OLAP FOR FINANCIAL ANALYSIS AND PLANNING
A Proof of Concept

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Abstract: We describe the design of an in-memory OLAP model for financial planning, analysis and reporting at a medium sized manufacturing company in South America. The architecture and data model design are explained within the context of the company's requirements and constraints.

1 INTRODUCTION

Financial analysis is a critical task that all managers should be able to carry out. Regardless of the nature of the business or the size of the organization, managers are required to diagnose the financial well being of the organization by analyzing profit and loss, key performance indexes, liquidity and returns, anticipating consequences of operational decisions and taking remedial action.

Accounting is the scorecard of business (Higgins, 2001): financial statements are a window into a company's financial performance, summarizing the company's activities into an objective set of numerical information that can be used by creditors, investors, stakeholders, regulators and, more importantly, for internal decision making.

Unfortunately, the manner in which financial statements are typically structured and presented does not help to convey the information required for sound financial analysis and planning. Business management based on performance indicators does not arise directly from accounting records, which are mainly concerned with preserving evidence of business transactions rather than the analysis and interpretation of the underlying data.

Online analytical processing (OLAP) has had a significant growth in the last decade with numerous products and applications developed in different business areas. The spreadsheet-like nature of OLAP is well aligned with the mental models that business users have of data.

In this paper we set out to describe a financial planning and analysis model based on OLAP technology. The work is focused on a medium sized company headquartered in Argentina, with operations throughout South America (hereafter referred to as the Corporation). The paper covers the initiation, analysis and design of the OLAP project.

The application will help the Corporation improve the planning process and the overall monitoring of the financial performance of the organization across its geographically distributed business units. The paper can be used as a teaching case in information systems aimed at introducing OLAP technologies and its application as a management tool in a real-world scenario. The next section describes the Corporation's background: its organizational setting and a description of the financial reporting processes used by the Corporation in the past. The paper follows with an overview of OLAP architectures, and describes the architecture adopted by the Corporation. Next the paper provides an overview of OLAP modeling and describes the design of the OLAP model for the financial analysis and planning application. OLAP concepts as well as definitions of accounting terms and financial statements concepts have been included in each section for pedagogical reasons. The paper ends with a summary and raises some points that could be used for class-based discussion.

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2 BACKGROUND

The Corporation is a mid-sized manufacturer and supplier of products for the food industry, mostly centered on seed crops with high content of Omega-3. Omega-3 is the common name given to a family of unsaturated fatty acids that has been shown to reduce risks of heart disease and have potential positive effects on other diseases (e.g. high cholesterol). Omega-3 is not produced by the human body and must be incorporated in the diet. The Corporation processes flax and chia seeds, to produce cold press oils and partially defatted flours. Cold press oils with high contents of Omega-3 can be consumed as part of a regular diet or used as additives in sunflower or olive oils. Partially defatted flours are included as additives in bakery and other products (bread, cookies, cereal and energy bars). Both flax and chia seeds have high contents of Omega-3. The Corporation has been especially successful at targeting whole food stores, supermarkets and the bakery industry. The combined annual production capacity of oil and flour extracted from chia and flax seeds has made the Corporation a major player of Omega-3 additives for the food industry in South America. The Corporation has recently added other seed crops to its list of products, including quinoa (sold as flour and whole grain) and safflower (processed to produce cooking oil, margarine and cosmetics). The Corporation has production and distribution capabilities in several countries in South America. It has its headquarters in Buenos Aires, Argentina, and affiliates in Uruguay, Brazil, Chile, Peru and Colombia. The Corporation's production plants are located in Argentina, Peru and Brazil. Chia and flax products are manufactured in Argentina, whereas quinoa products are processed in Peru. The Brazil affiliate is setting up a processing plant for safflower.

The Corporation has a matrix organizational structure, with management in each country and traditional functional areas (production, sales and marketing, finance). The finance division in each country reports to a country manager and to the Chief Financial Officer (CFO) with headquarters in Buenos Aires. The information technology (IT) function is small: an IT division headquartered in Buenos Aires led by an IT director that reports to the CFO's office. Each country holds a reduced IT support group that reports to the IT Director (in some cases no more than one or two people depending on the size of the branch).

The continued growth and expansion of the Corporation from a small family business into a multinational organization has created the need for a regional strategic planning process and information infrastructure. Each country is treated as a separate business unit, and has its own financial regulations, tax code, currency, interest rates and labor considerations. Consolidated corporate financial data is reported in dollars but is handled in each country using local currency.

The financial planning process at the Corporation includes two versions (scenarios) of the data (Actual and Budget). All financial statement accounts are recorded with a monthly granularity for each of the scenarios. Sales and expenses data should have the possibility of being sliced from multiple perspectives (dimensions of analysis), including countries, scenarios, products, and customers. Products are grouped in product lines according to the type of seed (chia, flax, quinoa, and safflower). Customers across countries are grouped according to the type of target industry (whole foods, supermarkets, bakeries, and cosmetics).

The planning process and consolidation of financial reports historically used by the Corporation is labor intensive. Most of the budget analysis is performed and kept in Excel spreadsheets whereas the financial information is handled through accounting applications running onsite at each country, or outsourced to a local accounting firm, according to the size of the branch. Accounting data is readily available, but the lack of a common analytical reporting framework paired with the differences among countries' accounting regulations and the distributed nature of the reporting process in terms of hardware / software platform and staff makes it difficult to have consistent reporting of analytical data with adequate levels of granularity across the Corporation.

The Corporation would like to create a financial planning and management reporting system that a) helps compare actual results versus planned scenarios and enables consolidation of financial data across countries b) measures the financial health of the organization through a number of key performance indicators (KPIs) included in a financial dashboard. Three types of KPIs are of special interest to the Corporation: (1) Profitability KPIs; (2) Solvency KPIs; (3) Cash Flow ratios.

The CFO's office has decided to initiate a project to develop a planning and financial analysis tool to meet the Corporation's immediate and future reporting needs.

3 OLAP TECHNOLOGY FOR FINANCIAL ANALYSIS AND PLANNING

The term OLAP, derived from Online Analytical Processing defines a technology that is based on multidimensional analysis of business data and allows the user to have a faster, better and more flexible access to such data. Originally introduced by Codd et al (1993), OLAP technologies are capable of capturing the structure of the real world in the form of logical arrangements of numerical data over multiple business dimensions, generally referred to as data cubes. A ‘slice’ of an OLAP data cube portrays business data in a spreadsheet-like representation (a 2D row-by-column arrangement of data), where each face of the data cube shows business metrics (sales, revenue, costs, earnings, or some other measure) for two or more dimensions simultaneously (Koutsoukis et al, 1999). This data driven decision making process, is made up of numerous, speculative “what if” and “why” data intensive simulations with the goal of studying the behavior of complex business problems under different conditions, called scenarios (Golfarelli, 2006). The virtue of OLAP is to allow business users to operate within the confines of the well known spreadsheet paradigm while at the same time eliminating some of the major drawbacks of spreadsheet applications: separation between data and models is enforced, as data is kept in the OLAP repository and is retrieved using spreadsheet type, pivot-table operators: (a) pivot and slice: users can arrange a selected subset of dimension configurations in a 2D cross-tab view of the data; (b) drill-down and roll-up: allows users to create data aggregations at different levels of a dimension hierarchy, or conversely, drill down to the most detailed levels of the data. OLAP technology has a very good fit with financial reporting and planning.

Financial statements are an important window on the reality of an organization [1], providing a short-term and long-term, structured view of its financial condition. The three principal reports used in standard accounting practice (Income statement, Balance Sheet and Cash Flow Statement) play distinctive roles but are tightly intertwined:

- The balance sheet is a snapshot taken at a given point in time of the company’s net worth: how much it owns (assets) and how much it owes (liabilities). Assets and liabilities that turn into cash within one year are described as short-term (or current), and all others are described as long term. Examples of current assets are cash itself and inventories (with the assumption that they must be sold within one year). Current liabilities include accounts payable and income taxes). Long term assets include the property and equipment essential for the company’s continued operation, typically subject to depreciation. Other long term assets include, intangible assets (e.g. intellectual property), and long term investments.
- The profit and loss statement (P&L, or income statement) does not look at net worth but instead measures the ability of a company to generate profit in a given time frame (how much money can the company make in a given period). In doing so, the income statement records the flow of resources over time (Higgins, 2001), with earnings reporting the difference between the company revenue stream and the costs and operating expenses that result from producing such revenue.
- The cash flow statement “follows” the cash (its sources and uses over a period of time), along three main activities: (i) cash flow from operations, (ii) cash flow from investing activities, (iii) cash flow from financing activities.

The interconnection among these reports based on well defined formulation, their time dependence and the demand for various types of financial data consolidation and analysis (temporal, geographic, or over product lines, customer groups and multiple planned scenarios) makes OLAP technology an ideal delivery platform for carrying out complex multidimensional analysis based on financial data. This has been well understood by the project management team at the Corporation who has set out to identify OLAP platforms that meet the requirements of the organization in terms of flexibility, speed, and adherence to budgetary constraints.

3.1 OLAP Architectures and in-Memory OLAP at the Corporation

OLAP structures are described in terms of logical rather than physical arrangements, to stress the fact that the underlying physical structure may vary, depending on the type of OLAP implementation. OLAP models can be built on top of relational databases, specialized multidimensional databases, or even memory-based data structures (more on this later on). But at a logical level, the OLAP concept remains identical or very similar across different OLAP products, technologies and physical data storage implementations.

Several OLAP architectures have been developed over the years, the most prominent being multidimensional OLAP (MOLAP) and relational OLAP (ROLAP). The differences between these technologies concern data storage and processing capability (Hasan & Hyland, 2001). MOLAP architectures implement the multidimensional view by storing cube data in sparse (usually proprietary) multidimensional array data structures (MDDS). Data is periodically uploaded from an organization's relational databases into an MDDS. The array model provides natural indexing, and as data is usually pre-aggregated in the MDDS, this improves flexibility and performance. MOLAP architectures are compact and efficient but don't scale well when handling large dimensions or cubes with large numbers of dimensions. ROLAP architectures used relational database base systems to store cube data, usually organized as star or snowflake schemas in the relational data warehouse. Using the source data directly allows users to drill down to lower data levels, typically at the expense of higher processing power requirements and slower performance. Some products have implemented hybrid models (also known and HOLAP, or hybrid OLAP). In such architectures, MOLAP cubes are deployed to handle aggregate data, with drill-down operations that enable users to pull detailed data from the relational data store.

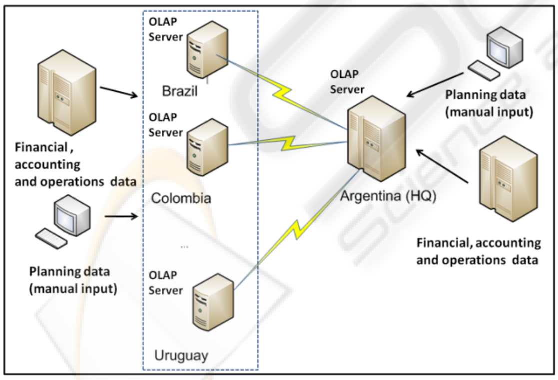


Figure 1: OLAP Architecture at the Corporation.

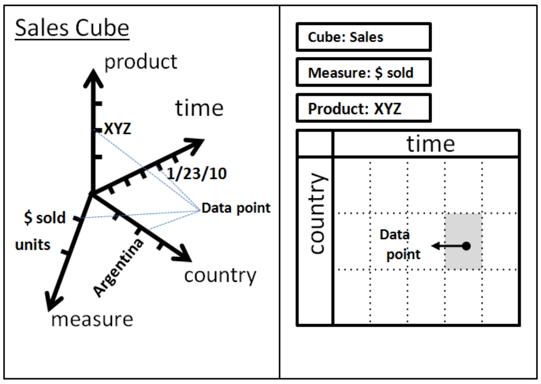
In-memory OLAP is a special case of OLAP (typically MOLAP) architecture that has become increasingly popular in the last years, and constitutes a shift in paradigm in terms of performance and scalability. The reason is simple: users can query OLAP models residing in RAM memory, which is at least several orders of magnitude faster than accessing data from disk storage. In in-memory OLAP, data is loaded into memory for real-time querying, including calculations and aggregations that can be swiftly generated on the fly. This technology has been around for a number of years, but only recently has the promise of RAM-based, high-speed analytical processing become a reality thanks to the introduction of 64-bit architectures with large memory address spaces. With 64-bit addressable memory space, RAM-based OLAP servers can easily handle 100 gigabyte cubes, something unthinkable not long ago.

Here the case is set out following a decision made by the Corporation to use an in-memory OLAP platform (IBM Cognos TM1) to develop the financial analysis and planning application. Figure 1 displays the proposed OLAP architecture based on TM1. An OLAP server is setup at each country, providing multiuser access to planning and financial analysis data. Budgets are prepared and entered at each site, whereas financial data is extracted from the local accounting systems (a set of files with accounting data is received on a monthly basis from the outsourcing service in those countries where the accounting systems are not run in-house). OLAP servers are interconnected in a star topology centered at Buenos Aires' headquarters that serves as the aggregation hub where data originating in each country is consolidated.

4 OLAP MODELING FOR FINANCIAL ANALYSIS AND PLANNING

The notion of a multidimensional data cube (also known as hypercube, or simply "cube") is central in understanding OLAP modeling. OLAP hypercubes play a similar role to tables in the relational database model: they constitute the building blocks for data storage, manipulation and retrieval. In a nutshell, a hypercube is a logical multidimensional array where each data value occupies a cell in the array, indexed by a unique set of dimension members (Hasan & Hyland, 2001). The example in Figure 2.a shows a Sales hypercube used to track the number of product units and dollars sold across different countries. A cell containing a data value in such hypercube is uniquely identified using four parameters: measure member (e.g. 'dollars sold'), country member (e.g. 'Argentina), time member (e.g. 'January 23, 2010'), and product member ('XYZ').

Visual representation of multidimensional business data requires mapping the n-dimensional space into two dimensions. This is accomplished by creating cross-tab representations of the hypercube data by combining multiple logical dimensions within the same display dimension over rows, columns and at the header level of the cross-tab grid. Figure 2.b shows a 2D, cross-tab representation of a section of the hypercube data, where the sales in dollars of product XYZ are displayed for each place of a sale (in rows), and time of sale (in columns).



(a) (b)

Figure 2: Hypercubes: (a) multidimensional representation; (b) 2D crosstab display.

An OLAP model is made up of a collection of cubes linked together through their common dimensions. These common dimensions, when identically structured, can be shared across cubes and are usually referred to as conformed dimensions. Kimball & Ross (2002) introduced the notion of conformed dimensions to describe dimension tables in a relational data mart that adhere to a common structure and therefore allow queries to be executed across data marts. Dimensions are not simple enumerations of members; instead, they are structured as multilevel hierarchies to allow for aggregations of data.

Also, and depending on the underlying features of the OLAP tool, cubes can be linked through business rules and calculated dimension members to enhance query performance and improve data integration across cubes. This is especially true for in-memory OLAP architectures, were calculated dimension members can be computed on the fly without lengthy waiting times. For a detailed critique of some of the dominant, product-specific approaches to the use of calculation rules in OLAP models see (Thomsen, 2002). For example, as shown in Figure 3, a Sales cube can share the *time*, *product* and *country* dimensions with a P&L cube (containing income statement data). Each data point (cell) in the region delimited by the ['$ sold'] member in the *measure* dimension identifies sales in dollars for each member of the *time*, *product* and *country* dimensions. Through a business rule attached to the P&L cube, each of this data points in the Sales cube can be "pushed" inside the P&L cube. There is no data duplication: the ['Sales'] member in the *accounts* dimension is a calculated member whose value for a given data point in the P&L cube is the result of an automated query operation on the Sales cube.

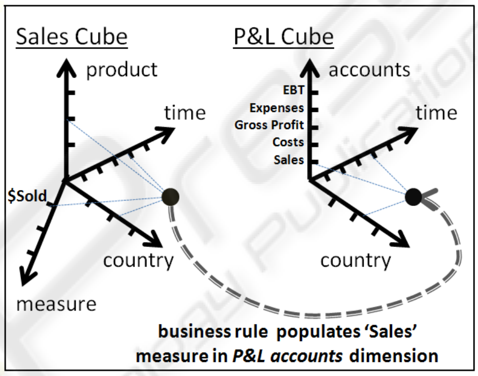


Figure 3: Calculated members and business rules.

We use the following notation to formulate the business rule as described before:

['Sales'] = DB(Sales,'$ sold', *country*, *time*, 'Total Products') (1)

DB(.) symbolizes the data extraction query rule. The expression between brackets [.] refers to the region in the cube (i.e. the collection of data points in the cube) affected by the rule; and the reference to a dimension indicates that the formula spans a whole dimension. Note that two of the Sales cube dimensions (*measures* and *products*) expressed in the rule have fixed members denoting that the data extraction rule proceeds on fixed sections of the cube ('$ sold' and 'Total Products'). The *product* dimension has to be rolled up at its highest level as it is not present in the P&L cube.

4.1 OLAP Model Specification

The following specification describes the data model and business rule formulation for the OLAP application to be implemented at the Corporation. The specification is presented from the point of view of users' requirements. Design considerations tied to the selected OLAP engine (IBM Cognos TM1) have been added as needed. Functional requirements should be addressed as much as possible through native features of the OLAP engine in order to avoid unnecessary programming.

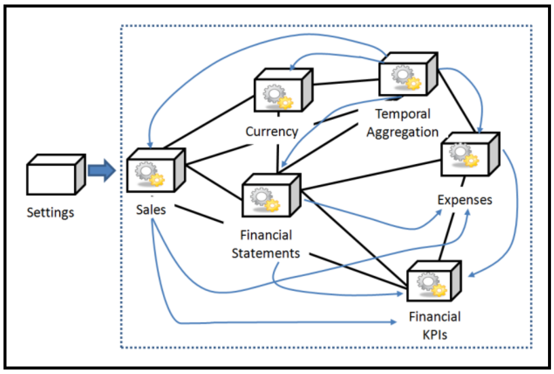


Figure 4: OLAP model for financial analysis and planning.

The OLAP model is composed of seven cubes sharing common, conformed dimensions and linked to each other through a set of business rules. Figure 4 depicts the data model, where straight lines linking cubes signal shared dimensions, curved lines linking cubes indicate the presence of data extraction query rules, and the gear icons mark the presence of intrinsic business rules calculations (calculated members formulated through dimension members of the same cube). For example, in the Sales cube:

['PL03-Gross Margin'] = ['PL01-Net Sales'] - ['PL02-Cost of Sales'] (2)

Table 1: OLAP model cubes and their dimensions.

CUBES	DIMENSIONS	BUSINESS RULES
Currency	year, period, country, currency_exchange	Y
FinancialStatements	country, scenario, currency_exchange, accounts, year, period	Y
Sales	country, scenario, currency_exchange, customertype, productline, salesmetrics, year, period	Y
Expenses	country, scenario, currency_exchange, productline, expenses, year, period	Y
FinancialKPIs	country, scenario, currency_exchange, productline, customertype, financial_kpis, year, period	Y
TemporalAggregation	period, consolidation_period	Y
Settings	parameter, parameter_value	

Table 1 displays the list of cubes that compose the OLAP model together with their business rules. Figure 5 shows the layout of dimension hierarchies used by the OLAP model.

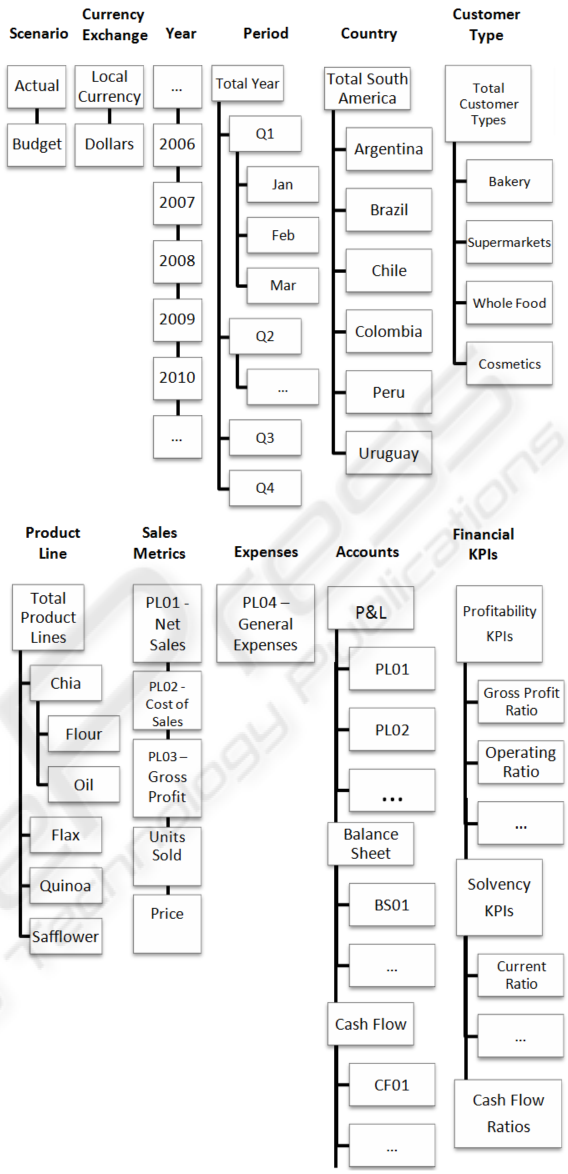


Figure 5: Layout of OLAP Model Dimensions.

The Sales, Expenses and FinancialStatements cubes store the core financial and accouting information. Currency provides local currency conversion for each of the countries into dollars. FinancialKPIs collects performance metrics derived from the FinancialStatements cube.

TemporalAggregation provides support for aggregating data over several *(n)* periods. Settings contains general parameters used in business rules by all the other cubes.

The *accounts* dimension in the FinancialStatements cube includes all of the accounts corresponding to the three standard financial statements: Balance Sheet, P&L Statement and Cash Flow Statement, listed as dimension members. Some of them are input members, others are calculated members, with values resulting from the application of business rules. They are depicted in Table 2, together with their interrelationship and/or formulation. Data entered in the local currency in each country is automatically converted to dollars for comparison and consolidation purposes using the Currency cube that feeds the corresponding exchange rate for each country and time period.

Data for each financial statement is entered on a monthly basis in two versions ('Actual' and 'Budget'): 'Actual' data flows from the accounting system, 'Budget' data is the result of the planning process; Sales metrics ('PL01', 'PL02') are extracted from the Sales cube, where data is entered by *productline* and *customertype* and aggregated in the query process that feeds the *Sales* (PL01) member.

General Expenses ('PL04') is a member of the FinancialStatements cube, and the Expenses cube. The ['PL04'] metric in the Expenses cube is calculated through an extraction rule that distributes expenses according to *productline* sales, feeding data from the Sales cube and FinancialStatements cube. Its formulation for the Expenses cube is shown below:

[PL04', *productline*] = (DB(Sales, *country, scenario, currency*, 'Total Customer Types', productline, 'PL01', *year, period*) /
DB(Sales, *country, scenario, currency*, 'Total Customer,Types', 'Total Products', 'PL01', *year, period*) *
DB(FinancialStatements, *country, scenario, currency* ,'PL04', *year, period*) (3)

As shown in Table 2, standard accounting rules are implemented (or validated) through the use of business rules and calculated members. For example:

- A company's assets are financed by either equity or debt (liabilities)
  ['BS06'] = ['BS09'] +['BS10'] (basic double-entry accounting formula)
- The sum of the cash flows in all three activities (operating, investing, financing) equals the change in the cash balances over the accounting period
  ['CF07'] =['CF01'] +['CF02']+ ['CF03'] +['CF06']

Following general accounting principles, when financial statements are aggregated over a period of *n* months over a calendar year starting at month *i* and ending at month *f*, the following conditions must be satisfied: a) all P&L ('PLxx') variables are aggregated by adding the values corresponding to each month; b) all balance statement variables take the values corresponding to month *f;* c) 'CF01' takes the value corresponding to month *i*; d) 'CF07' takes the value corresponding to month *f.* The TemporalAggegation cube has been added to handle the aggregation process over *n* months (*n* is an input parameter to the aggregation process).

Financial Performance indicators are calculated members resulting from business rules that extract data from the input cubes (Financial Statements, Sales, and Expenses) and are stored in the FinancialKPIs cube and the Sales cube.

- **Profitability KPIs:** these are measures of operating efficiency. Metrics are grouped by *country*, *customertype*, and *productline*, for any given period.
  - Gross profit ratio = ['PL03'] / ['PL01'] *100
  - Operating Ratio = ['PL02'] / ['PL01'] *100
  - Expense ratio = ['PL04'] / ['PL01'] *100 (rolled up on *customertype*)
  - Annualized ROE = ['PL08'] *12 / (['BS10', previous month] + ['BS10', current month] /2)] (measures the Corporation's efficiency at generating profits from every unit of shareholders' equity; rolled up on *customertype* and *productline*)
  - Unit marginal profit (UMP) = DB(Sales, 'Price',…) – (DB (Sales, 'Cost of Sales', …) / DB(Sales, 'Units Sold', …)
  - Marginal Profit per customer type (MPC) = ['UMP'] * DB(Sales, 'Units Sold', *customertype*,…)
  - Unit marginal profit per product (UMPP) = ['MPC','Total Customer Types', *productline*] / DB(Sales, 'Units Sold', 'Total Customer Types', *productline*,..) (marginal profit metrics help determine the contribution per product, and rank customer types based on average prices and unit marginal profits. They can be used to define price strategies)

- **Solvency KPIs:** these metrics show how well the Corporation can satisfy its short- and long-term obligations; grouped by *country* for any given period.
  - Current Ratio = ['BS04']/['BS07'] (measures short term solvency)
  - Liquid ratio = ['BS01']/['BS07'] (measures immediate solvency)
  - Cash Variation = ['BS01', previous month] - ['BS01', current month] (measures variation of cash in one period)
  - Debt to Equity ratio = ['BS09']/['BS10'] (measures long term solvency)
  - Proprietary of equity ratio = ['BS10']/['BS06'] (measures long term solvency)

Table 2: Financial Statements' *accounts* dimension.

Dimension member	Type	Business Rule
Profit & Loss (P&L) Statement		
PL01-Sales	Calc	['PL01'] = DB(Sales, *country, scenario, currency*, 'Total Customer Types', 'Total Products', 'PL01', *year, period*)
PL02-Cost of sales	Calc	['PL02'] = DB(Sales, *country, scenario, currency*, 'Total Customer Types', 'Total Products', 'PL02', *year, period*)
PL03-Gross profit	Calc	['PL03'] = ['PL01'] – ['PL02']
PL04-General Expenses	Input	Distributed by product line
PL05-Other income (expense)	Input	
PL06-Earnings before taxes (EBT)	Calc	['PL06'] = ['PL03]–['PL04'] +['PL05']
PL07- Provision for income taxes	Input	
PL08 – Net income	Calc	['PL08'] = ['PL06]–['PL07']
Balance Sheet		
BS01-Cash	Input	
BS02-Short term investments	Input	
BS03-Accounts receivable	Input	
BS04-Current assets	Calc	['BS04'] = ['BS01]+['BS02'] +['BS03']
BS05-Long term assets	Input	
BS06-Total assets	Calc	['BS06'] = ['BS04'] +['BS05']
BS07-Current liabilities	Input	
BS08-Long term liabilities	Input	
BS09- Total liabilities	Calc	['BS09'] = ['BS07'] +['BS08']
BS10-Shareholders Equity	Input	Checks that BS06 = BS09 +BS10
Cash Flow Statement		
CF01-Cash and cash equivalents, beginning of year	Calc	['CF01'] = ['BS01', previous month] +['BS02', previous month] Fed through rule from within the same cube Checks that CF01 =CF07 from previous month
CF02-Cash flows from (used in) operating activities	Input	
CF03-Cash flows from (used in) investing activities	Input	
CF04-Payments of capital and interest	Input	Feeds ['CF04'] in the Expenses cube
CF05-Other financing activities	Input	
CF06-Cash flows from (used in) financing activities	Calc	['CF06'] = ['CF04'] +['CF05']
CF07-Cash and cash equivalents, end of year	Calc	['CF07'] =['CF01'] +['CF02']+ ['CF03'] +['CF06']

- **Cash Flow ratios:** these metrics show the adequacy of cash at the Corporation to meet its obligations; grouped by *country* for any given period.
  - Capital Expenditure Coverage = ['CF02'] /['CF04']*100 - 100 (measures the ability of the company's operating cash flow to meet its capital requirements)
  - Operating Cash Flow Ratio = ['CF02'] /['BS07']*100 (measures how well the company's operations are able to cover current liabilities)

Having both actual and planned data as part of the OLAP financial model allows the Corporation to define KPIs aligned with its strategic goals and defined along multiple dimensions and varying granularity. Planned and actual KPIs can then be compared over time in order to measure and correct deviations.

5 SUMMARY

This paper provides a proof of concept for OLAP-based financial analysis and planning. It is also the first step of a more long-term project aimed at developing a full blown application based on an in-memory OLAP platform, and a detailed teaching case. We have described some of the salient features of the design of the OLAP model using a real-world scenario. OLAP technology helps create powerful data-driven software applications to help decision makers analyze financial data and make timely and better informed decisions.

6 POINTS FOR DISCUSSION

- What are the advantages and disadvantages of an in-memory OLAP approach?
- The OLAP model was designed using a set of dimensions described in Figure 5. What alternative designs would you consider? Discuss the way in which time dimensions have been treated.
- Using the business rules processed by the OLAP engine allows for self-contained applications that reduce the need for extra application programming. Are there any disadvantages to this approach?

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