USE OF MUTIDIMENSIONAL MODELING IN A DECISION SUPPORT SYSTEM OF A BANK

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Abstract

Computers are widely used in decision making in many financial institutions. Decision Support System (DSS) concepts are generally used for this purpose. Recently, new modeling techniques are introduced to enhance the Model Base Management System components of the DSS, for example, Multidimensional Modeling (MDM). In this paper, a local private bank is taken as an example to demonstrate how MDM can be applied.

INTRODUCTION

Currently, Decision Support Systems (DSS) are widely applied in many fields. Recently, a new approach to model base in DSS known as multidimensional modeling was introduced. The major advantage of multidimensional modeling (MDM) is that data can be organized in a way managers like to see them rather than the way the system analysts, do, and different views of the same data can be arranged easily and quickly.

In this paper, an application of MDM in a private bank in Colombo is presented. For obvious reasons, the name of the bank is not disclosed. This bank caters to a lot of corporate customers, which includes local and foreign-based corporations. The major business process selected within this bank is the "Money market" i.e., how money is lent to other brokers (banks or financial institutions) and borrowed from other brokers if necessary. An interest is charged on the money that changes hands. A currency trader carries out these transactions, which are in the region of millions of rupees, and ensures that the bank makes a profit.

The borrowers

- Other departments within the bank can borrow money. It is the Treasury Department that ensures that the money is available for these entities.
- Clients, in the form of companies or individuals, can borrow money.
- Other banks or financial institutions may borrow money from the private bank when their capital is depleted and their clients want to borrow money. The brokers for these institutions try to borrow money at a lower interest rate, and then lend it to their customers at a higher rate.

The process, in detail

- The money market is managed for the private bank by its Treasury Department.
- For a bank or financial institution to be involved in the money market, it should initially have a current account at the Central Bank of Sri Lanka.
- The Central Bank stipulates a minimum amount that should always be in this account at the end of the operational week, so the currency trader must always be careful to see that the balance is above this level.
• An operational week begins from a Thursday, goes onto Friday, with Saturday and Sunday being bank holidays, and then onto Monday, Tuesday and Wednesday.
• The Central Bank will also ensure that whatever transactions are done, that an amount equivalent to 12% of all the bank’s assets is withheld in this current account.
• This statutory deposit ensures that should the bank go bankrupt, this 12% can be used to repay some of the creditors.
• The money market is active from 7 o’clock to about 9 o’clock in the morning.
• Most of the brokers are linked by an on-line voice system, where they shout aloud their offers, or requirements.
• For example, there maybe a broker wanting to borrow money at an interest rate of 11.25%, and he will keep repeating this aloud on the voice system. If private bank feels that lending money at 11.25% is not profitable, they will not respond. Similarly with other brokers. Eventually, the potential borrower may raise the interest rate to 11.38%. If the currency trader from the private bank feels this is a profitable interest rate to lend money, he will get on the private phone line to the bidder and agree to a deal.
• Once a deal has been agreed on, the amount is entered into a computer linked to the Central Bank, and the respective amount will be transferred from the private bank’s account to the borrower’s account.
• If the current account balance of the private bank at the Central Bank goes below the stipulated minimum amount within the trading week, its trader must ensure that by Thursday, the balance is above the minimum level.
• This can be done by retrieving lent money, or borrowing from other institutions.
• If the account balance is below the minimum by Thursday, the Central Bank gives a warning. Three such warnings can lead to the bank’s license being cancelled.
• There can also be deals committed for the future with other institutions, up to a period of six months.
• A couple of brokers in Sri Lanka are not linked to this voice system, so they have to use a phone to contact the other brokers.

With all the information stated above, the following sections describes how a multidimensional modeling can be applied for decision making in various operations of the bank. Also comparison of relational model and multidimensional modeling is made in the context of this case study. Advantages of multidimensional modeling are highlighted.

DECISIONS FACED BY TRADERS

There are two main decisions faced by currency brokers [4]. In borrowing, the trader must try to borrow money at the lowest possible rate. While lending, the trader must go for the highest possible value. Currently, the interest rate fluctuates between 11% and 12%. So the decision is one of agreeing to lend or borrow at an acceptable interest rate.

Factors to consider

1. The current interest rate among the brokers.
2. Whether the current account balance at the Central Bank account is above the minimum.
3. Which day of the week it is.
MODELLING IN MULTI-DIMENSIONS

A multi-dimensional model [1] can be used by the private bank to help in the decision making for the money market. Displayed below is the multi-dimensional data model, which can store transactional data (the amounts transacted, in rupees).

AMOUNT

- The x-axis is the name of the institutions which borrow money or is used to borrow money from. The private bank actually deals with about 15 such institutions.
- The y-axis gives the type of transactions, along with some other statistics.
- The third axis (z-axis) gives the interest rate at which the transaction is carried out.
• A fourth axis exists, which is the date, including the day of the week. This dimension goes up to a period of six months, as there can be committed deals for the future during such a time period.
• Each cell will contain the value of money that was transacted.

THE MODEL USAGE

Once again, the main aim of the money market must be reiterated: i.e. to lend or borrow money in such a way that the institution gets the maximum profit possible. This model can be used to retrieve intelligence about the money market environment to help decision making. Stated below, again, are the factors to consider in making these decisions. Also stated are the techniques used to investigate these factors:

• **The current interest rate among the brokers:** This depends on the last transaction carried out, and the trader must actually keep this figure in mind.

• **Whether the current account balance at the Central Bank account is above the minimum:** this is found by subtracting all the lent money from the total of the previous day, and adding all the borrowed money. This value is then entered in the first row of the y-axis along the dimension “At the Central Bank”. Therefore, to find out what the current balance is requires the trader having to simply look at the value for that day. The value obtained must be greater than the minimum stipulated amount by the Central Bank. If it is lower than the minimum, the trader must ensure that by the close of Wednesday’s money market, the current balance is above the minimum.

• **Which day of the week it is:** found by referring to the fourth dimension.

  e.g.:

  ![Diagram of days of the week]

  Thu Fri Mon Tue Wed

  In actuality, the fourth dimension has values going up to six months, not just five. But since the day of the week is also included along with each individual date, the decision maker can refer to this dimension to find out which day of the week it is.

  ![Diagram of months]

  (1/1/yy) (2/1/yy) ............... (30/6/yy)

  At the end of the six months, the new dates (1/7/yy to 31/12/yy) are written to this dimension.
• Interest rate of previous transactions with a particular institution:

The gray line shows the name of the institution, while the black line shows the particular interest rate at which a transaction was conducted with this institution. The data can then be “diced” or “ranged” to a reduced model in order to show the blue lines and the red lines over several days, while eliminating data about transactions with other institutions.

For example, for institution A, the reduced model below will show the amounts transacted over four days (d1 to d4) and the interest rates at which they occurred. The cells will contain the amounts that changed hands.

Having several transactional details of this nature will enable the private bank trader to be aware of the rates the other party is willing to deal with. For example, if the model can show which is the highest interest rate that this institution was willing to pay for borrowing during the operational week, the trader from the private bank will know the highest rate he can ask for.

An alternative operations is for the model to be rotated in such a way that Transactions are displayed on the y-axis against Interest rate on the x-axis.

Now the model will look like the following. The gray strip indicates the position of institution A, for the corresponding interest rates for any transactions conducted.
Once this rotation is complete, a ranging operation can be carried out to show a two-dimensional array, which has the interest rates of transactions for institution A over several days. The ranging eliminates details of transactions with other institutions. The X indicates a transaction conducted at any point for A.

<table>
<thead>
<tr>
<th>AMOUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>12% X</td>
</tr>
<tr>
<td>11.75% X</td>
</tr>
<tr>
<td>11.5% X</td>
</tr>
<tr>
<td>11.25% X</td>
</tr>
<tr>
<td>11% X</td>
</tr>
<tr>
<td>Th Fr M Tu</td>
</tr>
</tbody>
</table>

- **Profits or losses made with this institution previously.**
  This value is found by referring to the highest row in the model i.e. on the y-axis, which is labeled “Profit”. When an institution returns money after a period of borrowing, an interest will be paid to private bank. This interest is considered to be the profit. When private bank returns any money it borrowed, it too will pay an interest to the lending institution. This interest will then be recorded as a negative value in the Profit field.

The dimension in gray shows the name of the institution the transaction was conducted with. The black line shows the profit made in that transaction. The model can be diced such that only data for the wanted institution is displayed.
Then these data elements can be combined to obtain a model as follows:

![Diagram showing a cube with dimensions Trans, Profit, and Interest rate across M, T, W, Th]

Institution: A

Along the "Transactions" dimension, the model is diced to show only the Profit position.
For example, institution D has carried out several transactions with the private bank at different interest rates over the days d1 to d4. This data can be ranged and displayed as below. The cells will contain the Profits made in these transactions.

![Diagram showing a cube with interest rates across d1, d2, d3, d4]

Institution: D

- **Amount of time any institution usually takes to return borrowed money.**
  This is something the bank should know about, because if a potential borrower takes a long time to return money borrowed at a low interest rate, private bank will not be making a substantial profit. So when a broker is asking for any lenders over the speaker system, private bank can use the model to find out the time taken by that broker's institution to return borrowed money. This operation involves subtracting the returned date of an amount, by a particular institution, with the date of borrowing.

E.g. Shown below is the day a transaction was conducted with a certain institution, and the day the borrowed money was repaid. To find out how many days have elapsed between d1 and d2, the field d1 is subtracted from d2. If the transaction has taken place over two months, then the difference in days is found by taking into account the change of month.

![Diagram showing a cube for Mon (d1/m1/yy) and Fri (d2/m1/yy)]

However, a situation can occur where an institution borrows a certain sum of money, and then before repaying this amount, borrows some more money. The two
borrowings may or may not be at the same interest rate. Therefore there should be a way for the system to know which deal was completed when in order to calculate the number of days taken to complete a transaction. So the way to deal with this is to make it mandatory for all borrowers to return the full amount at once. For example, if 50 million rupees was borrowed first, and then 20 million rupees, the borrower would be subjected to repay 50 million or 20 million at a time. If the borrower decided to repay 20 million first, then the system would consider that the second deal has been concluded first, and accordingly calculate the number of days taken for that deal.

Alternately, the situation may occur where two borrowings have been conducted by an institution where the borrowed amounts are exactly the same, but at different interest rates. For example, if 60 million rupees was borrowed twice at 11% and 11.25%, and the borrower decides to repay 60 million rupees, the problem arises as to which interest rate to use. The solution here is to use the first interest rate (i.e. 11%) and consider the first deal as having concluded. Hence, the number of days for the first transaction can be calculated.

- **Total profit for week.**
  A particular week is selected and all the values along the “Profit” dimension is summed up. This figure can be compared against some benchmark to see if the week has been profitable as expected. If it hasn’t been the private bank may have to be more aggressive in its money market transactions during the following week.

- **Any committed deals for the future.**
  A private bank undertakes future transactions as well. For example, some institute may want to borrow a certain some of money in two weeks. This transaction is entered into the model at a cell with a corresponding interest rate being its lowest value. When the deal is eventually transacted, the interest rate would probably be different. At that time, the transaction can be recorded with the corresponding interest rate in the appropriate cell.

**IMPLEMENTATION**

A multi-dimensional database can be implemented using techniques such as Massively Parallel Processing (MPP), Symmetric Multiprocessing (SMP), or an implementation on a Relational Database Management System (RDBMS).

The model described here does not result in a fully populated model. Therefore, the cells where no data are stored will have values termed “N/A”, or “not applicable”. Special software can be used to **compress** such cells, and therefore save storage space.

CA-Complete (software from Computer Associates) was labeled as dynamic spreadsheet (it contains up to 12 dimensions). It can compare, rotate, and “slice and dice” corporate data across different management viewpoints. Similar to CA-Complete, but with more capabilities, IMPROV (from Lotus Development Corp.) is a dynamic spreadsheet that allows the user to write models in an English-like-language and to easily change the structure of the output tables (for example, changing rows to columns). With its dynamic views, IMPROV is designed to rotate, hide, show, collapse, slice, dice and expand worksheets, rearranging.
data along 16 dimensions. It can instantly build new worksheets views. There are other software packages also available in the market and the bank is now studying the suitable software to implement the ideas presented in this paper.

RELATIONAL DATABASE PERSPECTIVE

A relational database can be used to store this data instead of a multi-dimensional database model. A relational database involves a set of tables on each aspect of the problem. Each table contains attributes which describes the aspect. Each dimension in the multi-dimensional model becomes one table in the relational database model.

<table>
<thead>
<tr>
<th>Date</th>
<th>Day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

The Date field links the tables to each other. When a transaction occurs on a particular day, the relevant data is entered to the appropriate table at the appropriate location.

Carrying out operations:

Stated below, again, are the factors to be considered in lending or borrowing money. Described next to each statement is how the operation would be conducted in the relational database model.

- The current interest rate among the brokers: this value, as when using a multi-dimensional database, has to be kept in mind by the trader.
- Whether the current account balance at the Central Bank account is above the minimum: this is found by referring to the “At Central Bank account” field in the Transactions table.
- Which day of the week it is: found by referring to the Date table. The queried date is found, and then its accompanying day displayed.
• Interest rate of previous transactions with this broker: this would involve giving a query asking for the interest rates of a particular institution over a certain period. The Transaction table will be queried, first for the date, and then for the institution, before the results being displayed.
• Profits or losses made with this institution previously: the Transaction table will be queried again, first for the time period required, then for the name of the institution, after which those records are displayed.
• Amount of time any institution usually takes to return borrowed money: again the Transaction table is queried. This would also involve first specifying a time period. Then the institution is specified, after which the borrowed date is subtracted from the returned date.
• Total profit for week: a query for the Transaction table once more. The time period specified is found by isolating the records for the week. Then the profits (or losses, displayed as negative profits) are summed to give the total profit for the week.
• Any committed deals for the future: such a value is simply entered in the Transaction table at the appropriate date.

ADVANTAGES OF MULTI-DIMENSIONAL MODELLING OVER RELATIONAL MODELLING

The main advantage of a multi-dimensional database[3] is that its structure provides the intuitive understanding needed by the trader. Just by looking at the model, the user will be able to read off valuable intelligence to make quick decisions. Using tables, it is difficult to find information as intuitively. These tables would involve going through several fields using the query values before reaching the wanted record(s). In the multi-dimensional model, the different perspectives (or dimensions) can be used to approach a solution faster, and therefore more efficiently. The multi-dimensional data model groups similar information along one dimension, which helps the intuitiveness of it. For example, all data relating to a transaction is grouped along the y-axis initially. Such organization will help the user to apply forecasting and analysis tools to manipulate data. This is referred to as analytical processing. The commands used to retrieve data from a multi-dimensional model is easier to express, than to obtain the same data in a relational model.

CONCLUSION

If private banks implement this multi-dimensional model, the money market transactions will become intuitive. Trends can be detected easily and therefore more intelligent decisions can be made. Other sophisticated software can be used as well, to derive more intelligent decisions from this model. Manipulation of the model is very easy to learn, therefore the time spent on becoming familiar with it will be quite short.

REFERENCES


