Star Schema Implementation for Automation of Examination Records

Er. Muheet Ahmed Butt[1], Dr. S. M. K. Quadri[2], Er. Majid Zaman[3]
Directorate of Information Technology & Support Systems, University of Kashmir, Srinagar, J&K, India
Head & Director, PG Department of Computer Science, University of Kashmir, Srinagar, Srinagar, J&K, India
Directorate of Information Technology & Support Systems, University of Kashmir, Srinagar, J&K, India

Abstract: *Data warehousing systems enable enterprise managers to acquire and integrate information from heterogeneous sources and to query very large databases efficiently. Data in a data warehouse does not conform specifically to the preferences of any single enterprise entity. Instead, it is intended to provide data to the entire enterprise in such a way that all members can use the data in the warehouse throughout its lifespan [7]. This work explores using the star schema for Automation of a Data Warehouse. An implementation of a data warehouse for an Examination Automation System is presented as an example.*

Keywords

Data Warehousing, Data Mining, Star Schema, Data Set.

1.0 Introduction

A 'data warehouse' is a repository of an organization's electronically stored data. Data warehouses are designed to facilitate reporting and analysis [5]. This classic definition of the data warehouse focuses on data storage. However, the means to retrieve and analyze data, to extract, transform and load data, and to manage dictionary data are also considered essential components of a data warehousing system [11]. These operations depend more on the way the data is stored..

There are two leading approaches to storing data in a data warehouse

i. Dimensional approach and
ii. Normalized approach

In the dimensional approach, transaction data are partitioned into "facts", which are generally numeric transaction data, and "dimensions", which are the reference information that gives context to the facts [9]. A key advantage of a dimensional approach is that the data warehouse is easier for the user to understand and to use. The retrieval of data from the data warehouse also tends to operate very quickly. The main disadvantages of the dimensional approach are:

i. in order to maintain the integrity of facts and dimensions, loading of data from different operational systems is complicated, and
ii. it is difficult to modify the data warehouse structure if the organization adopting the dimensional approach changes the way in which it does business.

In the normalized approach, the data in the data warehouse are stored following, to a degree, the Codd normalization rule. Tables are grouped together by subject areas that reflect general data categories. The main advantage of this approach is that it is very easy to add information into the database. A disadvantage of this approach is that because of the number of tables involved, it can be difficult for both users to join data from different sources into meaningful information and then access the information without a precise understanding of the sources of data and of the data structure of the data warehouse.

These approaches are not exact opposites of each other. Dimensional approaches can involve normalizing data to a degree [12]. In this paper we have implemented a Star Schema Model of a Data Warehouse of an Central Automation of Examination System catering many colleges, Departments, Courses, Subjects, Subject Groups, Marks and tried to prepare results notifications at various levels which will enable us to build a build a Decision Support Database for future analysis.

The rest of the paper is organized as follows: Section 2 provides the information pertaining to various Data Warehouse Schemas used with their advantages. Section 3 provides the design of an example Data Warehouse for Examination Automation System giving detailed attribute information pertaining to the fact table. Section 4 provides the overall association of various dimensional table with the fact table. Section 5 provides the association of the fact Dimension of the Star Schema implementation for this example with other Dimensions

in the schema. It also provides the results of the simulations of said implementation. Section 6 provides the means for aggregation of data present in the Star Schema Data Warehouse Design for Decision Support Systems. Section 7 provides brief description about the On-line Analytical Processing (OLAP) capabilities provided by the data warehouse or data mart. Section 8 provides the brief comparison between the 3rd normal form and star schema implementation on the same test data. Conclusions drawn are depicted in Section 9. Section 10 lists the references and Appendix 1 provides the pictorial representation of the star schema and its relationship of fact tables with other dimensions.

2. Data Warehouse Schémas

A schema is a collection of database objects, including tables, views, indexes, and synonyms. There is a variety of ways of arranging schema objects in the schema models designed for data warehousing. The main database Schemas are:

2.1 Star Schemas

The star schema is perhaps the simplest data warehouse schema. It is called a star schema because the entity-relationship diagram of this schema resembles a star, with points radiating from a central table [6]. The center of the star consists of a large fact table and the points of the star are the dimension tables. A star query is a join between a fact table and a number of dimension tables. Each dimension table is joined to the fact table using a primary key to foreign key join, but the dimension tables are not joined to each other. The optimizer recognizes star queries and generates efficient execution plans for them. It is not mandatory to have any foreign keys on the fact table for star transformation to take effect. A star join is a primary key to foreign key join of the dimension tables to a fact table. The main advantages of star schemas are that they:

- Provide a direct and intuitive mapping between the business entities being analyzed by end users and the schema design.
- Provide highly optimized performance for typical star queries.
- Are widely supported by a large number of business intelligence tools, which may anticipate or even require that the data warehouse schema contain dimension tables.

Star schemas are used for both simple data marts and very large data warehouses.

2.2 Snowflake Schemas

The snowflake schema is a more complex data warehouse model than a star schema, and is a type of star schema [6]. It is called a snowflake schema because the diagram of the schema resembles a snowflake. Snowflake schemas normalize dimensions to eliminate redundancy i. e., the dimension data has been grouped into multiple tables instead of one large table. While this saves space, it increases the number of dimension tables and requires more foreign key joins. The result is more complex queries and reduced query performance. The main advantages of Snowflake schemas are that they:

- save memory space for data.
- increases the number of dimension tables and requires more foreign key joins.
- the result is more complex queries.

2.3 3NF Modeling

Third normal form modeling is a classical relational-database modeling technique that minimizes data redundancy through normalization [6]. When compared to a star schema, a 3NF schema typically has a larger number of tables due to this normalization process. 3NF schemas are typically chosen for large data warehouses, especially environments with significant data-loading requirements that are used to feed data marts and execute long-running queries. The main advantages of 3NF schemas are that they:

- Provide a neutral schema design, independent of any application or data-usage considerations
- May require less data-transformation than more normalized schemas such as star schemas

3.0 Designing Data Warehouse

An example of a record in a fact table for an Examination Automation System for a University, on a single event, such as a result of a Student at a particular session of an Academic year at Under/Post Graduate Level, has been considered.

In addition to the fact tables Table 1, there are also dimension tables in the database. These dimension tables describe the options to "cut" or view the data in the fact table. The star and snowflake schemas all use more than one dimension table in their database [2][3]. The records in a single dimension table represent the levels or choices of aggregation for the given dimension [7][17]. The classic data warehouse example used is the Result dimension [10][12]. The records in the Result dimension table will indicate that the fact table data can be aggregated by Subjects assigned, Enrollment of Students, Marks Obtained etc. Another dimension would be date. Using the date dimension we would be able to analyze data by a single date or dates aggregated by month, quarter, fiscal year, calendar year, holidays, etc.

For an Examination Automation System, a simple fact table would have the following column variables is show in table below.

Table 1: Fact Dimension Details

fact_DIM

ROLLNO key	Rollno Pertaining to a Session	Numeric
REGNO key	Registration No. of Student	Alphanumeric
RESULT	Calculated Result	Alphanumeric
TOTALM	Total Marks	Numeric
RESGAZ	Showing Statue Result	Alphanumeric
Sesson_ID Key	Session of Examination FKey	Alphanumeric
college_id Key	College Code FKey	Alphanumeric
dateID Key	Date FKey	Alphanumeric
course_code Key	Course Opted FKey	Alphanumeric
facultyID Key	Faculty Opted FKey	Alphanumeric
groupID Key	Subject Group Table FKey	Alphanumeric

4.0 Star Join Schema

The star join schema (also known as the star schema) is a database in which there is a single fact table and many dimension tables. These tables are not normalized. They are unlike traditional operational data bases where one attempts to normalize the tables [10][14]. In the fact table there is one segment for each dimension. The fact table uses a compound key made up of the group of the dimensions. In addition, the fact table usually contains additional variables which typically are additive numbers, i.e., numeric facts. In our Examination Automation System example the individual dimension table would capture views by:

- Enrollment containing registration no, name and parentage
- Subjects taken by the student
- Student enrolled in the course
- Marks obtained in every subject
- Date of declaration, session, year
- College information
- Course information
- Faculty details etc.

For the full star schema of Examination Automation System see Appendix 1 at the end of the paper.

5.0 Data Sets Building Using Star Schema

Users of the Examination Automation System will want to look at the data summarized to various levels. Joining selected dimension tables to the fact table will provide the user with a dataset on which to aggregate the needed information [1].

For example, to generate the result of the student would require a the join of five tables namely Fact Table, Enrollment Dimension Table, Course Dimension Table , subject_groups Dimension Table and marks Dimension Table. The resultant data file will then be aggregated by using the Proc Summary step to produce a dataset for analysis. Below is a demonstration of this approach.

An Examination Automation System of 2500000 records in the fact table with 12 column variables, totaling to 30 megabytes of space. The memory taken by the dimension tables are depicted in table below.

Table 2: Dimension Table records in Megabytes

DIMENTION NAME	**SIZE**
Enrollment	176.388 MB
Subject	0.056 MB
Marks	150.5 MB
Course	0.020 MB
College	0.008 MB
Date	0.015 MB
Faculty	0.012 MB
Group	0.095 MB
Session	0.010 MB
Total Space	**327.10 MB**

5.1 Generating the Final Result Notification

An algorithm was devleloped and code implemented in SQL using SQL Server Management Studio Express as Front end and Microsoft SQL 2005 at the back end for testing the described schema. The results of the simulation are presented in table below

Table 3: Client Statistics for the above query resulted in the following details.

Client Statistics Information	Trial 3	Trial 2	Trail 1	Average
Client Execution Time	20:25:51	20:25:46	20:25:36	
Query Profile Statistics				
Rows returned by SELECT statements	27453	27453	27453	27453
Network Statistics				
Number of server round trips	3	3	3	3
TDS packets sent from client	3	3	3	3
TDS packets received from server	1974	1974	1974	1974
Bytes sent from client	2220	2220	2220	2220
Bytes received from server	8074601	8074601	8074601	8074602
Time Statistics				
Client processing time	551	568	817	645.3333
Total execution time	859	861	1127	949
Wait time on server replies	308	293	310	303.6667

6.0 Building the Decision Support Database

Similarly, other datasets could be generated for analysis. Using the building blocks of the fact table and the various dimension tables, one has thousands of ways to aggregate the data. For expedient analysis purposes, frequently needed aggregated datasets should be created in advance for the users [15][16]. Having data readily and easily available is a major tenet of data warehousing. For Examination Automation System, some aggregated datasets were:

- Generating the Final Result Notification per Subject, College, Subject Groups, Year Wise, Gender etc.
- Remuneration for Paper Checkers, Checking Assistants and other Officials.
- Students Count by Age, Gender, Pass, Fail, Reappear in subject pertaining to per college, subject, year, group of subjects.
- Interests of Various of Students in Courses, Colleges, Subjects etc and Improvements to be made in the Education System etc.
- No of Students enrolled for a particular course, subject, college, courses within a college, subject within a college.
- Students who have passed with and without statues.
- Percentage of result, subject wise, college wise, course wise, group wise.

As one can see, the Star Schema lends itself well for Custom analysis.

7.0 OLAP and Data Mining

On-line Analytical Processing (OLAP) is the analytical capabilities provided by the data warehouse or data mart. One can view granular data or various aggregations of data for business analyses using graphical-user-friendly tools [4][18]. Data warehouse and data marts exist to answer questions and find business opportunities. There are many ways to analyze data using procedures such as Proc decodeMks, Proc getResult, Proc fmaster, Proc rollidx, Proc Tabulate.

Finally, data mining is the name given to newer statistical techniques used to explore voluminous data stores. These techniques include decision trees and neural networks. These methods, like neural networks, can sometimes handle co-linearity better than the older statistical techniques.

8.0 Comparison with 3rd Normal Form

A comparative study was also performed by taking same amount of test data and the observations were tabulated in the below mentioned table. It was observed that there was a big tradeoff between the memory and the speed in the implementation of 3rd Normal form and Star Schema.

Table 4: Execution Time for Result Preparation

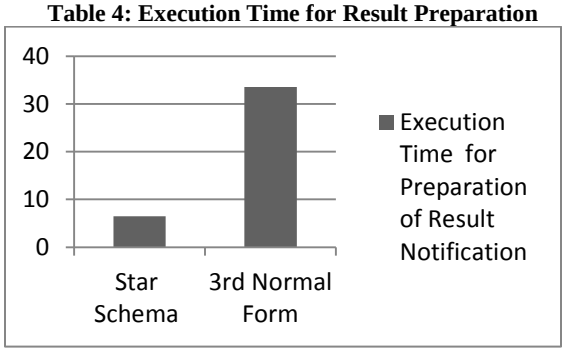
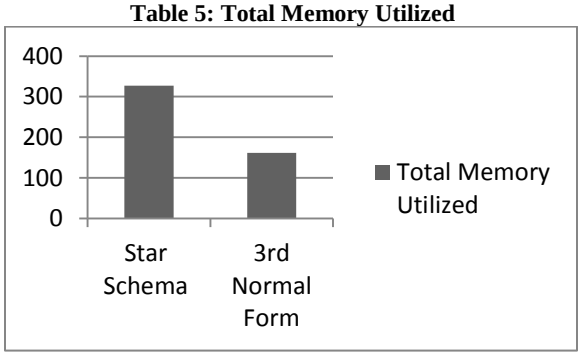


Table 5: Total Memory Utilized



9.0 Conclusion

The data warehousing technology i s gaining wide attention, and many organizations are building data warehouses (or, data marts) to help them in data analysis in decision for decision support. Data Warehousing is a newly emerged field of study in Computing Sciences. Due to its viz. multidisciplinary nature, it has overlapping area of studies in three different computing disciplines. This overlapping sometimes may cause contradictory definitions for a specific concept. To overcome this problem of data warehousing for Examination Automation System, it was considered for Star Schema Design. In this regard various functional dimensions of the Examination System were designed and connected to a Fact Transaction Dimension. Furthermore the general issues like the Client Statistics and Query Design were taken up and various Decision Support Databases were designed and implemented using the same star Schema.

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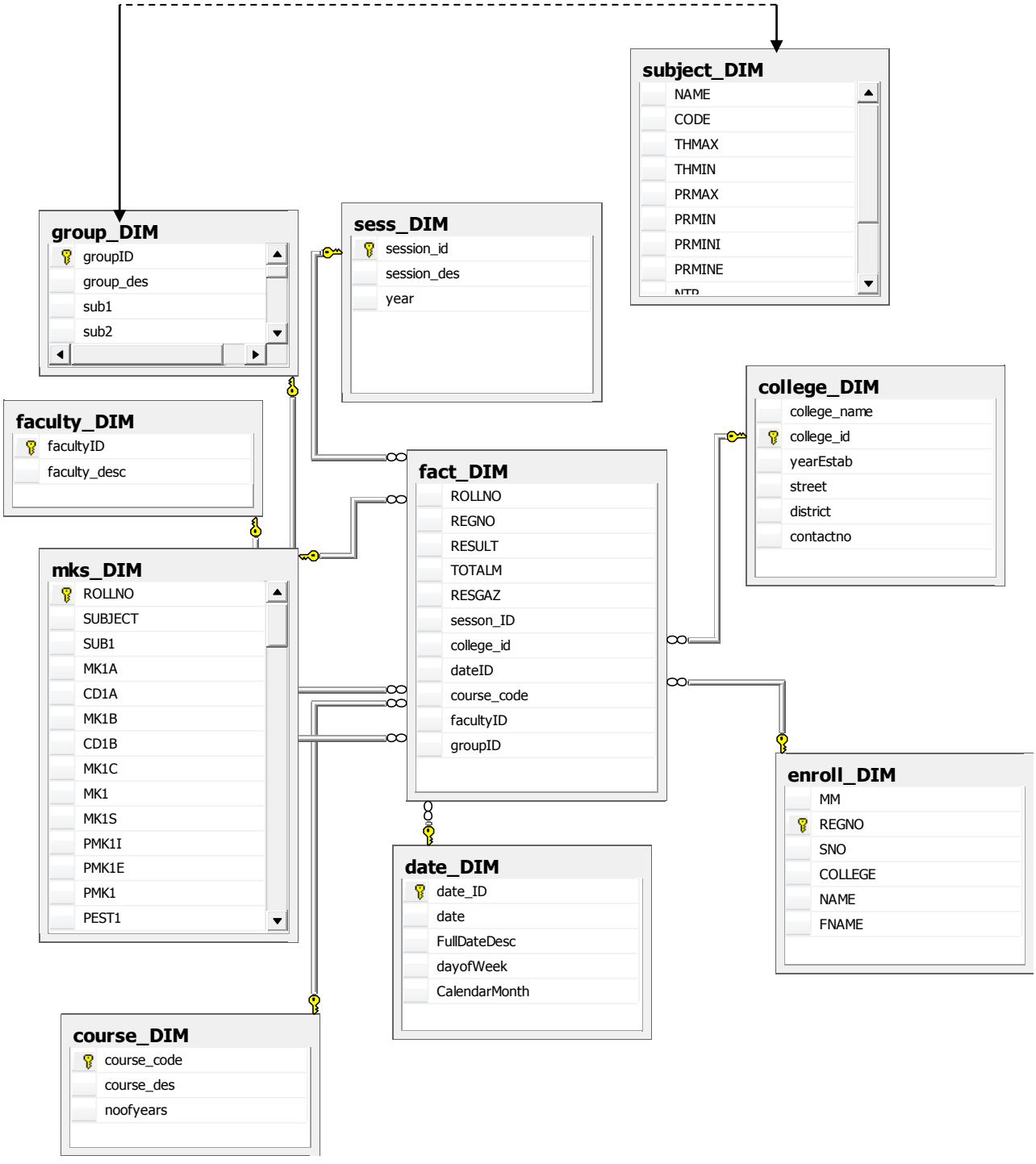
Appendix 1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NAME
CODE
THMAX
THMIN
PRMAX
PRMIN
PRMINI
PRMINE
group_DIM
groupID
group_des
sub1
sub2
sess_DIM
session_id
session_des
year
college_DIM
college_name
college_id
yearEstab
street
district
contactno
faculty_DIM
facultyID
faculty_desc
fact_DIM
ROLLNO
REGNO
RESULT
TOTALM
RESGAZ
sesson_ID
college_id
dateID
course_code
facultyID
groupID
mks_DIM
ROLLNO
SUBJECT
SUB1
MK1A
CD1A
MK1B
CD1B
MK1C
MK1
MK1S
PMK1I
PMK1E
PMK1
PEST1
enroll_DIM
MM
REGNO
SNO
COLLEGE
NAME
FNAME
date_DIM
date_ID
date
FullDateDesc
dayofWeek
CalendarMonth
course_DIM
course_code
course_des
noofyears