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Controlling System for Stock Raw Material for Production Planning and Inventory Control in a Pharmacy Company

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Abstract – *Master production schedule and material requirement planning are two important tasks for production planning and inventory control to monitor the stock of raw materials and finished goods. However, data used in master production schedule and material requirement planning come from various sources which have various types of data without good integration. This makes the forecasting of production planning and inventory control to provide raw materials for production not adequate. One of the applications for production planning and inventory control is EXACT. However, the application is operational-based. Thus, it cannot show the analysis of data. This paper proposes a data warehouse system that can provide a report for the production planning and inventory control system. By using a data warehouse, the necessary reports can be served quickly and flexibly in accordance with the needs of planning and inventory control system. Kimball Nine step is a method employed for designing a data warehouse, especially if each part is designed gradually. The development of data warehouse can give the report faster and more complete by accessing the dashboard. It also simplifies the process which occurs in the data retrieval of planning and inventory control system forecast.*

Keywords: *Data Warehouse, Stock, Raw Material, Finish Goods, Production Planning and Inventory Control*

Nomenclature

DVL	It is an abbreviation of Darya-Varia Laboratoria which is one of pharmaceutical companies that manufactures drugs. This study is conducted in this company
PPIC	It is an abbreviation of production planning and inventory control. PPIC is a department or part of a company which is largely responsible for coordinating the procurement of goods/services/finished products and controlling inventory
MPS	It is an abbreviation of master production schedule. It provides an overview of the number of items produced over a given period of time. MPS is based on forecasting the need for required equipments, an allocation process for carrying out the desired amount of equipments with respect to the capacity held (workers, machinery, and materials)
MRP	It is an abbreviation of material requirement planning, which is a computer-based information system designed to order and schedule the requested raw materials, components and sub-assemblies in a coordinated way
EXACT	The main application in Darya-Varia Laboratoria company which produces data of online transactional processing (OLTP)
BOM	The materials that form the product
BOO	The process that forms the product

I. Introduction

DVL (Darya-Varia Laboratoria) is one of pharmaceutical companies that manufacture drugs. In order to synchronize the demand of customer and the number of sales target, DVL has a production planning and inventory control (PPIC) division serving as a production planning of a product. One of the job descriptions of the PPIC as part of production planning is running the MPS and MRP system. The main purpose of the system is to forecast the quantity of all kinds of production materials related to the quantity of products to be made. Planning and decisions taken by PPIC are based on existing reports in the main application combined with the calculations performed using spreadsheet excel. The number of reports used as references for making decision in PPIC relates to the duration. It means that the large number of sources will result in the longer time to take decisions.

Moreover, the changes can occur suddenly because the management does not have accurate data.

Information for business can be provided by the

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construction of data warehouse [1]. Data warehouse can be said as consistent data. Therefore, it serves as a data provider of decision support systems and company information [2]. The data warehouse provides relevant information to management and executives for making decisions. The data warehouse application can also display reports quickly and precisely [3]. Data warehouse can assist the management in analyzing the existing conditions in the long period of time, because the data warehouse can hold historical data so that the management can see trends that occur from time to time.

By utilizing the dashboard application, the management can easily see the conditions that exist in the organization, which are presented in graphical forms [4]. A good performance measurement tool is needed to provide a structured way to gain an insight in inventory management's business processes by monitoring relevant metrics. Such a tool would also complement existing Business Intelligence literature [5].

DVL started to build a data warehouse to support the report and also used as a business analysis tool since 2015. First, DVL built a data warehouse in the sales for monitoring of sales performance using Kimball model.

Many organizations need to create data warehouse to collect the massive data time-series that can be used for decision support. These organizations face a range of choices, both in terms of software tools and development approaches. Making good choices requires an understanding of two main data warehouse models, Inmon's and Kimball's [6]. The main reason DVL uses Kimball because they want to build from the smallest division; they start from request of management team.

This is different from Inmon's model which populated partially to known requirement of data warehouse [7]. By centralizing the source data, this research is expected to be one of the solutions so that the reports required by PPIC can be drawn quickly and dynamically.

The successful enterprise solutions and business intelligence data warehouse is implemented in many areas [7]-[10].

II. Related Work

II.1. Material Requirement Planning

Material requirement planning (MRP) is a computer-based information system designed to order and schedule the requests of raw materials, components and sub-assemblies in a coordinated way. However, MRP has to determine and support the needs of the master production schedule, control supply, production scheduling, maintaining the schedule.

The objective of the MRP system is to control the level of inventory, to determine the priority items, and to plan the capacity for changing the production system.

Generally, the purposes of inventory management by using the MRP system are similar to those of other systems, namely: improving service to customers, minimizing inventory investment, and maximizing operating efficiency.

Figure 1 shows the MRP structure which describes a plan coming from several sources such as the company's orders, product planning generated by meeting management, and planning based by market demand. That plan will be discussed at marketing department and production meeting. This meeting will produce an MPS (master production schedule). It will be conducted every year, month or if there are sudden changes made by management.

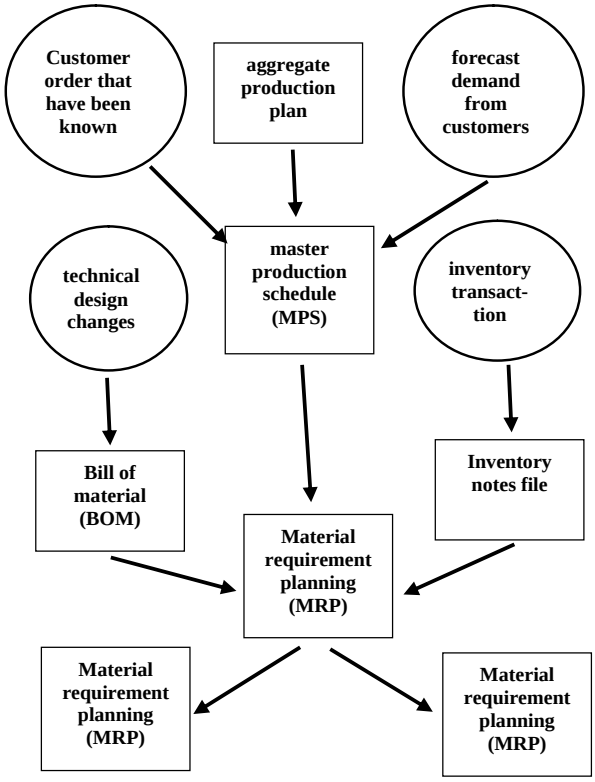

Fig. 1. MRP structure

II.2. Data Warehouse

According to Kimball and Ross [9], database management system is a computer application whose main objective is to save the retrieved data, and to modify data in a very structured way. Usually, data within the database management system (DBMS)is mutually shared with the application. A data warehouse can be built using a top-down approach, a bottom up approach, or a combination of both. The top-down approach starts with overall design and planning. It is useful in cases where the technology is mature and well known, and where the business problems that must be solved are clear and well understood. The bottom-up approach starts with experiments and prototypes. This is useful in the early stage of business modeling and technology development [10].

Currently, data warehouse is typically not only designed for efficient processing of read analysis queries over large data, allowing only offline updates at night, but it must also support the increasing demands for the

latest versions of the data. In other words, the current data warehouse must be close to real time [11].

The data warehouse is a decision support system in which the data warehouse plays an important role in decisions made by the executive [12], [13]. Building a data warehouse is inseparable from a process called ETL (extraction, transformation, and loading). ETL is not a one-time event. As data sources change, the data warehouse house will periodically update. ETL process must be designed for ease of modification [14]. Figure 2 shows the data warehouse architecture which consists of some parts. Operational source system (OSS) is the storage of all transaction data from a business application. It needs good processing capabilities and the availability of a reliable system. The transaction data is processed (extract) into the data staging. A process inside data staging area (DSA) is a process often known as ETL. In addition, the process also requires a temporary storage medium when the data is processed and before it is loaded into the next components. Data Presentation Area (DSP) is a place where the data has in aggregation with ETL process running in query of analysis process.

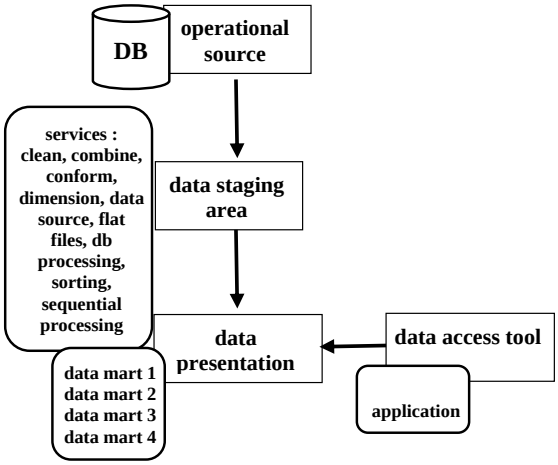

Fig. 2. Data Warehouse Architecture

The model used in the DSP model is different from the data in the OSS, where the model used is not third normal-dimensional model of the form (3NF). According to Kimball, building a data warehouse must pass through nine steps called nine-step methodology. The nine stages are: choosing the process, choosing the grain, identifying, and conforming to the dimensions, choosing the fact, storing pre-calculations in the fact table, rounding out the dimension table, deciding the duration of the database, tracking slowly changing dimensions, deciding the query priorities and the query models.

III. System Implementation

The method in this study consists of some steps: (1) Requirement analysis with data and information collection through interviews and observations of the system information that is currently running as well as operational databases used. Requirement analysis is one of the important tasks to ensure successful data warehouse project. It collects and restructures base information that establishes data warehouse design and development of front end application [15]; (2) an analysis of the information needs to be presented to the management; (3) designing the data warehouse using a dimensional approach (Kimball). The information on dashboard is generated by data warehouse using Datazen server and Datazen publisher. The nine-step of Kimball to construct data warehouse in this company is conducted in the following steps:

a. Choosing the Process

This phase will be the source of the measurement determination of the subject of the problems being faced.

By observation of operational process analysis, there are several processes found, such as: monitoring stock, input yearly rolling forecast, input monthly rolling forecast, monitoring of production lead time. Monitoring stock can be called by record inventory transaction, involving received product, placing product into inspection hold, releasing product from inspection hold, placing product in bin, until releasing product from warehouse [16].

b. Choosing the Grain

This phase determines the existing record in the fact table. Once determined grain fact tables can be found, the dimension possessed by each table can be identified. Grain gained in the design of data warehouse includes: (1) balanced inventory: product, warehouse, batch, time, type, quantity. (2) production lead time: product, batch, duration. (3) rolling forecast monthly: product, month, year, quantity. (4) rolling yearly forecast: product in quantity.

c. Identifying and Conforming the Dimension

This phase makes a set of dimensions required to answer all questions in the fact table. This phase identifies the dimensions in detail to describe something.

This identification needs several dimensions such as date, product, warehouse, transaction type, BOM, and BOO (Table I).

TABLE I
LIST OF DIMENSION

Dimension	Table name	Description
Date	_dimDate	Time describe date, month, quarter, and year
Product	*dim*Product	Item relation
Warehouse	_dimWarehouse	Storage
Transtype	_dimTransType	Condition type product in inventory
BOM	_dimBOM	List of material making up the product
BOO	_dimBOO	List of process making up the product

d. Choosing the Fact

This phase creates the fact table according to the process analyzed and selected grain.

Each fact has data that can be calculated and then displayed as reports, charts, and diagrams. The following facts can be seen in Table II.

TABLE II
LIST OF FACT

Fact Table	Description
_factInventoryBalanced	Noted product inventory summary and detail report
_factProductionLeadtime	Noted the completion of the manufacture of products in each batch that is being made in accordance with the process, so that the data can be drawn lead time per product
_factRollingForecastMonthly	Forecast data record / ROFO agreed by management and marketing according to the ability of warehouse for 1 year
factRollingForecastYearly	Forecast data record / ROFO agreed by management and marketing according to the ability of warehouse for a month

e. Stooring Pre-Calculation in the Fact Table

In this phase, the fact table must be re-examined to create custom column which requires a calculation. Here is the pre-calculation of the table facts:

(1) *_factInventoryBalanced*: total quantity of existing products in warehouse.
(2) *_factProductionLEadtime*: the number of days in completing the first batch process.
(3) *_factRollingForecastYearly*: the number of product production planning quantity.
(4) *_factRollingForecastMonthly*: the number of product production planning quantity.

f. Rounding Out the Dimensions Table

In this phase, the dimension table is re-examined and the hierarchy of dimension attributes is determined to simplify the analysis process.

This phase covers information such as a list of descriptions of the dimension tables and the list of tables.

Figure 3 details the product dimension tables.

g. Choosing the Duration of Database

The data warehouse is fed by operational database in the last five years as seen Table III. This data can be achieved from application of EXACT.

h. Tracking Slowly Changing Dimension

This scheme uses slowly changing dimension (SCD) type two. If the data changes or updated, the new one becomes a new record on table in data warehouse. So, the old data is still there on table as history.

Table IV shows SCD in Products table.

i. Deciding Query Priorities and the Query Models

In this phase, the process ETL predetermines time of withdrawal. Every dimension and fact table has different time in withdrawing data from the operational database 404 EXACTas can be seen in Table V.

Column Name	Data Type	Allow Nulls
ProductKey	int	☐
ProductID	varchar(30)	☐
ProductName	varchar(200)	☑
ProductCost	float	☑
ProductPrice	float	☑
ProductTypeCode	varchar(30)	☑
ProductTypeName	varchar(100)	☑
ProductBufferQuantity	int	☑
ProductBatchQuantity	int	☑
ProductMinOrder	int	☑
ProductProductionLea...	int	☑
ProductOrderLeadtime	int	☑
ProductClass	varchar(10)	☑
ProductUOM	varchar(10)	☑
ProductStartDate	datetime	☑
ProductEndDate	datetime	☑
ProductStatus	varchar(10)	☑
		☐

Fig. 3. Product Dimension Detail

TABLE III
DURATION OF DATABASE

App	Db	Year	Will Fed	In Db
EXACT	404	2010	Jan 2010 – Feb 2016	5 Years

TABLE IV
LIST OF DIMENSION

Attribute	SCD Type
ProductKey	-
ProductID	-
ProductName	Type 2
ProductCost	Type 2
ProductPrice	Type 2
ProductTypeCode	Type 2
ProductTypeName	Type 2
ProductBufferQuantity	Type 2
ProductBatchQuantity	Type 2
ProductMinOrder	Type 2
ProductLeadtime	Type 2
ProductClass	-
ProductUOM	-
ProductStartDate	-
ProductEndDate	-
ProductStatus	-

TABLE V
LIST OF TIME SCHEDULE

Table name	Time	Period
_dimProduct	02:00	1 days
_dimWarehouse	02:00	1 days
_dimTranstype	1 once	1 once
_dimDate	02:00	1 days
_dimBOO	03:00	1 days
_dimBOM	03:00	1 days
_factRollingForecastMonthly	04:00	1 Month
_factRollingForecastYearly	04:00	1 Year
_factProductionLeadtime	04:00	1 days
_factInvBalanced	04:00	1 days

IV. Analysis Results

IV.1. Extract, Transform, Load (ETL)

ETL system, more than any other part of the data warehouse edifice, is a legacy system that needs to be maintainable and scalable over long periods of time [17].

ETL is one of keys of success to build data warehouse. The required data is currently extracted from operational database to the staging table on data warehouse. It was followed by a process of transformation from entity table to the entity data warehouse.

The process transformation might have some types. The types include copy, insertion, calculation automatically removing, etc. This phase must provide the entity data warehouse which is from the operational data.

Figure 4 shows that the ETL processes extracted data from tables EXACT toward *_dimProduct* table through a transformation process that is done in the table *_stgDimProduct.*

Figure 5 shows the detailed process of data extraction which occured. Data are drawn still in the form on operational standards.

Figure 6 shows the process of mapping source fields with fields of *_stgDimProduct*. Figure 7 shows a process of transformation and loading are carried from table to table *_dimProduct* staging*_stgDimProduct*heading through the process of slowly changing dimension.

Figure 8 shows the ETL process of*_dimProduct* table at run time.

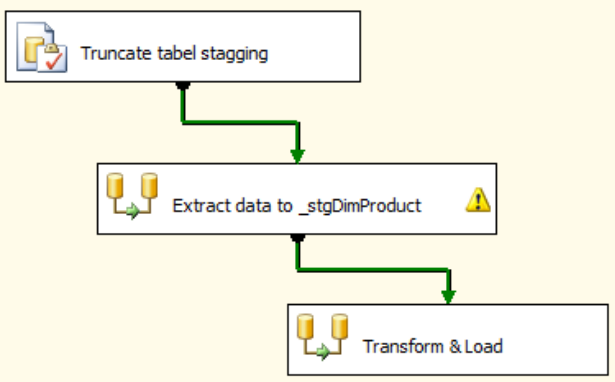

Fig. 4. ETL Product dimension Process

Fig. 5. Extraction Staging Product Dimension

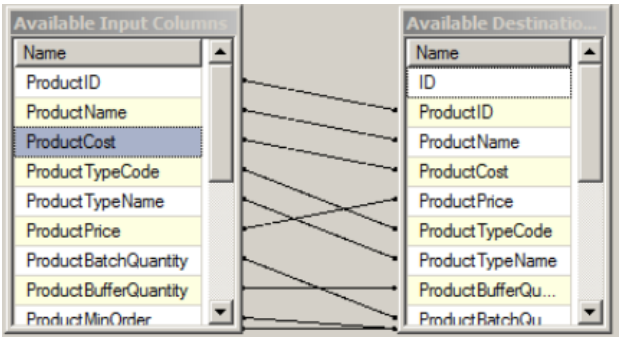

Fig. 6. Mapping Staging product dimension

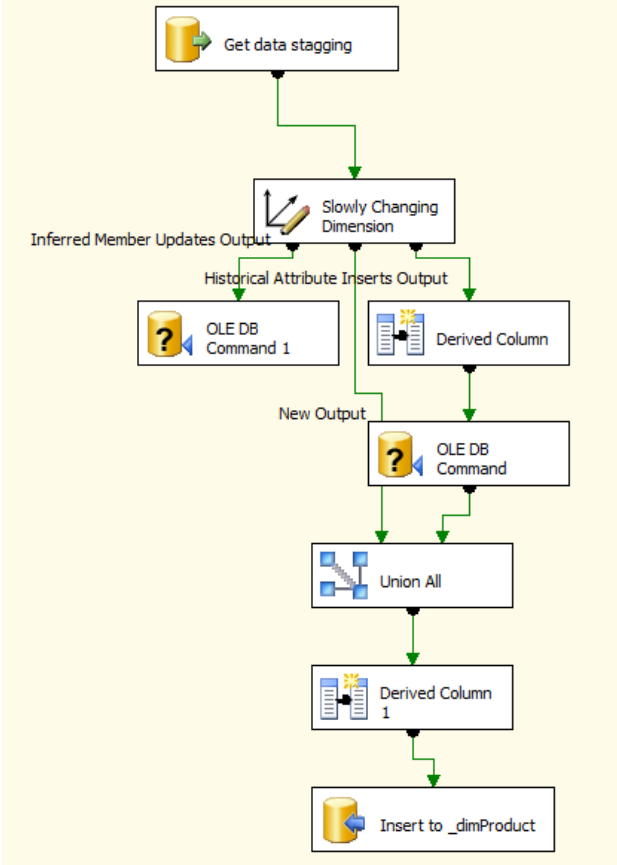

Fig. 7. Transform and Load Process Product Dimension

Fig. 8. Product Dimension ETL When Run

IV.2. Data Backup, Security, Storage Analysis

For security reason, backup data is done on two models. The first backup is carried out by internal IT daily and weekly. The second one is carried by vendor monthly. Daily backup is performed every completed hour of work and stored on DVD or external hard drive.

Security of data and information to be presented is very important not only for inter-company but also for all divisions which have the opened report. Therefore, granting access of each user is very necessary. It is supported by the configuration dashboard in *Datazen*.

In the process of OLTP, storage capacity is a major problem that must be considered. Process insert, update, and delete will affect the growth of data. To determine the amount of storage capacity, an analysis is carried out to identify the storage capacity required. Moreover, this

issue becomes more serious since nowadays the data can be stored via multi platform and multiuser [18]. The formula uses in the calculation of the storage requirements of records in *SQL Server 2005* (SQL Server books online). This formula is used by the fact *_factInvBalanced*:

Total storage of fact and dimension tables can be seen in Table VI. The table shows that the most active table is _factInvBalanced and _factRollingForecastMonthly, because two of the table have the highest number of records. It means the transactions in this table is so many.

TABLE VI
STORAGE SIZE ANALYSIS

Table name	Byte	Total Record 1 Year	Total Record 5 Year	Size (Mb)
_factInvBalanced	324	30420	201092	64.5
_factProductionLeadtime	58	3564	19959	1.5
_factRollingFOrecastMonthly	104	9804	54903	5.7
_factRollingForecastYearly	100	151	864	0.1
_dimProduct	430	635	1016	0.5
_dimWarehouse	1902	72	116	3.05
_dimBOM	86	3321	5314	0.78
_dimBOO	86	555	888	0.09

IV.3. Process Comparison

The analysis are conducted to compare the currently running processes with the process which occurs using the data warehouse.

Figure 9 shows that the process that occurs when using applications was 5 step process consisting of: process taking the required template from the application EXACT PPIC, MPS forecast process for the next month, uploading process template that has been filled with the results forecast application into an EXACT, generating process uploaded on the app uploaded EXACT order forecast to run, and also opening the MPS MRP report.

However, Figure 9 shows the process that occurs when using a data warehouse system: forecast Process with existing template, upload process template that has been filled with the forecast, open the dashboard PPIC.

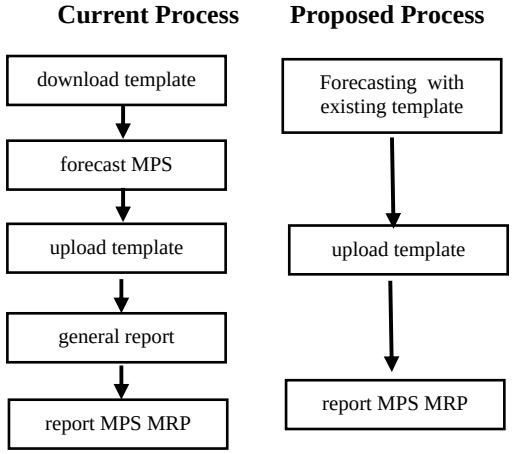

Fig. 9. Comparison Upload Process

By minimizing the existing process in MPS forecast PPC uploading process can be faster in monitoring the production process, especially in the manufacture of products.

V. Conclusion

Data presented in several dimensions is related to the issue of stock items. So, the calculation and planning of manufacture of products made by PPIC can be monitored properly. The data is shown in graphs and tables, thus helping PPIC and also the DVL management team read information for analysis. Changes in product manufacturing planning which often become a case can be solved because the data changes can be seen on the dashboard. So, it can help PPIC analyze and take decisions quickly and re-upload to the system faster.

For future development, based on this data warehouse system, executive information system (EIS), decision support system (DSS), or data mining can be created to facilitate the management in analyzing the data more deeply, taking decisions, and performing a wide range of predictions that are beneficial to the company. Further research should take into account other dimensions related to the stock and manufacture of items such as the working time of employees and the capacity of machines to forecast accurately.

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