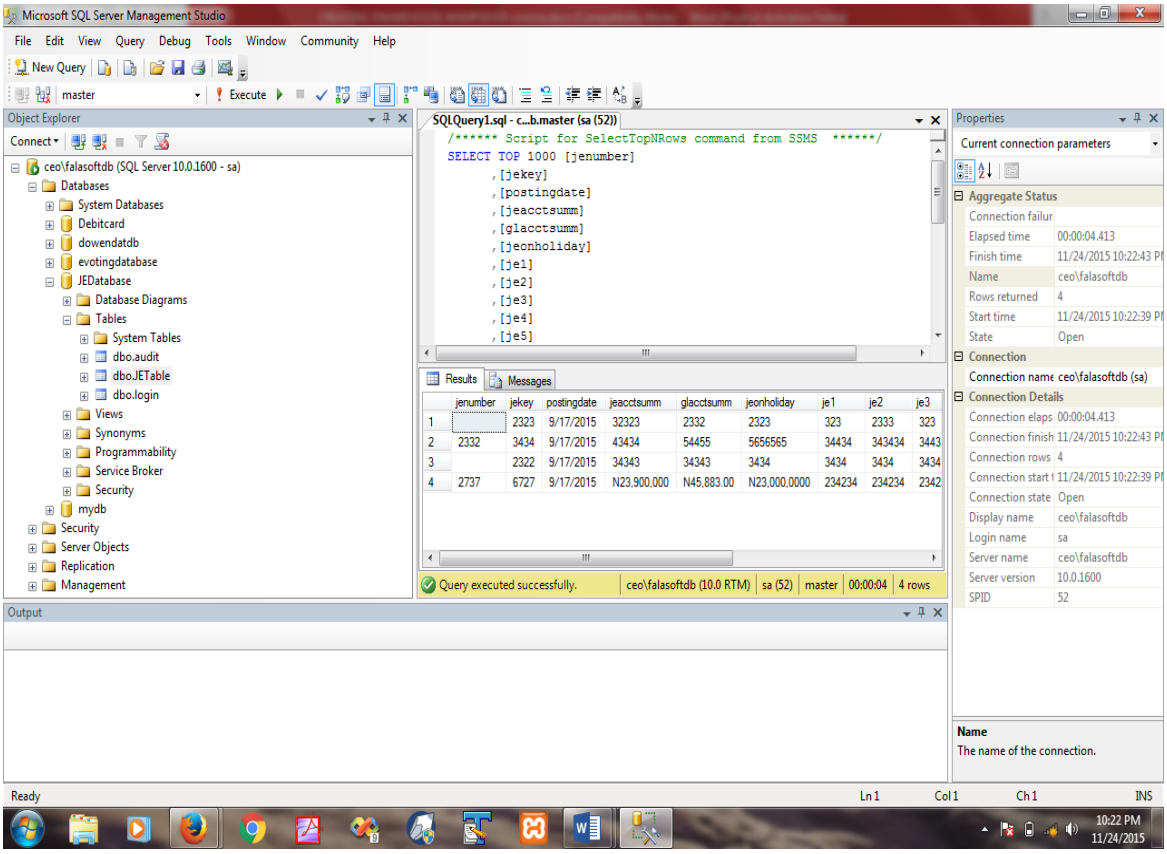

Fig. 3: Journal Entry data population in the General Ledger Table

In the Microsoft SQL Server Management Studio, a database is created with the selected tables 1 to 8 above, and fields specifying their properties such as type, collation, attributes, null, default and actions. See figures 3 and 4.

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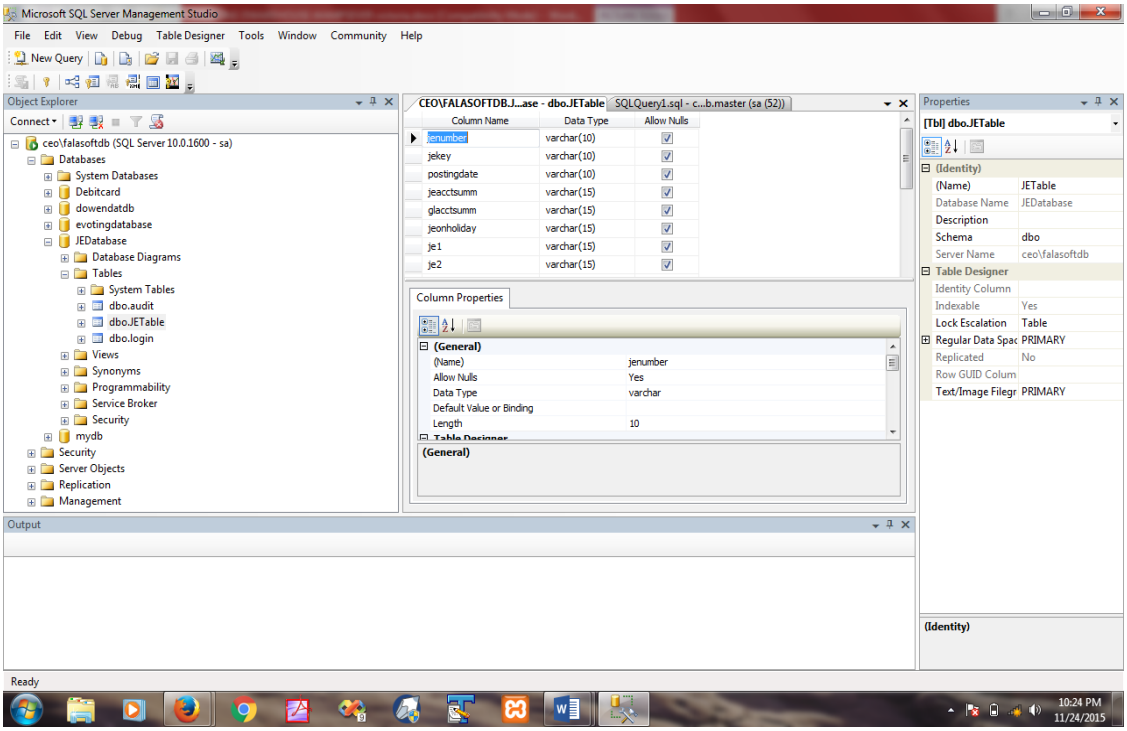

Fig. 4: General Ledger Table data and content types specifications

After creating the tables' format, there are several forms of exporting the format such as CSV, CSV for Microsoft, Microsoft for Excel, PDF, Open Document Spreadsheet, XML, and SQL etc. But for convenient data collation by the operating unit users, CSV for MS Excel of Microsoft Excel is preferred and not SQL format since the users cannot relate directly with the database. There is also a need to specify to the user, what each column represents to avoid input of wrong data by putting field names in the first row of the sheet. See figure 5

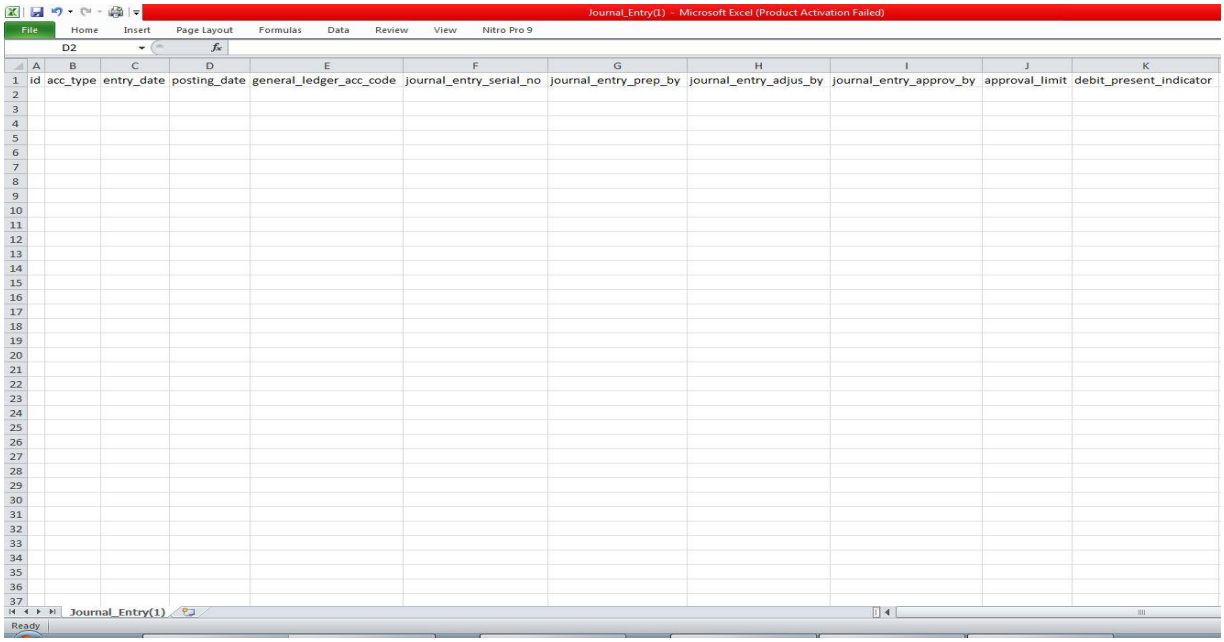

Fig. 5. Display of column field names for users' data input guide.

Mode of Extraction:

After exporting the file to individual operating units desktop or laptop, the appointed operating unit administrator would populate the tables with relevant data.

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With individual operating units having populated their tables with relevant data, the extraction process is completed for that session. The populated tables are sent online back to the University database server for the commencement of the transformation and loading processes by the SQL Server. The various forms cannot be directly uploaded to the SQL server, as it would need to be transformed to an SQL format compatible with the server.

Server Administration Tasks:

Using SQL Server Management Studio 2008 R2, a connection is first created by selecting the database which has been created on the local server. Then use the Import and Export Tool of SQL Server Management Studio 2008 R2 to Import the details from individual format of each operating unit (CSV, Excel, Open Document Spreadsheet) by selecting the source and destination of the data.

Fig 6: Import and Export Tool of SQL Server to Import the data details

Transformation:

After importing the data, there is need for transformation and cleansing of the data to check if the details are correct and also align with the database format. If there are details that are not relevant, they are truncated from the database.

Online Server (Data Warehouse):

The online server works more or less like the local server, it serves as the data warehouse for the activities. Purchase an online domain to host the server. The domain gives room for files, applications, mails, database upload and features such as mails and multi-users.

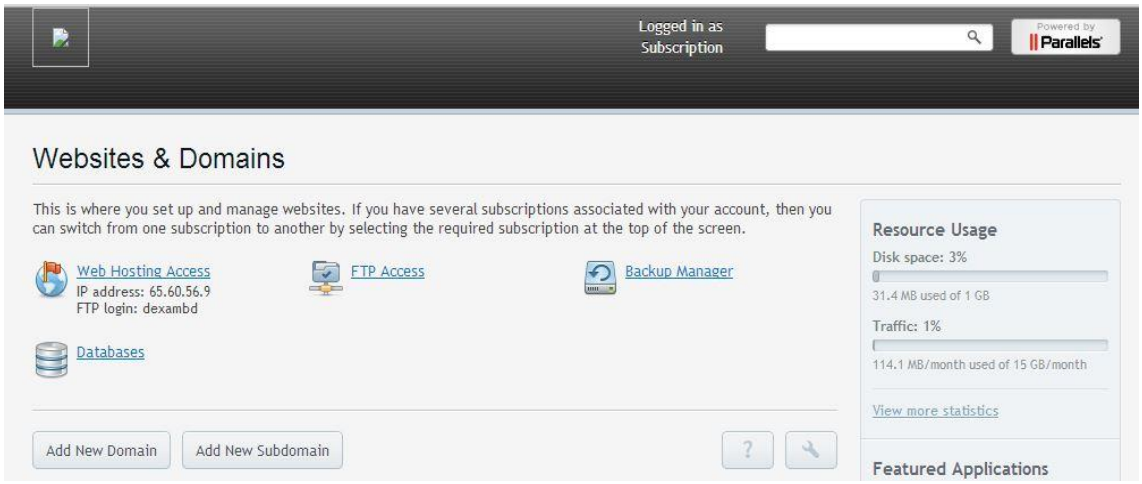

Fig. 7: An online server

ISSN 2350-1022

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The online database is the main feature needed for the function of the server. After the purchase of the domain, the database name is created with its access like that of the local server.

Database creation requires the name of the database to be used, the Structured Query Language type (SQL) and the authentication. The database name will be used as the same on the local host e.g. Journal and the Structured Query Language used is MSSQL Server since it was used to create the database on the local server using SQL Server Management Studio

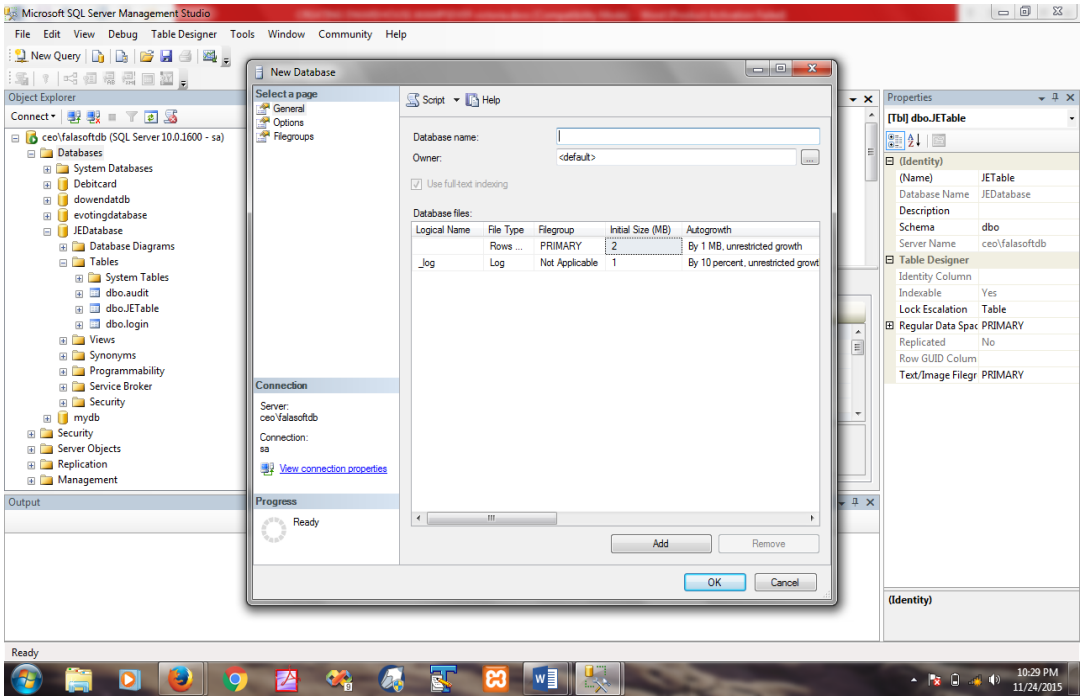

Fig. 8. Creation of the database

A message shows the successful creation of the online database. To verify the successful creation, you go back and view the databases on the domain. See figure 8.

Types of Queries that can be made to Data Marts in the Data Warehouse by the University Management for Decision Support

i. Assets Table:

- What are the assets identified as 'not found' during the last inventory for an operating unit?
- What are the assets acquired by an operating unit during the last fiscal year?
- Which assets have invalid locations and need to be corrected?
- What are values of the assets declared as 'not found' during the last inventory?

ii. Student Table:

- Which students have taken more than 2 carry over courses in the last 4 semesters and what are the courses.
- Which studesnts have been dismissed or suspended for examination malpractice in the last 2 semesters?
- Which studesnts have been dismissed or suspended within the last 4 semesters for breaching the security rules of the University?

iii. General Ledger Table:

- Account Name, Account Number, Fiscal year, Fiscal month, Budget actual, budgets estimate, Year to date GL balance,

- What are the actual fiscal year-to-date balances through the end of the latest accounting period for the University?
- How do our internet facility costs this year compared to last year?
- How much funds are yet to be retired by staff this session?
- Which operating unit incur the highest stationeries expenditure this academic session?

iv. Salary Table:

- What are the factors responsible for the upsurge in salaries payment this fiscal year compared with previous fiscal year?
- How many staff benefited from this year increment in salary and what is the genaral factor responsible?
- How much staff salaries were seized in the presnt fiscal year for not complying with the University rules of retirement?

v. Admissions Table:

- How many people applied to specific key programs in each of the colleges? How many were offered admission, and how many accepted the offer?
- What is the breakdown of admissions by ethnicity of the applicants in the last 3 years?
- What are the admissions trends by programs over the past 5 years?

vi. University Clinic Table:

- What are the student clinic admissions trends by gender over the past 2 semesters?
- How many students were treated for chronic ailments in laat 2 semesters?
- How many staff were reffered to specialist or other hospital and for what ailments this academic year?
- What is the value of drugs expended on staff in the last 2 semesters?

V. CONCLUSION

This paper discussed the lack of information integration that results in University ineffective governance, increased information costs and information duplication. Because diverse operational systems exist in the various departments of the University in different legacy formats, facilities embedded in SQL Server 2008 R2 were used to build a data warehouse as a data integration repository. This repository is used for online analytical processing (OLAP) and other interrogatories aimed at discovering trends and patterns useful for decision support of the University management.

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