

DECISION SUPPORT BASED ON DATA FROM INTEGRATED MANUFACTURING SYSTEMS

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Abstract: All kind of decision is based on data. Manufacturing enterprises uses integrated systems for day to day transactions and data storage. The way this data is stored do not favor an integrated enterprise analyses. This work goal is to present a Data Warehouse environment reference to integrate data from different modules used in manufacturing enterprises supported by integrated manufacturing systems (called ERP – Enterprise Resources Planning). This environment aggregates some Data Marts that focus in specific subjects. It will be presented some Data Mart proposals for subjects like sales, production and quality; and its utilization in related decision.

Keywords. Production management, decision support, systems integration.

1. Introduction

Decision making is an important factor for competitiveness and survival of a company. According to Gomes et all (2002), decision is a process of choice between alternatives. All functions and processes of a company involve decisions. Production management process, like others, needs information from diverse areas, as the proper production, finances, sales, quality control and product design. Traditionally, each sector is owner of its information, which is restricted to its environment and systems, making it difficult to another sectors access this information (Favaretto, 2001). For this reason decisions are made on the basis of a limited vision of the situation due to limitation in accessing the information.

Between others processes of a company, those related with production management, costs management and financial can be highlighted. The information systems named ERP (Enterprise Resources Planning), that are used in the operational support of these processes, do not collaborate with data integration from different areas or modules (Correa et all, 2001). Miele and Takahashi (2002), affirm that the knowledge (and information) management still is not used strategically by the companies as a form of competitive differential. Second Han and Kamber (2001), there exists a great amount of available data, however it is not transformed into useful information.

This work is a reference that companies can follow to integrate data from different systems and modules, supplying important information support to the decision making process.

ERP systems are called *transactional* (Han and Kamber, 2001); because they are developed specifically to process transactions, as the processing of an invoice or a production order release. The data generated and used for these systems are stored in specific tables for each system or module, and are of difficult access for other systems. As example, the function of production planning could use detailed information about customers to define production priorities; however this information usually is confined to sales departments systems. For reasons like this the availability of integrated information is limited.

Inmon et all (2001) affirms that the environment created by the use of *Data Warehouse* technology enable the companies to integrate data from diverse systems and distinct modules creating business opportunities from its usage. The same author places as advantage of this technology the fact of the final users are able to configure specific query, through a friendly interface.

According to Machado (2000), there is a process of *Data Warehousing*, being the data integration a basic stage of this process. In this process a storage environment of these integrated data is constructed, that allows transactional systems (like ERP systems) keep its routine operations without performance damage.

The objective of this work is to propose a reference for data integration proceeding from ERP systems, using the technology of Data Warehouse. This reference will explore the main data sets of transactional environment, the integration possibilities of these data and the results that may be achieved with this. Finishing, it will be indicated how this environment can help decision making in different areas.

The structure of this work is now presented. After this introduction it will be presented the necessary concepts for the development of the research. Later, a presentation of the current situation will be made, and then the exploration of some possibilities. Finishing some conclusions on using the environment of Data Warehouse together with manufacturing integrated systems mainly ERP systems.

2. Concepts

According to Gomes and Braga (2001), *data* are basic and quantitative information, comments of facts generally occurred, as for example, the initial time of a specific production operation or the number of units resultant of this. *Information* is organized data in a significant way, being a useful subsidy to decision making. *Intelligence* (or knowledge) is the information that makes possible the executive to take a decision. Making an analogy, the data are the base of a pyramid, and intelligence is the top. In the middle there is information.

ERP systems and other transactional systems work with data, which are stored as they had been collected, in a detailed way. The widest technology used for this storage is called *relational data bases*, where the relations between data sets (called *entities*) are modeled. This technology is known in most of the companies, and also used in lots of available applications.

This relational environment uses a specific language for queries realization, called SQL (Structured Query Language), and allows the query under a condition of specific fields (attributes) from a data base, as example all products bought from a specific supplier. This language is useful for day to day queries. It fails to take care of specific analysis and in aggregation and integration of information for decision support. Moreover, it requires specific knowledge, which overloads the IT (Information Technology) specialists of the company (Kimball, 1998).

In accordance with Han and Kamber (2001), a *data cube* allows data modeling and seeing in multiple dimensions. In general terms, *dimensions* are the perspectives or entities on which the company wants to keep information. As examples, dimensions can be relative to products, suppliers, materials, time and others. The dimensions have *attributes* (fields). Obligatorily each dimension has a *key attribute* which allows distinguishing an occurrence (register) of a dimension from others occurrences.

Each dimension must have an associated table, called *dimension table*. For example, a *products* table dimension can have attributes like: description, type, production place and packing type.

A dimensional model typically is organized around a central subject (Kimball, 1998; Han and Kamber, 2001), named *fact*. Sales or production can be facts. Facts are analyzed by numerical measures, as sales amount in monetary units or number of produced units. It allows analyses between the dimensions. One *fact table* contains measures that will be analyzed and keys for identification of respective dimensions. Despite this structure being called *cube*, model construction is possible in *n*-dimensions, called multidimensional or simply dimensional. This situation can be seen in the Fig (1).

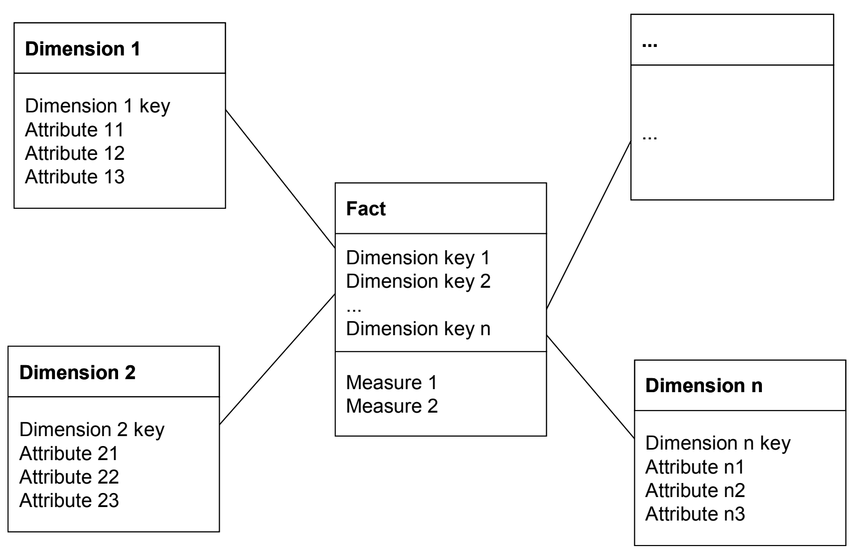

Figure 1. General aspect of a dimensional model.

When related to specific aspects of a company, as sales, production, maintenance and others, the development of these models is called *Data Mart* (Inmon, 2001).

A set of Data Marts forms an environment of Date Warehouse. According to Machado (2000), this environment is a warehouse of historical data, whose purpose is to present information that allow analyzing metrics (measures) and its evolution in time. Moreover, development and implementation of this environment involve data integration from diverse sources and its transformation in consistent information, to its posterior utilization in decision making by final users (Campos and Borges, 2002).

Information about dimensions is stored for some years in a Data Warehouse, enabling users to discover behavior standards. Some operations can be performed in this environment. *Drill Down* and *Roll Up* operations can change our data vision in hierarchic levels of a dimension. *Slice* and *Dice* operations navigate through dimensions of a cube.

Data Warehouse is an output of a *Data Warehousing Process*. This process has some steps. First of them is dimensional modeling, like presented. Next step is to find where each required data is stored, probably in sparse data base used in ERP systems and other information systems. Usually this data is not in the same basis like produced units per weeks and sold units per day. Because of this is necessary to transform, clean and integrate this data that is now ready to populate Data Warehouse. Another step is to create some views of entire Data Warehouse, named *Data Marts.* Finally a friendly environment where final user can make OLAP queries is created to finish the process. This can be seen in Fig. (2).

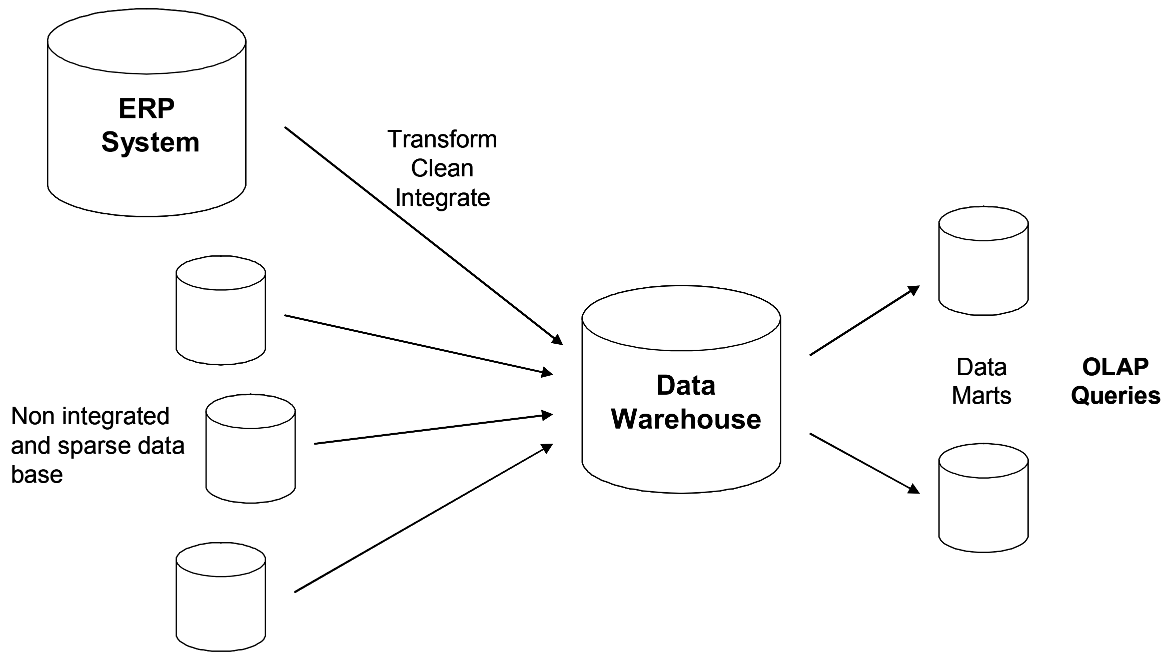

Figure 2. Data Warehousing process.

3. Description of current situation

In accordance with Schroeck et all (2002), currently exists many companies who had invested great amounts in ERP solutions and are frustrated with the lack of ability of these systems to supply timely integrated information. In accordance with the authors, the great number of ERP systems implantations is due to the following factors:

- To be immune to millennium bug.
- The adoption of processes orientation as a strategy imperative, due to reengineering.
- The technical and functional advance made by the main suppliers of ERP systems.

Wyderka (2000) affirms that some necessities of the companies had been attended, but not all. Although ERP systems are good to data capture and to store, they possess limited functionalities to make analyses and reports of these data. Users are continuously looking forms to extract information. The focus of these systems is day to day queries and transactions.

Managers of a specific area have information availability only from his area, what limits their decisions. For example, deciding which is the best tool to process an operation, there is not access to this operation income with different types of tools and the set up cost.

Companies needs to complement ERP systems reports with integrated information from diverse systems, and also integrated with external systems. Moreover, it is necessary a friendly interface and usage for the final user. To a large extent of companies, the development of a specific report is a work for specialized teams, what demand some days or weeks. Many times, the user needs this information quickly and cannot wait more than some minutes to get it. An environment of Date Warehouse can help in this situation.

It must be clarified that the use of this environment does not damage the use and performance of ERP systems. This is because Data Warehouse makes a data extraction and summarization; and stores the result in independent tables creating a redundancy. This generates an extra volume of data to be stored but the performance of ERP system is kept and also a good query performance is obtained at the Data Warehouse environment.

4. Possibilities

Some possibilities of using Data Warehouse together with ERP systems will be explored in this topic. The dimensions and facts of each one of these possibilities will be presented. Also a localization of the main related decisions will be made. All presented cases uses the dimension *time*, enabling users to analyze the evolution of any dimension in relation to time.

4.1. Sales Data Mart

This is a classic construction, present in almost all examples found in literature. One Sales Date Mart will be presented, considered by Kimball (1998).

The fact analyzed here is *sales amount* expressed in the following measures: units sold, income and cost. Time dimension can have the attributes day, week, month and year. This indicates that the research of other dimensions across the time will be made in the base of these attributes, or daily, weekly, monthly and annual. Other attributes can be used, depending on the utility, as day of the week, number of the week in the year, quarter and others.

Another dimension for this Data Mart is *product*. Main suggested attributes are: description, trade, category and department.

Complementing the Kimball (1998) example, dimension *points of sales* is added, with attributes like address, city, state, region and country.

Finishing we have a dimension related to *promotion*. In this dimension we have some attributes like: promotion's name, announcement type and media. The dimensional model of this Data Mart is seen in the Fig. (3).

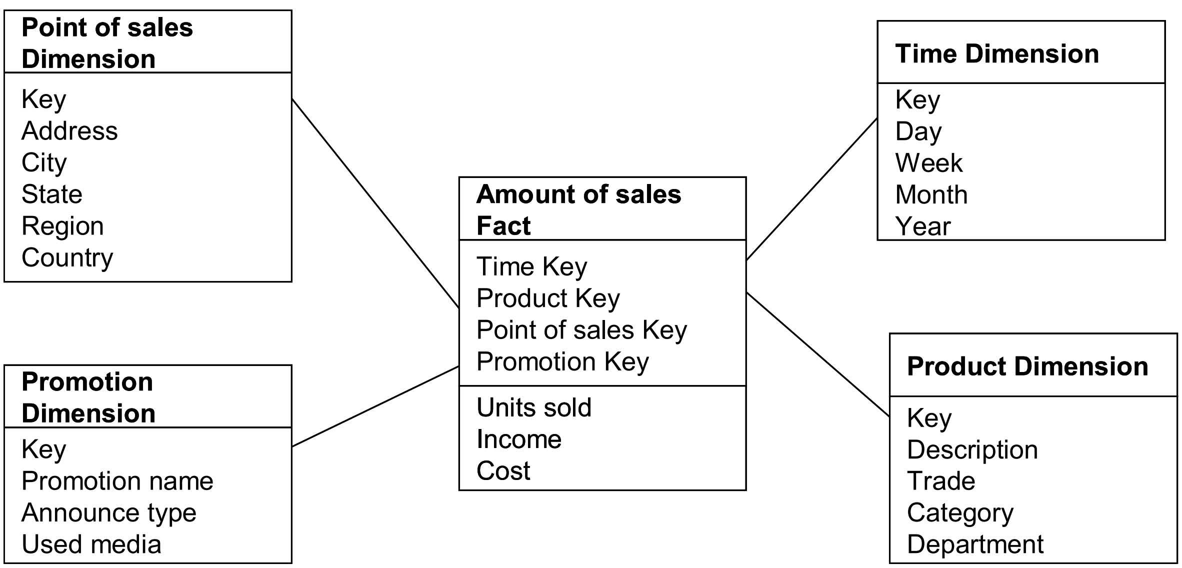

Figure 3. Sales Data Mart dimensional model.

With these dimensions, following queries can be made for example:

- Which is the sales amount of determined product, in determined city, in a specific month of the year?
- How many units of a product type had been sold in a specific promotion, in determined region between the two first weeks of a year?
- Which is the product promotion cost?

As it can be seen, crossing between dimensions is free, and has the goal to enable wider analyses than those carried through on the basis of standardized reports.

Beyond the presented dimensions, others can be added, like transports, salesmen and customers. This will enable making analysis in a bigger number of dimensions, extending the range of related decisions.

This Data Mart can support decision processes in diverse areas beyond sales, for example:

- Production - identifying some products seasonality, for consideration in production planning, purchases and supplies.

- Logistic - identifying which states of the country have bigger delivery volume, creating specific channels for these states.
- Marketing - which promotions that had given better results and which cities that need new promotion strategies.

4.2. Production Data Mart

In this Data Mart, the fact to be analyzed is *production*, analyzed under the measures of produced units, spent time with production activities and these activities cost. Users of this *Data Mart* are production and industrial managers, beyond people from financial and controlling areas.

For time dimension the same previous considerations can be made. Also the same *product* dimension presented previously can be used, with the attributes: description, trade, category and department.

An interesting dimension to be added is related to *resources*. Possible attributes can be resource type (equipment, tool, and transport), resource subtype (cut, finishing and weld equipments for example) and resource localization on shop floor. These dimensions can help productivity and cost analysis.

Another dimension that can be used is related to *production orders*. The attributes that can be used are: release date, planned finish date and real finish date of an order. This dimension can help in total cost of a production order queries and how many products had been produced related to released orders in the last month.

The *customer order* dimension can be added with attributes like customer, order priority, value category (small, medium or great value orders) and order urgency (urgent or normal). Some queries that can be made with these dimensions are related to monthly production cost of urgent orders or low value orders. In Fig. (4) the Production Data Mart dimensional model is presented.

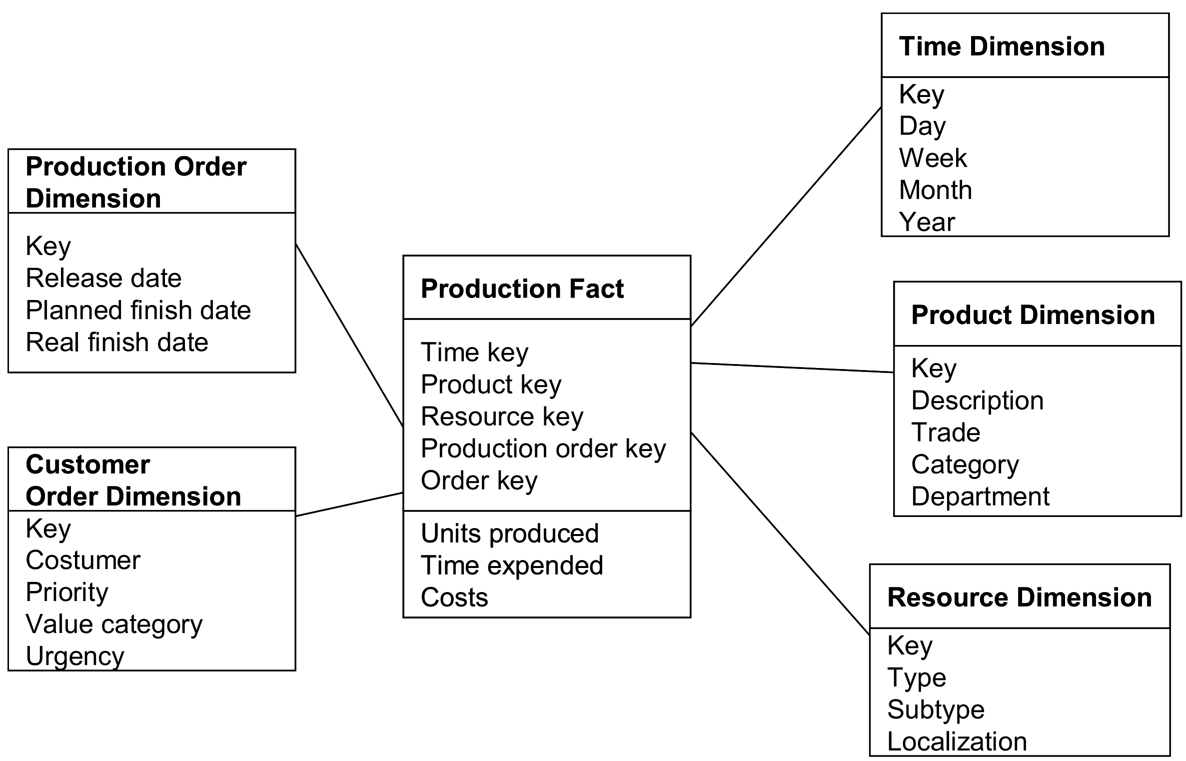

Figure 4. Production Data Mart dimensional model.

Crossing dimensions, the following research can be made:

- Which is the weekly spent time in production equipments to produce urgent orders?
- Which is the cost of monthly production related to specific equipment in processing orders from a specific customer?
- How many units are annually produced to customers with great priority in resources located in specific localization?

These are only few of possible crossings. Other dimensions could be added, like workers and materials.

This Data Mart can support decisions of other sectors beyond those directly related to logistic and production. They are:

- Sales - with the analysis of *customer order* dimension is possible to trace different strategies for different customers, as well as different procedures for different orders priority can be made.
- Maintenance - tracking the use of resources related to products categories, to establish different maintenance programs.
- Finances and controlling - to evaluate production costs in function of other dimensions.

An observation that must be made in relation to this Data Mart is about data generation and collection. Some companies experience problems with production control data collection, because it is made using manual appointments that must be typed in a system, being exposed to errors and imprecision (Favaretto, 2002).

4.3. Quality Data Mart

Aspects of quality will be analyzed in this Data Mart. The fact is *Non Conformity* (NC) related to number and cost of occurrences of NC.

Time dimension also must be present, and previously presented attributes can be kept.

Another dimension to be used is *NC code*. It is usual that companies use codes to express one specific type of non conformity, also using significant digits (as in group technology). The attributes of this dimension can be: non conformity category (rework, scrap and devolution), code group (finishing, project or raw material non conformity, for example) and a code specification. This dimension helps Drill down and Roll up queries.

The dimension *place* also must be used, to track non conformities occurrences in specific places of the company. It also will allow Drill down and Roll up analyses. The attributes can establish a hierarchy of these places, and can be the following ones: plant, department, sector, line and equipment. In this way it will be possible to know the number and the cost of occurrences of non conformity for each place.

The dimension non conformity *event* also can be used, supplying useful possibilities of research. The key of this dimension can be a sequential and unique number, generated automatically for each event. Attributes of this dimension can be: NC generation date, NC detection date, NC generation operation, NC detection operation, NC responsible and part where NC had occurred.

Dimension *worker* can be added, with attributes like: worker identification (key) and work shift. Fig. (5) below presents Quality Data Mart dimensional model.

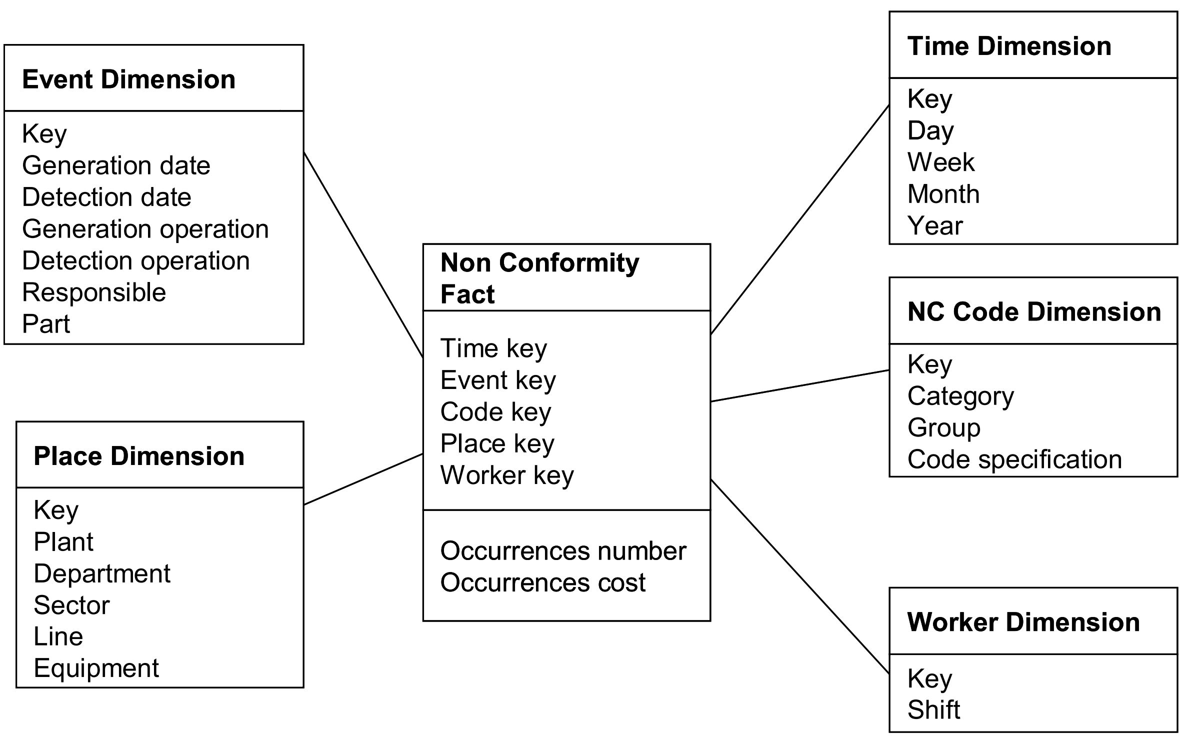

Figure 5. Quality Data Mart dimensional model.

Possible queries in this Data Mart are:

- Equipment that generates great number of NC throughout one month.

- Which NC (using its code) that are causing big monthly costs?
- Which products and workers who cause greater NC generation?

This kind of information is useful for areas like quality management, production planning, technical assistance, maintenance management, product design, human resources department and purchases. Related decisions to this information are innumerable inside a company.

4.4. Other Data Marts

Besides presented Data Marts, others can be used, like the following:

- *Logistic*. This Data Mart can be related with measures like the number of logistic occurrences (internal deliveries, transports, storage and others), cost and time expended in this occurrences. Some possible dimensions are: time, product, modal (transport type), customer and service provider. It can be used by the logistic, production planning and sales areas.
- *Project management*. This Data Mart can be useful for diverse areas of the company that manage projects, as example product design, Information Technology service provider, quality improvement programs and others. Measure used is the number of projects, and some possible dimensions are: time, project *status*, company area, project type and project responsible.
- *Engineering change management*. This Data Mart is related to all changes related to engineering (product design, process planning and others). Used measure is number of changes. Some dimensions are: time, change type, treatment, area, reason, responsible and product.

5. Conclusions

The main conclusion of this work is that Data Warehouse environment can help the information needs for decision support, when using integrated data from ERP systems.

This environment construction enables efficient decisions in a integrated manufacturing systems environment. Beyond analytical information directly gotten from transactional systems, complementary information can be used from queries in Data Marts.

This can lead to a *cockpit* development that would be an environment where managers (from any sector or hierarchic level) have immediate access to important information for supporting decision making.

According to Schroeck et al. (2002), development of new ERP systems modules have increased the users demand for fast integrated data access. This also favors using Data Warehouse environments.

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