INSTITUTO POLITÉCNICO
DE VIANA DO CASTELO

KEY PERFORMANCE INDICATORS IN A HIGH EDUCATIONAL INSTITUTION: A BUSINESS INTELLIGENCE APPROACH

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I dedicate this project to my parents, to my relatives, to my friends.

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Abstract

Nowadays it is impossible for organizations to perform business activities without using the Information and Communication Technologies (ICT), which includes computers, networks hardware and applications. Usually organizations use applications to perform their business processes storing daily transactional data related to products, customers and other entities into operational databases. Operational databases are embedded into applications in order to provide to users mechanisms to analyze data and get reports from different points of view. On the other hand, there is an increasing amount of data stored in operational databases, which can be used in analytical reports in order to help managers in decision making activities. In this context, it is important for organizations to evaluate if their applications work well and answer to the business requirements, as well as control all business processes in all organization´s levels, namely, produce reliable and high quality products, increase customers' satisfaction, improve application performances and the quality of services provided to costumers and collaborators. For this purpose, organizations have the opportunity to comply with ISO (International Organization of Standards) requirements, guidelines and instructions in order to improve quality of processes, and then achieve the Quality Management System (QMS) in different levels of the organization.

In order to improve business performances in enterprises, decision makers define key performance indicators (KPI) for all (or some) business processes, which are based according to their strategies and goals, to evaluate, control and monitor services in order to improve business activities. For this purpose, Business Intelligence (BI) system demonstrates to be a possible solution to achieve this issue, allowing to integrate all enterprise operational data into a single data repository, get analytical data and generate reports. In general, a BI application is a meta-data driving tool, which has the capability to extract data from different systems and store them into a data repository (also called a data warehouse). It gives the opportunity to gather, store, filter and analyze huge volumes of data, providing to access historical data and develop set of reports in a quick and easy manner in order to support decision making activities.

During the last years there are many examples of the application of BI systems in different types of organizations. BI systems can also be used in educational institutions. Applying BI in educational institutions gives the opportunity to integrate all

data of educational processes into data warehouses, from where it is possible to deliver KPI reports for decision makers through the use of Online Analytical Processing tools. In this context, this project focuses to apply BI systems in a Quality Management System (ISO 9001 Standard) implemented in a high educational institution (Polytechnic Institute of Viana do Castelo), with the objective to provide analytical tools to decision makers in order to evaluate, control, monitor and improve educational performances in all levels of the institution. With this work we have developed a BI application to provide IPVC decision makers with management tools to analyze data from QMS and get KPI reports with the purpose to satisfy the needs and expectations of IPVC managers.

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Abbreviations

BI	Business Intelligence
DI	Data Integration
DW	Data Warehouse
EDW	Education Data Warehouse
EDW	Enterprise Data Warehouse
IS	Information Systems
IT	Information Technology
IPVC	Viana do Castelo Politechnic Institute
ISO	International Organization for Standards
KPI	Key Performance Indicators
MDX	Multidimensional Expression
OLAP	Online Analytical Processes
OLTP	Online Transactional Processes
RDMS	Relational Database Management Systems
SSIS	SQL Server Data Integration Service
UDM	Unified Dimensional Model

Chapter 1 – Introduction

1.1 Background

Nowadays, we live in an information age where huge volumes of information are stored around us and we have to choose from mountains of data to produce useful information. Very often we have difficulties to find and choose the right information, losing resources and a lot of time filtering and sorting data in order to find the right one from the huge of data volumes which are collected and produced by organizations. People waste a tremendous amount of time trying to find and sort through the information in order to perform their tasks. According to Forrester Consulting research [1 p. 23], "office workers spend 42% on working on information and 58% using the information making reports and analyzing".

Indeed, the data produced and stored by enterprises increases overtime as a result of their internal and external processes, which are related to their products and customers services. In this context, organizations have the objective to reduce the amount of time consumed on searching and sorting through mountains of data and spend more time on analysis and making decisions.

In a competitive environment, organizations need to have the right and on time information in order to be able to get advanced position in the markets. Traditionally, in enterprises, information is located in various internal or external places in different sources and for business people (for example the managers and decision makers), it becomes harder and harder to find the right information, which consumes a lot of time and energy. In this context, Business Intelligence (BI) Systems are used to overcome these difficulties, since they enable to get quickly needed information by transforming mountain of data into meaningful, useful and insightful information, which will help to meet business requirements to make real time decisions. In recent years, demands for BI systems are increasing in enterprises. BI systems begin to rise due to the increasing data volumes, the growing of complex business operations, the necessity to generate reports with increasing complexity and the need to answer to complex regulatory and general report requirements. Furthermore, most of enterprises have to comply with rules and implement BI tools to ensure legal compliance [1 p. 5].

On the other hand, enterprises need to implement quality management system (QMS) in order to improve and control all processes in the organization that will help to monitor and evaluate business operations and satisfy customers demand. Using the QMS, organizations manage their work in a systematic manner, where all activities are documented in accordance with the written manuals, procedures, instruction, specification and forms, which help to determine whether prescribed activities are accomplished successfully. QMS stores large volumes of information related to products and services that can be used to monitor the performance of the services and define actions to improve the performance, efficiency and accuracy of services. Decision makers have the necessity to have access to performance indicators to control and evaluate business processes. To access to the set of indicators about processes, there is a need to concentrate all information into a data repository, from where decision makers should be able to access indicators related to their business processes using simple, fast and easy tools that will help to define strategies and make decisions.

Considering the points mentioned previously in the context of the evaluation and improvement of processes across departments in enterprises, BI solutions reveal to be appropriate solutions. BI applications can be valuable tools to evaluate, monitor, control and audit all organization levels using Key Performance Indicators. Using BI solutions decision makers have the opportunity to access real time information, be provided with high quality reports and to achieve a level of maturity to implement multiple BI projects in the future.

In fact, Business Intelligence requirements are increasing and enterprises are depending on IT staff to fulfill these requirements. They usually depend on IT personnel to get requested BI reports. Business requirements can be inconsistent because they depend on economic impact, regulations and many other factors. Consequently, BI applications and models need to be changed and populated overtime in order to support new type of requirements and make new type of analysis. On other hand, business requirements changes very frequently overtime, and by this fact companies need different kind of management reports to overcome market changes and get advanced position against to competitors. In another point of view, IT staff needs time to develop new type of reports for business, however the managers or decision makers need to get the required report in a very short time, for that reason there is a need of “BI self service

tool"[1 p. 7], which will decrease IT support to a minimum level.

On the other point of view, Business Intelligence (BI) applications are composed by multiple tasks and components such as data integration, modeling, warehousing, OLAP, matrix creation and management, reports, dashboards, queries alerts and many more. When business requirements frequently changes overtime, implementing many component BI projects becomes hard and difficult. In this context, in order to simplify the implementation of BI projects, there is a need to use a kind of BI tool that has the capability to automatically update all dependent components when occurs changes in any single component [2 p. 4] Unfortunately not all BI tools have such kind of automatically components changing capability. According to Forrester [2 pp. 5-6] BI applications are classified into two categories: "first generation metadata-driven BI" and "second generation metadata-data driven BI", where second generation BI systems are improved BI systems, which has agile and self service capability.

1.2 **Problem Description**

The Polytechnic Institute of Viana do Castelo (IPVC) is a high public educational institution providing opportunities for quality training in the human, cultural, scientific and technical sectors. IPVC integrates seven organizational structures, namely, five schools (Education School, Agricultural College, Technology and Management School, Management Sciences School, Health School), Social Services and Central Services.

Recently, the IPVC implemented a quality management system (QMS)[1] in 2009 that allowed to ensure the ISO 9000 certification. QMS is used to perform daily services in the organized manner, covering the activities of the IPVC materialized in many processes, in particular, Academic, Environment, Health and Safety, Social Services, Courses Creation/Restructuration, Training, Economic-financial management, Management of works and Infrastructure, Information Management, Management and Improvement System, Project Management, Information Systems Management, Observatory, Promotion and Image, Human Resources and Technical and Educational Resources.

[1] IPVC-QMS, 2009, Web site that supports the Quality Management System of the Viana do Castelo Polytechnic Institute. Available on: http://www.sgq.ipvc.pt/publico.html

Nowadays, the QMS plays an important role in the management of the IPVC. In fact, the QMS can help managers to perform services effectively, as well as to define actions to improve it. In that context, top managers (and especially QMS managers) have defined a set of key performance indicators (KPI) in order to observe and evaluate all management processes to support decision making activities. The purpose of KPI is to get quantifiable measure, which reflects critical factors of success towards the institution strategy and goals. In the case of IPVC, the defined KPIs comprise the twenty-four processes covered by QMS of the institution departments, which are dispersed geographically. In this sense, IPVC has the need to integrate all data of QMS into one place that will help to define and evaluate institution work and to be eligible to compare current state with their strategies and goals. In fact, integrating all data across all the schools will give the possibility to get valuable information on how the work is performed by IPVC departments. The integration of all data across all the schools to produce KPI will allow to have an important tool to monitor IPVC activities. For the Institution, it is necessary and important to provide decision makers with tools that will permit to access KPIs on time, based on information produced by the QMS. KPI reports are vitally important for IPVC in order to monitor and analyze all services, activities, as well as to improve the performance objectives.

In that perspective, it is appropriate to study and explore the implementation of a Business Intelligence environment for the managers of the quality management system in Polytechnic Institute of Viana do Castelo. In this context, the motivation of applying BI application in the IPVC Quality Management System (QMS) is to develop a decision support system that will help to control, evaluate and improve IPVC educational performances.

1.3 **Objective**

The purpose of this project is to support quality management staff in decision making activities, in order to give opportunity to define and evaluate the institution services, compare institution strategies and goals and help in the planning of the future improvements. In this sense, the main objective is to implement a decision support system using BI technologies that will answer to the Key Performance Indicates (KPI) requirements. For this purpose decision makers need to access information about all the

processes of IPVC schools from one system to simplify and support decision making activities. Using business intelligence applications it is possible to satisfy business needs and QMS manager's expectations, such as increase productivity of work and improve and optimize processes in educational institution. In this work we will consider and apply BI tools in order to develop a decision making system to answer to the KPI requirements specified by the QMS managers. For this purpose, we define the following objectives in the frame of our project:

- Develop a Data Warehouse system in IPVC, which will give advantages to integrate all IPVC QMS processes data into one common place and to achieve a maturity level to be able to develop various business intelligence projects in the future, depending on demands and necessities;
- Analyze integrated data and prepare analytical reports;
- Develop a decision support system for IPVC in order to support decision making activities;
- Develop tools in order to monitor and evaluate predefined Key Performance Indicators (KPI) to assess the state of education performance in a short period of time.

In the context of the decision support system, the objective is to create a Business Intelligence environment in a high educational institution. Within this project we will provide to the IPVC decision makers (or managers) with analytical reports in order to help and support right decisions making in a timely manner. To develop this project we will need to integrate all information about IPVC processes from different data sources into a single repository, called Educational Data Warehouse, which is suitable for direct querying and analysis, as well as to apply Business Intelligence tools to generate reports and dashboards using predefined Key Performance Indicators in order to observe and evaluate all management processes in a timely manner.

Taking into account the objectives of this work and due to time limitations and difficulties to involve QMS managers, the BI system in this project has only been fully implemented for some processes of IPVC. However, we consider that, despite these limitations, the project is a contribution to demonstrate the advantages and benefits to develop BI tools in a high educational institution.

1.4 Structure of the document

The thesis is composed of five chapters.

Chapter 1 introduces the project, the problem description and the purpose of this document.

Chapter 2 presents the concepts and objectives of Quality Management Systems (QMS) and ISO standards.

The next chapter is about Business intelligence (BI) concepts and its components such as operational systems, data warehouse, data analysis and reporting.

The fourth chapter is entirely devoted to implementation details of BI system for IPVC QMS. In this chapter we present business needs, the methodology used to develop the project, the data warehouse models and reports.

The last chapter of this document consists of summary and conclusions about this project and points future work as well.

Chapter 2 - Quality Management Systems

2.1 Introduction

Traditionally organizations move their activities by the need to produce high rates of performance, efficiency and efficacy, the satisfaction of their employees, customers and suppliers in order to be competitive and to enable organizations to face competition. The application of Quality Management Systems – QMS, particularly the ISO 9001 standard in organizations allows the definition of a set of processual and organizational documentation in order to guide and achieve high levels of efficiency, improve the services performance and to improve the internal and external quality of the services provided. In this sense, in the next sections we will describe shortly the objectives, the characteristics and the general benefits of the implementation of QMS in organizations.

2.2 Quality Management Systems Objectives

Quality Management System (QMS) is a set of coordinated activities, which guarantees a common attitude in the management of an organization and helps to control all processes in order to improve the efficiency and performance of the business. In organizations all rules are defined as policies, procedures, tasks, which are aligned into QMS functions with their objectives to help end-users to perform their daily work.

The objective of QMS is to satisfy business' and customers' requirements and at the same time, to extend the business operations outside of the company. QMS allows companies to present high rates of yield, by the satisfaction of their clients, partners or collaborators, and by maintaining high levels of competitiveness that allows them to face concurrency and assure their survival in the markets where they develop their activities. QMS includes many organizational processes and functions, which are interlinked between them in order to satisfy stakeholders and customers. In this sense, the main purpose of QMS is to increase customers' satisfaction, credibility, and improve products and services quality [3].

The development of QMS documentation is achieved by defining quality standards and practices in order to monitor and review external or internal performance against the defined quality standards and practices.

The document structure of a Quality Management System consists of a set of documents, where is specified quality requirements, which are materialized through procedures, policies, structural matrixes and forms. With this information it is possible to define quality standards and identify and provide the best practices in order to monitor and review the efficiency and performance of the processes.

In general, organizations use QMS to manage their work in a systematic manner. As mentioned in Westinghouse Electric Company QMS document, "In QMS all activities are documented in accordance with written manuals, procedures, instructions, specifications and drawings that contain appropriate criteria for determining whether prescribed activities have been accomplished satisfactorily" [4 p. 5].

In terms of objectives, the QMS implementation in economical organizations and in educational institutions can converge for a set of goals [5]:

- To improve the quality of products and/or services;
- To use information and access it in timely manner;
- To optimize processes by providing automatic transmissions of requests between the users and services;
- To reduce execution time of tasks and answer to requests efficiently;
- To increase the collaboration between internal and external stakeholders by using centralized environments (for example web-based applications);
- To determine key indicators in order to evaluate and monitor services.

In general the Quality Management Systems that are applied to customer's satisfaction must comply with standards of information systems requirements defined by credible institutions like the ISO (International Organization for Standards). This institution is recognized by providing a set of standards in order to improve the efficiency and performance in many areas of the companies, with the purpose to define guidelines and to develop more efficient, safer and cleaner products and services. Using the ISO recommendations, companies are able to be recognized as a reliable system,

which gives opportunity to increase chances to do business in worldwide more effectively [5].

One of that standards is the QMS ISO 9001 certification standard. It corresponds to a tool in order to achieve customer enhanced satisfaction. Implementing the ISO standards gives opportunity to obtain advanced management mechanism, which will allow to improve products and services to increase chances of success in the global competition. In a general point of view the ISO 9001 is a standard documentation of processes consisting of a set of process matrixes, procedures, work instructions, process forms, requirements and other kind of documentation related to processes [6]. In the next section we will present a general description about this standard.

2.3 International Organization for Standardization (ISO)

International Organization for Standardization (ISO) is a worldwide organization which develops ISO standards. These standards are developed in terms of voluntary technical efforts in order to improve the performance and efficiency of diverse types of business operations. The use of ISO standards gives the opportunity to improve all kind of business operations and to develop more efficient and safer products/services. ISO Standards safeguard users and consumers. Its related documents are divided into three main dimensions of sustainable development: economic, environment and social fields [5].

The work of preparing International Standards is performed through ISO technical committees, cooperating with international organizations, governmental and non-governmental bodies. However some companies provide certification services which are previously certified by the ISO technical committees, for example, SGS - Société Générale de Surveillance SA[2], APCER[3], which belong to the IQNET (The international Certification Network) Association[4].

The ISO 9000 is a family member of international quality management standards and guidelines. It is recognized in establishing effective and efficient quality management systems. In the field of Information Systems, ISO Technical Team 176 (TC 176 - see Appendix A) is responsible for the development of standards for quality

[2] http://www.sgs.com/
[3] http://www.apcer.pt/
[4] http://www.iqnet-certification.com/

management and quality assurance [5]. In this standard, the documents for Quality Management Systems are comprised by [5]:

- ISO 9000:2005 - Quality management systems – Fundamentals and vocabulary;
- ISO/FDIS 9001:2008 - Quality management systems –requirements;
- ISO 9004:2000 – Guidelines for performance improvement;
- ISO 19011:2002 Guidelines for quality and/or environmental management systems auditing.

In other hand, the ISO 9000 provides the basic concepts of QMS based on eight quality management principles and is used to achieve processes with continuous improvement capability. These eight principles are: customer focus, leadership, involving people, process approach, systems approach, continual improvement, factual decision making, and mutually beneficial supplier relationships. The ISO process approach is illustrated in Figure 1. During the implementation of a QMS, there are five sections in ISO 9001 standard that indicate activities that need to be taken into account [5 p. 2]:

- Overall requirements for the quality management system and documentation;
- Management responsibility, focus, policy, planning and objectives;
- Resource management and allocation;
- Product realization and process management;
- Measurement, monitoring, analysis and improvement.

As we mentioned, the ISO 9001 specifies basic requirements for QMS, which are needed to provide products and services to enhance customer satisfaction and meet regulatory requirements. In practical terms, the application of the ISO 9001 requirements allows to achieve first level of QMS performance in order to develop high quality of products and fulfill customer's needs and expectation.

After a system answers to the requirements of ISO standards, it can be used for certification, registration or contractual purposes in order to be recognized. One fact is that ISO 9001 Standard recognizes that "customers play a significant role in defining requirements as inputs" [7 p. 11]. QMS supports the monitoring of customer satisfaction, which is necessary to evaluate and validate whether customers'

requirements have been meet. The ISO 9004 version gives some guidelines in order to improve QMS by considering all involved parties interests and to extend the benefits obtained from ISO 9001. This version is used to achieve systematic and continual improvement of organizations overall performances.

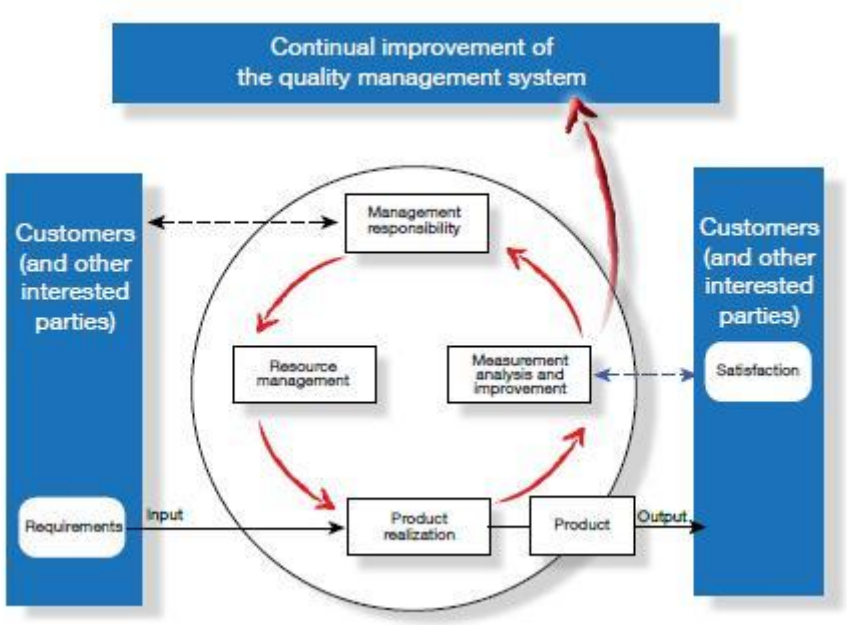

Figure 1 - ISO 9000 process approach [5 p. 2]

In terms of the control of the implementation of the ISO 9002 family, the ISO 19011 Standard is used for auditing the QMS and has guidelines and instructions on how the audit of management systems should be performed. During the performing of an audit, organizations need to ensure that QMS was implemented successfully and meet all the requirements, which were predefined in ISO 9001 or ISO 9004 standards. In companies, audits are performed by ISO 9001 Auditing Practice Group (APG) [8].

2.4 Applicability of Quality Management System

There are many good reasons why organizations must apply QMS into their systems, for example:

- To produce products with consistent quality;
- To improve their quality of services provided to clients;
- To improve companies' management processes;
- To answer customer's requirements of having a certification;

- To monitor their processes and achieve great client satisfaction.

In order to implement a QMS in an organization, the top managers should define a set of quality policies, quality objectives and quality indicators. The quality objectives are measured using quality indicators which includes data availability, data quality and customer satisfaction. The ISO suggests some steps (or guidelines) to implement efficiently the standard [5 p. 4]:

1. Fully engage top management
    - Define the reasons why the organization wants and needs to implement ISO 9001;
    - Define the mission, vision, and values in the organization;
    - Define the organization's stakeholders: customers, suppliers, stockholders, employees, society, etc;
    - Define the quality policy;
    - Define and align organizational objectives and related product/ service quality objectives
2. Identify key processes and the interactions needed in order to meet quality objectives
3. Implement and manage the QMS and its processes (using process management techniques)
4. Build the ISO 9001-based QMS, in special to:
    - Identify ISO 9001 requirements;
    - Map these requirements with the implemented QMS, where applicable;
    - Make a gap analysis: identify where in the organization the requirements of the existing system are fulfilled, and where they are not;
    - Include in the QMS processes the activities, procedures and controls needed.
5. Implement the system, train company staff and verify effective operation of the processes
6. Manage the QMS:
    - Focus on satisfaction of customers;
    - Monitor and measure the operation of the QMS;
    - Strive for continual improvement;

- Consider implementing business excellence models in operations of the company.

7. If necessary, seek third party certification/registration of the QMS or as an alternative, issue a self-declaration of conformity.

2.5 Benefit of Quality Management System

In terms of the benefits of the QMS implementation in an organization, QMS enables to achieve the goals and objectives set out in its policy and strategy. According to Department of Trade and Industry document, "It provides consistency and satisfaction in terms of methods, materials, equipment, among others, and interacts with all activities of the organization, beginning with the identification of customer requirements and ending with their satisfaction, at every transaction interface" [9 p. 1].

The usage of QMS functions gives opportunity to have access to a set of key performance indicators that reflects the activities of the organization and, in this sense, it allows to monitor services performance. In the last years, many companies and organizations applied the ISO 9001 (and other) standards. In general, by the results achieved and mentioned in the literature, a good quality system can bring the following benefits:

- Set direction and meet customers' expectations;
- Improve process control;
- Reduce wastage;
- Lower costs;
- Increase market share;
- Facilitate training;
- Involve staff;
- Raise morale.

Chapter 3 – Business Intelligence systems

3.1 Introduction

Day after day, managers need each time more information about the various business activities of their organizations, to take strategic decisions based on the information, which are located in the available business sources. Usually, the historical information of these organizations is stored in information repositories, on which analytic processing servers process all the possible analysis combinations, disposing fast response times to all possible queries that decision agents may post.

The Business Intelligence concept refers to a set of techniques, which can be used to help managers in their decisions in order to respond to business needs using information technology (IT) capabilities. In this context, the tools to analyze the business needs could be analytical reports in order to prospect new market needs, which have the objectives to timely respond to customers, manage customer satisfaction, increase profit, optimize business processes, among others. In order to develop a Business Intelligence system, the Information Technology (IT) structure could include operational systems, databases, data warehouses, online analytical processes (OLAP), reporting tools and other IT components. In this sense, using this kind of systems to analyze data with the purpose to deliver analytical reports, gives the opportunity to align IT to business needs. Additionally, the relationship between the IT capabilities with BI systems offers the possibility to provide organizations with advanced analytical solutions, which allow to improve business processes, increase satisfaction of business persons and be aware about the business competitive environment in terms of concurrency and challenges.

A Business Intelligence system relies on intelligence information which is used to support the effective decision making activities concerning production, marketing and personnel. **"**Effective decisions are choices that move an organization closer to an agreed-on set of goals in a timely manner" [1 p. 8]. The decision makers in this process could be top managers of the company, the chief executive officer (CEO), the president, chairpersons or others. The key of organizational success is to make good choices based on specific goals, measures, information and feedbacks.

In order to make effective decisions, in general, the high level managers of an organization consider the set of business goals to measure how chosen courses are moving toward to these goals. The information about business processes is based on these measures, which must be provided in a timely manner. Decisions are made based on "foundation information" about current business conditions and are evaluated after receiving the "feedback information" as a result of decisions [10 p. 9]. Figure 2 illustrates the concepts of effective decisions that consist of three keys: specific goals, concrete measures, and timely foundation and feedback of information.

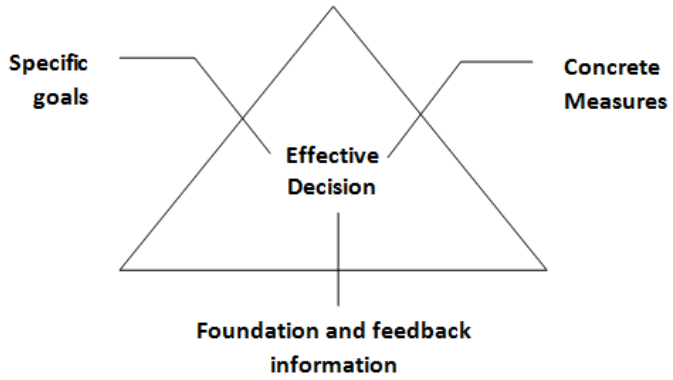

Figure 2 - Three keys for effective decision making [10 p. 10]

Organization need to define measures to understand if their goals and objectives are achieved or not. As goals are more specific the measures could be defined more clearly and are more measurable. Measures are the result of decision processes and feedbacks in the company, they are used to evaluate and monitor business processes. For example, consequences of some decisions in a company could be sales increase or decrease and this information will appear automatically in defined measures. The feedbacks are inputs (sales increased, or decreased) from customers that affect organization as a result (value) of decisions, which are represented in measures. Business goals define the status levels of the measures, so if values are less than defined goal the decision is evaluated as a bad decision, and if it is more than or equal, then decision could be evaluated as a good decision, meaning that specific goals were achieved. In an educational institution a global goal could be "students' satisfaction in alimentation process" measured by "percentage of meals served" in canteen with a goal of 80%, from where "percentage of meals served" is a specific goal. We can measure

decision rightness based on the increase or decreased of student's meal service percentage in canteen. Table 1 is an example that shows decisions making support table.

Global Goal	**Specific goal**	**Measures** (How we know our goals is reached or not?)	**Foundation and Feedback Information**
1.students satisfaction in alimentation process	Maintain students number of meals served at canteen	Students meal served are 80% and more	If enrolment are: >=80% ☺ < 80% ☹
2. Students registration academic service	Increase students online subscription	Students online subscription are 70% and more	If Online subscription are: >=70% ☺ < 70% ☹

Table 1 - Decision making support table

Decisions determine the general course that organization is going to take in a defined period of time. Decisions point the organizations toward to its goals. The goals have the repeatable measures that are used to control process toward defined goals and determine whether the organization is making effective decisions.

3.2 **BI systems**

"Business Intelligence is the delivery of accurate, useful information to the appropriate decision makers within the necessary timeframe to support effective decision making" [10 p. 14].

Business persons have to make effective decisions on time, which must rely on trusted information from well designed measures. Business Intelligence application has the capability to provide business persons with feedback information about their business performances in a timely manner. The feedback information from customers has a vital importance for business persons to make effective decisions and to evaluate decisions at all organization levels. Business Intelligence delivers timely updated information, which significantly influences on decision making processes.

Business Intelligence has the capability to analyze huge volume of data. The exploration of data sources could reveal trends, correlations and dependences, but such kind of relations could be impossible to be noticed by human being using either layout-let (designed to get appropriate report) or led discovery (information we find determines, where we want to go next) [10 p. 16]. In Business Intelligence systems "highly sophisticated mathematical algorithms are applied to the data to find correlations between characteristics and events. This type of information can be extremely helpful in organizations when planning marketing campaigns, setting up cross-product promotion or doing capacity planning for the future, determining when additional resources and efforts would be produced for the most effective results" [10 p. 17].

3.3 **Applying BI systems in companies**

Inside each company decision makers' activities can be classified into three levels [10 p. 18]: upper level decision makers, middle level decision makers and operational level decision makers. Figure 3, Figure 4 and Figure 5 present decision makers' levels, measures and timing of the foundation and feedback information at each level of the organization. At different levels of management different type of Business Intelligence tools and techniques are required to approach predefined goals. In each level of management specific goals, concrete measures, timing of foundation and feedback information is required in order to make effective decision.

Figure 3 - Specific goals at each level of the organization [10 p. 18]

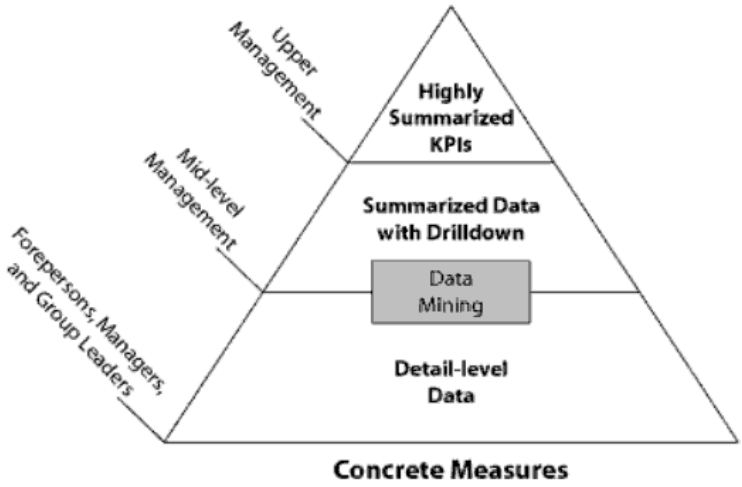

Figure 4 - Concrete measures at each level of the organization [10 p. 18]

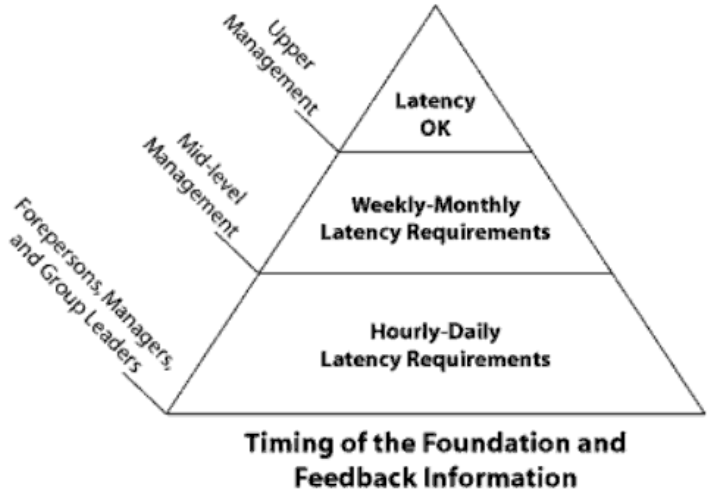

Figure 5 - Timing of the foundation and feedback information [10 p. 19]

Upper level decision makers set long term goals, where measures that are defined are highly summarized. Highly summarized measures are also known as Key Performance Indicators (KPI).

Middle-level decision makers manage departments and organization at operational level. Middle level decisions are based on short term goals that are needed for planning to manage functional processes in organizations. Decision makers need to get reports about business activities and to apply drilldown techniques to the reports. Drilldown techniques are provided by BI reporting service that are used to obtain more detailed information and help to make better decisions.

Middle level management can also use data mining techniques effectively for making decisions.

Operational level decision makers (forepersons, managers, and group leaders) rely on day-to-day operational goals in order to manage daily information to react to changes. Based on the feedback information decision makers need to react quickly to improve processes on time.

3.4 Applicability of Business Intelligence

In general, the amount of information in organizations increases over time due to business processes. It is very important for enterprises to maintain and manage all information related to their businesses. In fact decision makers have the need to get complete reports about all business in a very short time. For that purpose, there is a need to have a system which will have the capability to access a variety of data sources (systems, databases, office programs, text files, web, etc) and to integrate all information into one common place. For such kind of advanced business needs, the solution can be provided by Business Intelligence (BI) systems. A BI tool gives the opportunity for decision makers to access all data, integrate them in a Data Warehouse (DW) and get analytical reports in a very short time. Figure 6 presents traditional business intelligence architecture with components that can be used to deliver solutions for business needs.

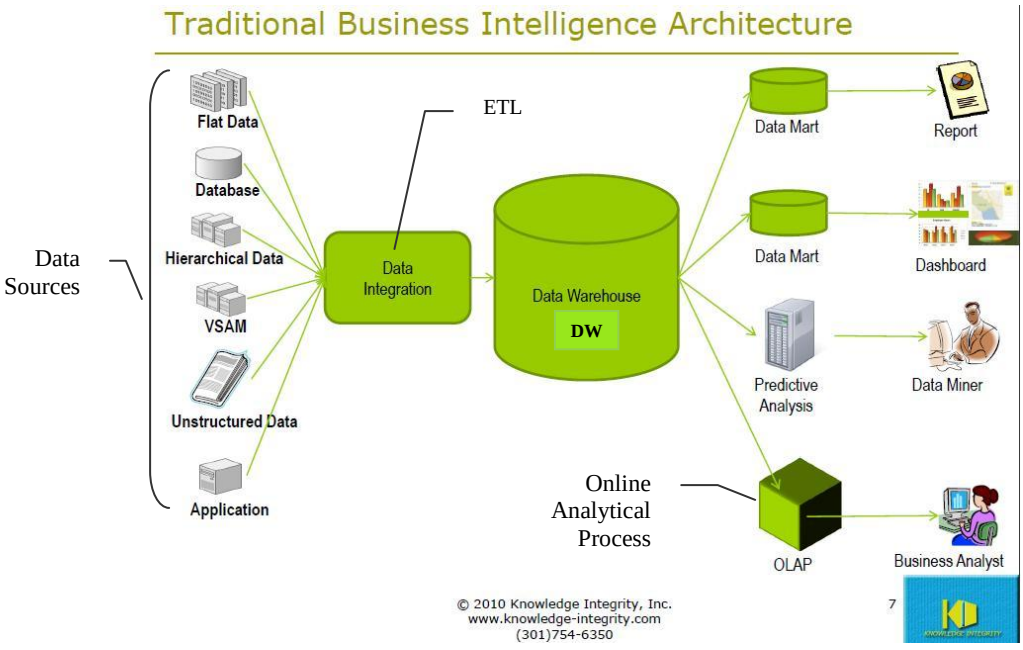

Figure 6 - Traditional Business Intelligence Architecture [11 p. 7]

The major steps to deliver timely BI reports for business persons are: extraction, transformation, loading, creating data marts with Online Analytical Processes (OLAP) and deliver BI reports. Extraction, transformation and load are related to data integration process (DI), which is performed by BI systems to allocate data into a DW as shown in Figure 6. To implement DI process it is essential to identify data sources. In BI systems, data is extracted from enterprise sources such as ERP, CRM, financial systems, databases, text files, among others. These sources may reside in different locations and on different platforms. After data is loaded into DW, BI systems apply OLAP techniques to generate Data Marts (DM) [12]. Using OLAP data is stored into small databases called Data Marts, which give the opportunity to generate various reports, to have fast access to data by specific groups and distribute information to remote sites. As shown in Figure 6, BI starts from data sources to support users in the process of analyzing very large quantity of information and delivers management reports. It generates semi or fully automatic reports in order to answer daily business questions [13 p. 5].

In an organization, the following steps should be performed to implement a BI project [14]:

1. Define data sources – In enterprises departments, data is usually stored in databases via applications;
2. Understand business needs – The identification and understanding of business needs will enable to construct DW and transform data to business information;
3. Create Data Warehouse - Define measures, dimensions and fact tables to create a data warehouse;
4. Make an ETL process – ETL process is used to store information into the data warehouse. BI tool can automatically import and transform data from different systems and different locations.
5. Analyze data and deliver reports – OLAP tool is used to store data in cubes from DW in order to analyze data. From cubes, reports are developed and distributed to decision makers.

These described five steps are the traditional path to develop BI projects. It enables to answer to business needs in enterprises by focusing on exploring and

delivering real time business information. BI has also the possibility to use predictive analysis tools, which helps to give recommendations to business persons using data mining techniques. For example, it allows to estimate the future growth of the enterprises according to its business types [14].

Business requirements often change overtime and depend on economic impact, regulations and many other factors. Because of that, BI applications and models need to be changed and populated overtime in order to support new type of requirements and make new type of analysis. For this reason, it is recommended to decrease reliance on Information Technologies staff [1 p. 2]. BI applications need to provide the ways for decision makers to fulfill their information requests related to their businesses via self-services.

New generation business intelligence applications have seven characteristics such as "access any data source, easy and accurate data visualization, see relationships, communication and collaboration, data in view all of the time, intuitive interface, desktop or server based" [15]. They have also self-services capability which uses five type of BI search: report search, faced search, NLP search, exploration engines and text mining [16] that gives opportunity to search and explore large volume of data. Next generation BI system provides with advanced reporting tools, which gives ability to get dynamic reports. Advanced reporting tools allows to type key words in natural language to find needed information in a very short time. New generation BI tools use advanced language processing algorithms, which gives opportunity to parse questions in common language into SQL standard language with the objective to query databases (Figure 7).

Finally, it should be noted that, according to Massachusetts Department of Elementary and Secondary schools [17 p. 6], BI can bring a set of benefits in educational institutions, which include:

- To provide decision-makers with the meaningful information on what is working and what is not in education processes according to student attendance, grades, test scores, observations, disciplinary actions, and more;
- Efficiently examine performance over time at multiple levels: student, class, grade level, school, and district.

- Easily aggregate and disaggregate data, compare disparate data, and produce customized reports, providing more detailed and insightful information through the data analysis process (Figure 8).

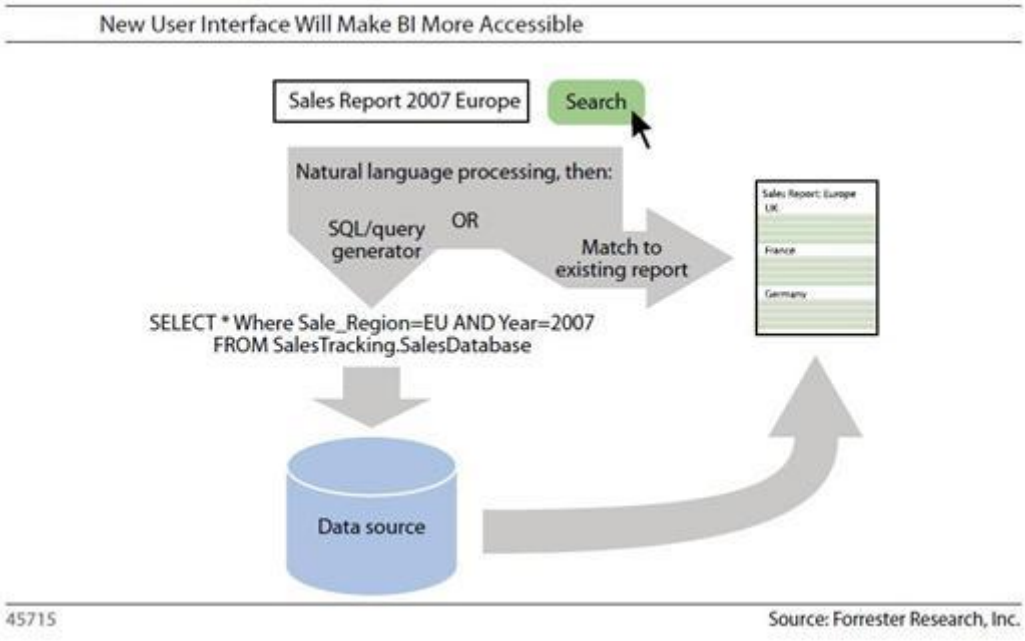

Figure 7 - Self-Service BI application [18 p. 5]

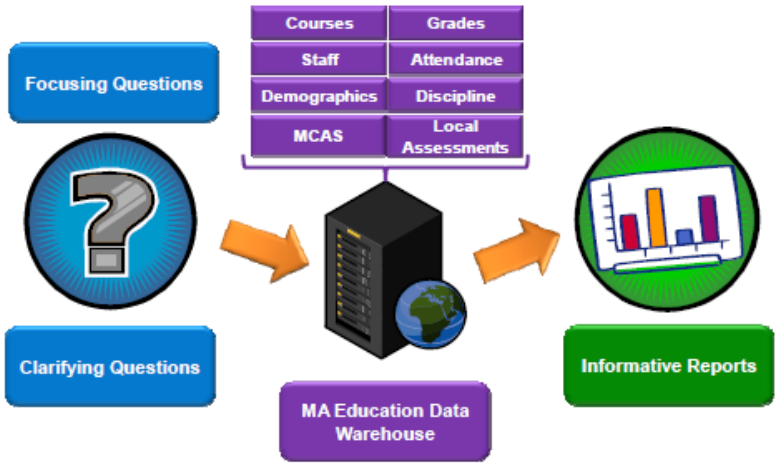

Figure 8 - Massachusetts DW - clarifying questions through the data analysis process [17 p. 6].

3.5 Key Performance Indicators (KPI)

The objectives of key performance indicators (KPI) are to better evaluate organizations current business conditions and to help in planning the future. KPIs are used to measure business progress toward organization strategy and goals. Each KPI is a high summarized measure which is used in upper level of decision making. Decision makers define long term goals based on organizations strategy and mission which are not often changed. KPIs definition takes into account detailed goals and measures, which will reflect organizations most vital aspects. Measures represent a status indicator, showing whether these measures are within an expectable range [10 p. 19]. In the case of an educational institution, KPI could be: students' online subscription, accommodation occupancy rate, student's accommodation satisfaction, alimentation service, among others.

Key Performance Indicators (KPIs) are frequently used in dashboard reports in order to improve strategic and decision making activities. A Business Intelligence system can provide organizations with digital dashboard reports which are used to help executives and decision makers to make decisions better and faster [19 p. 3]. It enables decision makers to establish measures and criteria that are used to monitor and evaluate all business processes at a single glance in all level of the organization. Dashboards are based on Key Performance Indicators (KPI) measures and can include business values, goals, status and trends [20 p. 212]. Business intelligence usually gives the capability to create dashboard reports which are composed with KPIs components using visual graphical images such as stop light, gauges and other symbols. Dashboards reports provide the necessary status information about business trends at a single glance. Using dashboards in decision making activities, decision makers are able to evaluate organizations health and correct problems on time. Dashboard reports are also useful to determine how the organization moves towards specified goals. Figure 9 shows a digital dashboard report example, where we can see values, goals, status and trends of KPIs.

All processes which influence organizations businesses could be captured in dashboards. This feature distinguishes dashboards from other reports as an effective management tool for measuring, evaluating and monitoring all organization levels in order to compare performance with defined goals. The KPIs types depend on the nature of the organization and organization's strategy.

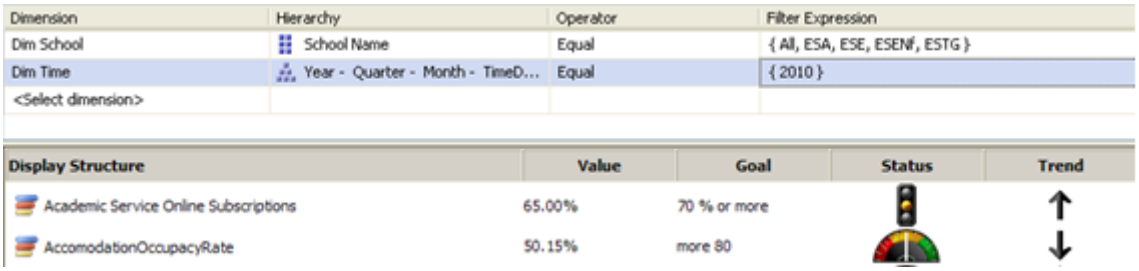

Figure 9 - Digital Dashboard report

3.6 **Operational Database**

Operational databases are used to store daily transactional data during business processes. The usage of operational database systems allows the management of data in an organized manner. Operational databases are also called transactional databases or Online Transactional Processes (OLTP). According to Larson [10 p. 26], "OLTP systems are embedded into the applications and front users are able to manage their data by inserting, editing, deleting, updating, filtering, summarizing and reporting".

There are several kind of databases such as row oriented, column oriented, object oriented, among others. From them, row oriented relational database management systems (RDBMS) are mostly used in applications to support OLTP, which are data source systems for BI tools and data warehouses [21 p. 13].

In databases, similar and logically connected data are grouped into subjects called data entities or tables. These data entities/tables have relationships between them, which form the relationship model, that's why these systems are called Relational Databases Management systems (RDMS).

In RDBMS tables consists of a set of attributes [22 p. 25] also called fields, which defines what kind of data can be stored. The data which is stored in the fields are called tuples or records. Table must have a unique name and fields have a name and type, where type specifies what type of data can be stored and name gives a way of accessing. Each table must have a primary key that identifies each record. The relationships between tables can be established using reference keys. Reference key means that a table has a Foreign Key [22 p. 315] that is a field or a combination of fields whose values match a primary key of another table.

Figure 10 represents an example of a relational model of OLTP system. We have four data entities - Class, Student, Presence and Lesson that are related to each other. Table Class has one attribute Class_id, which is the Primary Key. Tables Student and table Lesson are related to table Class using Reference key.

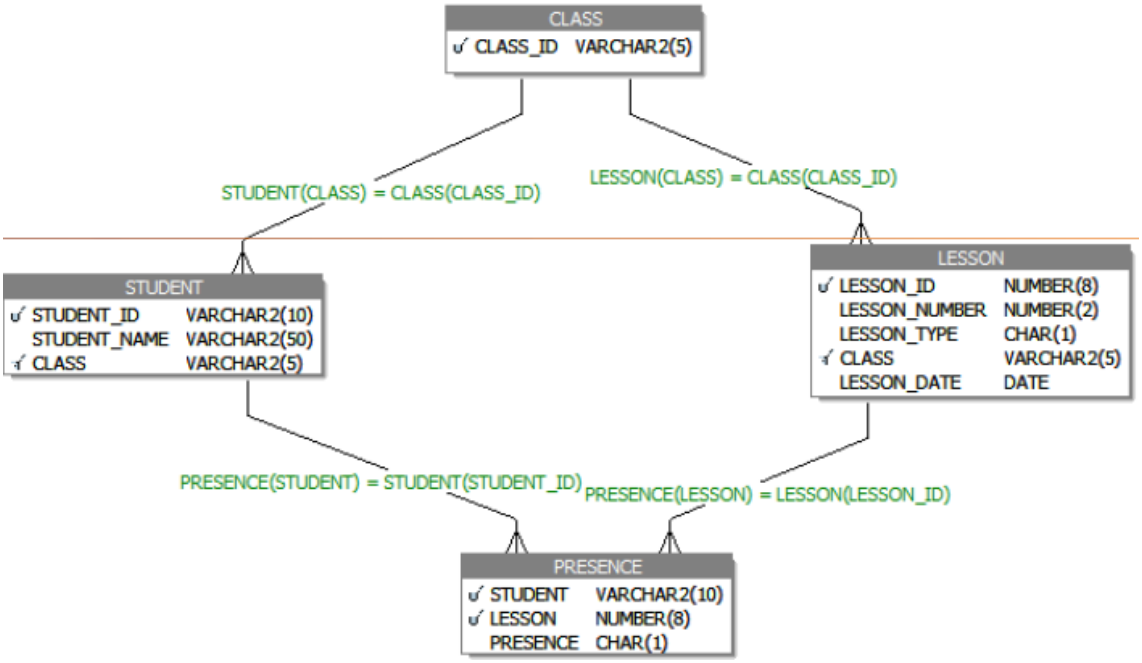

Figure 10 - Relational Database Model [23]

Database systems have data query tools that use SQL (Standard Query Language), and are used to retrieve information from databases using the relational model of the databases [22 p. 20]. With Data Query Tool we can manipulate data from databases in order to retrieve appropriate information, make summary of data, get reports, edit, delete, update and transfer data into other database systems.

3.7 Data Warehouse systems

"A data warehouse is a subject-oriented, integrated, time variant, non-volatile collection of data that serves as a physical implementation of a decision support data model and stores the information on which an enterprise needs to make strategic decisions" [24 p. 2].

Data Warehouse (DW) platform consist of hardware servers, operational systems, database management systems and storage infrastructure [25 p. 6]. Data

Warehouses concepts can be used in any kind of business fields. They can be used in manufacturing, educational institutions, tourism industry, among others.

OLTP systems are used as data sources for data warehouses (DW). The objective of a DW is to collect and integrate all data across different systems and locations and locate them into one source. From the transactional databases we can store large volume of data in a DW, in a central, manageable, analytical, governable location, from where we can get summary reports, which will help to support decision making processes [26 p. 33]**.** Allocating the data into a DW from multiple data sources is the result of integration process, with the purpose to have accurate information in a timely manner.

Data warehouse models includes business entities like customer, product, finances and functions like sales, supply chain, operations, which represent whole enterprise performance. The data which will be stored in DW will be historical, read-only data.

The process of storing data from transactional databases into a data warehouse is called ETL process, which means Extract, Transfer and Load [10 p. 30]. ETL process has the objective to collect data from diverse sources and to aggregate it into a dataset to provide DW with complete, trusted data [27 p. 9].

A data warehouse consists of dimension tables and fact tables. In dimension tables data is stored by subject. Fact tables are connected to dimension tables from where they take quantitative/qualitative values. For example students name, address and phone number could be stored in students dimension table. From dimension tables, data are populated into fact tables and measures are calculated.

A measure, also called a fact, is a numeric quantity which expresses some characteristic of organizations performance. The information that this quantity represents is used to support or assess the performance and decision making of an organization [10 pp. 30-31].

Numerical measurements are stored in fact tables which are taken from the intersection of dimension tables [28 p. 12]. For example, students' subscription number across schools, locations and time could be a numerical measure in fact table, where schools, location and time are intersection (dimensions).

The creation of a data warehouse is a preparation step in order to use business intelligence systems. To analyze data, it is better to run BI systems over DW than over OLTP systems. The reason is that the use of a DW allows to have complete, integrated and historical information and at the same time, the system is independent from transactional processes. In fact, if we use a transactional database to analyze the data whilst there are a lot of transactions, there is the possibility that the system will halt and overload.

The most usual process to create a DW system is to use a database system such as Relational Database Management System (RDBMS). To create a data warehouse there is two possible data models: Star and Snowflake models. They are based on relational database concepts and are composed of dimension and fact tables. In star model each dimensional table is directly connected to fact tables. Figure 11 is an illustration of DW star model.

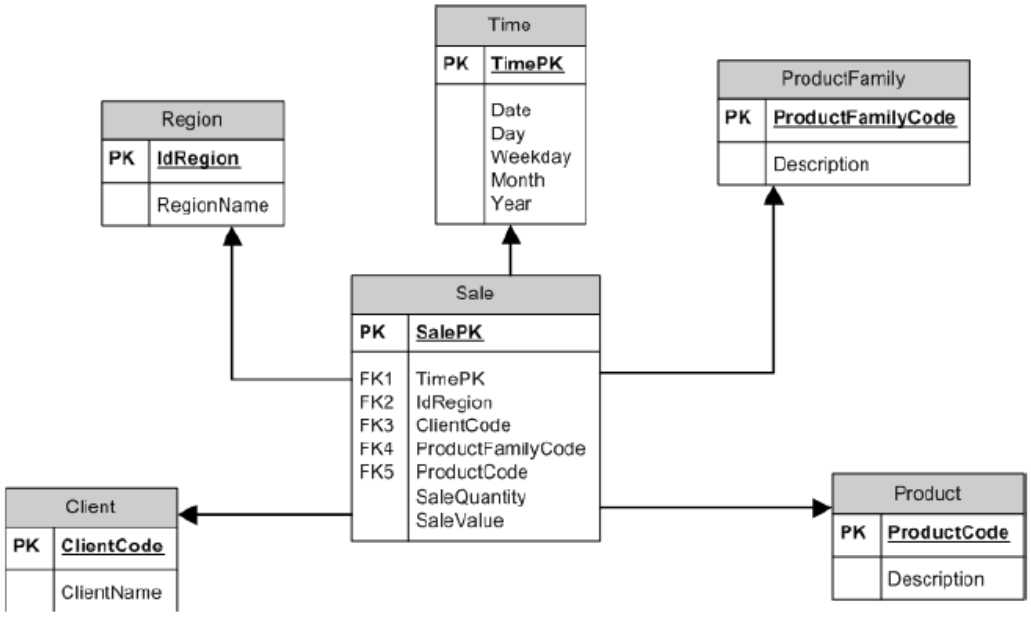

Figure 11 - Data Warehouse Star Model [29 p. 19]

On the other hand, snowflake model is based on hierarchies. **"**A *Hierarchy* is a structure made up to two or more levels of related dimensions. A dimension from the next at an upper level of the hierarchy completely contains one or more dimensions lower level of the hierarchy" [10 p. 35]. In Snowflake model each level of a hierarchy is stored in a separate dimension table and they are connected to fact

tables thought the up hierarchy dimensional tables. Figure 12 illustrates a DW snowflake model.

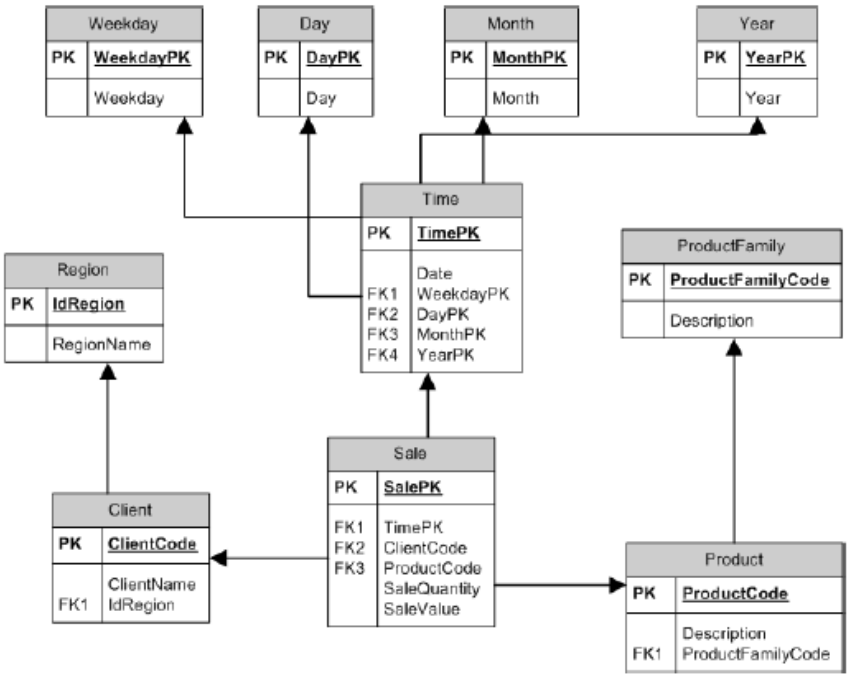

Figure 12 - Data Warehouse Snow Flake Model [29 p. 20]

The use of a data warehouse gives the opportunity to deliver solutions quickly, and allows enterprises to be mature and be ready to provide data for new solutions. With extended, growing and customized capability, DW allows to develop multiple new BI solutions and be mature to answer new type of business demands in the future [25 p. 8]. In fact, according to Massachusetts Department of Elementary & Secondary Schools [17 p. 5]**,** Data Warehouse can bring a lot of benefits to educational institutions, like:

- Time saving in making decisions;
- Being able to access real time information on time in order to improve educational performances;
- Data warehouse can be used to aggregate and disaggregate data and produce customized reports;
- Integration and transformation capability to allocate all data about educational processes in one common place for future use.
- Historical perspective.

3.8 **Online Analytical Process (OLAP)**

BI application offers analysis services tools to analyze business data. This process is called Online Analysis processes (OLAP). OLAP tool use a cube structure, being data extracted from data warehouse and loaded in cube. OLAP has multiple features such as Key Performance Indicators to monitor business processes, Multidimensional Expression (MDX) to get analyzed information for reports and Unified Dimensional Model (UDM) which enables to slice-dice and get summarized information.

After the execution of data integration process, which loads data into a DW, it is possible to apply OLAP tool to analyze integrated data. To analyze data, OLAP uses multi-dimensional data cubes retrieving information from measures, dimensions, hierarchies and cubes [10 p. 39].

OLAP cube consists of cells which store summarized data called measures. Dimensions divide a cube into sections. Each tuple in OLAP cube is associated to hierarchies. Hierarchies are dimension levels which are also defined in cube [10 p. 284]. Figure 13 illustrates an example of a data cube.

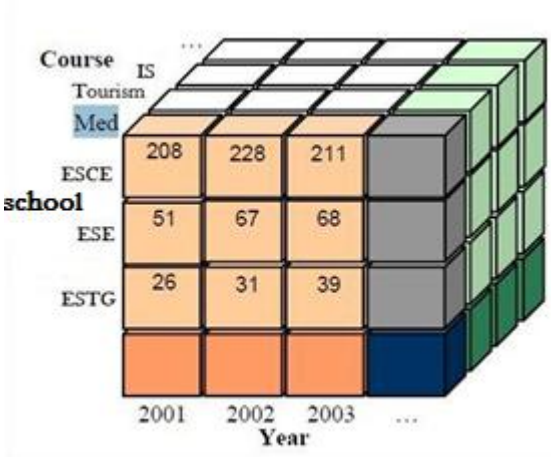

Figure 13 - A data cube example.

In OLAP cube it is possible to calculate measures and navigate through the cube using MDX expressions and functions. Calculation can involve a number of different fields from different tables. In OLAP calculations are performed using Multidimensional Expression language (MDX). For example, in OLAP, KPI could be developed using MDX expressions for dashboards reports, which could be used to

calculate the KPI values, goals, current status and trends in order to compare values with business rules.

OLAP tool gives the ability to use several useful operations such as:

- Roll-up - taking the current data objects and doing further grouping by one of the dimensions;
- Drill-down - The drill-down operation is the opposite of roll-up. It navigates from less detail data to more details;
- The slice operation performs a selection on one dimension of the given cube, resulting is a sub-cube;
- The dice operations define a sub-cube by performing a selection of one or more dimensions;
- Pivot (Rotate) - Pivot is a visualization operation that rotates the data axes in view in order to provide an alternative presentation of the data. It allows visualization of the other side of the dice.

3.9 **BI Reports**

The main purpose of BI tools is to deliver reports to decision makers. All the strike of BI is to create high quality reports in a timely manner. BI reporting service enables the distribution of reports throughout the organization in a timely manner using Information Technologies (IT). Reporting service are composed by multiple programs, has series of services, web applications and databases, that work together in order to create a report management environment. BI uses data marts from the analysis service (shown in Figure 14) to develop web based or local reports. Analysis service allows to access data with external applications to develop reports that could be used in different applications like spreadsheets. BI report services allow to provide users with reports in most appropriate formats, since it is in general possible to produce different kind of report formats such as HTML, PDF, TIF, among others.

Reports can be constructed using SQL (Query relational database), MDX (Query Multidimensional Databases) and DMX (Query for Data Mining). These queries are used to extract data from defined sources and to provide these data to reports. Once the report is developed, it can be deployed in a report server. End-users can interact with

reporting servers indirectly through the use of Web Services. Reporting server responds to web services requests to deliver the report. Delivered reports from BI systems usually give the ability to execute operations like drill down to access detailed information if needed. It is common, that the delivered BI reports use a web-based environment, which gives the possibility to make the reports available in one common place, so that end-users are able to subscribe and access reports from a website. It is also possible to share reports through the network service. BI reports could also be subscribed and be emailed to users.

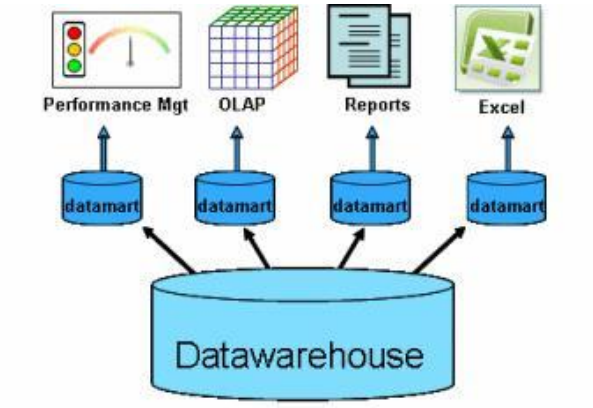

Figure 14 - BI Report Service [30]

3.10 **Business Intelligence Vendors**

Nowadays there are many BI tools available on the market, which are successfully used by enterprises and companies to support decision making activities. Below we present a list of some BI tool vendors:

- Microsoft SQL Server 2005 http://www.microsoft.com/sqlserver/2005/en/us/
- Pentaho Business Intelligence Suite, http://www.pentaho.com/
- Jaspersoft Business Intelligence (BI) Software , http://www.jaspersoft.com/, http://jasperforge.org
- Balanced Insight , http://www.balancedinsight.com/
- BIReady , http://www.biready.com/
- Kalido, http://www.kalido.com/
- Tableau software, http://www.tableausoftware.com/

- WhereScape , http://www.wherescape.com/home/home.aspx
- IBM Cognos, http://www-01.ibm.com/software/data/cognos/
- Endeca , http://www.endeca.com/
- Sap Netweaver BW, http://www.sap.com/index.epx
- Attivio, http://www.attivio.com/
- Composite software, http://www.compositesw.com/
- LogiXML, http://www.logixml.com/, http://www.freereporting.com/, http://software.logixml.eu/
- Zoho Reports, http://www.zoho.com/reports/lp/business-intelligence-software-online.html
- Oracle Business Intelligence 11g, http://www.oracle.com/ http://www.oracle.com/oms/businessintelligence11g/index.html
- Maia Intelligence, http://www.maia-intelligence.com/
- SAS, http://www.sas.com/
- Teradata, http://www.teradata.com
- Talend, http://www.talend.com/
- UC4 Software, www.uc4.com
- Microstrategy, http://www.microstrategy.com/

Chapter 4 - BI System Implementation in IPVC

4.1 Introduction

The Polytechnic Institute of Viana do Castelo (IPVC) has implemented its Quality Management System (QMS) in 2009 in order to perform its daily work in an organized manner in terms of decision making tasks as well as to perform the costumers' services. The implemented QMS covers twenty-four processes of its departments. On the other hand, IPVC decision makers have the necessity to achieve quick access to integrated information about all processes that can be used to support decision making activities. Traditionally, IPVC managers based their decisions and tasks to evaluate schools work (in special services) and to be able to monitor in a timely manner all processes, which will help to act and improve educational processes on time if they discover that the processes state do not align with defined strategies and goals. For this purpose the decision makers of the IPVC have defined a set of Key Performance Indicators (KPI), which will represent the state of each process. The possibility to obtain KPIs will permit to decision maker persons to be able to control and manage the services performance. To support these needs and answer to IPVC decision makers requirements, we apply a business intelligence application over IPVC QMS. The objective is to use Business Intelligence application to increase productivity of work and to improve and optimize processes in IPVC.

In this project we want to study, explore and implement a business intelligence environment for Quality Management system of Polytechnic Institute of Viana do Castelo in order to help and to support decision making activities in the institution. We implement IPVC BI project with SQL Server 2005 technologies to answer to the QMS Key Performance Indicators requirements. Through the use of BI tool, we develop an educational data warehouse (EDW) in SQL Server Database with the purpose to integrate data of all twenty four processes. As the data about IPVC processes were spread in different locations, sources and systems, it was vital to allocate all data into a single data repository to integrate all internal and external processes information into one source. Then we were able to analyse the information from EDW with OLAP tool

using Analysis Service, and finally we developed KPI reports to monitor and evaluate IPVC processes and support decision making activities.

In order to develop this project we choose to use Microsoft SQL Server 2005 software, which is considered a modern analytical BI tool and a growing data warehousing platform [31]. SQL Server 2005 has all the components which are necessary to develop BI projects in a single application. It allows to integrate data using Integration Service, to analyze data using Analysis Service and to develop reports using Reporting Service. All these services are located in a single user friendly application that SQL Server 2005 provides. SQL Server 2005 components have close relationship to each other so that when changes occur in one component, they are reflected in all dependant components. In this project we also decide to try to use another BI tool to deliver the reports to decision makers. We choose to use Tableau software to be able to develop next generation BI reports. With Tableau BI tool we connect to analysis service cubes in order to get data source and to develop high quality reports with a high level of interactivity enabling users to easily navigate and explore information.

4.2 IPVC and Quality Management System

The IPVC has implemented a QMS that covers the activities of seven organization units that includes schools, Social Service and Central Service. As an Educational Institution the IPVC provides opportunities for quality training in the human, cultural, scientific and technical sectors through its five schools [32]:

- Escola Superior de Educação (ESE) - Teacher Training College
- Escola Superior Agrária (ESA) - Agricultural College
- Escola Superior de Tecnologia e Gestão (ESTG)– School of Technology and Management
- Escola Superior de Enfermagem (ESEnf)– School of Nursing
- Escola Superior de Ciências Empresariais (ESCE) – School of Business Studies

The IPVC Quality Management Systems (IPVC – QMS 2009) [32] complies with ISO 9000 certification standard requirements and covers the following units process [32]: Academic Service, Environment, Health and Safety, Alimentation,

Accommodation, Scholarships, International Cooperation, Creation/ restructuring of Courses, Planning, Implementation and Evaluation, Supply, Heritage, Accounting & Treasury, Dispatch and Archive, Document Management, Management and Improvement System, Management Contracts and Infrastructure, Project Management, Management Information Systems, Observatory, Graphic Production and Audiovisual, External and Internal Communication, Human Resources, Library and Management of Education Space. The Quality Management System of IPVC also complies with COBIT (The Control Objectives for Information and related Technology) requirements following the policies and good practices for IT security and control. The following information is included in the IPVC QMS [32]:

- Process matrix;
- Procedures and work instructions;
- Forms;
- Data sheet occurrences;
- Other important documents and processes.

4.3 IPVC QMS Process Description

IPVC QMS are composed with twenty four processes of its departments. All these processes were explored and analyzed to be able to apply BI approach in order to answer to the defined business requirements. These twenty four IPVC processes are:

- Academic Service process

  Computer Application of Academic Management System manages all academic service processes. It tracks all educational records (in paper and digital forms) and generally include documentation about admissions, students registration, enrollment in classes, grades, graduation and more which is related to Academic Service responsibility.

- Environment, Health and Safety process

  QMS system manages all processes which are related to environment, health and safety in IPVC schools. The system tracks all the information associated to environment, health and safety processes such as simulation in schools, complaints, number of books and tutorials, staff and others.

- Social Service sub process – Alimentation

  QMS manages all processes which are related to alimentation process in IPVC schools, the system records information about student enrollment in alimentation system and food orders, food supplement and other services which are done during the alimentation process.

- Social Service sub process – Accommodation

  Academic accommodation service is a process which is composed by a sequence of tasks related to accommodation processes. The system manages the following accommodation services: booking rooms, maintain accommodation environment for customers (students, teachers, and other institute member)-and satisfy accommodated persons.

- Social service sub process – Scholarship

  Social Service system manages scholarship processes and records all the information related to scholarship. System records the following processes: scholarship interviews, responds, improvements, denials and others which are related to getting scholarship.

- International Cooperation process

  IPVC QMS manages all processes related to International Cooperation which includes establishment of protocols and agreements with partners, sending and receiving students and teachers, scholarship transfers and other information which is related with international cooperation processes.

- Process of Course Creation / Restructuring

  Process of course creation and restructuring is being managed by QMS of IPVC in order to simplify work during schedule restructuring and course planning. The process includes: proposal and restructure of courses, course validations and other information which is related with course creation and restructuring process.

- Formation process – Planning

  IPVC QMS manages schools' planning process which is related to application fees, submissions, schedules preparations, planning of programs and proposals to produce and also includes other tasks which are associated with IPVC planning process.

- Formation process – Implementation and Evaluation

  Implementation and Evaluation process in IPVC schools is managed by QMS of IPVC. They use QMS to perform their task such as evaluation of teaching activities, report submission, conducting surveys, grade mobility, and other activities to evaluate IPVC schools work.

- Economic and Financial Management – Supply process

  In IPVC schools economic and financial department uses QMS to manage supply process in schools. It helps to integrate business partners to achieve new level of efficiency and productivity. QMS tracks all information which is related to supply process: supply producers, supply fees, stocks management, materials, proposals, supplier's contracts/breaks and more.

- Economic and Financial Management – Heritage process

  QMS of IPVC manages heritage processes in schools by tracking the information into the system about conferences which is held in schools, storing information about physically existing assets, documented and undocumented goods, preparing heritage documentations and others related to this process.

- Economic and Financial Management -Accounting & Treasury

  QMS of IPVC manages accounting and treasury processes in schools. It tracks all information about changes in budgets, monitor- purchased software's in schools and analyzes revenues and commitments.

- Information Management – Dispatch process

  QMS of IPVC manages dispatch process of IPVC schools and tracks information about complaints done by telephone or in person.

- Information Management – Document Management process

  QMS manages document management process and tracks information related to compliance with regulatory requirements in schools.

- Management and Improvement System

  QMS of IPVC manages IS management and improvement process. It tracks information such as identified occurrences, performed and planned systems audits, achievement of quality, questioners and satisfactions, among others.

- Management contracts and Infrastructure process

QMS helps to manage the work in schools which is related to management contract and infrastructure in schools. QMS tracks information about planned and executed tours, schedules and more.

- Project Management process

  QMS performs all work which is related to project management process in IPVC schools. System tracks all the information related to project management performance, planed/undertaken activities, execution and reprogramming of applications, funded and approved IT project.

- Management Information systems

  QMS of IPVC manages processes of Management Information Systems in IPVC schools by tracking the following information: requested and inadequate conducted trainings, occurrences of application server software, time of components recovery, incidents types, backups, critical data and much more which is relating to management information system process.

- Observatory process

  QMS of IPVC manages observatory process in schools and records information about validated and invalidated questioners, companies and institutions surveys and other information related to IPVC schools observatory process.

- Promotion and Image - Graphics Production and Audiovisual process

  QMS of IPVC is used during graphics production and audiovisual process. It records the information which is related to this process such as recording information of studies complaints, submission of complaints and works conducted across the schools and courses.

- Promotion and Image - External and Internal Communication

  QMS of IPVC manages external and internal communication processes in schools. QMS records the information related to this process such as disclosure of achievements, approvals, proposals, satisfaction, trainings offered, consultations/portals details, publications and other information related to external and internal communications in schools.

- Human Resources process

QMS of IPVC manages human resources process in schools. It records information about dossiers of individuals, employee's details, training hours and more which is required by human resources process.

- Library Process

  Library process is about helping students, faculty and staff by understanding their needs and providing books and catalog of online available resources offered by library systems. Library process has Student registration service for borrowing and returning books, and to register complaints. They also have internal processes between the libraries, to exchange resources and enhance their work in order to increase the satisfaction of library customers.

- Education Technical Resources - Education Spaces Management process

  IPVC Quality Management systems is used to perform management of educational spaces in schools by recording level of satisfaction during questionnaires, requests for spaces, capacity of spaces and other information which is related to management of education spaces.

4.4 Using Agile BI methodology

Business requirements are consistently changing in global market and it is difficult to predict what business requirements will come tomorrow [33]. Therefore business persons do not know what business needs that they will have tomorrow. They only know what they want today. Even if they know what they want, they often change their minds. In this case, there is an advantage to apply an agile methodology (reacting quickly on changes) in BI development.

The Agile BI methodology consists of five life cycle implementation steps: story conference, task plans, development, sprint demo and retrospective [34 p. 9]. These steps are iterative and helpful in project implementation. The advantages of this methodology are:

- Understanding correctly business requirements;
- Appropriate respond to changes;
- Simplicity;
- Satisfy early and continuous delivery of valuable software;

- Least effort and delivery of the project in a short time.

In the context of this project we decide to use an agile methodology, by the fact that other methodologies in general are inappropriate when requirements change quickly and BI projects do not work well when using standard software development lifecycle [34]. The option to use Agile BI methodology was very useful and helpful to start the project implementation effectively and to make the development process simple.

For the development of this BI project, we divided implementation tasks into five steps, which were frame in time boxes as suggested by TDWI's (The Data Warehouse Institution) webinar - "Developing an Agile BI Environment" [34]. IPVC BI project processes were developed and deployed through the execution of the five steps defined in methodology (story of conference, task plans, development, sprint demo and retrospective), which were panned and scheduled in time. Figure 15 illustrates the IPVC BI project agile methodology steps.

In order to implement the BI system, the first step was to investigate and explore IPVC schools' twenty four processes to understand KPI requirements. The KPI requirements were a starting point to decide how data warehouse should be modeled and this modeling was done in a top-down approach. So, KPIs were a guideline which was used as a source for the implementation of the project.

Following the Agile BI methodology, we start from the story of conference step. We get the requirements (KPI list) of the twenty-four processes. The completion of this step took a lot more time than originally planned as we faced some problems and difficulties to get and understand KPI requirements list from QMS managers. Then, we chose three processes from KPIs requirements list: 1. Academic Service process; 2. Environmental, Health and Safety process; 3. Alimentation process.

In the task plan step we define technical tasks and its plans on the paper to implement the chosen processes. According to the three process KPIs list, we define star models (dimensions and fact tables) to implement the DW. Then we establish task plans to implement the project and answer the business requirements. In the execution of this step, we faced some problems to clarify the defined KPI requirements that were sometimes general and ambiguous, due to difficulties to get access to right persons in QMS department. For that reason Task Plan step took a lot of time to define fact tables, measures, dimension tables and relationships between them for each process in order to

be able to calculate defined KPIs. After this step, we were able to create our DW model in the development step.

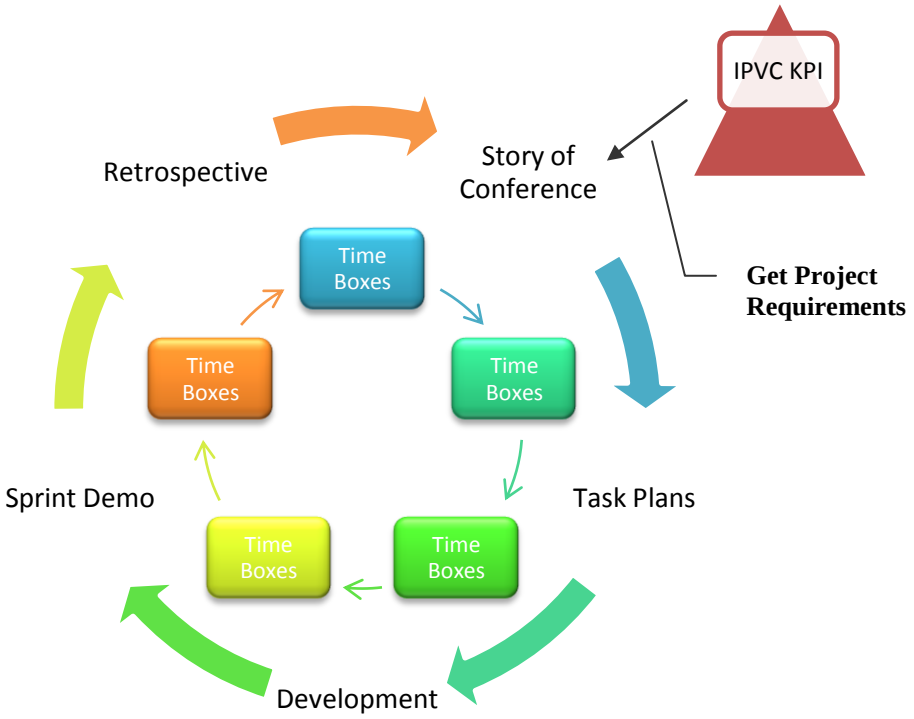

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Figure 15 - BI Agile Methodology Life Cycle (adapted from [34])

In the development step we began to develop and deploy our project with the selected BI Tool. Our task plan document was used as a guideline in this step. We also made self monitoring of our work. Following the task plans we construct the DW and develop and deploy BI application. We use OLAP tool to generate the multidimensional structure materialized as a cube according to the defined measures and calculations that are used to answer the KPI questions. Next we develop reports in Microsoft Excel and web based environment to deliver them to decision makers.

In sprint demo step, we prepared a demo version of our project in order to present results to QMS managers. This demo version was used to allow users to check and validate if results are acceptable and what they really require and need. To support the validation process we create a validation document, which includes the KPI requirements, DW model, report in Microsoft Excel format with charts and web based reports. At the same time, in this step, we evaluate performed work during our development cycle in order to optimize next processes. The evaluation of project development cycle was helpful to perform next lifecycle processes more effectively.

It is noteworthy that the used methodology considers one day of work to present and validate the demo version, but in our case iterations for validation took more than two or three weeks. Indeed, as the project was not coming from top managers, there were difficulties to execute some steps that require the availability of managers to participate in working sessions.

Finally, in retrospective step we evaluate the correctness on how our last development cycle went, in order to improve next processes lifecycles and we began the next important business KPI requirements and start the lifecycle again.

Following this "Agile BI" methodology we develop and deploy all twenty four processes of IPVC schools. Unfortunately we were not able to validate all twenty four processes. We could validate only some of the processes. In fact, during the implementation of this project, we faced several difficulties that hampered the development of the final BI system, namely:

- General and ambiguous KPI requirements list which have created difficulties in the definition of DW;
- Communications problems – There was some difficulties to communicate with QMS persons in English in order to clarify KPIs;
- Time – We have to implement the project in a short time period;
- Limited human resources - The project was very huge and complex to be fully implemented by one person;
- Availability problems – The IT project was not requested from the top managers, which had resulted in difficulties to be able to schedule meetings with QMS person;
- In particular decision makers have not been directly involved in the project development cycle, which created difficulties to execute the validation process.

4.5 **Selected BI Tools**

To implement the IPVC BI project we choose SQL Server 2005. The selection of SQL Server 2005 was based on several reasons. First, SQL Server 2005 meets the needs and requirements to develop the project. Second, considering that most of technological solutions implemented in IPVC are based on Microsoft technologies, this

option can facilitate the use of SQL Server and its integration in IPVC information system. Finally, this option was also due to time limitation for the execution of the project and considering that it was more important to focus on having a final solutions rather than in testing capabilities of different solutions.

Microsoft SQL Server 2005 provides all aspects of Business Intelligence and has the following services [10]:

- Integration Service – known as Data Transformation Service (DTS). It has the ability to integrate all information across the organizations units into one source (Data Warehouse) in timely manner.
- Online Analytical process (OLAP). It is the tool which is used to analyze data to make reports. OLAP provides aggregate functions such as count, sum, minimum, and maximum, among others to develop appropriate measure groups in OLAP cube.
- KPI (Key Performance Indicators). This tool is used in OLAP cubes to develop digital dashboard reports, which will help decision makers to evaluate and monitor organization processes faster and support decision making activities. KPI could be classified in different status levels which can be, for example, very good, good, fair, bad or very bad. To classify indicators, the limits for each status level should be defined, in order to be able to identify business conditions at a single glance on digital dashboard.
- Multidimensional Expression (MDX) queries and scripts are used to get information from analysis services cubes and allow to make calculations, get measures and to develop reports.
- Unified Dimensional Model (UDM) allows to slice and dice and summarize information by demand and to present information in a meaningful manner.
- Data mining tools are used to find and present patterns and behaviors, which might not otherwise be found in the data.
- Reporting Service and Microsoft Business Intelligence accelerators are used to facilitate the delivery of information to decision makers through the entire organization. In SQL Server 2005, report services are created using business intelligence development studio and Visual Studio 2005 tools.

During our research we attended The Data Warehousing Institute (TDWI)[5] webinars that introduced participants to various next generation BI systems and solutions. From the various solutions that demonstrate a number of interesting features, we consider that it could be advantageous to analyze the possibility to use Tableau software reporting solution in IPVC, since Tableau software offers a set of features that seems to be useful to be used in order to improve and enhance this project. Furthermore, Tableau software was selected as winner of 2010 CODiE Awards for "Best Software Development Solution" [35]. With Tableau it is possible to access all major data sources including text files, Excel, Access, SQL Server, SQL Server Analysis Services, Oracle, DB2, MySQL, PostgresSQL, Firebird, Netezza, Intesystems Cache, Hyperion Essbase, Teredata and Vertica [36]. Furthermore, Tableau allows to integrate multiple databases. Through the connection to different data sources we are able to develop different kind of graphical reports that Tableau software provides. These reports are very dynamic, allowing users to make operations such as new calculations, filtering, grouping and accessing the data, which gives "self-service" opportunity to deliver BI reports and reduce IT staff involvement. In fact, using the Tableau software, users are able to use self-service functionalities to develop new kind of measures for the reports without IT person's involvement. On the other hand, Tableau software does not provide instruments to develop data warehouses, but it is oriented to access all major kind of data and to deliver very high quality reports. For that reason the use of SQL Server 2005 reveals to be a good solution to make data integration and data warehousing to integrate all data, while Tableau can be used to develop advanced reports to support decision making activities. Tableau reports could be published in Power Point, PDF and in other applications format or in web format using Tableau Server service, where end-users could get extremely dynamic reports.

4.6 **Implementation**

To develop this project, we had to execute a set of steps for each QMS process in order to implement a solution that will respond to the KPI requirements defined by QMS managers. In the following sections, we present a description of the steps that should be executed to deliver KPI reports to decision makers.

[5] http://tdwi.org/

4.6.1. Data Source

In order to implement this project we should have access to three sources of information: data of IPVC Quality Management System (QMS), forms and the KPI requirements list. Lamentably, for reasons beyond the project we were unable to get data from IPVC QMS. Due to this fact and in order to be able to execute the project, we rely on the Key Performance Indicators (KPI) requirements. In order to overcome the unavailability of data to develop the project, we decide to generate some random data to populate the data warehouse with the objective to validate our implementation.

4.6.2 Educational Data Warehouse (EDW)

The development of the project has resulted in the definition and creation of an educational data warehouse model of the twenty-four processes. Figure 16 presents a partial view of IPVC DW model which is prepared to store data of IPVC processes.

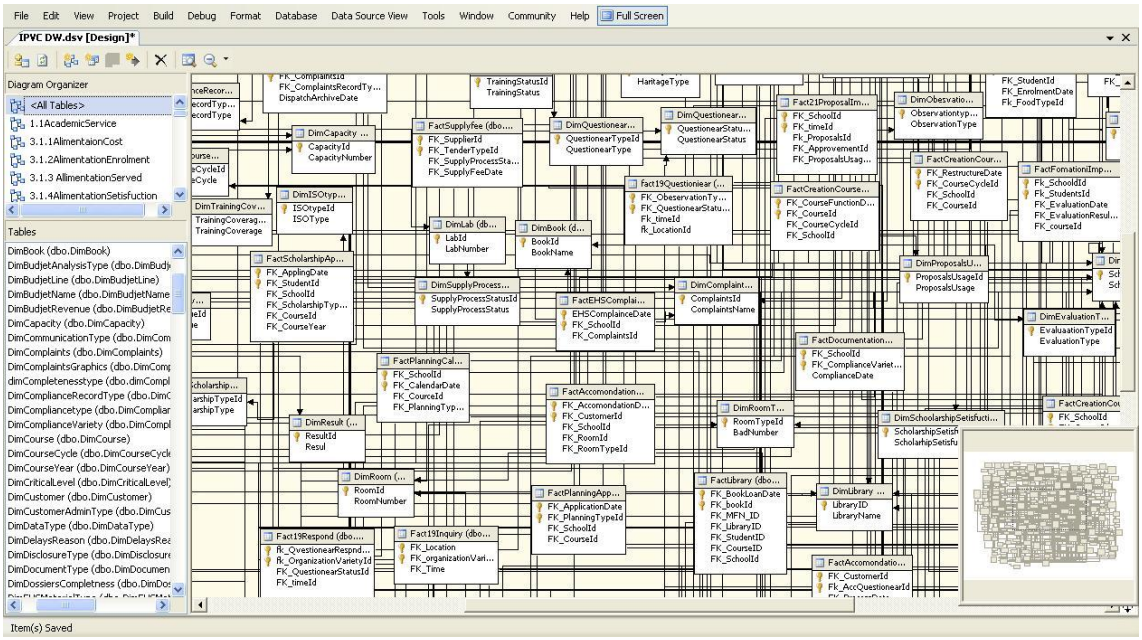

Figure 16 - IPVC Schools Data Warehouse Model

This DW will be used to create cubes with the OLAP tool for further analyzing and report delivering. The IPVC DW is composed by 79 fact tables and 108 dimension tables. Because of this huge number of data entities and relations between tables (dimension tables and fact tables), we decide to divide and present the final DW model into smaller models corresponding to each 24 processes in order to facilitate the

presentation of our work and to demonstrate how KPI requirements have been answered. Each DW model is represented with all dimensions tables which are involved in each process in order to facilitate the interpretation of each model. However in the final EDW model, there exists only one table for each dimension, like, for example time dimension, student dimension, among others.

4.6.3. ETL (Extract, Load, Transform) process

After we define and construct the DW model considering the KPI requirements, it is necessary to load data from IPVC QMS into DW in order to do calculations and support KPI requirements. For this purpose, we should perform Data Integration (DI) process, which includes ETL (Extract, Load and Transform) tasks. However, as referred before, we were unable to have access to data sources of QMS. As it was not possible to get data source of the processes from IPVC schools and in order to validate our work, we generate random data in Microsoft Excel to be loaded in EDW. However we consider that this situation does not invalidate the developed work, as project objectives was to develop a decision support system for IPVC, and it will be possible in the future to create the ETL process to load data from IPVC QMS data sources. Nevertheless, for the purpose of our work, we have analyzed the steps that are involved in the creation of an ETL process using SQL Server Integration Service (SSIS) tool (Figure 17). SSIS is a graphical tool that can facilitate the definition of an ETL process. Traditionally data integration process involves the following steps:

- Extraction of Data

  In order to build ETL process the first step involves the extraction of data from the data source. Data extraction process involves the identification and selection of data for transformation. The data selection task is used to access data for selection purpose establishing a connection to databases or files. The SSIS tool is used to establish a connection to data sources and extract data for the transformation purpose. In order to make data selection, when it is necessary to select data from various tables at one time, we need to define a SQL-Query command to access several entities taking into account relationship between data sources. After the connection to data sources is successfully established we can

make data selection. It could be done using SSIS package item in Data Control Tab.

- Transformation of Data

  Selected attributes must comply with DW requirements and be suitable, otherwise data will not be delivered to data warehouse and destination errors will occur. The transformation step involves operations like the conversion between data types of different databases systems used in data sources and DW.

- Load of Data

  After data is transformed into required format, we can load data into data repository.

Figure 17 represents a possible ETL process for academic service using the SSIS tool of SQL Server, allowing to define all steps involved in a ETL process to load data to the DW.

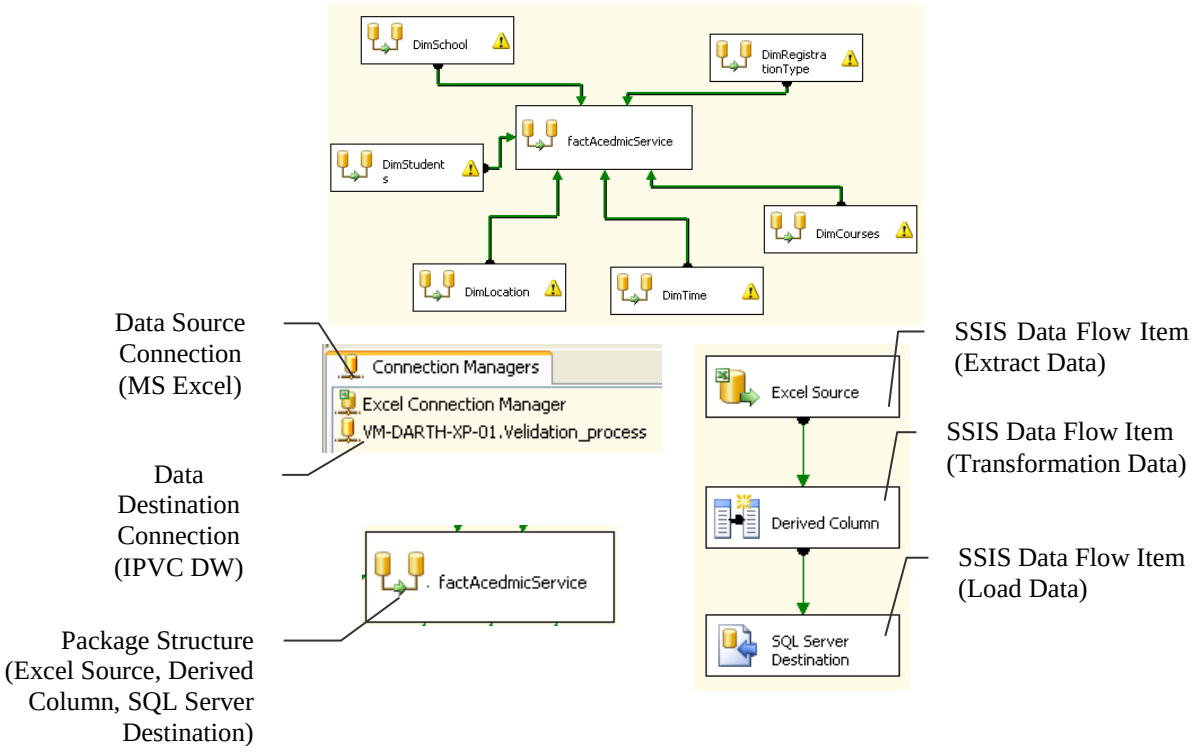

Figure 17 - Example of Academic Service ETL process

4.6.4 Online Analytical processes (OLAP) Tool

After data is loaded into Data Warehouse, we move data into OLAP cubes to analyze information and develop reports. With OLAP tool we can easily store the data

into cubes. It gives the opportunity to construct cubes based on dimension tables, fact tables and to build hierarchies with multiple levels. In some applications, OLAP tools (for example Microsoft Visual Studio used in this project) include a cube designer which allows to define dimensions (used to summarize values) and measures (the values to be aggregated) to generate the multidimensional structure. These tools permit to define general aggregations functions such as sum, count and average to define measures, or to define more complex functions using MDX commands. Figure 18 presents an example of the cube designer interface with the definition of measures and dimensions in the case Academic Service process.

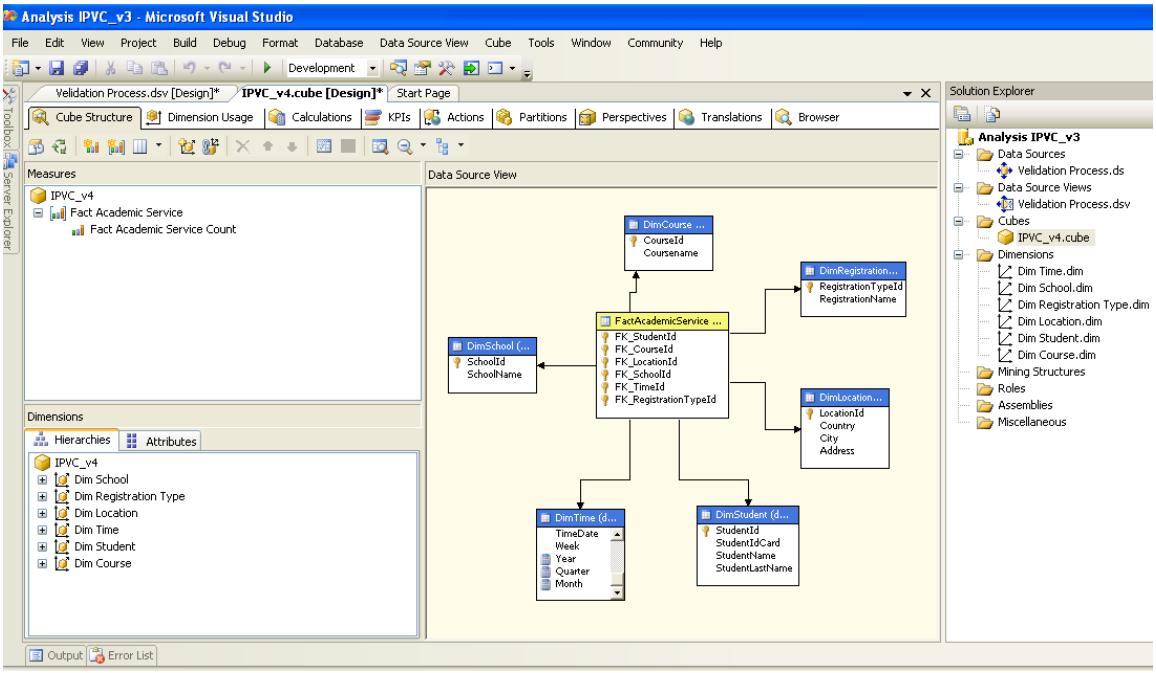

Figure 18 - Cube structure interface

In order to support some of the KPI requirements we need to make additional calculations using MDX expressions. In this case we can create a calculated member, which is similar to creating a computed value. In our project we effectively use calculation expressions to get specific measures needed for KPI. These calculations are allocated in the cube cell. Calculated measures are done in the Calculations tab of the Cube Design tab. For example Figure 19 shows the definition of a measure used to calculate online subscription rate of students.

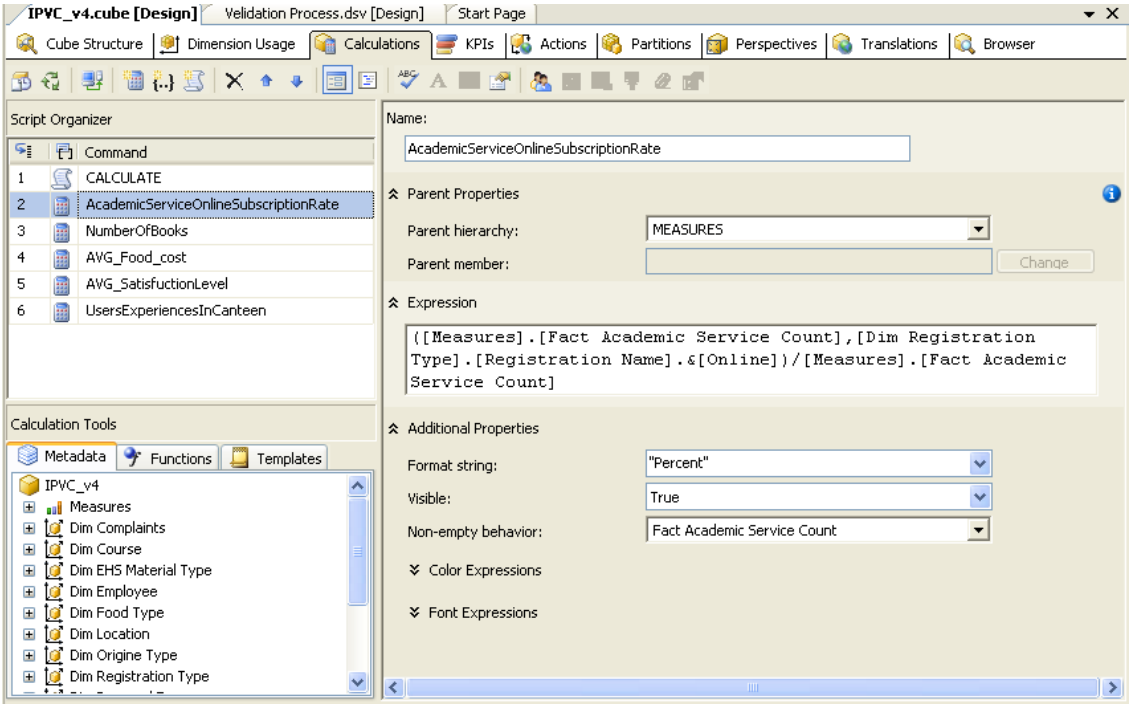

Figure 19 – Definition of a calculated measure.

4.6.5. Management reports

After creating OLAP cubes, we can use Analysis Service measures to calculate all KPI in order to develop reports and to support decision makers in decision making activitites. All the tasks in previous steps were made in order to be able to develop BI application and to deliver reports to QMS staff. We allocate all processes data information into a single repository called IPVC Data Warehouse and then we use OLAP Tool to analyze all the information in data cube. We define all necessary calculations to answer the KPI requiriments. At this point, it is possible to browse the cube in the Browser tab of the Cube Designer, that allows to select dimensions and measures in order to visualize and analyse measures values by drilling into detail from summary, navigating hierarchies, sorting, ranking, filtering, charting and exporting. Figure 20 represents browser view to test developed report correctness.

Finally we are able to develop reports. For the purpose of this project, the reports were developed in two formats: Microsoft Excel and Web. In fact, the QMS managers perform their work using Microsft Excel application, so it will be advantages for QMS persons to get the reports about IPVC processes in Microsoft Excel format with charts

in their computers. We decide also to provide users with the access to the same reports using web browsers.

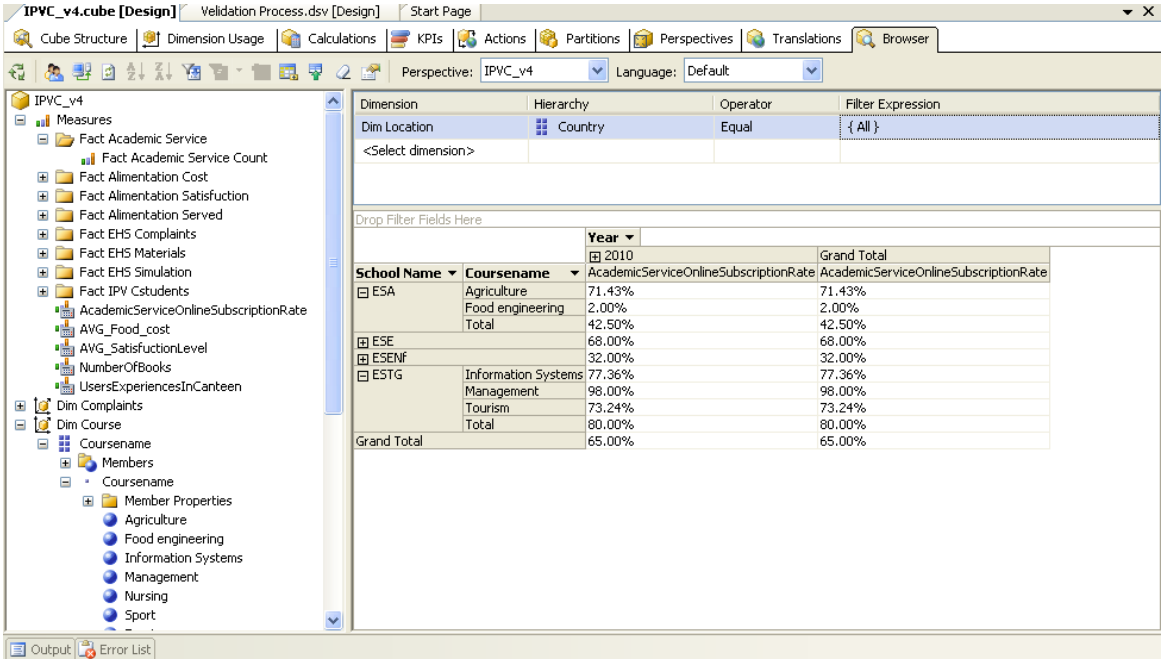

Figure 20 - Web browser tab of the Cube Designer

According to the Agile BI methodology that were used in the implementation life cycle of our project, we use the reports as a documentation for validation processes. To interact with end users we present the Microsoft Excel reports and web reports in order to evaluate the correctnes of reports and to be sure if it is exactly what they require.

Additionally, we implement digital dashboards using KPIs to support business requirements. BI dashboards are intended to provide decision makers with an overview of business performance at a glance, using attractive and intuitive visual interface. From a decision maker‘s perspective, dashboards provide a useful way to view data in a format that is easy to understand and to assimilate for managers.

In that context, we use the KPIs tab of the Cube Designer to define status levels, in order to be able to see KPI digital dashboard and identify IPVC education processes conditions at a single glance. Figure 21 represents the definition of KPI digital dashboards for the first IPVC process of KPI requirements.

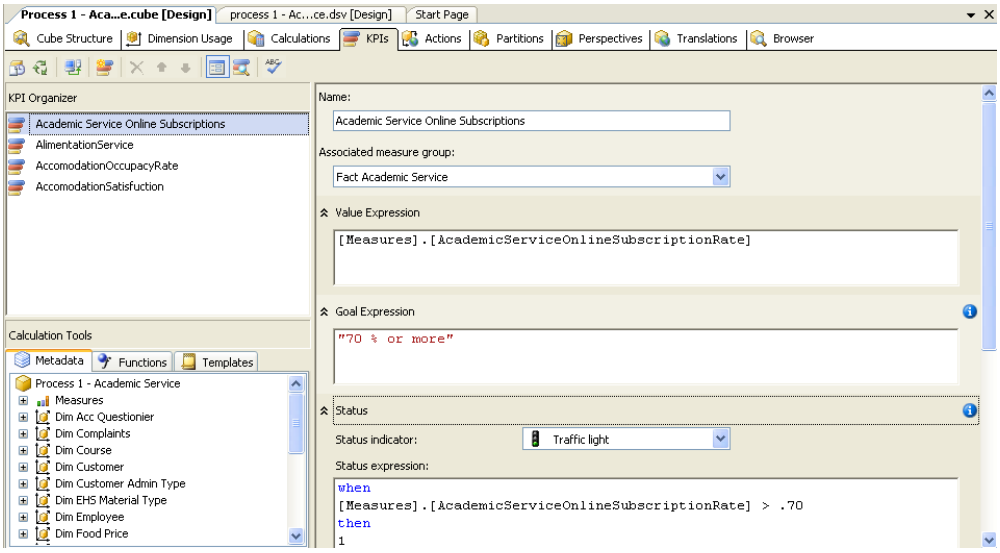

Figure 21 - KPIs tab on the Cub Design

To configure the KPI tab, we define the goal value to be attained in Goal Expression. Then the Status Expression is used to determine the current status of the KPI that will be used to picture status level. For example, in the case of students' online subscription rate, the KPI value should reflect the following status level:

- Values greater than 70 percent should get a very good status;
- Values greater than 30 percent, but less or equal than 70.00, should get normal status;
- Values less or equal to 30 percent should get bad status.

To apply this status into KPI, we have to define the Status Expression field using the following Multidimensional Expression (MDX):

```
Case
   when [Measures].[AcademicServiceOnlineSubscriptionRate] > .70
            then 1
   when [Measures].[AcademicServiceOnlineSubscriptionRate]>.30
             and
[Measures].[AcademicServiceOnlineSubscriptionRate]<= .70
            then 0
   when [Measures].[AcademicServiceOnlineSubscriptionRate] <= .30
      then -1
End
```

After defining the digital dashboard KPI, we can deploy this modification to the Analysis Service Database in order to be available to users. Figure 22 presents can see KPI deployment result shown in KPI Browser.

Dimension	Hierarchy	Operator	Filter Expression
Dim School	School Name	Equal	{ All, ESA, ESE, ESENf, ESTG }
Dim Time	Year - Quarter - Month - TimeDate	Equal	{ 2010 }
<Select dimension>			

Display Structure	Value	Goal	Status
Academic Service Online Subscriptions	65.00%	70 % or more	
AccomodationOccupacyRate	50.15%	80% more	
AccomodationSatisfuction	23.40%	75% more	
AlimentationService	100.00%	90% more	

Figure 22 - IPVC Digital Dashboard report

4.7 **Answering IPVC Business Needs**

The top position persons of IPVC schools need to analyze the data available from IPVC Quality Management systems (IPVC QMS). They would like to have analytical reports about all IPVC processes. As QMS staff uses Microsoft Excel to perform their work, they also would like to get BI reports in the same environment. The final purpose of this project is to implement a system which allows to calculate required KPIs and to deliver reports. In the following points, we present the business needs, DW models, OLAP cubes, reports and dashboards developed for the first four IPVC processes, namely, Academic Service, Environment Health and Safety, Alimentation and Accommodation. The remaining IPVC processes business needs and DW models are presented in Appendix B, since we were unable to validate these processes during the time of development as mentioned previously.

In general, the structure of data warehouse model contemplates a set of dimension attributes, as well as measures (for example: quantity, sum, and average, from others). However, in our project, some data warehouse models do not include measures, as we developed measures inside the cubes to calculate and answer KPI requirements through the use of functions and MDX expressions.

- **Academic Service Business Needs**

IPVC QMS staff needs to analyze all business processes which are related to academic service department work. They want to analyze the information across schools, courses, students, registration types and years and to be able to drill down to

the quarter, month and date level. Academic Service KPI requirement includes the percent of student's online subscription (Table 2).

Process	Process/ Sub-process	Indicator	Calculation Formula	Unit of Measure
Academic Service	Academic Service	online subscriptions rate	Number of online subscriptions / Total number of subscriptions	%

Table 2 - Student online subscription KPI requirement

To answer this KPI requirement, we define the star model of academic service process illustrated in Figure 23, which is composed of a fact table and its connections to dimension tables. The model includes dimensions about students, schools, time, courses, locations and students registration type.

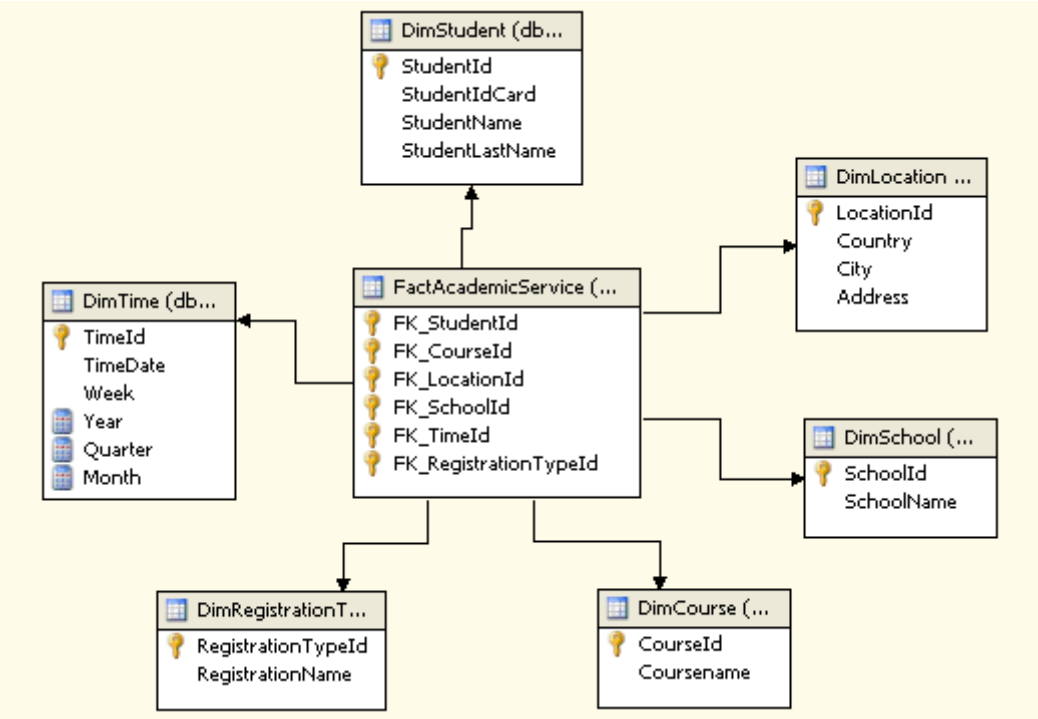

Figure 23 – Star model of student's online subscription of academic service process

To define the cube measures, we use count function from OLAP environment to get a measure (Fact Academic Service Count) that corresponds to the total number of students' subscription. Using this measure we are able to calculate students' online subscription rate applying the following MDX command:

Calculation name: AcademicServiceOnlineSubscriptionRate

MDX Expression: ([Measures].[Fact Academic Service Count],[Dim Registration Type].[Registration Name].&[Online])/[Measures].[Fact Academic Service Count]

Figure 24 presents the defined measures and dimensions for OLAP cube.

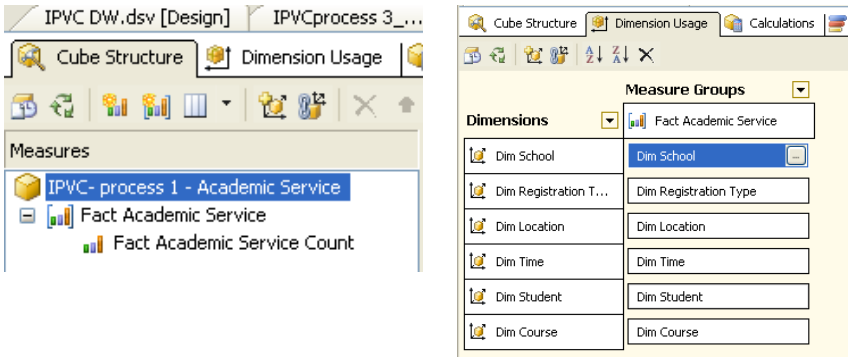

Figure 24 - OLAP cube of students online subscription of academic service process

After the definition of the cube, we produce a set of reports. Figure 25 presents an academic service report, which answers academic service process KPI requirements – "Students Online Subscription". The report is in Microsoft Excel format and includes the following column fields: school name, course name, time and academic online service subscription rate. With this report QMS person can see the student's online subscription rate in academic service by year, school and courses. Furthermore, QMS persons can also use drill down techniques and see the information in more detail if needed.

	A	B	C
1	Year - Quarter - Month - TimeDate	2010	
2			
3	School Name	Coursename	AcademicServiceOnlineSubscriptionRate
4	ESA		43%
5		Agriculture	71%
6		Food engineering	2%
7			
8	ESE		68%
9		Sport	68%
10			
11	ESENf		32%
12		Nursing	32%
13			
14	ESTG		80%
15		Information Systems	77%
16		Management	98%
17		Tourism	73%
18			
19	Grand Total		65%

Figure 25 - Microsoft Excel report of student's online subscription

Figure 26 presents a graphical chart of students' online subscription rate of academic service, where QMS person can visualize students' online subscription rate by school and courses.

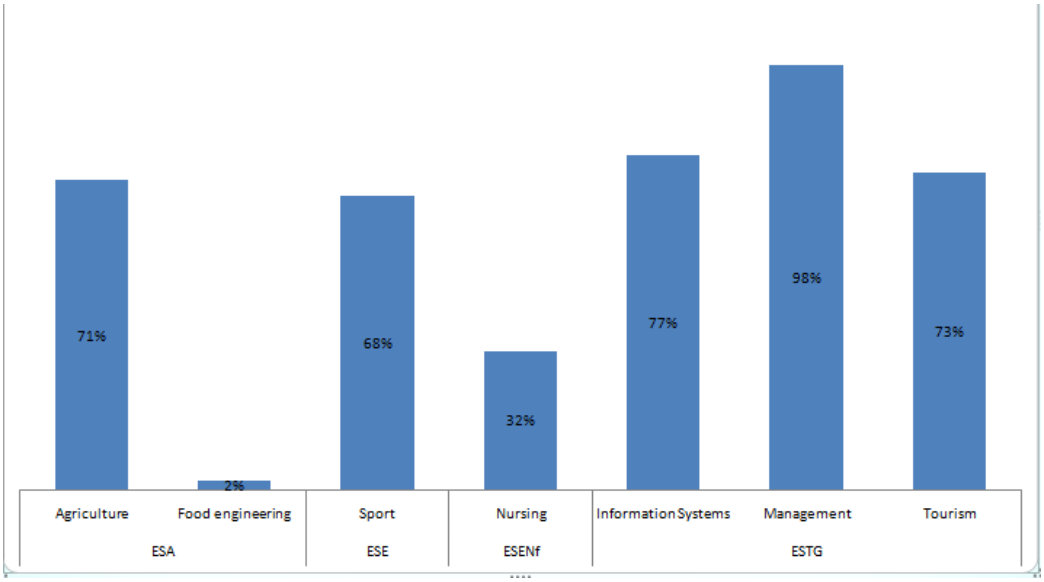

Figure 26 - Chart report of students' online subscription

- **Environment, Health and Safety**

In relation to Environment, Health and Safety (EHS) managers are interested in analyzing the information in IPVC schools related to simulacra, complaints and manuals. The first defined KPI requirement of EHS process is related with the number of simulacra in IPVC (Table 3).

Process	**Process/ Sub-process**	**Indicator**	**Calculation Formula**	**Unit of Measure**
Environment, Health and Safety	Environment, Health and Safety	Simulacra indicator	Number of simulacra performed per year	Number

Table 3 - Simulacra KPI requirement

Figure 27 presents the defined star model for EHS simulacra process, which is composed of one fact table and its connections to four dimension tables that include employee, schools, time and simulacra type (for example: water or fire).

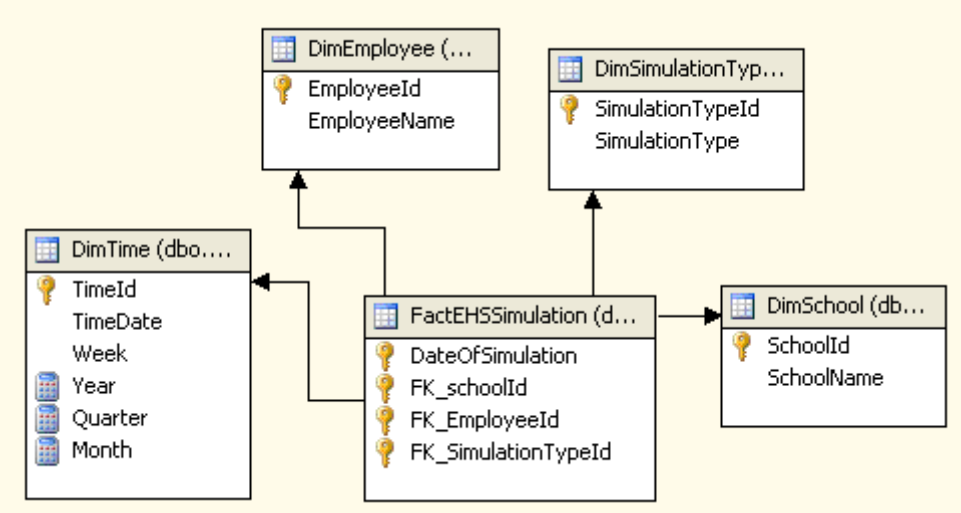

Figure 27 – Star model of simulacra indicator of EHS process

The measure defined (Fact EHS Simulation Count) in this case is delivered using the count function that corresponds to the total number of simulacra.

Based on the defined cube, we create a simulacra report, which answers EHS process KPI requirements – "number of simulacra" (Figure 28). The Microsoft Excel report has column fields that include school name, year, simulation type and EHS simulacra number. With this Microsoft Excel report, QMS person can see the performed simulacra in IPVC by schools, simulation type and year. Furthermore, QMS persons can also use drill down techniques and see the information in more detail if needed.

	A	B	C	D
1				
2				
3	School Name	Year	Simulation Type	NumberOfSimulacra
4	ESA			2
5		2009		1
6			Fire	1
7				
8		2010		1
9			Fire	1
10				
11	ESENf			2
12		2009		2
13			Fire	2
14				
15	ESTG			7
16		2009		5
17			Fire	4
18			Water	1
19				
20		2010		2
21			Fire	2
22				
23	Grand Total			11

Figure 28 - Microsoft Excel report of EHS simulacra indicator

Figure 29 presents a graphical chart of simulacra number by type and schools, from where QMS persons can easily analyze EHS process in IPVC and see EHS simulacra number by school and simulation type. QMS persons can also use drill down techniques and see the information in more detail. This chart can be useful to answer questions such as how many simulacra have been performed in each school by simulation type and year.

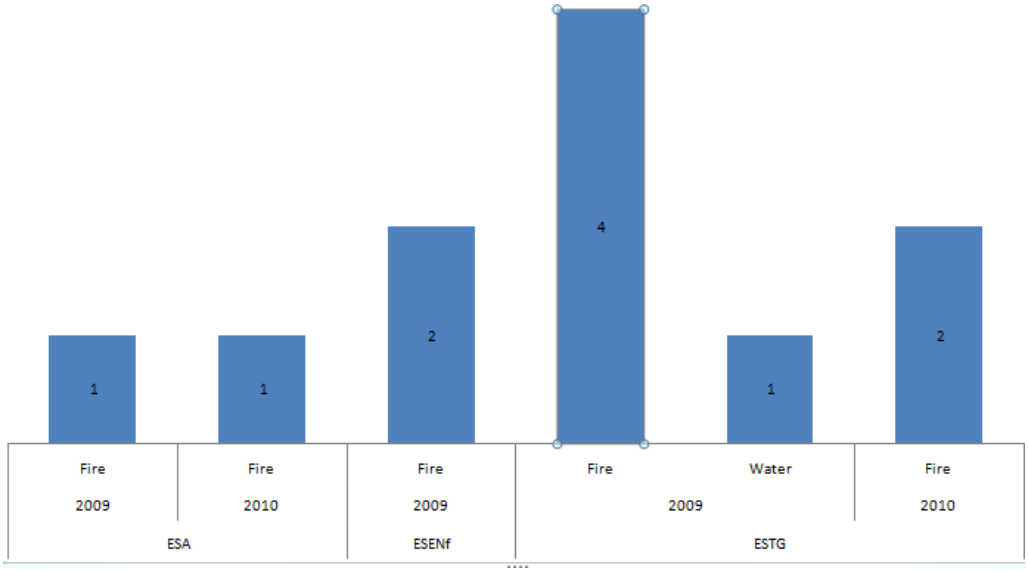

Figure 29 - Chart report of EHS simulacra indicator

Figure 30 presents a web format report of EHS simulacra process in IPVC. QMS persons can consult the EHS simulacra number by school, simulation type, year and quarter. Besides, web report allows end users to use drill down techniques and see the information in more detail if needed.

EHS report of simulacra indicator

		2008		2009	2010
		2008Q1			
		200801	200803		
ESA	Fire	1		1	1
	Water	1			
ESE		1		1	2
ESENf				2	
ESTG		2	1	5	2

Figure 30 - Web report of EHS simulacra indicator

Another KPI requirement for EHS process is about complaints number and it is presented in Table 4.

Process	Process/ Sub-process	Indicator	Calculation Formula	Unit of Measure
Environment, Health and Safety	Environment, Health and Safety	Number of complaints	Number of complaints per time levels	Number

Table 4 - EHS complaints KPI requirement

Figure 31 presents the defined star model of EHS complaints process, which is composed of a fact table and its connections to dimension tables that include complaints type, schools and time.

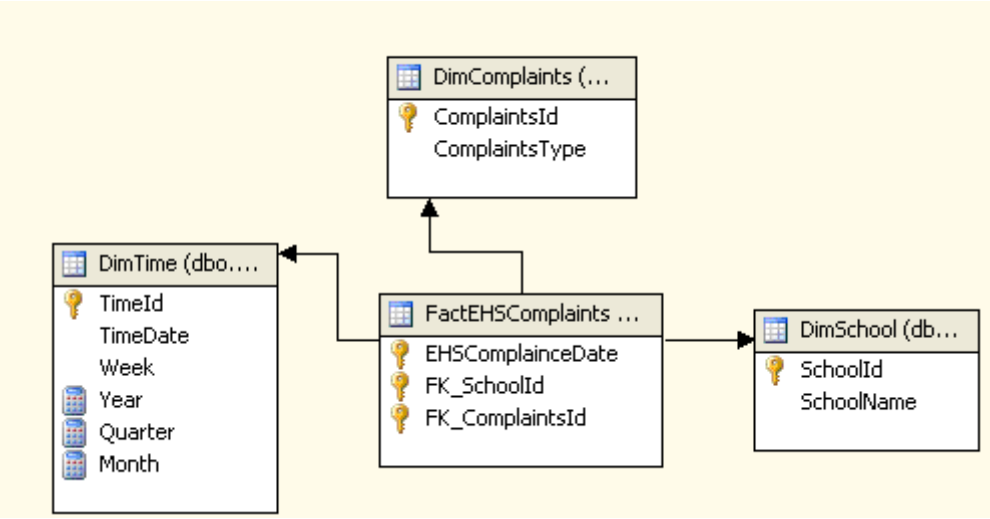

Figure 31 – Star model of complaints number of EHS process.

We develop the number of complaints measure (Fact EHS Complaints count) using the count function inside the cube, which allows to count all the records in fact table. With the count function we are able to get all complaints number by each schools and time levels.

Figure 32 presents a report with the number of complaints in Microsoft Excel format. The report includes columns fields such as school name, complaints type and year. Furthermore, QMS persons can also use drill down techniques and see the information in more detail.

	A	B	C	D
1				
2				
3	School Name	Year	Complaints Type	NumberOfComplaints
4	ESA			12
5		2008		2
6			Library	2
7				
8		2009		1
9			Library	1
10				
11		2010		9
12			Canteen	4
13			Library	5
14				
15	ESE			4
16		2008		1
17			Bar	1
18				
19		2009		1
20			Bar	1
21				
22		2010		2
23			Bar	2
24				
25	Grand Total			16

Figure 32 - Microsoft Excel report of EHS complaints number

Figure 33 presents a bar chart of complaints number in schools, where users can see what type of complaints exist in each school by years.

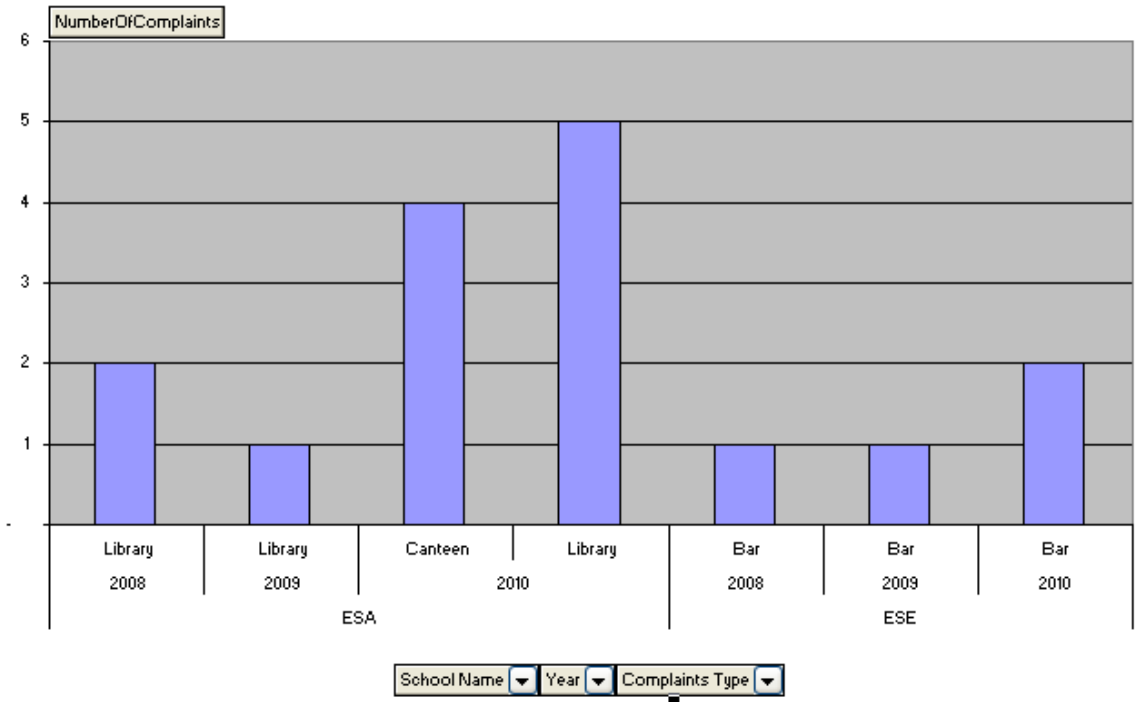

Figure 33 - Chart report of EHS complaints number

Figure 34 presents a web format report of EHS number of complaint in IPVC. QMS persons can analyse EHS complaints number by school, year, quarter and month, in order to identify the services that have more complaints.

EHS report of complaints number

		2008	2009	2010		
				2010Q1		
				201001	201002	201003
ESA	Canteen			2	2	
	Library	2	1	1	2	2
ESE	Bar	1	1	1	1	
ESENf	Academic Service		1			
	Bar		1			
ESTG		3	5	16	3	5

Figure 34 - Web report of EHS complaints number

Finally, Table 5 presents the manuals KPI requirements, which is the last defined requirement for the environment, health and safety process.

Process	**Process/ Sub-process**	**Indicator**	**Calculation Formula**	**Unit of Measure**
Environment, Health and Safety	Environment, Health and Safety	Manuals indicator	Number of Proposals / Number of Manuals	Number

Table 5 - EHS number of manuals KPI requirement

The star model of EHS manuals is presented in Figure 35. The model includes dimensions for school, time and material type.

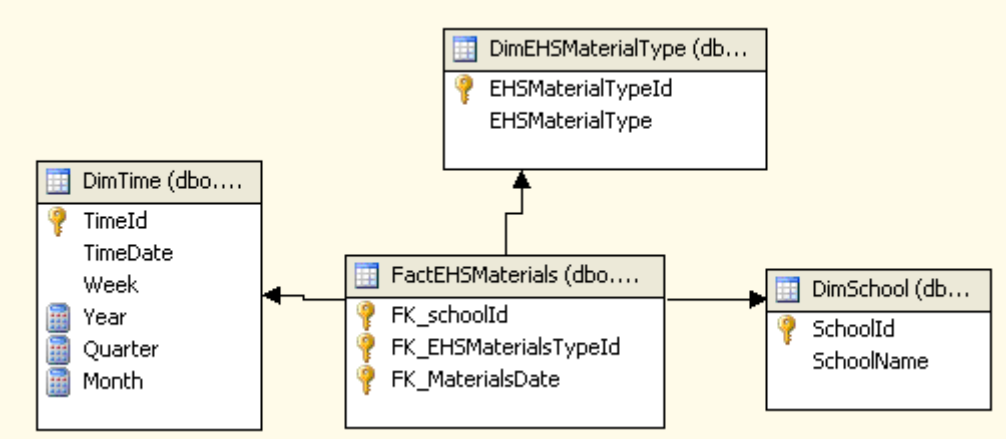

Figure 35 – Star model of manuals indicator of EHS process

In order to answer this KPI requirement, we develop a measure to get the number of manuals and proposals using the count function inside the cube. To calculate EHS manuals indicator we define the following MDX command:

Measure Name: Manuals indicators

MDX Expression: ([Measures].[Fact EHS Materials Count],[Dim EHS Material Type].[EHS Material Type].&[Proposals])/([Measures].[Fact EHS Materials Count],[Dim EHS Material Type].[EHS Material Type].&[Manual])

Figure 36 presents a report in Microsoft Excel with the number of manuals, proposals and manuals indicator value by school and year. QMS staff can see the list of manuals and proposals that are available in EHS process across schools by years and months.

	A	B	C	D	E
1					
2					
3	School Name	Year	ManualsIndicator	Proposals	Manuals
4	ESA		1,33	4	3
5		2008	1,00	1	1
6		2010	1,50	3	2
7					
8	ESTG		1,25	10	8
9		2008	2,00	2	1
10		2010	1,14	8	7
11					
12	Grand Total		1,27	14	11

Figure 36 - Microsoft Excel report of EHS manuals indicator

Figure 37 presents a graphical chart report of manuals KPI, from where QMS person can have a graphical view of the number of manuals, proposals and manuals indicators.

Figure 38 presents a web format report of manual KPI. QMS person can see EHS materials number by school and time level. Additionally, web report allows end users to use drill down techniques and see the information in more detail.

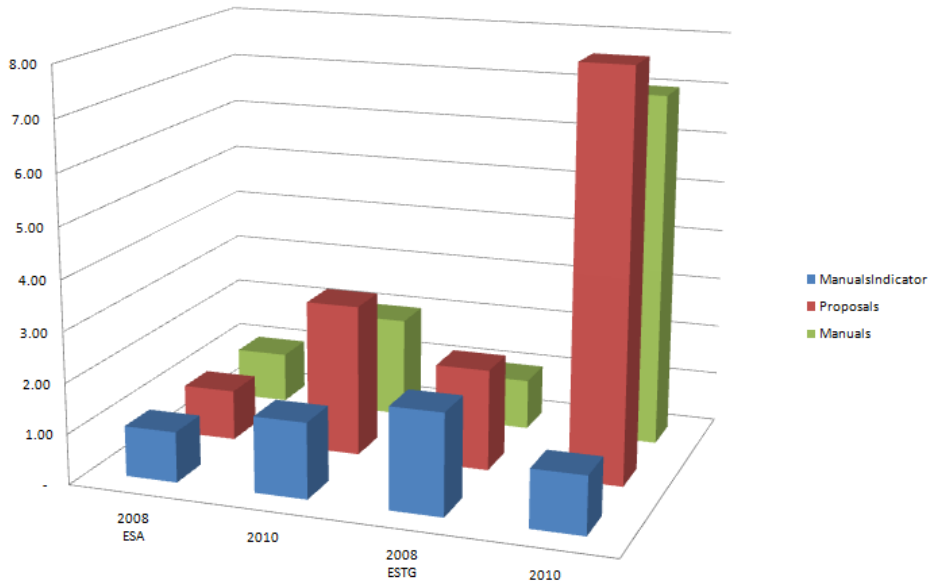

Figure 37 - Chart report of EHS manuals indicators

EHS report of manuals indicators

School Name	Year	Proposals	Manuals	Manuals Indicator
⊟ ESA				
	⊟ 2008			
		1	1	1
	⊞ 2009			
	⊞ 2010			
⊞ ESE				
⊟ ESENf				
	⊞ 2009			
⊟ ESTG				
	⊟ 2008			
		2	1	2
	⊞ 2009			
	⊞ 2010			

Figure 38 - Web report of EHS manuals indicator

- **Social Service - Alimentation**

IPVC QMS staffs need to analyze data processes which are related to alimentation processes in IPVC schools. They would like to analyze the information

about bars and canteens across the schools and time. For this purpose QMS managers have defined the KPI requirements. Table 6 presents the KPI requirement related to average cost of alimentation.

Process	Process/ Sub-process	Indicator	Calculation Formula	Unit of Measure
Social Service	Alimentation	Average Cost	Average cost by product	Number

Table 6 - Alimentation average cost KPI requirement

In order to answer KPI average cost requirement, we define a star model for alimentation process (Figure 39), that includes two fact tables in order to store information about alimentation cost and served products.

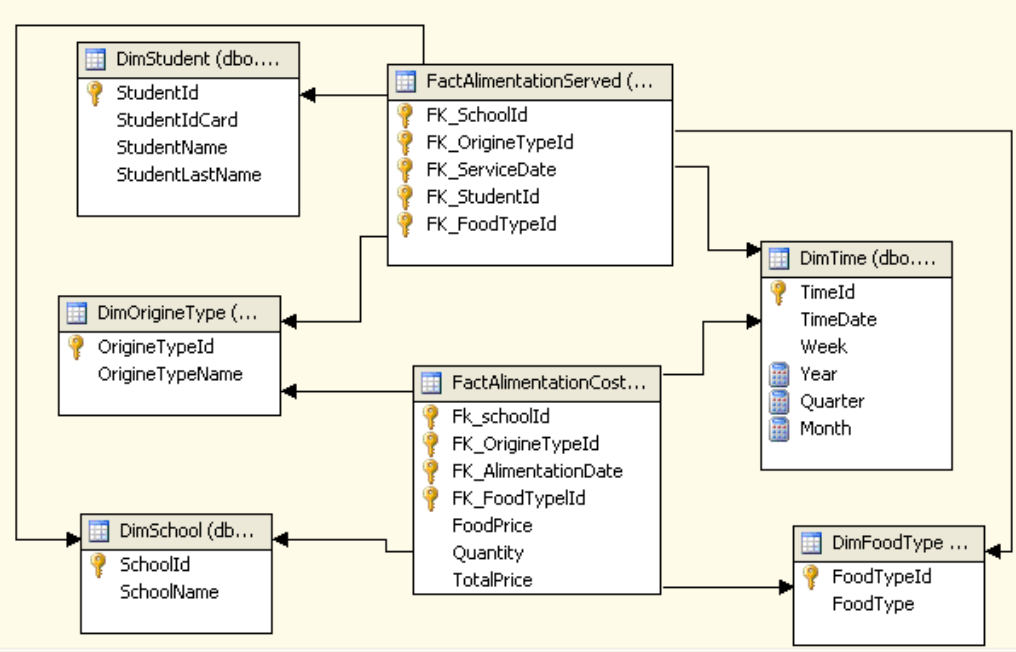

Figure 39 – Star model of average cost of alimentation process

To calculate average cost, we develop a measure (Fact Alimentation Served Count) to get served products using the count function and a measure (Total Price Sum) to get the total price of products using the sum function on measure TotalPrice of alimentation cost fact table. Using these measures, we define the following calculated measure to answer KPI requirements:

Measure Name: Average_cost

MDX Expression: [Measures].[Total Price Sum]/[Measures].[Fact Alimentation Served Count]

Figure 40 illustrates a report in Microsoft Excel format that presents average costs by year, origin type, food type, school name and food price. With this report QMS person can see food price in IPVC by schools, food and time period.

	A	B	C	D
1	Month	201002		
2				
3	School Name	Origine Type Name	Food Type	Average_cost
4	ESA			
5		Bar		
6			Compal	0,75
7				
8		Cafeteria		
9			Meal	2,20
10			Soap	0,90
11				
12	ESTG			
13		Bar		
14			Compal	0,75
15			Tosta Mista	0,90
16				
17		Cafeteria		
18			Meal	2,20
19			Soap	0,90
20				
21	Grand Total			

Figure 40 - Microsoft Excel report of alimentation average cost

Figure 41 presents a bar chart report of alimentation cost by school, food type year and month, where it is possible to use drill down techniques and see the information in more detail.

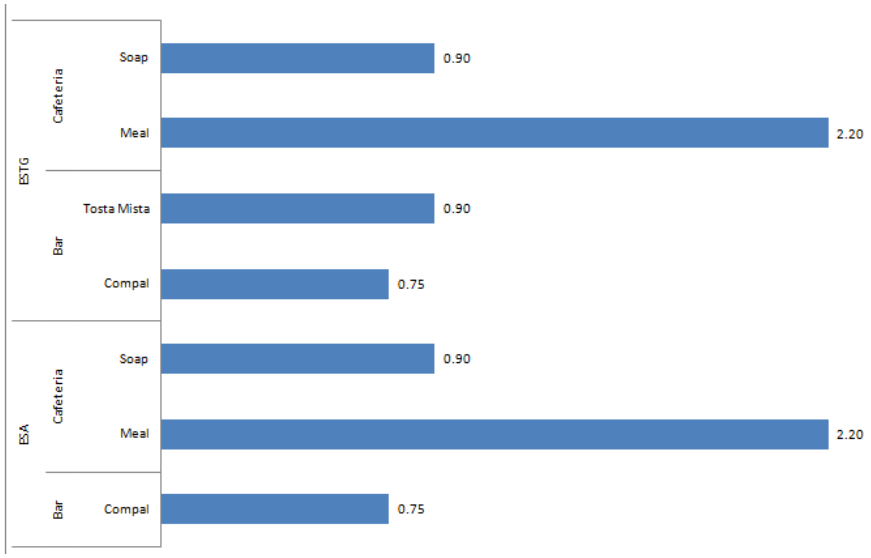

Figure 41 - Chart report of alimentation average cost

The second KPI requirement of alimentation process is related to the percentage of students that use canteens' service (Table 7).

Process	Process/ Sub-process	Indicator	Calculation Formula	Unit of Measure
Social Service	Alimentation	% of users in canteens	Number of served meals / Number of enrolled students	%

Table 7 - Percentage of users in canteens KPI requirement

Figure 42 presents the star model created to get the percentage of users in canteens. The model includes fact tables with enrolled students in IPVC and served meals in canteens. The dimensions in the model are schools, time, food type, students and origin type.

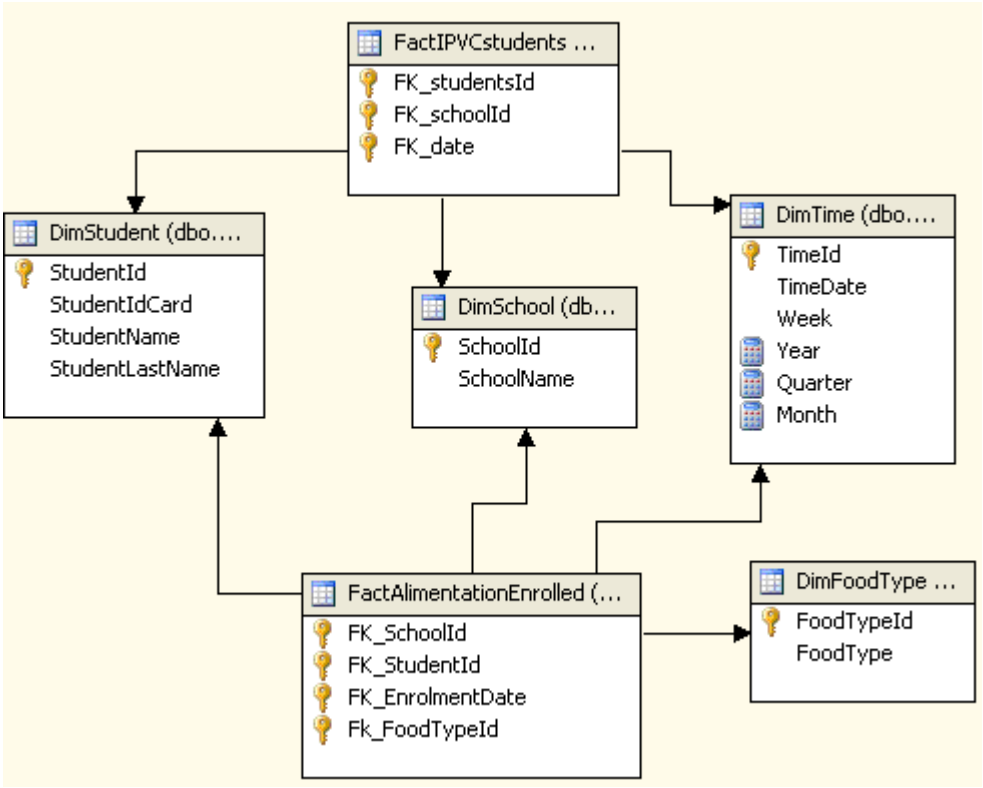

Figure 42 – Star model of percentage of users in canteens of alimentation process.

To answer this KPI requirement, we develop two measures using the count function: one to determine the number of enrolled students (Fact IPVCstudents Count) and another to get the number of served meals (Fact Alimentation Served Count). Using these measures we are able to calculate the percentage of users that have meals at canteens through the definition of a calculated measure:

Measure name: UsersInCanteen

Expression: [Measures].[Fact Alimentation Served Count]/[Measures].[Fact IPVCstudents Count]

Figure 43 presents a report with the percentage of users of alimentation services, which is in Microsoft Excel format and includes the following column fields: school name, time level and percentage of users in canteens.

	A	B
1	Year - Quarter - Month - TimeDate	All
2		
3	School Name	UsersInCanteen
4	ESA	79%
5	ESE	54%
6	ESENf	52%
7	ESTG	91%
8	Grand Total	80%

Figure 43 - Microsoft Excel Report of alimentation users' percentage in canteen

Figure 44 presents an example of a chart report with the percentage of users in canteens by school and by time level.

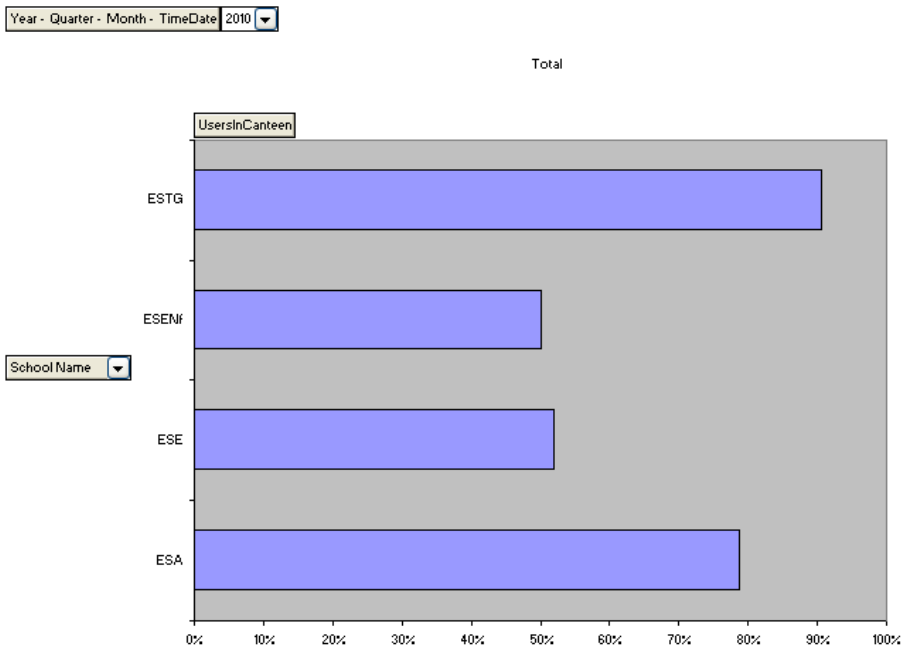

Figure 44 - Chart report of alimentation users' percentage in canteen

The third KPI requirement of alimentation process is the average level of users' satisfaction in canteens and bars (Table 8).

Process	Process/ Sub-process	Indicator	Calculation Formula	Unit of Measure
Social Service	Alimentation	Average level of satisfaction in Canteens and bars	∑ satisfaction level / number of responses obtained	Inquiry scale

Table 8 - Average level of satisfaction KPI requirement

Figure 45 represents the star model of alimentation satisfaction level, which is composed of a fact table and its connections to dimension tables. The model includes the following dimensions: schools, time, satisfaction level, origin type and students.

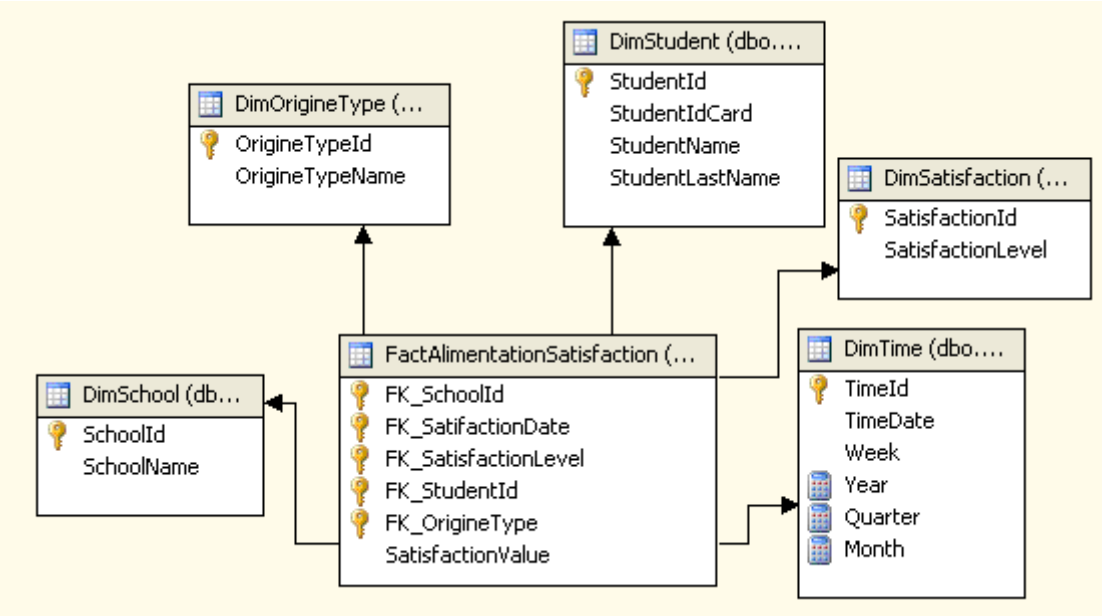

Figure 45 – Star model of average satisfaction of alimentation process

To answer this KPI requirement, we use the count and sum functions. With count function we develop measure (Fact Alimentation Satisfaction Count) to get number of responses and with sum function we develop measure (Satisfaction Value) to get sum of satisfaction values. In order to calculate average satisfaction level of canteen and bars and answer KPI requirement we apply following MDX command:

Measure name: AVG_SatisfactionLevel

MDX Expression: [Measures].[Satisfaction Value]/[Measures].[Fact Alimentation Satisfaction Count]

Figure 46 presents alimentation satisfaction level in that includes following column fields: school name, year, origin type and average satisfaction level. Figure 47 represents charts report of alimentation satisfaction levels in schools.

	A	B	C
1	Year	(Multiple Items)	
2			
3	School Name	Origine Type Name	AVG_SatisfactionLevel
4	ESA		2
5		Bar	2
6		Cafeteria	2
7			
8	ESE		4
9		Bar	5
10		Cafeteria	4
11			
12	ESENf		3
13		Cafeteria	3
14			
15	ESTG		4
16		Bar	3
17		Cafeteria	4
18			
19	Grand Total		3

Figure 46 - Microsoft Excel report of alimentation average satisfaction level

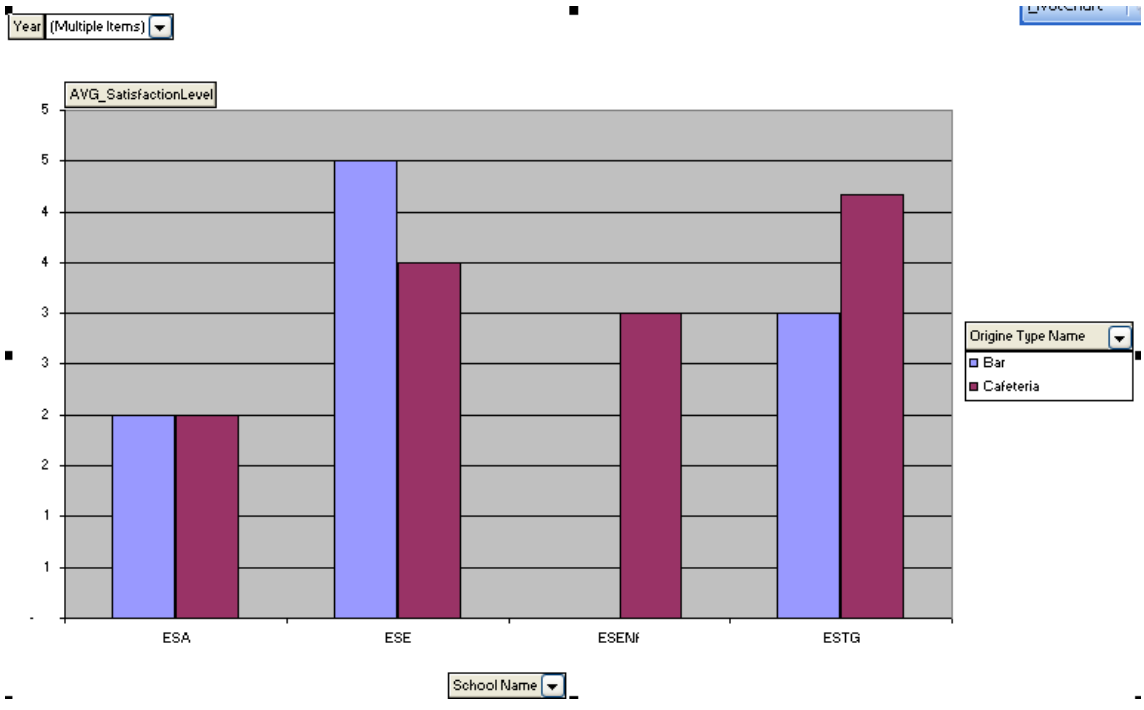

Figure 47 - Chart report of alimentation average satisfaction level

- **Social Service - Accommodation process**

IPVC QMS staff has defined KPI to analyze services, which are related to accommodation process. The KPI list includes the occupancy rate of residences, the variation of housed students in residences and users' satisfaction.

The first KPI requirement is about occupancy rate of residences (Table 9).

Process	Process/ Sub-process	Indicator	Calculation Formula	Unit of Measure
Social Service	Accommodation	Occupancy rate of residences	Number of housed students / total number of beds	%

Table 9 - Occupancy rate of residences KPI requirement

To answer occupancy rate KPI requirement, we define the star model of accommodation occupancy process, which is illustrated in Figure 48.

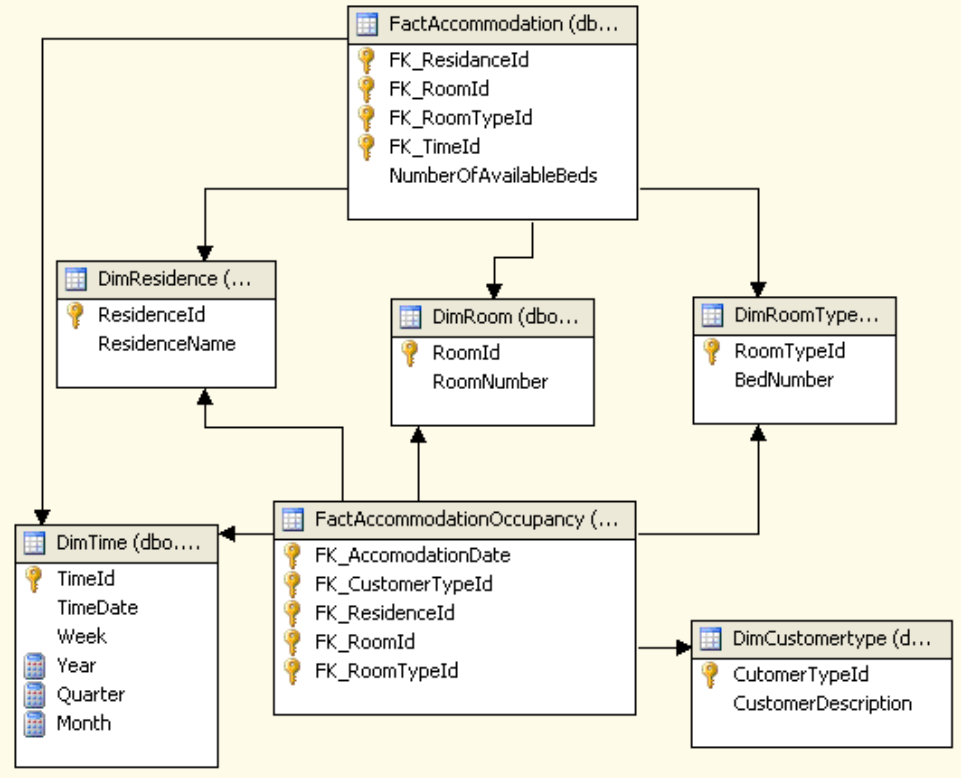

Figure 48 – Star model of occupancy rate of accommodation process

In order to calculate occupancy rate and answer KPI requirements we have to define the following measures:

- The total number of beds in residences (Number Of Available Beds) using the sum function on fact table measure NumberOfAvailableBeds;
- The number of housed students (Fact Accommodation Occupancy Count) using the count function;
- The occupancy rate (AccommodationOccupancyRate) using the following MDX expression: [Measures].[Fact Accommodation Occupancy Count] / [Measures].[Number Of Available Beds]

Figure 49 presents a report in Microsoft Excel format that permits to visualize accommodation occupancy by residence name and year. Furthermore, QMS persons can also use drill down techniques and see the information in more detail. Figure 50 presents a bar chart report of accommodation occupancy rate in IPVC.

	A	B	C
1			
2			
3	Residence Name	Year	AccomodationOccupancyRate
4	ESA		33%
5		2010	33%
6			
7	ESTG		50%
8		2010	50%
9			
10	Grand Total		40%

Figure 49 - Microsoft Excel report of accommodation occupancy rate

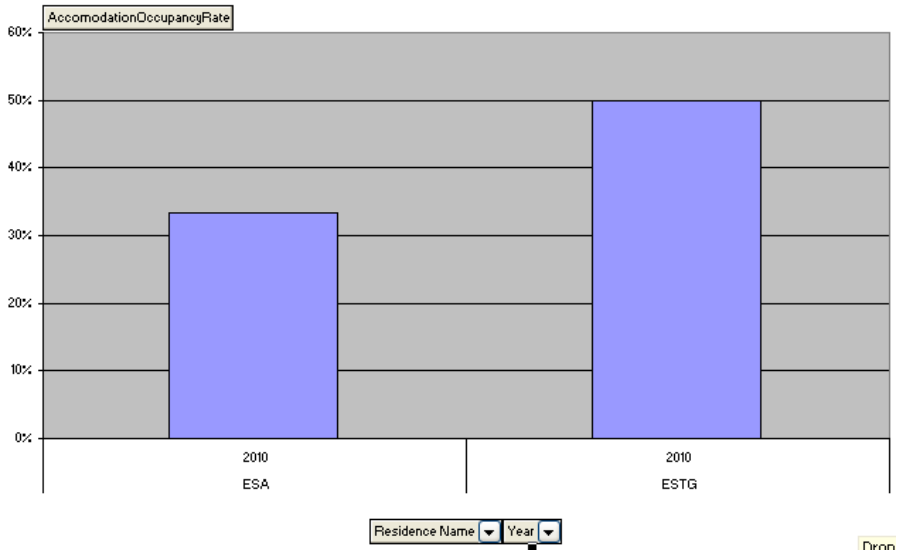

Figure 50 - Chart report of accommodation occupancy rate

Table 10 presents the second KPI requirement of IPVC accommodation process related to the variation of housed students.

Process	Process/ Sub-process	Indicator	Unit of Measure	Calculation Formula
Social Service	Accommodation	Homologous variation of housed students	%	Number of housed students in year n / Number of housed students in year n-1

Table 10 - Housed students' variation KPI requirements

To answer homologous variation of housed students KPI requirement, we use the fact table of accommodation occupancy table presented in Figure 48. In this case, we have to use parallel period function, which can be used to return a member from a prior period in the same relative position as a specified member [1 p. 310]. Using this function, we define a calculated measure using a MDX expression as follows:

Measure name: AccommodationVariation

MDX Expression: ([Measures].[Fact Accommodation Occupancy Count]/
((ParallelPeriod([Dim Time].[Year - Quarter - Month - TimeDate].[Year],1,
[Dim Time].[Year - Quarter - Month - TimeDate].currentmember),
[Measures].[Fact Accommodation Occupancy Count]))) -1)

Figure 51 presents the accommodation variation rate which answers KPI requirements. The report is presented in Microsoft Excel format and allows to analyse variation rate by residence name and year. The variation rate of housed students can also be presented using a chart as illustrated in Figure 52.

	A	B	C
1			
2			
3	Residence Name	Year	AccommodationVariation
4	ESA		
5		2009	33%
6		2010	25%
7			
8	ESTG		
9		2009	50%
10		2010	33%

Figure 51 - Microsoft Excel report of accommodation variation rate

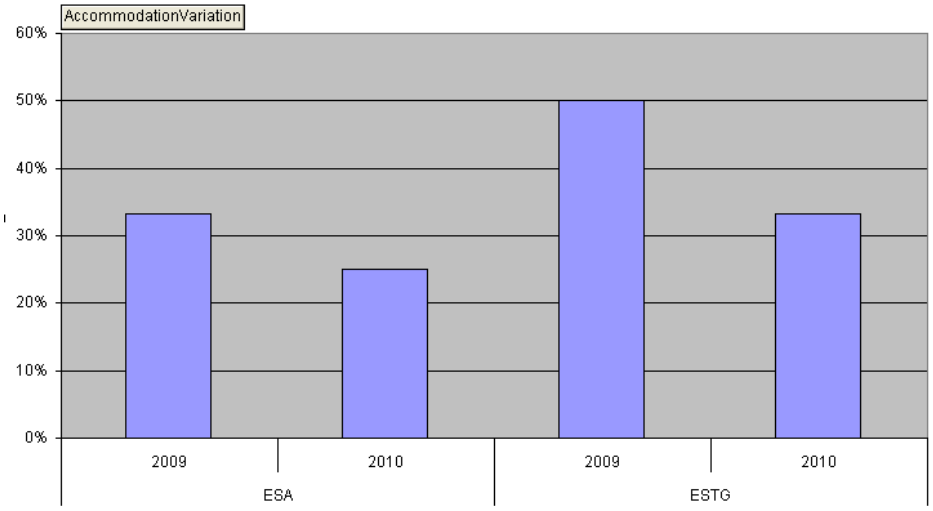

Figure 52 - Chart report of accommodation variation rate

Table 11 presents the third KPI requirement for IPVC accommodation process which is related to users' satisfaction.

Process	**Process/ Sub-process**	**Indicator**	**Calculation Formula**	**Unit of Measure**
Social Service	Accommodation	Satisfaction level	∑ (classification for question x weighting) / number of responses	%

Table 11 - Accommodation satisfaction level KPI requirement

For this indicator, we define the star model of accommodation satisfaction level as illustrated in Figure 53, which includes a fact table and dimensions related to customers, schools, time, and questions asked to users.

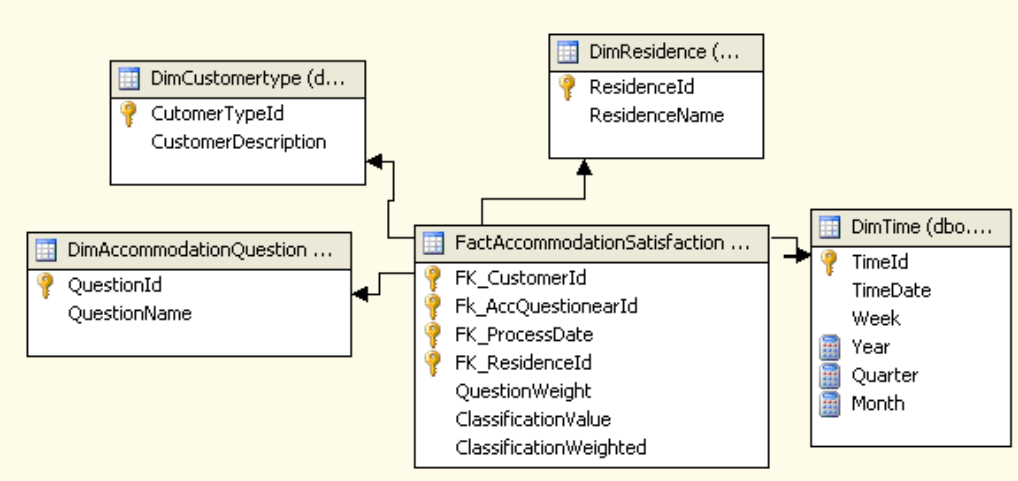

Figure 53 – Star model of satisfaction level of accommodation process.

In order to calculate accommodation satisfaction level to answer KPI requirement, we define a calculated measure (AccommodationSatisfactionRate) using the following expression:

[Measures].[Classification Weighted]/[Measures].[Question Weight]

Figure 54 presents an accommodation satisfaction report in Microsoft Excel format with the values of accommodation satisfaction level by residence and time levels. Figure 55 presents the same report using a graphical chart.

Residence Name	Year	Quarter	AccommodationSatisfactionRate
ESE			2,5
	2008		4,0
		2008Q1	4,0
	2009		1,0
		2009Q1	1,0
ESTG			3,4
	2008		3,0
		2008Q1	3,0
	2009		2,5
		2009Q1	2,5
	2010		3,7
		2010Q1	3,7
Grand Total			3,3

Figure 54 - Microsoft Excel report of accommodation satisfaction

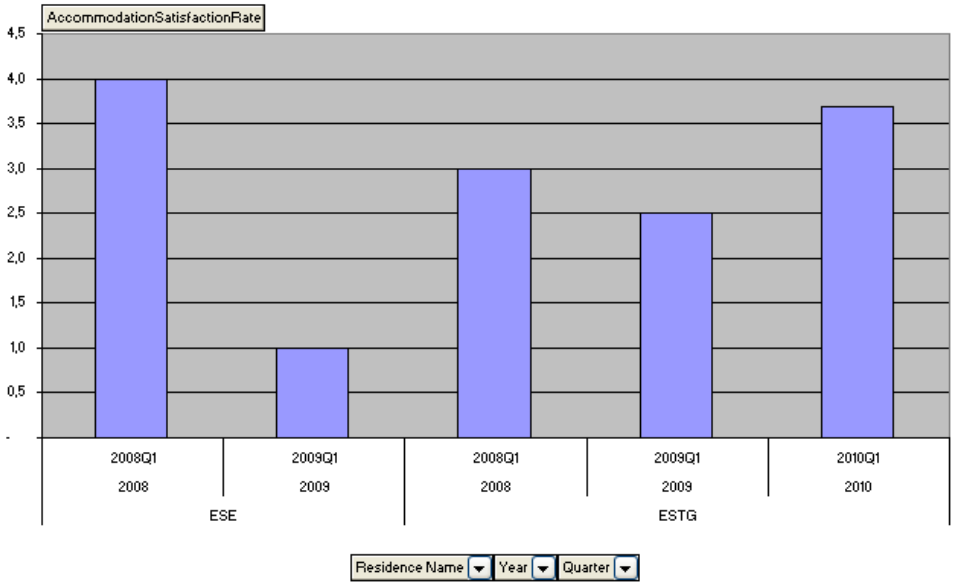

Figure 55 - Chart report of accommodation satisfaction

4.8 Key Performance Indicators (KPI) in Dashboard Report

As we can observe the developed solution gives the ability to create reports that allows the QMS managers to analyze services performance through the visualization of KPIs in different ways. This type of report gives a set of dynamic tools to analyse data, like drilling into detail from summary, navigating hierarchies, sorting, ranking, filtering, charting and exporting. This tool offers a great independence in the way that users interact with the information facilitating the support decision making activities.

On the order hand, BI solutions usually include the capacity to create dashboards for decision makers. BI dashboards are intended to provide decision makers with an overview of business status at a single glance, using appealing and intuitive graphical interface that can be used with a few simple clicks of the mouse. From a decision maker‘s point of view, dashboards provide a effective and simple approach to view data and information using components such as single metrics, graphical trend analysis, capacity gauges, geographical maps and variance comparisons, which are presented in a format that is easy to understand and use by managers [37].

As previously mentioned, SQL Server 2005 offers the possibility to create KPI digital dashboards. In this project, we create an example of a dashboard for some of the KPI requirements. In this sense, we define the limits for each status level that is used to picture status level and deploy KPI dashboard. Figure 56 presents the digital dashboard created with KPI value, goal and status for academic service online subscriptions, alimentation cost, alimentation experience, alimentation satisfaction level, EHS number of manuals, EHS number of complaints, EHS number of simulacra, accommodation variation, accommodation occupancy rate and accommodation satisfaction level.

In the context of this project, we have decided to experiment a different solution in order to create dashboards with the objective to provide decision makers with different types of functionalities in terms of KPI visualization. As mentioned previously, we select the Tableau software which gives a set of functionalities to provide interactive data visualizations, as well as dashboards and reports. Through the use of this software, it is possible to connect SQL Server Analysis Service cube and create the structure of dashboards to present KPI using reports and charts. Figure 57 illustrates an example developed in this project that presents KPI values using different type of presentation.

Dimension	Hierarchy	Operator	Filter Expression
Dim School	School Name	Equal	{ All, ESA, ESE, ESENf, ESTG }
<Select dimension>			

Display Structure	Value	Goal	Status
Academic Service Online Subscriptions	65.00%	70 % or more	
Accommodation satisfaction rate	3	5	
AccommodationVariation	1.#INF	30% or more	
AccomodationOccupancyRate	45.65%	90 % or more	
Alimentation average cost	1.4	1.20 or less	
Alimentation average satisfaction level	3	4 or more	
Alimentation epxerience	80.00%	70 % or more	
EHS number manuals Indicators	1.47	1.4 or less	
EHS number of complaints	50	50 or less	
EHS number of simulacra	20	5 or more in a year	

Figure 56 - IPVC digital dashboard report

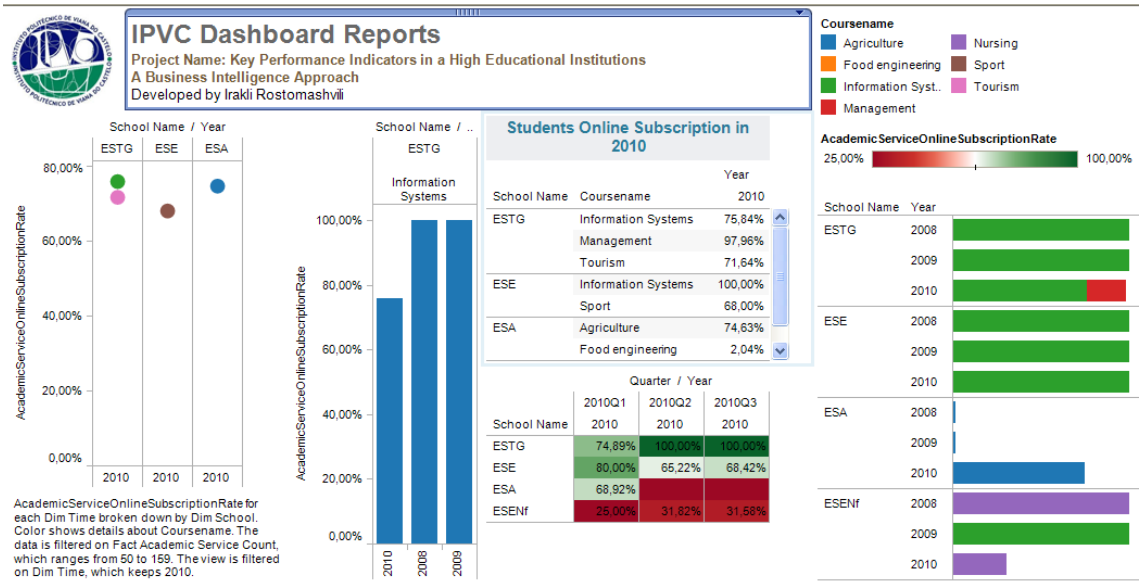

Figure 57 - Dashboard report with Tableau Software

Chapter 5 - Conclusions and Future Work

5.1 Conclusion

The main objective of this project was to develop a Decision Support System (DSS) for Quality Management System (QMS) departments in a High Educational Institution, in particular in the Polytechnic Institute of Viana do Castelo. In the context of our project, we studied and explored Business Intelligence (BI) systems and the benefits that can bring to educational institutions. In general, BI is a group of software programs and technologies that gives opportunity to gather an increasing data from business operations, store them in a single data repository for analyzing and delivering real time reports in order to support the decision making activities in the organization. One of the sources that BI can use to get business information could be from QMS. QMS allows the definition of a set of processual and organizational documentation in order to guide and achieve high levels of efficiency, improve the business processes performance and the internal and external quality of the services provided. On the other hand, QMS can be a valuable source of information to deliver Key Performance Indicators (KPI) for decision makers to support the task to control and manage the services performance. In the case of IPVC, a set of KPIs have been defined by stakeholders to control, evaluate, monitor and improve business processes. For this reason, we consider that BI solution can be a valuable and necessary solution to support business needs that will enable to provide KPI reports and gives opportunity to measure effectiveness of business performances in all departments.

In the context of project "Key Performance Indicators in a High Educational Institutions: A Business Intelligence Approach", we focused on the development of a BI systems solution in order to support the analyses of the IPVC processes performance. In this context we implemented Key Performance Indicators reports for the QMS staff in order to make available needed information, as well as to assist decision maker persons to perform their work and to increase the analysis and decision making activities.

To achieve these goals, we select BI system SQL Server 2005 tool in order realize our expected results. We apply agile BI methodology and divide BI implementation lifecycle process into five steps: Story of Conference, Task Plans,

Development, Sprint Demo and Retrospective [34]. Following the Agile methodology framework we have performed the following main tasks: gather, collect and analyze KPI requirements, define star models, define dimensions and measures, develop Educational Data Warehouse (EDW) and OLAP interface, develop reports, and finally, present demo version of BI project to end users with the purpose of validation.

During the implementation of the project a top down approach was used. Our starting point was the IPVC schools Key Performance Indicators (KPI) requirements and forms. With these requirements we define and built an Educational Data Warehouse (EDW) to prepare an environment to allocate all schools operational data into one source. The developed IPVC EDW enables QMS person to access needed information in real time and get reports. It will give advantage to IPVC in better management and improvement of educational quality and processes. With BI Online Analytical Processes tool (OLAP) we analyze all the data and make calculations to get measures in order to support the KPI requirements. Then we were able to provide end-users with reports in Microsoft Excel programs and web browsers.

One of the main advantages that this project brings to IPVC is data warehousing, where all processes are materialized into one data source from where IPVC can access all kind of data depending on the business requirements. Using the DW, QMS persons can access KPI state at a single glance at all level of IPVC which will help to evaluate, control and monitor all processes. As a result, data warehousing gives huge benefits to IPVC, by the fact that it allows to achieve a level of maturity that gives the opportunity to be ready to answer to new requirements and implement multiple BI projects in the organization. In this context, the existence of DW will help organizations to concentrate, focus and deliver more time to develop BI reports, which gives opportunity to be in forward against competitors. In the case of IPVC BI project, developed DW allows to apply next generation BI tool in order to deliver advanced reports in a very short time for IPVC staff. For this purpose we use Tableau Software to deliver dynamic reports which gives opportunity to explore reports and manipulate the data more efficiently and effectively.

This project was the first attempt to apply Business Intelligence system in IPVC QMS schools. The developed project brings a list of valuable benefits to IPVC, namely:

- Allocate all Institute processes data into a single repository Data Warehouse. It gives the ability to access the information related to the Institute and deliver the reports for decision makers;
- IPVC Data Warehouse has historical perspective and gives the opportunities develop customized reports.
- Monitor and evaluate predefined Key Performance Indicators (KPI) and assess the state of education performances in a very short time.
- Decision makers are provided with reports about KPI in timely manner. They will not lose time searching information to perform their work and they will more concentrate to improve the quality and services.
- Decision makers of IPVC can use BI tool successfully to evaluate and monitor all activities and processes at a single glance and, like that, prescribe timely actions for the improvement.
- Ability to deliver new IT solutions quickly. It allows IPVC to be mature and be ready to quickly develop different kind of BI projects in the future.

Finally, we would like to mention that, during the implementation process, we faced some problems that hampered the project execution, that are mainly related with the fact that this project was not required by top managers of IPVC. For that reason, we encountered several difficulties, namely, to get and understand IPVC KPI requirements that was sometimes imprecise and ambiguous, to access data sources of QMS system, and to access and schedule meetings with the right persons in order clarify KPI requirements and validate processes. For that reason, we have developed DW models and generated reports for all processes but we were able to validate only four processes. However we handle to overcome these problems and we develop a first implementation of a BI DSS for IPVC, considering that the results of this project are a valid contribution for the provision of tools to support decision makers of IPVC.

The result of our project shows the advantages and benefits that integration of BI applications and QMS can bring to IPVC, contributing to the provision of tools to support management and decision making activities. The developed decision support system could simplify the IPVC work and it will help decision persons to make timely decisions based on real time information in order to improve educational processes.

5.2 Future work

In the frame of this thesis work we focused in developing a BI system in order to support the KPI requirements for the IPVC schools. However there are some issues that could be the subject for future work, namely:

- Complete the validation of all processes;
- Improve business layers, to improve the reports and increase decision makers' satisfaction.
- Expend and improve the decision support system by applying data mining techniques to discover interesting patterns inside the institute in order to predict future trends and to plan institution work in a better way.

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Appendix A– Current standards from ISO/TC 176 and its subcommittees

Standard/ document	Title	Edition
ISO 9000:2005	Quality management systems – Fundamentals and vocabulary	Third
ISO 9001:2008	Quality management systems – Requirements	Fourth
ISO 9004:2000	Quality management systems – Guidelines for performance improvements	Second
ISO 10001:2007	Quality management – Customer satisfaction – Guidelines for codes of conduct for organizations	First
ISO 10002:2004	Quality management – Customer satisfaction – Guidelines for complaints handling in organizations	First
ISO 10003:2007	Quality management – Customer satisfaction – Guidelines for dispute resolution external to the organization	First
ISO 10005:2005	Quality management – Guidelines for quality plans	Second
ISO 10006:2003	Quality management – Guidelines for quality management in projects	Second
ISO 10007:2003	Quality management – Guidelines for configuration management	Second
ISO 10012:2003	Measurement management systems – Requirements for measurement processes and measuring equipment	Second
ISO/TR 10013:2001	Guidelines for quality management system documentation	First*
ISO 10014:2006	Quality management – Guidelines for realizing financial and economic benefits	First
ISO 10015:1999	Quality management – Guidelines for training	First
ISO/TR 10017:2003	Guidance on statistical techniques for ISO 9001:2000	Second
ISO 10019:2005	Guidelines for the selection of quality management system consultants and use of their services	First
ISO/TS 16949:2002	Quality management systems – Particular requirements for the application of ISO 9001:2000 for automotive production and relevant service part organizations	Second
ISO 19011:2002	Guidelines for quality and/or environmental management systems auditing	First

Note: TR – Technical Report, TS – Technical Specification
** First edition as a TR, replacing the International Standard ISO 10013:1995.*

Appendix B – IPVC business needs and DW models

B.1. Introduction

In the frame of this project we had access to the Key Performance Indicators (KPI) list to develop the BI application. In general, IT projects development life cycle requires intensive interaction with business managers to define and specify the requirements in order to understand the business needs. As it is frequent in this kind of projects, the provided requirements were ambiguous, so we need to get explanations from QMS personnel. For this purpose, during the project implementation process, we would have to schedule a set of meetings in order to understand KPI requirements. However, QMS managers were unavailable to schedule those meetings to clarify the requirements or the scheduled meetings were not enough to understand some processes. For that reason, we decide to interpret the business needs using other sources, such as internet, interviews with front office personnel and teachers from other universities. As QMS managers do not had time to validate all processes, we present the processes that we have developed, being only presented the models.

B.2. Implementation process

In this appendix we present a set of multi-dimensional data-models created in this project. The option to present models in appendix is due to the fact that QMS managers do not had time to validate processes and were not involved intensely in agile methodology steps during the BI project implementation. Since we were not able to validate all processes, for the reason already stated in this document, we choose an approach that includes the study of the KPI requirements of some processes. Based on the document provided by QMS staff, we studied KPI requirements and try to understand information requirements in order to develop multi-dimensional model to support these requirements. However, there is several information, in particular the defined measures, for which we were unable to understand purposes as they were defined in KPI requirements list. Nevertheless, we manage to define some data models to support the information requirements. In the future perspective, when it will be possible to perform the validation of processes for KPI, the developed models will be a

good starting point to do the calculation and easily change formulas to get new kind of measures or to improve the defined measures.

In this context, we present in the next section we present the business needs, KPI requirement, star models and measures developed in this project in order to answer the KPI requirements list. For each KPI, we will present the definition as it was listed on the KPI requirement document. We ignored measures that we did not have a minimum understanding of its meaning. Finally, we would like to underline one more time that in this appendix we present the KPI with any kind of validation.

B.3. IPVC Business Needs

- **Social Service - Scholarship**

IPVC QMS staff has needs to analyze all processes which are related to scholarships in IPVC schools. They are interested in analyzing the information about interviews and visits to students applying for scholarships, as well as users' satisfaction related to provided services.

Table 1 presents IPVC Scholarship process KPI requirements list provided by QMS managers.

Process	**Process/ Sub-process**	**Indicator**	**Calculation Formula**	**Unit of Measure**
Social Service	Scholarships	Percentage of interview conducted for students applying for scholarship of 1st year and 1st enrollment	Number of interviews / Number of students applying for scholarship of 1st year and 1st enrollment	%
Social Service	Scholarships	Percentage of domiciliary visits to students applying for scholarship of 1st year and 1st enrollment	Number of home visits / Number of students applying for scholarship of 1st year and 1st enrollment	%

Table 1 - Scholarship interviews and domiciliary visits KPI requirements.

To answer the first two KPI requirements shown above, we define a star model for scholarship process as illustrated in Figure 1, which is composed of fact table and

dimension tables which includes schools, time, students, courses, course year and enrollment number. The fields withInterview and withHomeVisit of fact table will have a value of zero or one indicating, respectively, if it has been conducted an interview or made a domiciliary visit to the student or not.

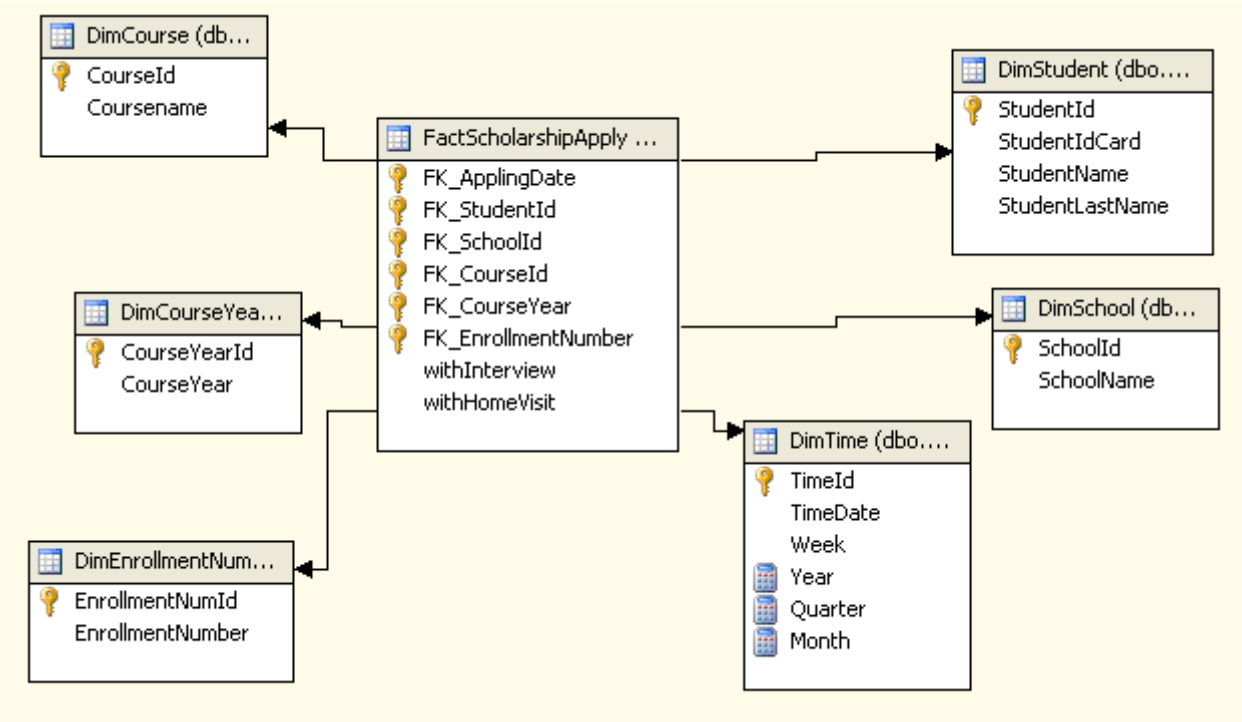

Figure 58 – Star model of scholarship interviews and domiciliary visits.

To answer KPI requirements we define the following measure:

- Percentage of interview conducted for students applying for scholarship of 1st year and 1st enrollment:

  Measure name: IntervStudents

  Expression: ([Measures].[With Interview],[Dim Course Year].[Course Year].&[1st],[Dim Enrollment Number].[Enrollment Number].&[1st])/([Measures].[Fact Scholarship Apply Count],[Dim Course Year].[Course Year].&[1st],[Dim Enrollment Number].[Enrollment Number].&[1st])

- Percentage of domiciliary visits to students applying for scholarship of 1st year and 1st enrollment:

  Measure name: DomVisitsStudents

Expression: ([Measures].[With Home Visit],[Dim Course Year 1].[Course Year].&[1st],[Dim Enrollment Number].[Enrollment Number].&[1st])/([Measures].[Fact Scholarship Apply Count],[Dim Course Year 1].[Course Year].&[1st],[Dim Enrollment Number].[Enrollment Number].&[1st])

Appendix A – IPVC business needs and DW models

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In this appendix we present a set of multi-dimensional data-models created in this project. The option to present models in appendix is due to the fact that QMS managers do not had time to validate processes and were not involved intensely in agile methodology steps during the BI project implementation. Since we were not able to validate all processes, for the reason already stated in this document, we choose an approach that includes the study of the KPI requirements of some processes. Based on the document provided by QMS staff, we studied KPI requirements and try to understand information requirements in order to develop multi-dimensional model to support these requirements. However, there was several information, in particular the defined measures, for which we were unable to understand purposes as they were defined in KPI requirements list. Nevertheless, we managed to define some data models to support the information requirements. In the future, when it will be possible to perform the validation of

processes for KPI, the developed models will be a good starting point to do the calculation and easily change formulas to get new kind of measures or to improve the defined measures.

In this context, we present in the next section the business needs, KPI requirement, star models and measures developed in this project in order to answer the KPI requirements list. For each KPI, we will present the definition as it was listed on the KPI requirement document. We ignored measures that we did not have a minimum understanding of its meaning. Finally, we would like to underline one more time that in this appendix we present the models defined for KPI with any kind of validation.

B.3. IPVC business needs

- **Social Service - Scholarship**

IPVC QMS staff has needs to analyze all processes which are related to scholarships in IPVC schools. They are interested in analyzing the information about interviews and visits to students applying for scholarships, as well as users' satisfaction related to provided services.

Table 1 presents IPVC Scholarship process KPI requirements list provided by QMS managers.

Process	Process/ Sub-process	Indicator	Calculation Formula	Unit of Measure
Social Service	Scholarships	Percentage of interview conducted for students applying for scholarship of 1st year and 1st enrollment	Number of interviews / Number of students applying for scholarship of 1st year and 1st enrollment	%
Social Service	Scholarships	Percentage of domiciliary visits to students applying for scholarship of 1st year and 1st enrollment	Number of home visits / Number of students applying for scholarship of 1st year and 1st enrollment	%

Table 1 - Scholarship interviews and domiciliary visits KPI requirements.

To answer the first two KPI requirements shown above, we define a star model for scholarship process as illustrated in Figure 1, which is composed of a fact table and dimension

tables which includes schools, time, students, courses, course year and enrollment number. The fields withInterview and withHomeVisit of fact table will have a value of zero or one indicating, respectively, if it has been conducted an interview or made a domiciliary visit to the student or not.

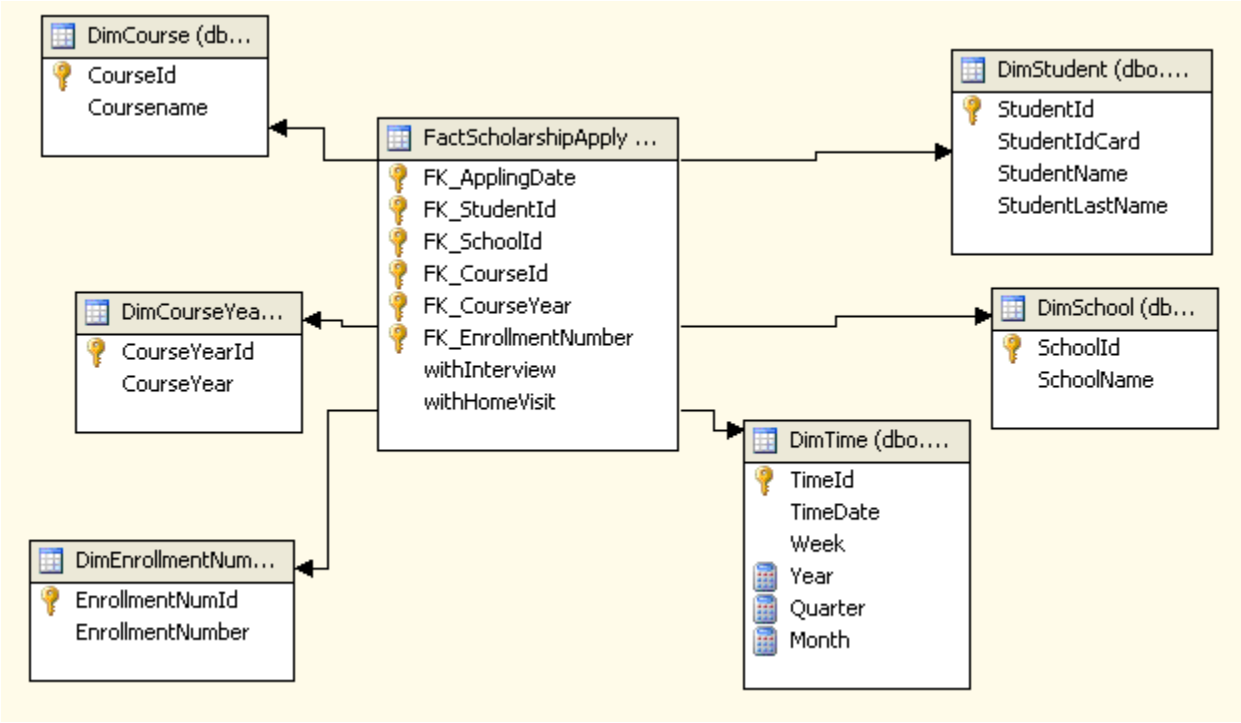

Figure 1 – Star model of scholarship interviews and domiciliary visits.

To answer KPI requirements we define the following measure:

- Percentage of interview conducted for students applying for scholarship of 1st year and 1st enrollment:

  Measure name: IntervStudents

  Expression: ([Measures].[With Interview],[Dim Course Year].[Course Year].&[1st],[Dim Enrollment Number].[Enrollment Number].&[1st])/([Measures].[Fact Scholarship Apply Count],[Dim Course Year].[Course Year].&[1st],[Dim Enrollment Number].[Enrollment Number].&[1st])

- Percentage of domiciliary visits to students applying for scholarship of 1st year and 1st enrollment:

  Measure name: DomVisitsStudents

Expression: ([Measures].[With Home Visit],[Dim Course Year 1].[Course Year].&[1st],[Dim Enrollment Number].[Enrollment Number].&[1st])/([Measures].[Fact Scholarship Apply Count],[Dim Course Year 1].[Course Year].&[1st],[Dim Enrollment Number].[Enrollment Number].&[1st])

Another KPI requirement of scholarships process is related to users' satisfaction (Table 2)

Process	**Process/ Sub-process**	**Indicator**	**Calculation Formula**	**Unit of Measure**
Social Service	Scholarships	Average level of satisfaction of scholarship services	∑ (question rating x weighting) / number of response	Inquiry scale

Table 2 - Scholarships satisfaction KPI requirement.

To answer the last KPI requirements of scholarship process, we define the star model illustrated in Figure 2, which is composed of a fact table to register satisfaction levels and dimension tables, which includes schools, time, students, course, and scholarship satisfaction type.

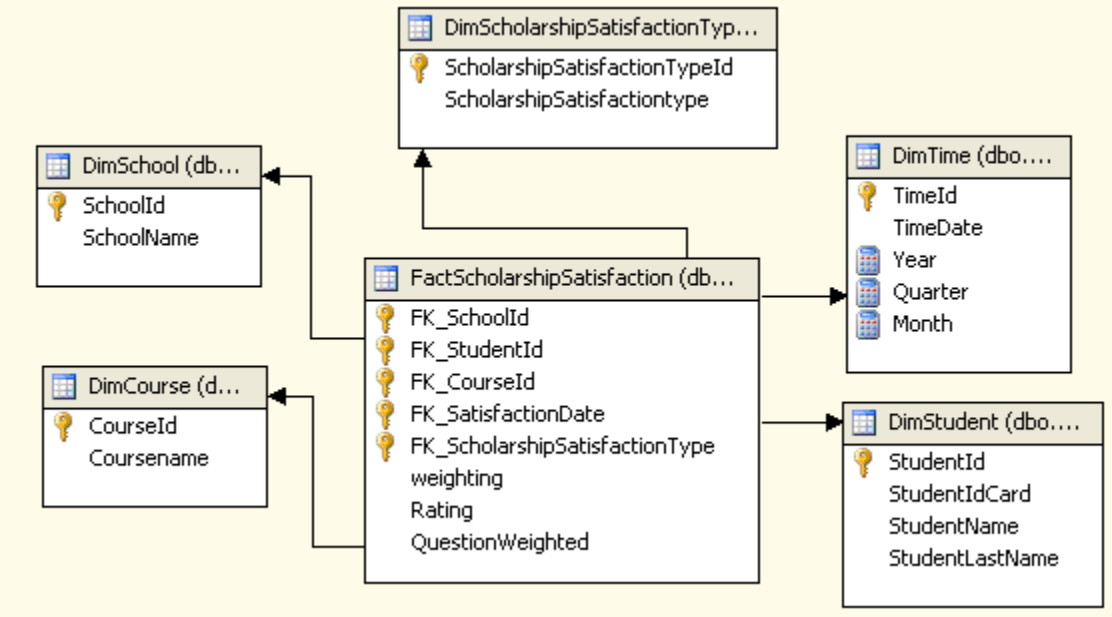

Figure 2 - Star model scholarship satisfaction process

For this KPI, we define a calculated measure to determine the average level of satisfaction of scholarship services using the following formula:

Calculated measure name**:** AVGsatisfactionArea

MDX expression: [Measures].[Question Weighted]/[Measures].[Weighting]

- **International Cooperation**

IPVC QMS staff has needs to analyze international cooperation department's work in IPVC schools. They need to be able to analyze the information about partnerships, agreements, protocols and student, teacher and non-teacher mobility.

Table 3 represents IPVC International cooperation mobility KPI requirement.

Process	Process/ Sub-process	Indicator	Calculation Formula	Unit of Measure
International Cooperation	International Cooperation	Teachers Mobility	Variation of number of teachers sent per year	%
			Variation of number of teachers received per year	%
International Cooperation	International Cooperation	Students Mobility	Variation of number of students sent per year	%
			Variation of number of incoming students per year	%
International Cooperation	International Cooperation	Non-teachers Mobility	Variation of number of non-teachers sent per year	%
			Variation of number of non-teachers received per year	%

Table 3 - International cooperation mobility KPI requirements

Figure 3 presents the fact table created to store information about mobility of teachers, students and non-teachers and dimension tables about schools, time, courses, mobility type (sent or received) and group type (teacher, student or non-teacher).

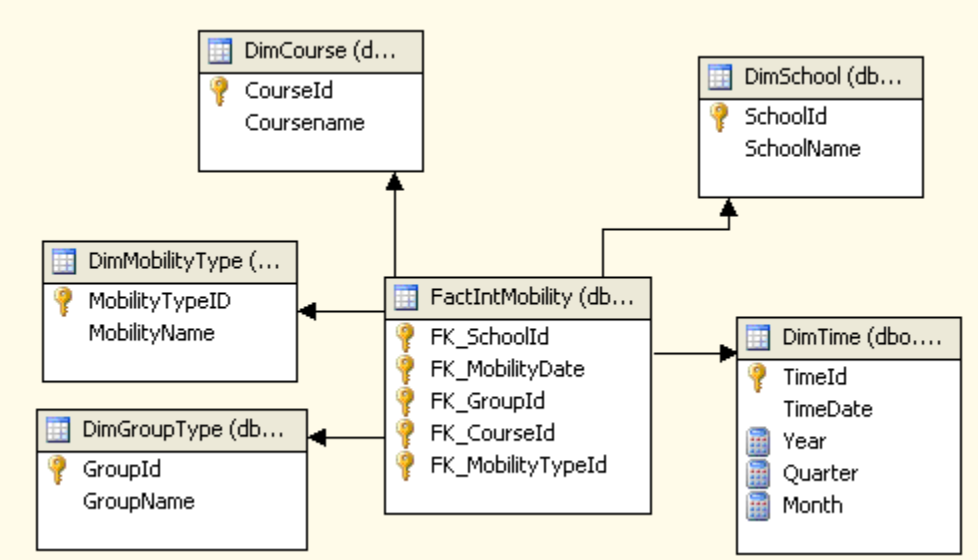

Figure 3 – Star model of international mobility.

To answer KPI requirements we define the following measure:

- Variation of number of teachers sent per year:

  Measure name: NumberTeachersSent

  Expression: ([Measures].[FactIntMobility Count],[Dim Group Type].[GroupName].&[Teacher], [Dim Mobility Type].[Mobility Name].&[Sent])

  Measure name: VarNumberTeachersSent

  Expression: ([Measures].[NumberTeachersSent]/(ParallelPeriod([Dim Time].[Year].[Year], 1, [Dim Time].[Year].currentmember), [Measures].[NumberTeachersSent]))-1

- Variation of number of teachers received per year:

  Measure name: NumberTeachersReceived

  Expression: ([Measures].[FactIntMobility Count],[Dim Group Type].[GroupName].&[Teacher], [Dim Mobility Type].[Mobility Name].&[Received])

  Measure name: VarNumberTeachersReceived

  Expression: ([Measures].[NumberTeachersReceived]/(ParallelPeriod([Dim Time].[Year].[Year], 1, [Dim Time].[Year].currentmember), [Measures].[NumberTeachersReceived]))-1

- Variation of number of students sent per year:

  Measure name: NumberStudentsSent

  Expression: ([Measures].[FactIntMobility Count],[Dim Group Type].[GroupName].&[Student], [Dim Mobility Type].[Mobility Name].&[Sent])

  Measure name: VarNumberStudentsSent

  Expression: ([Measures].[NumberStudentsSent]/(ParallelPeriod([Dim Time].[Year].[Year], 1, [Dim Time].[Year].currentmember), [Measures].[NumberStudentsSent]))-1

- Variation of number of students received per year:

  Measure name: NumberStudentsReceived

  Expression: ([Measures].[FactIntMobility Count],[Dim Group Type].[GroupName].&[Student], [Dim Mobility Type].[Mobility Name].&[Received])

  Measure name: VarNumberStudentsReceived

Expression: ([Measures].[NumberStudentsReceived]/(ParallelPeriod([Dim Time].[Year].[Year], 1, [Dim Time].[Year].currentmember), [Measures].[NumberStudentsReceived]))-1

- Variation of number of non-teachers sent per year:

  Measure name: NumberNTeachersSent

  Expression: ([Measures].[FactIntMobility Count],[Dim Group Type].[GroupName].&[Non-teacher], [Dim Mobility Type].[Mobility Name].&[Sent])

  Measure name: VarNumberNTeachersSent

  Expression: ([Measures].[NumberNTeachersSent]/(ParallelPeriod([Dim Time].[Year].[Year], 1, [Dim Time].[Year].currentmember), [Measures].[NumberNTeachersSent]))-1

- Variation of number of non-teachers received per year:

  Measure name: NumberNTeachersReceived

  Expression: ([Measures].[FactIntMobility Count],[Dim Group Type].[GroupName].&[Non-teacher], [Dim Mobility Type].[Mobility Name].&[Received])

  Measure name: VarNumberNTeachersReceived

  Expression: ([Measures].[NumberNTeachersReceived]/(ParallelPeriod([Dim Time].[Year].[Year], 1, [Dim Time].[Year].currentmember), [Measures].[NumberNTeachersReceived]))-1

Table 4 presents IPVC International cooperation partnerships KPI requirement.

Process	**Process/ Sub-process**	**Indicator**	**Calculation Formula**	**Unit of Measure**
International Cooperation	International Cooperation	Partnerships	Number of protocols/365	%
			Number of mobility agreements (established and renewed) per year/365	%

Table 4 - International Cooperation partners KPI requirement

Figure 4 represents fact table of international cooperation protocols and its connections to dimension tables. We have the following dimensions: schools, time, agreement type, partners and protocol types.

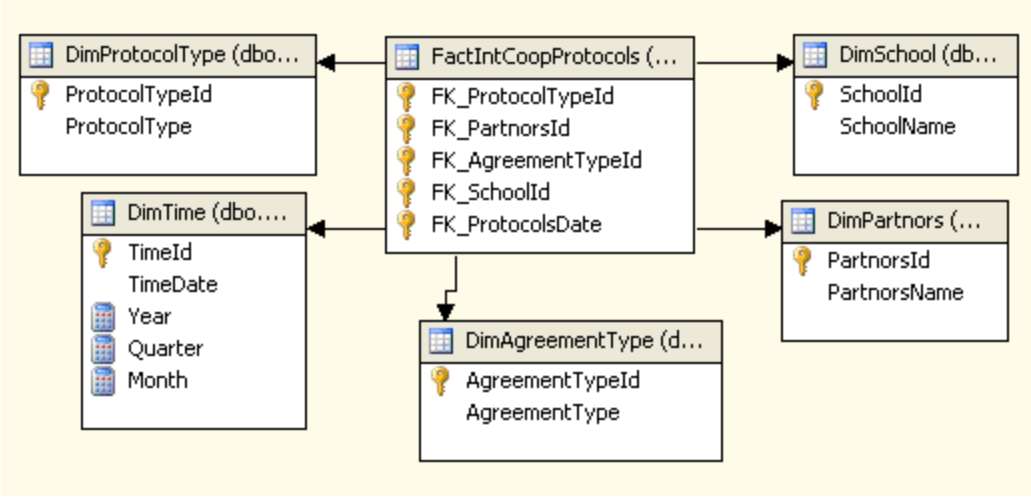

Figure 4 – Star model of International cooperation protocols

To answer KPI, we define the following measure:

MDX command

Calculated measure name: ProtocolRate (Partners)

MDX code: [Measures].[Fact Int Coop Protocols Count]/365

Calculated measure name**:** AgreementRate (Partners)

MDX code: ([Measures].[Fact Int Coop Protocols Count],[Dim Agreement Type].[All])/365

- **Creation and Restructuring of Courses**

IPVC QMS staff would like to analyze courses creation and restructuring process in schools. They need to begin analyze the information in schools about proposed and restructured of courses in each semester.

Table 5 represents creation restructuring of courses KPI requirement.

Process	**Process/ Sub-process**	**Indicator**	**Calculation Formula**	**Unit of Measure**
Creation / restructuring of Courses	Creation / restructuring of Courses	Proposed courses or restructuring of the 1st Cycle	Number of Courses Validated IPVC / Number of courses offered or restructured	%
		Proposed courses or restructured 2nd Cycle	Number of 2nd Cycle Courses Validated IPVC / Number of courses offered or restructured	%

		Restructuring of Courses in Operation 1st Cycle	Number of courses restructured 1st cycle / functioning course number	%

Table 5 – Creation restructuring of courses KPI requirements

Figure 5 presents fact table of course functioning course and its connections to dimension tables. We have the following dimensions: schools, time, courses and courses cycles.

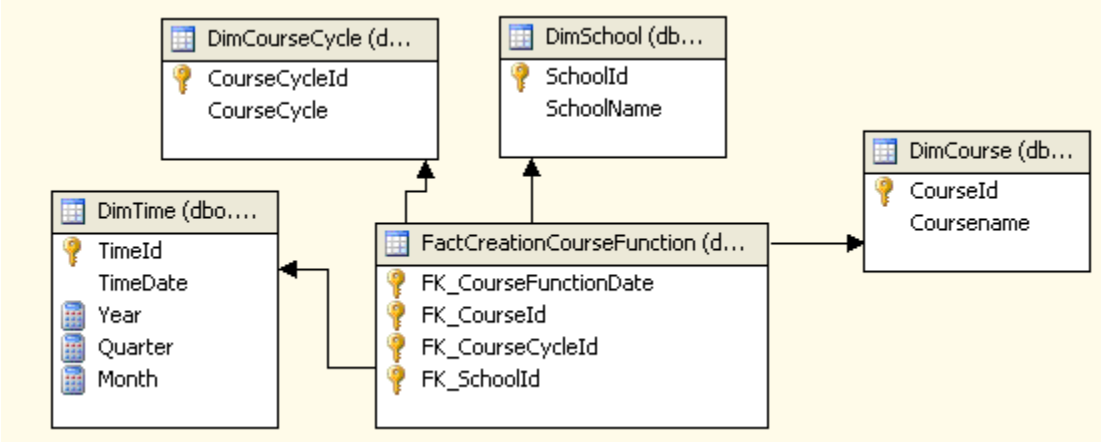

Figure 5 – Star model of functioning courses

Figure 6 represents fact table of course offers and its connections to dimension tables. In we have the following dimensions: schools, time, courses and courses cycles.

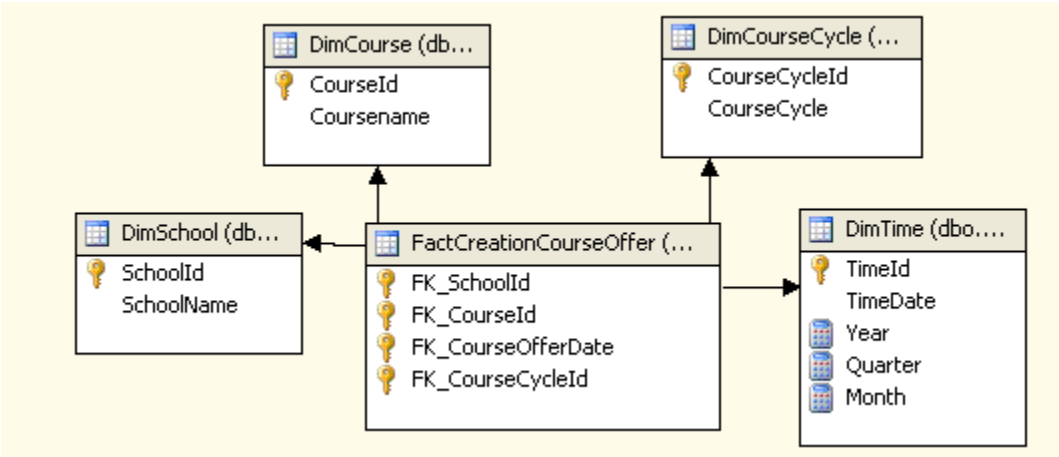

Figure 6 – Star model of functioning course Offer

Figure 7 represents fact tables of restructured courses and its connections to dimension tables. We have following dimensions: schools, time, courses and courses cycles.

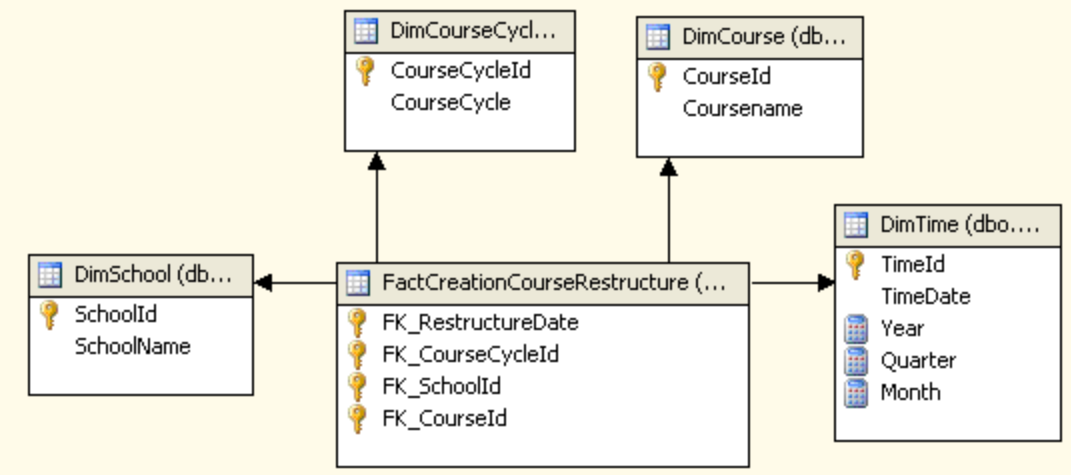

Figure 7 - Star model of courses restructure

Figure 8 represents fact table of validated courses and its connections to dimension tables. We have the following dimensions: schools, time, courses, course years and courses cycles.

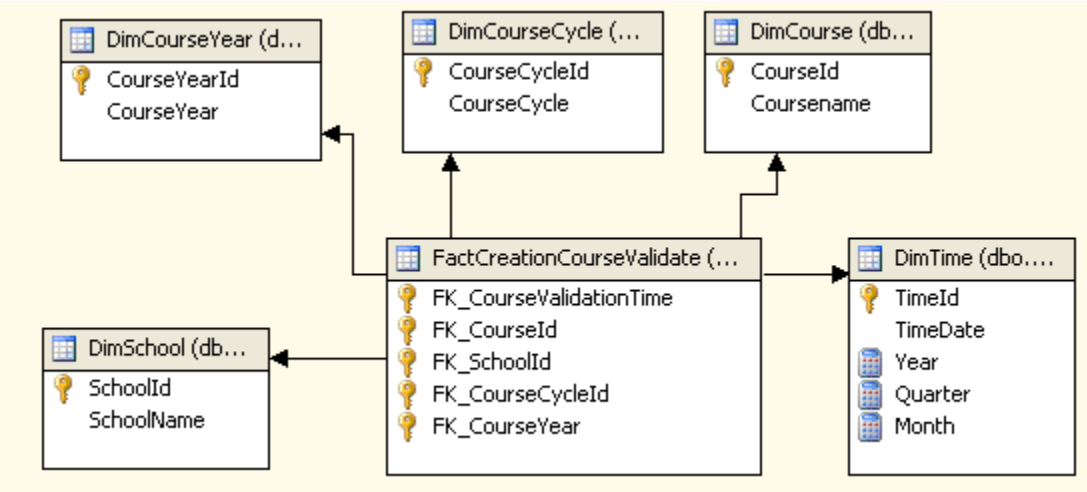

Figure 8 - Star model of courses validation

- **Formation – Planning**

IPVC QMS staff would like to analyze all work which is related to formation planning processes in IPVC schools.

Table 6 presents a planning of formation KPI requirement.

Process	**Process/ Sub-process**	**Indicator**	**Calculation Formula**	**Unit of Measure**
Formation	Planning	Application fee of needs	# delivered / # expected	%
		Fee schedules	# Schedules prepared / #	%

		prepared	hours required	
		Rate of submission of evaluation schedule	# Calendars made / total # calendars	%
		Application fee for the programs of Un. Curriculum	# Programs produced / total # programs	%
		Number of proposals	# Proposals	Number

Table 6 – Formation planning KPI requirements

Figure 9 represents Star model of planning application fee and its connections to dimension tables. We have the following dimensions: schools, time, courses and planning types.

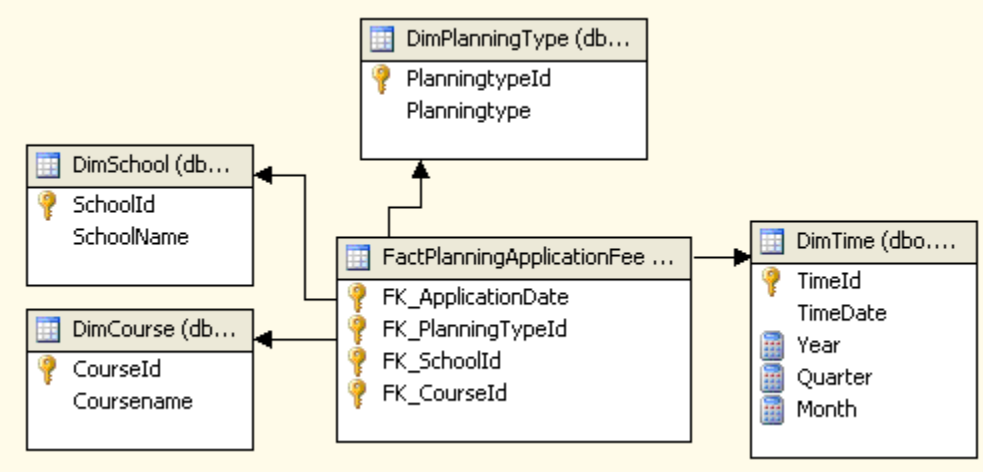

Figure 9 - Star model of planning application fee

Figure 10 presents the fact table of scheduling and its connections to the dimension tables. We have the following dimensions: schools, time, courses, hour required, planning types which are related to formation planning processes.

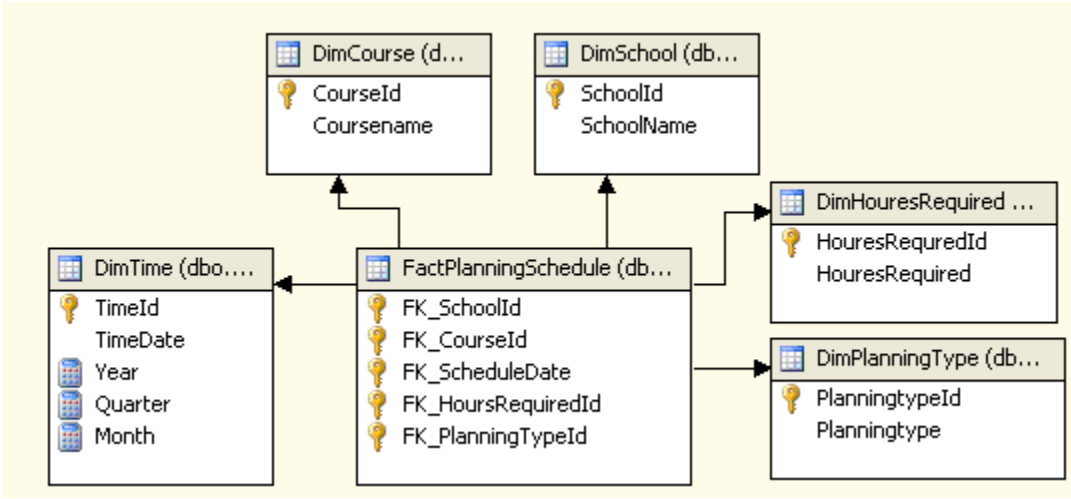

Figure 10 - Star model of scheduling

Figure 11 represents fact table of planning proposals and its connections to the dimension tables. We have the following dimensions: schools, time, and courses which are related to formation planning processes.

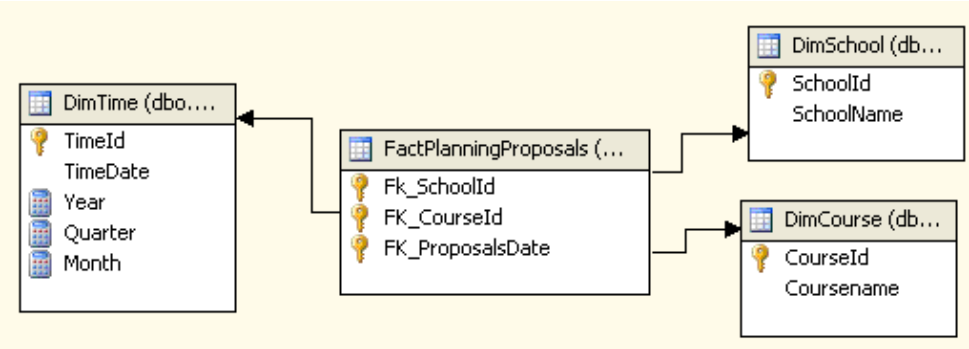

Figure 11 – Star model of Proposals

Figure 12 represents the fact table of planning programs and its connections to the dimension tables. We have the following dimensions: schools, time, and courses.

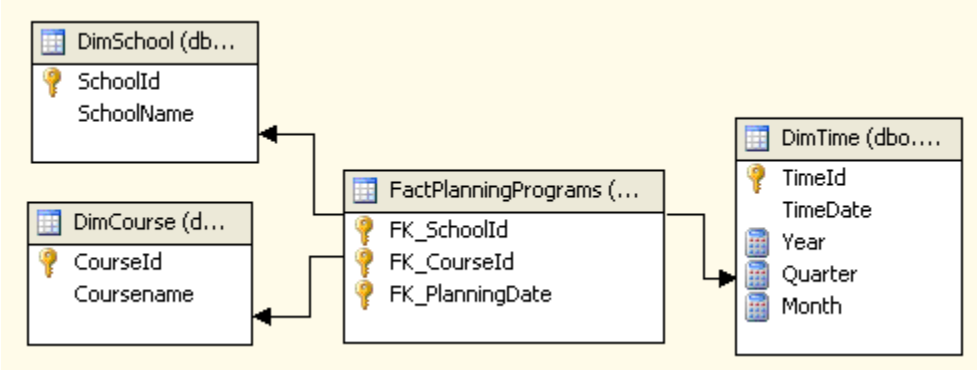

Figure 12 - Star model of planning programs

Figure 13 represents the fact table of planning calendar and its connections to the dimension tables.

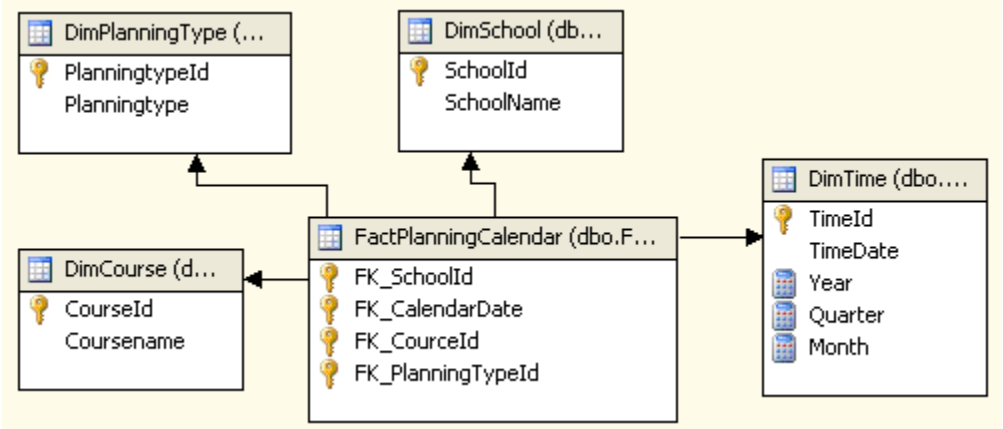

Figure 13 - Star model of planning calendar

- **Formation – Implementation and Evaluation**

IPVC QMS staff has needs to analyze formation implementation and evaluation process in schools. They need to get reports and then to be able drilling down to the year, quarter and month and date levels.

Table 7 represents creation restructuring of courses KPI requirement.

Process	**Process/ Sub-process**	**Indicator**	**Calculation Formula**	**Unit of Measure**
Formation	Implementation and Evaluation	Rate of availability of briefs (summary).	% Compliance	%
		Rate of release of Number of from teaching activity	% Compliance	%
		Rate of submission of the report of the PA at the end of school year	% Compliance	%
		Satisfaction survey of students in quality	% Of positive responses	%
		Launch rate of the Number of Internships / Clinical Training / IPP	% Compliance	%
		Launch rate of grade in mobility	% Compliance	%
		Degree of student satisfaction in the quality survey (course)	% Of positive responses	%
		Entrega do Relatório da Direcção de Curso	% Compliance	%

Table 7 – Implementation and evaluation process KPI requirements

Figure 14 represents the fact table of formation brief evaluation and its connections to the dimension tables. We have the following dimensions: schools, time, evaluation type and evaluation result.

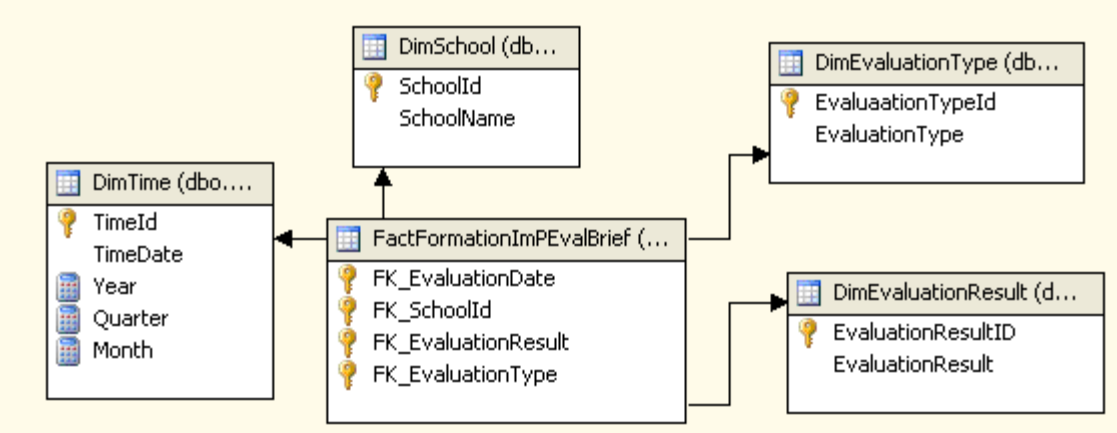

Figure 14 - Star model of brief evaluation

Figure 15 represents fact table of evaluation teaching implementation and its connections to the dimension tables. We have the following dimensions: schools, time, evaluation result, courses and teachers.

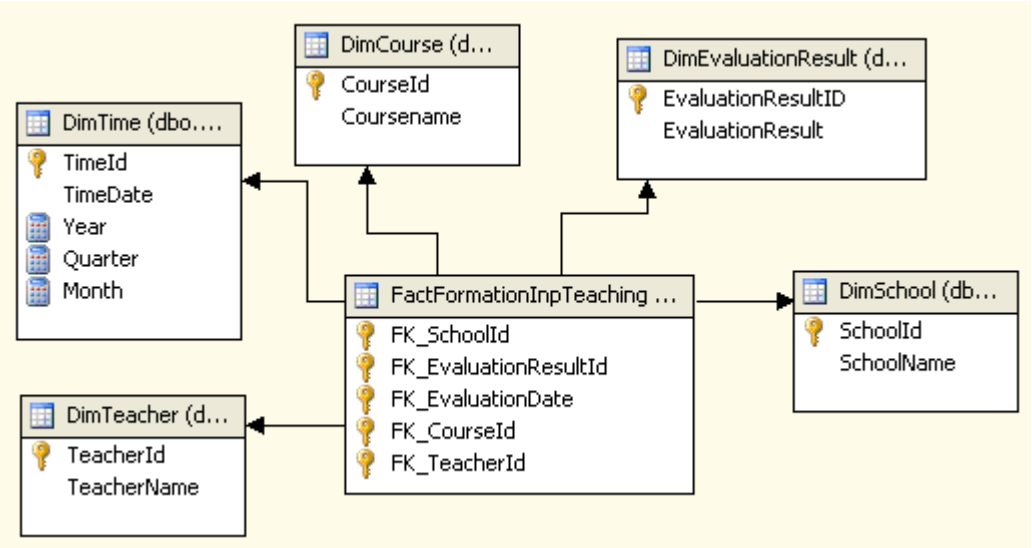

Figure 15 - Star model of evaluation teaching implementation

Figure 16 represents the fact table of Evaluation PA and its connections to the dimension tables. We have the following dimensions: schools, time, evaluation result, students and courses which are related to formation implementation and planning processes.

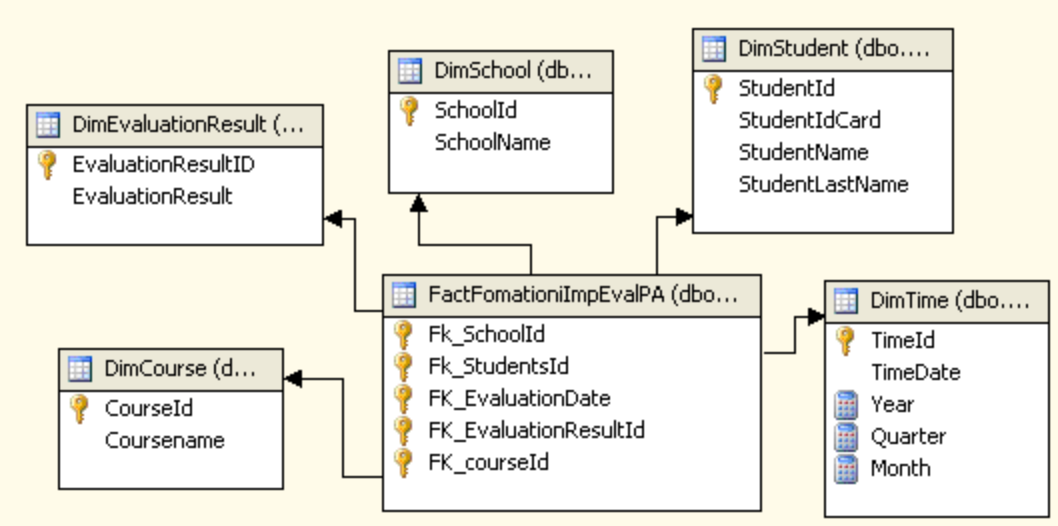

Figure 16 - Star model of evaluation PA

Figure 17 represents the fact table of grades evaluation and its connections to the dimension tables. We have the following dimensions: schools, time, evaluation result, students, teacher, courses and course year.

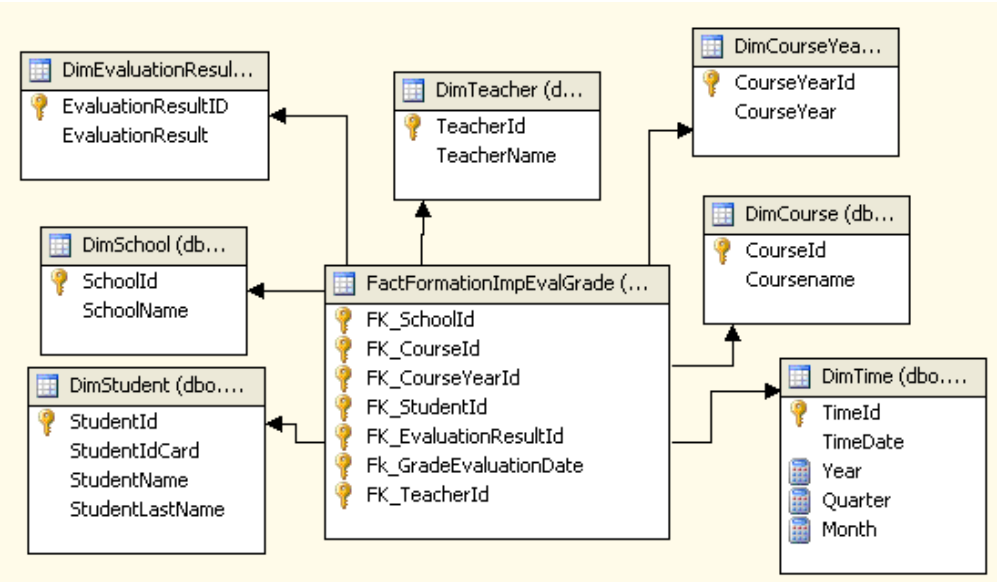

Figure 17 - Star model of grades evaluation

Figure 18 represents the fact table of launch evaluation and its connections to the dimension tables. We have the following dimensions: schools, time, evaluation result, evaluation type, students and courses.

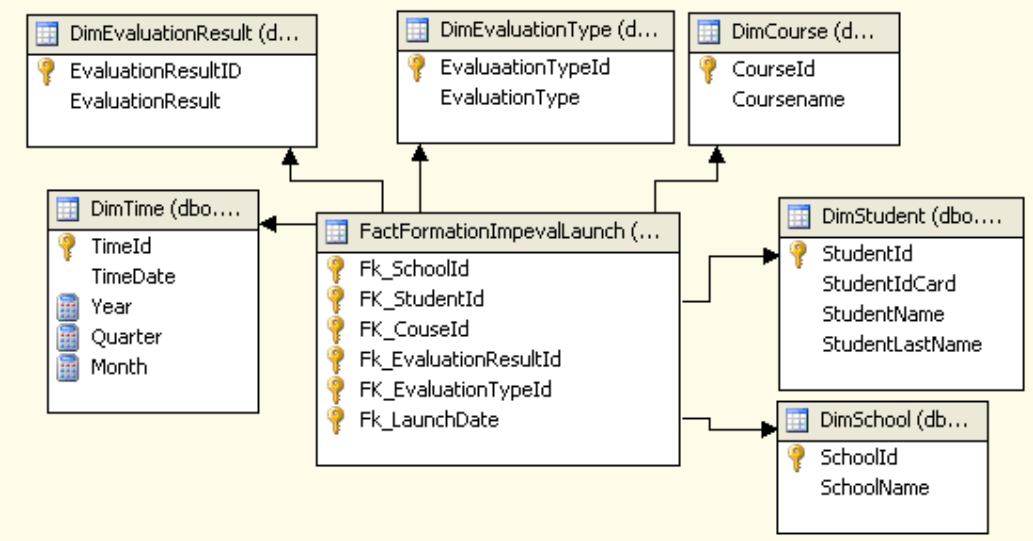

Figure 18 - Star model of evaluation launch

Figure 19 represents the fact table of students' evaluation and its connections to the dimension tables. We have the following dimensions: schools, time, evaluation result, students, courses and course years.

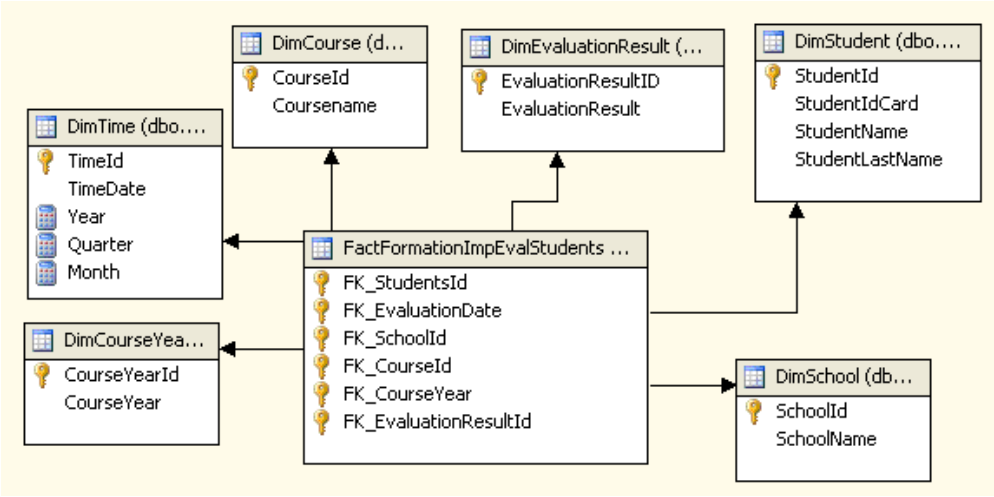

Figure 19 - Star model of student's evaluation

Figure 20 presents the fact table of degree evaluation and its connections to the dimension tables. We have the following dimensions: schools, time, evaluation result, students, and courses which are related to formation implementation and planning processes.

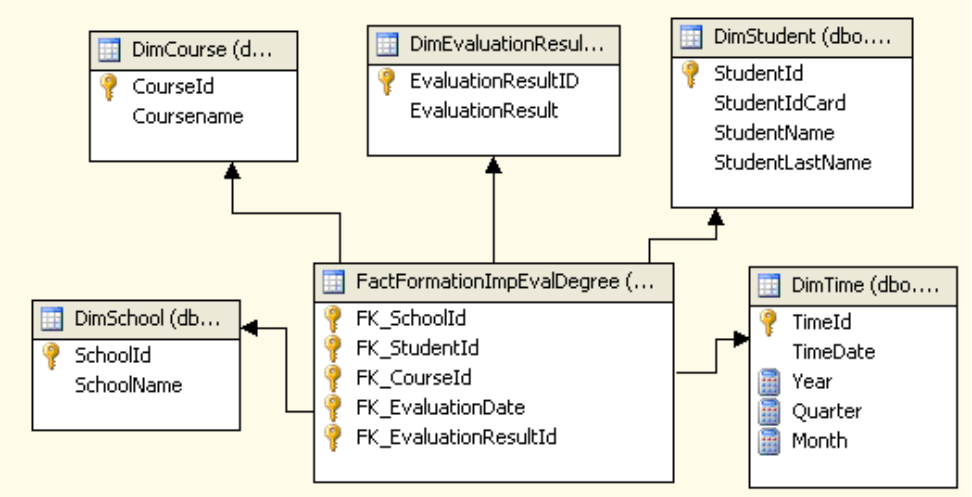

Figure 20 - Star model evaluation degree

- **Economic and Financial Management - Supply**

IPVC QMS staff has needs to analyze economic and financial department supply management process. They are interested in analyzing all the information about proposed dates, periods of tenders, stock breaks and more.

Table 8 represents supply process KPI requirement.

Process	**Process/ Sub-process**	**Indicator**	**Calculation Formula**	**Unit of Measure**
Economic and financial management	Supply	Average time to perform the procedures	Date of approval of the procedure - proposed date of employment - period of tender	Days
		Fee Defaults	Total demerits / Total supplies or months of employment	%
		Supplier Rating	Classification "B" class	%
			Classification "C" class	%
		Break stocks	Number of Breaks	Number

Table 8 – Supply process KPI requirements

Figure 21 presents the fact table of supply procedures and its connections to the dimension tables. We have the following dimensions: schools, time, procedure types and stock.

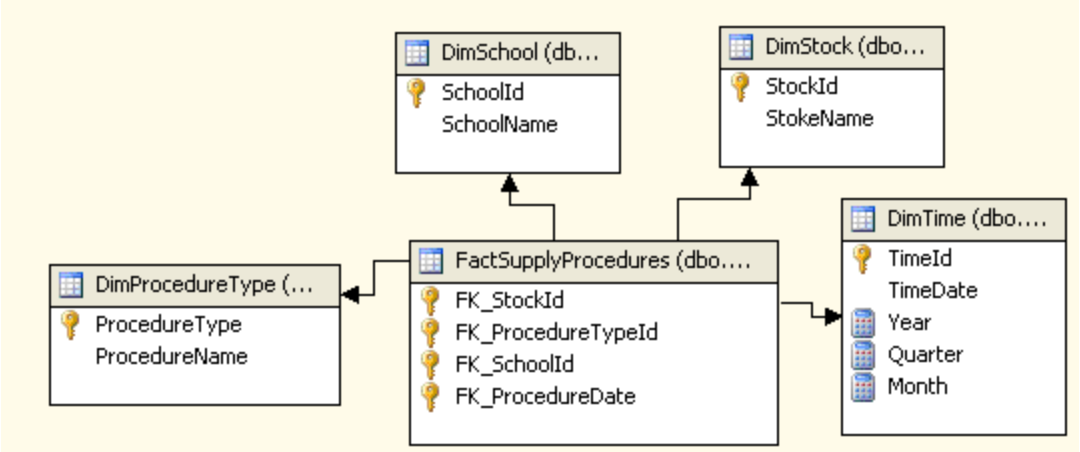

Figure 21 - Star model of supply fee

Figure 22 represents the fact table supply fee and its connections to the dimension tables. We have the following dimensions: time, tender types, employee and supply process status.

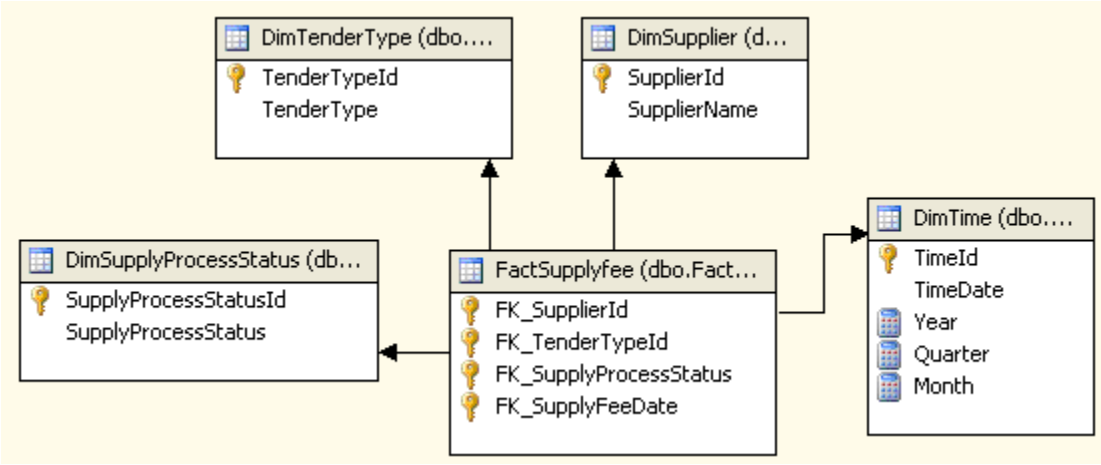

Figure 22 - Star model of supply fee

Figure 23 represents the fact table of supply contracts breaks and its connections to the dimension tables. We have the following dimensions: time, tender types, employee and supply process status.

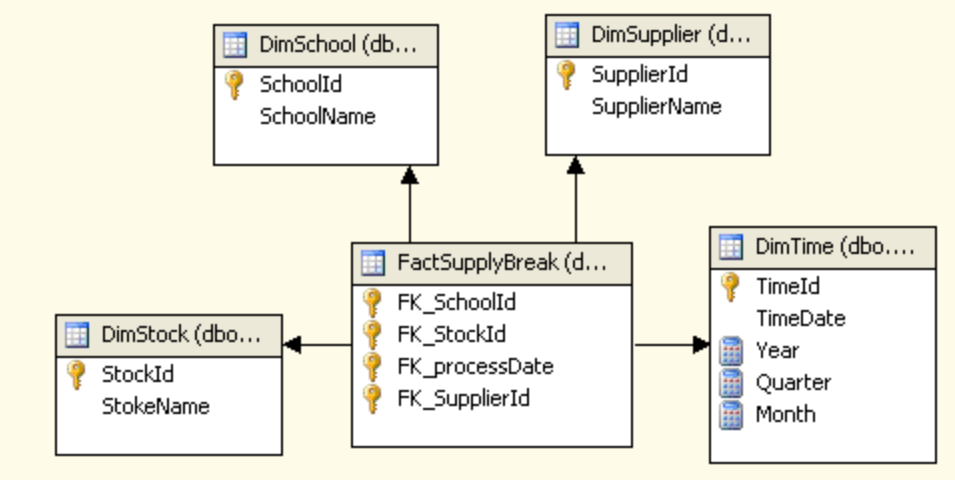

Figure 23 - Star model of supply breaks

- **Economic and Financial Management – Heritage**

IPVC QMS staff would like to analyze in economic and financial department Heritage process. They are interested in analyzing information about existing physical of assets, conducted conferences, documentation of goods.

Table 9 presents heritage process KPI requirement.

Process	**Process/ Sub-process**	**Indicator**	**Calculation Formula**	**Unit of Measure**
Economic and financial management	Heritage	Number of Existing Assets Physically, undocumented	Conducting periodic conferences	Number
		Number of documented goods and Number of found	Conducting periodic conferences	Number

Table 9 – Heritage process KPI requirements

Figure 24 represents the fact table of heritage and its connections to the dimension tables. We have the following dimensions: time, heritage types, document types and school.

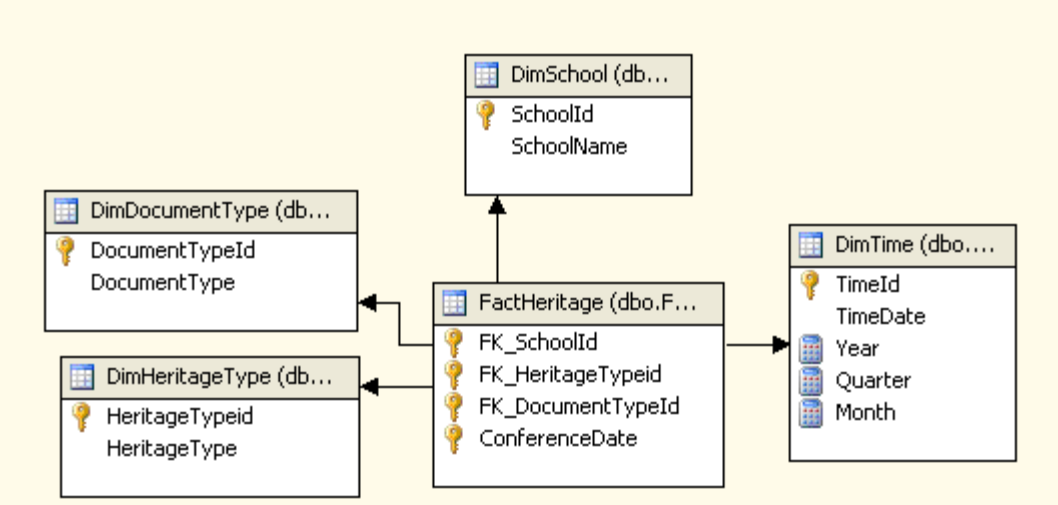

Figure 24 - Star model of heritage

- **Economic and Financial Management - Accounting and Treasury**

IPVC QMS staff would like to analyze in economic and financial department Accounting and Treasury process. They are interested in analyzing information about budgets and budgets changing, software's releases.

Table 10 presents accounting and treasury process KPI requirement.

Process	**Process/ Sub-process**	**Indicator**	**Calculation Formula**	**Unit of Measure**
Economic and financial management	Accounting & Treasury	Number of changes between budget lines	Number of changes	Number/ Month
		Timeliness of the register on the Software SIGO	Releases out of time	Number
		Budgetary Analysis	Revenue Collected - Commitments undertaken	Number

Table 10 – Accounting and treasury process KPI requirements

Figure 25 represents the fact table of account changing and its connections to the dimension tables. We have the following dimensions: schools, time, budgets name and budget lines.

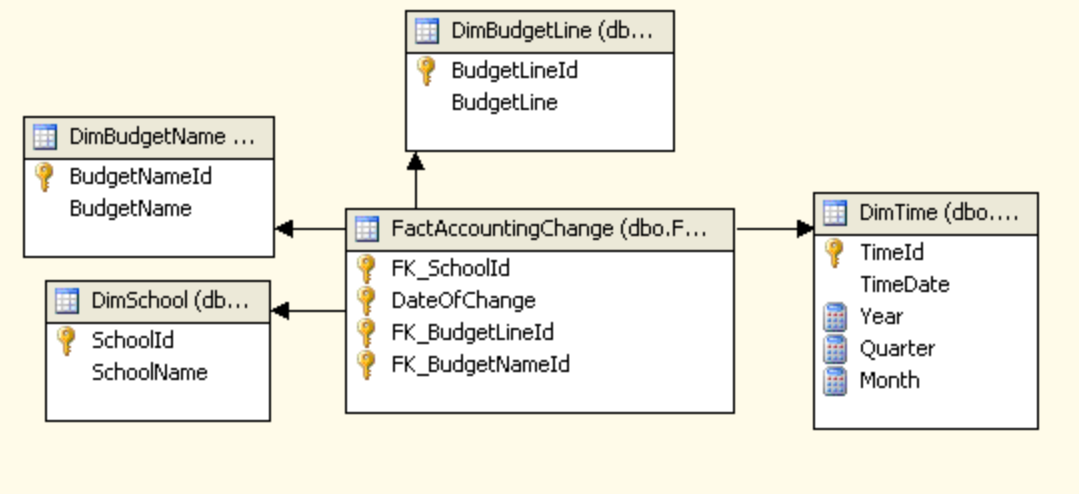

Figure 25 – Star model of account change

Figure 26 represents the fact table of accounting releases and its connections to the dimension tables. We have the following dimensions: schools, time, release status, software's and release type's lines.

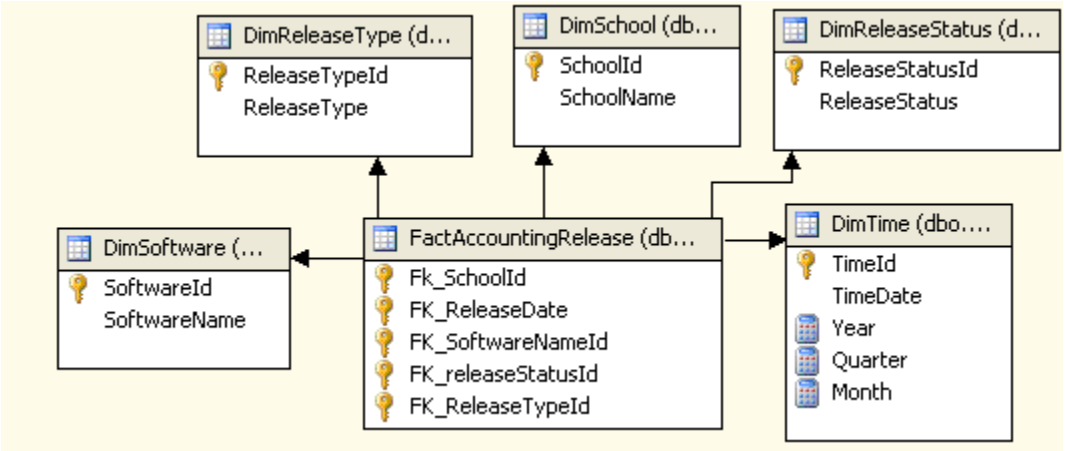

Figure 26 - Star model of accounting releases

Figure 27 presents the fact table of accounting budget and its connections to the dimension tables. We have the following dimensions: schools, time, and budget revenues, analysis and names.

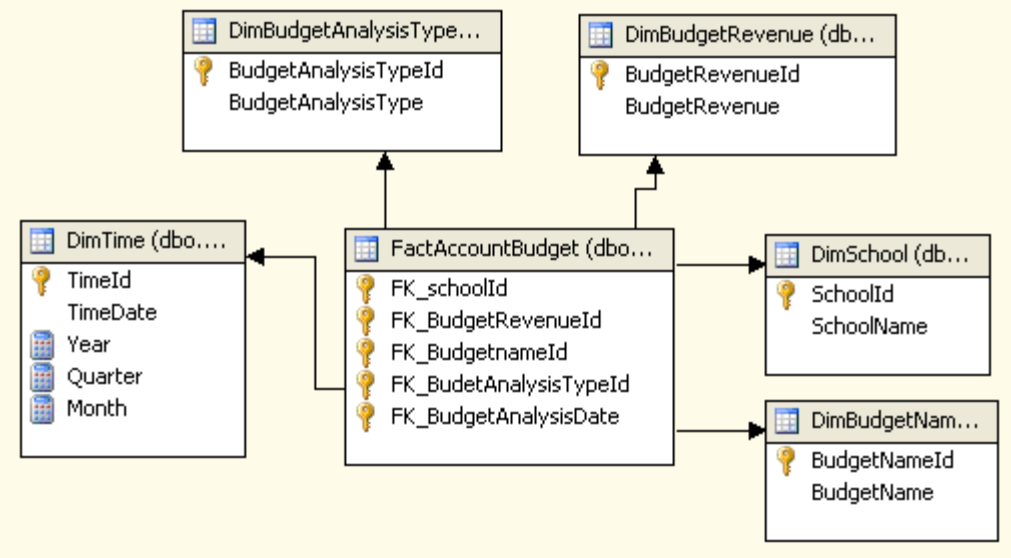

Figure 27 - Star model of accounting budget

- **Information Management – Dispatch and Archive**

IPVC QMS staff would like to analyze in department of information and management the Dispatch and Archive process. They are interested in analyzing information which is related to customer's complaints.

Table 11 represents accounting and treasury process KPI requirement.

Process	**Process/ Sub-process**	**Indicator**	**Calculation Formula**	**Unit of Measure**
Information Management	Dispatch and Archive	Number of complaints related to telephone and face-Care	records of incidents / complaints book	Number

Table 11 – Accounting and treasury process KPI requirements

Figure 28 represents the fact table of dispatch/archive and its connections to the dimension tables. We have the following dimensions: schools, time, compliance record types and complaints.

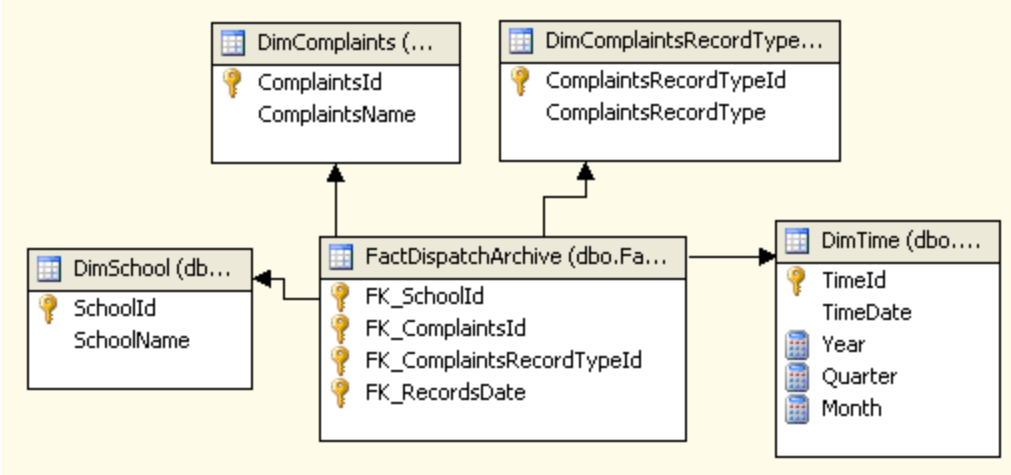

Figure 28 - Star model of Dispatch/Archive

- **Information Management - Document Management**

IPVC QMS staff would like to analyze Document Management process. They are interested in analyzing information related to regulatory complaints.

Table 11 represents accounting and treasury process KPI requirement.

Process	**Process/ Sub-process**	**Indicator**	**Calculation Formula**	**Unit of Measure**
INFORMATION MANAGEMENT	Document Management	Compliance with regulatory requirements (4.2.3 and 4.2.4)	Number of non-compliances	Number

Table 12 – Accounting and treasury process KPI requirements

Figure 29 represents the fact table of document management and its connections to the dimension tables. We have the following dimensions: schools, time, and compliance variety which.

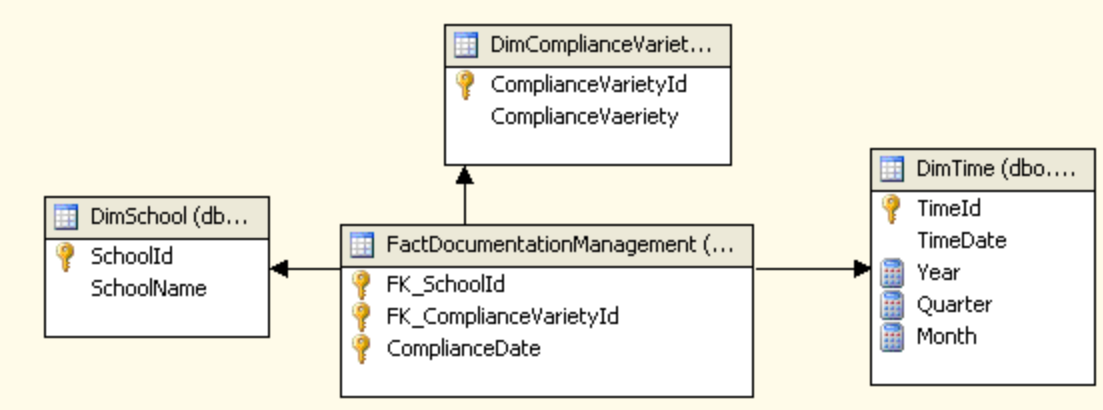

Figure 29 – Star model of document management

- **Management and improvement of system**

IPVC QMS staff would like to analyze system improvement management process. They are interested in analyzing information about systems treatments, compliances with the annual program of audits, quality achievements and assessment satisfactions.

Table 13 represents accounting and treasury process KPI requirement.

Process	**Process/ Sub-process**	**Indicator**	**Calculation Formula**	**Unit of Measure**
Management and improvement of system	Document Management	Treatment occurrences	Number of Occurrences identified - Number of Occurrences treated	Number
		Compliance with the annual program of audits	(Number of audits / Number of audits planned) X 100	%
		Process indicators in targets	(Paragraph indicators within the targets / indicators total Number of) x 100	%
		Achievement of quality objectives	(Number of achievements / Number of total goals) x 100	%
		Assessment Questionnaire Employee Satisfaction	weighted average index of satisfaction	Inquiry scale
		Student satisfaction rating-quality education (school)	% Of positive responses	%

Table 13 – Accounting and treasury process KPI requirements

Figure 30 represents the fact table of system treatment result and its connections to the dimension tables. We have the following dimensions: schools, occurrence type, treatment status, software, data type and date.

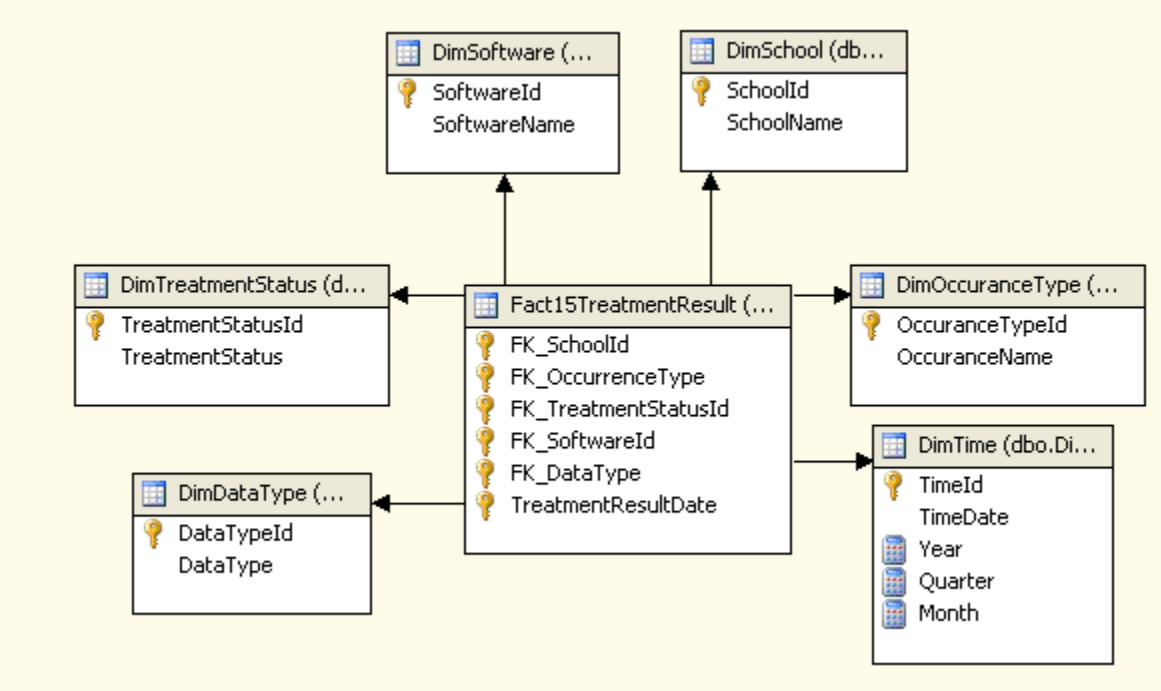

Figure 30 - Star model of system treatment result

Figure 31 represents the fact table of system compliances and its connections to the dimension tables. We have the following dimensions: schools, time, audit status, software, ISO type and audit Type.

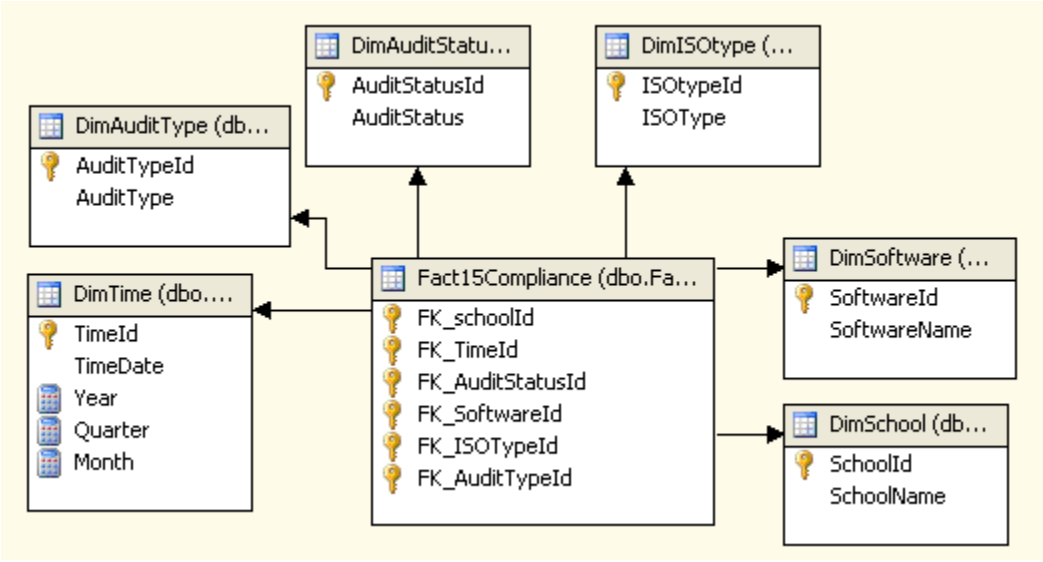

Figure 31 - Star model of system compliances

Figure 32 represents the fact table of indicator and its connections to the dimension tables. In dimensions tables are stored all information about schools, indicators, time and process.

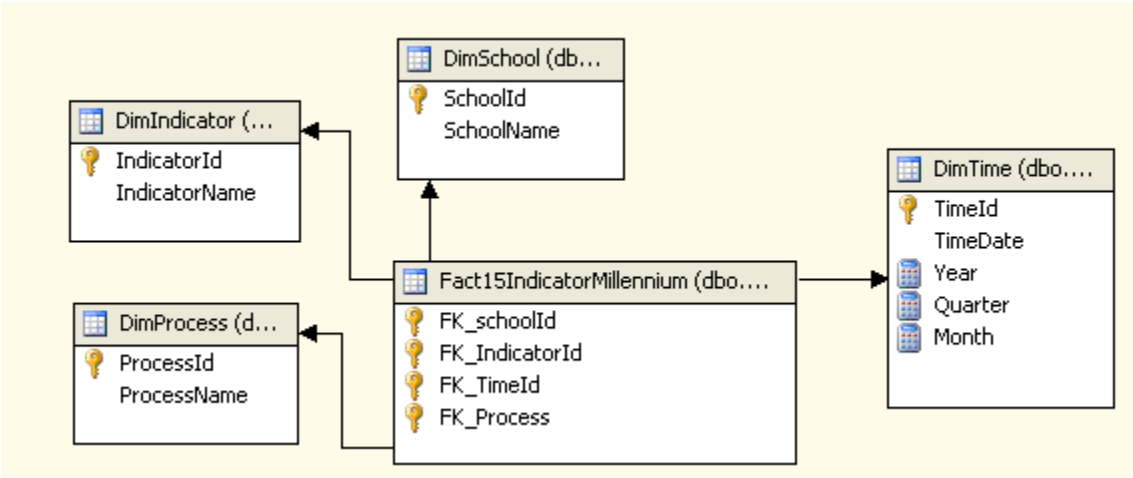

Figure 32 - Star model of indicator

Figure 33 represents the fact table of system achievements and its connections to the dimension tables. In dimensions tables are stored all information about schools, achievements, time and software's which are related to management improvement system process.

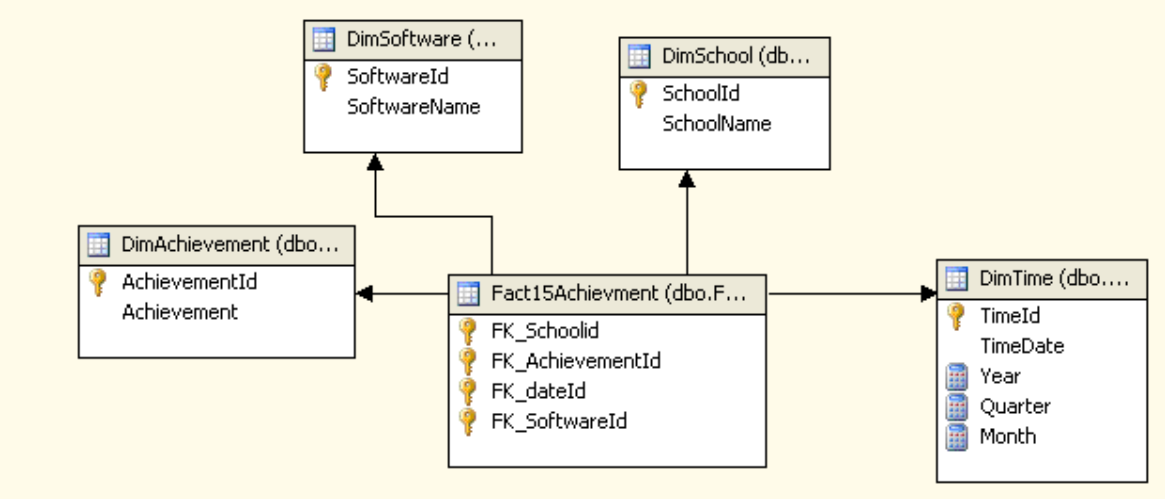

Figure 33 - Star model of system achievement

Figure 34 represents the Fact Fact15SEmployeeSatisfuction table and its connections to the dimension tables. In dimensions tables are stored all information about time, schools,

satisfaction, process and software's which are related to Management Improvement System process.

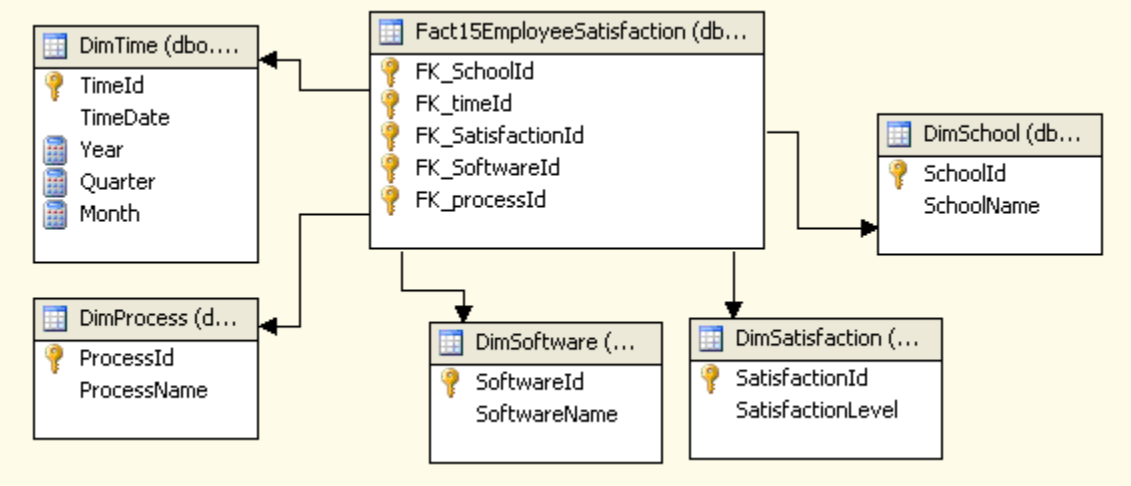

Figure 34 - Star model of Fact15SEmployeeSatisfuction

Figure 35 represents the fact table of schools satisfaction and its connections to the dimension tables. We have the following dimensions: schools, courses, satisfaction Type, time and students.

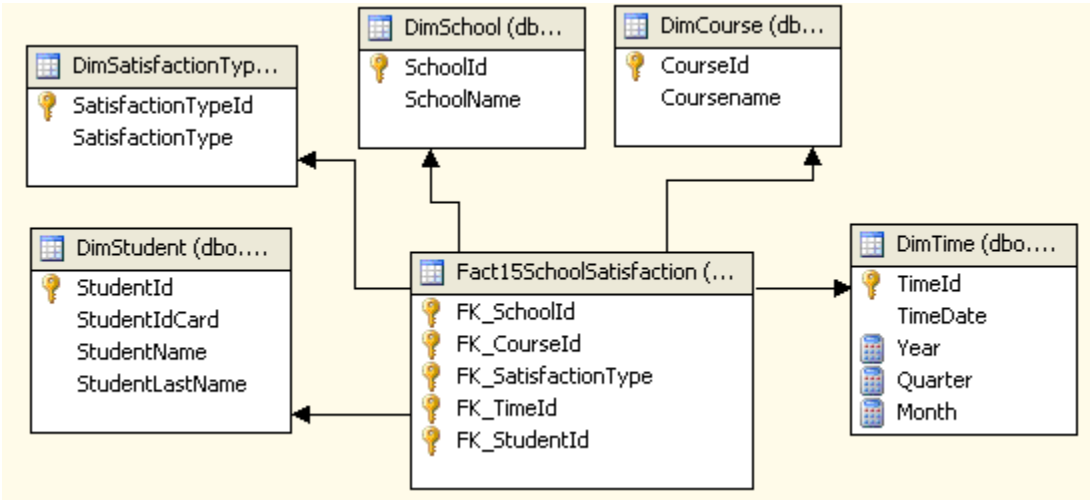

Figure 35 - Star model of schools satisfaction

- **Management contracts and infrastructure**

IPVC QMS staff would like to analyze management contracts and infrastructure process. They are interested analyzing information about systems treatments, compliances with the annual program of audits, quality achievements and assessment satisfactions.

Table 14 presents accounting and treasury process KPI requirement.

Process	**Process/ Sub-process**	**Indicator**	**Calculation Formula**	**Unit of Measure**
INFORMATION MANAGEMENT	Management contracts and Infrastructure	Detours Planned / Executed	Number of maintenance Number of t performed / Number of planned maintenance	%
		more Jobs than the scheduled	value of work to be deducted from most of the work unless / value of the initial proposal	%
		Failure of Time	Delays attributed to the executor / execution time	%

Table 14 – Management contracts and infrastructure KPI requirements

Figure 36 represents the fact table of constructs detours and its connections to the dimension tables. We have the following dimensions: schools, employee, time and management statuses.

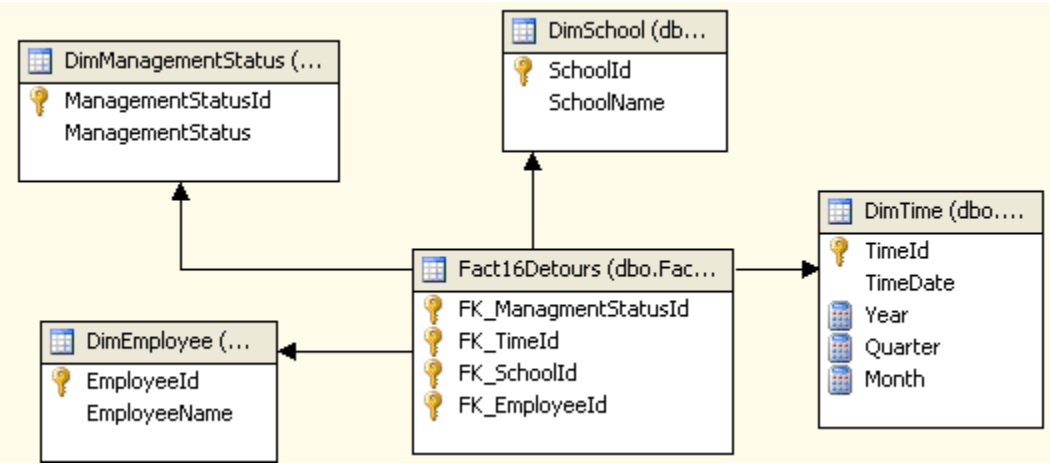

Figure 36 - Star model Contracts Detours.

Figure 37 represents the fact table of contractor jobs and its connections to the dimension tables. We have the following dimensions: schools, time jobs type and schedule statuses which are related to Management contracts and infrastructure process.

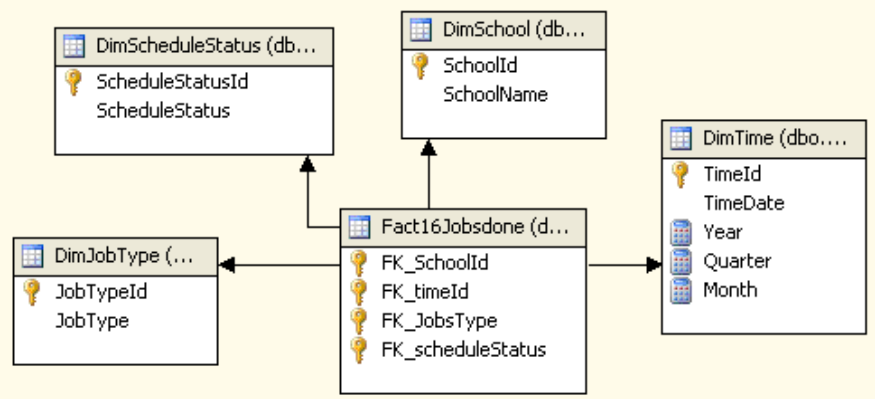

Figure 37 - Star model of contractor jobs

Figure 38 represents the Fact table and its connections to the dimension tables. In dimensions tables are stored all information about schools, time delay reasons and execution time, which are related to management contracts and infrastructure process.

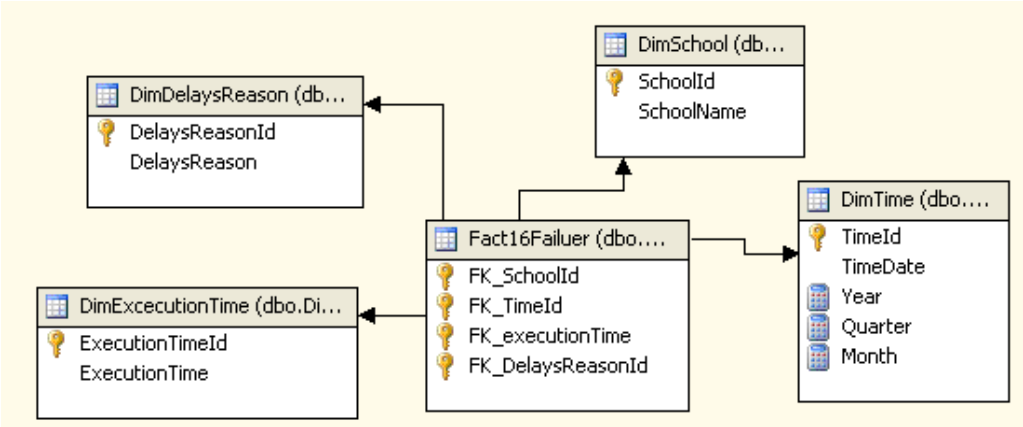

Figure 38 – Star model of Failure

- **Project Management**

IPVC QMS staff would like to analyze project management process. They are interested in analyzing information about implementation of applications, schedules, plans and undertaken activities.

Table 15 presents project management process KPI requirement.

Process	**Process/ Sub-process**	**Indicator**	**Calculation Formula**	**Unit of Measure**
INFORMATION MANAGEMENT	Project management	Physical implementation rate (value obtained from the last application for external entities approved reprogramming)	Activities undertaken / planned activities (schedule)	%
		Financial execution rate	Financing run / Funding approved	%

Table 15 – Project management KPI requirements

Figure 39 represents the fact table of undertaken activities and its connections to the dimension tables. We have the following dimensions: schools, time applications and schedules.

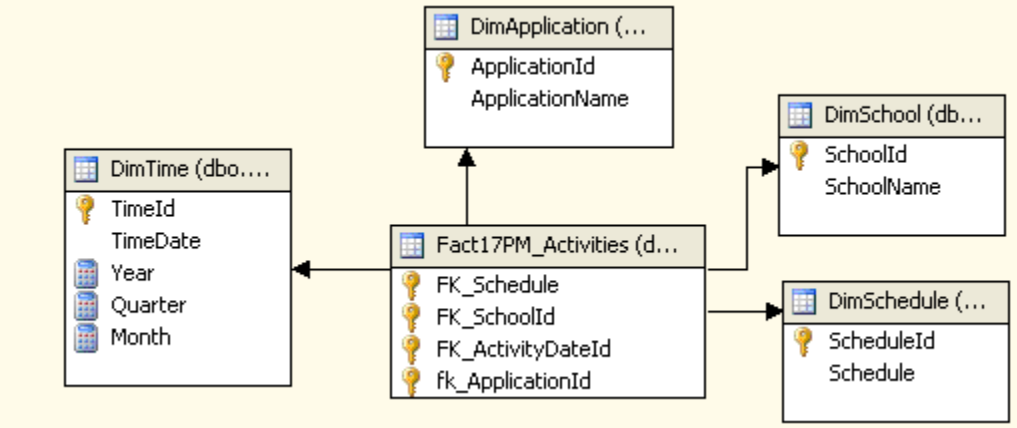

Figure 39 - Star model of undertaken activities

Figure 40 represents the fact table of projects finances and its connections to the dimension tables. We have the following dimensions: schools, time applications and finances which are related to project management process.

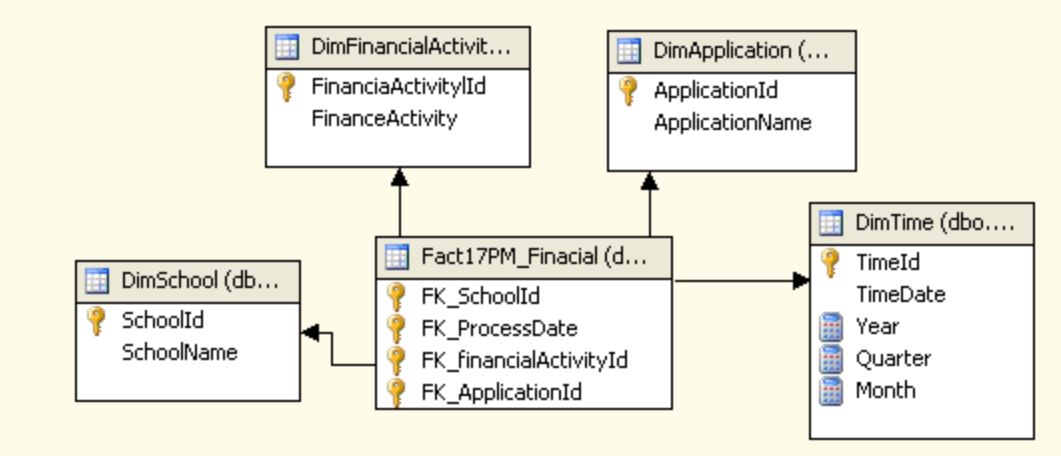

Figure 40 – Star model of projects finances

- **Management information systems**

IPVC QMS staff would like to analyze management information systems process. They are interesting analyzing information about conducted trainings, information systems occurrences, backups and tests.

Table 16 presents management information system KPI requirement.

Process	**Process/ Sub-process**	**Indicator**	**Calculation Formula**	**Unit of Measure**
Management Information Systems	Management Information Systems	Number of requests for support from users caused by their inadequate training		Number
		Number of occurrences per annual application server software that caused breaks in operation	Number of occurrences per annual application server software that caused breaks in operation	Number
		Average time (days) answer to the recovery component of the tech Number of logical infrastructure without purchasing components	Average between the date of the occurrence of computer failure and date of incident resolution computerized	Number of Days
		Rate of incidents that require support on site (outside the Computer	(Total number of incidents that require support local / Total	%

		Services) of the occurrence	incidents) * 100	
		Event rate resolved and finalized the responsibility of Computer Services	(Occurrences resolved and completed / finalized Total occurrences) * 100	%
		Rate of incidents reopened	(Total number of incidents reopened / Total incidents) * 100	%
		Rate backups of critical data (defined by the policy of backups)	(Number of backups of critical data / Total data critical) * 100	%
		Rate tests successful backups of data from Information Systems	(Number of tests performed backups / Total number of backups made) * 100	%

Table 16 – Management information systems KPI requirements

Figure 41 represents the fact table of IS trainings and its connections to the dimension tables. We have the following dimensions: schools, time training types and software's.

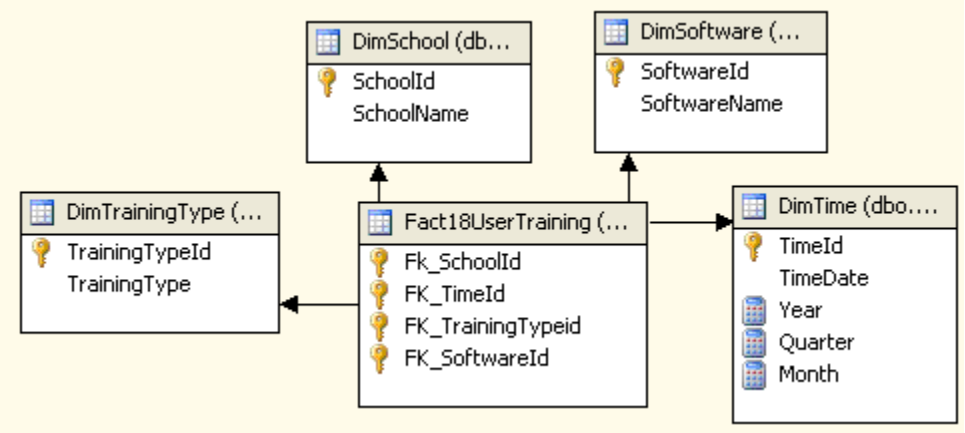

Figure 41 - Star model of IS trainings

Figure 42 represents the fact table of IS occurrences and its connections to the dimension tables. We have the following dimensions: schools, time occurrences type, occurrences events and software's.

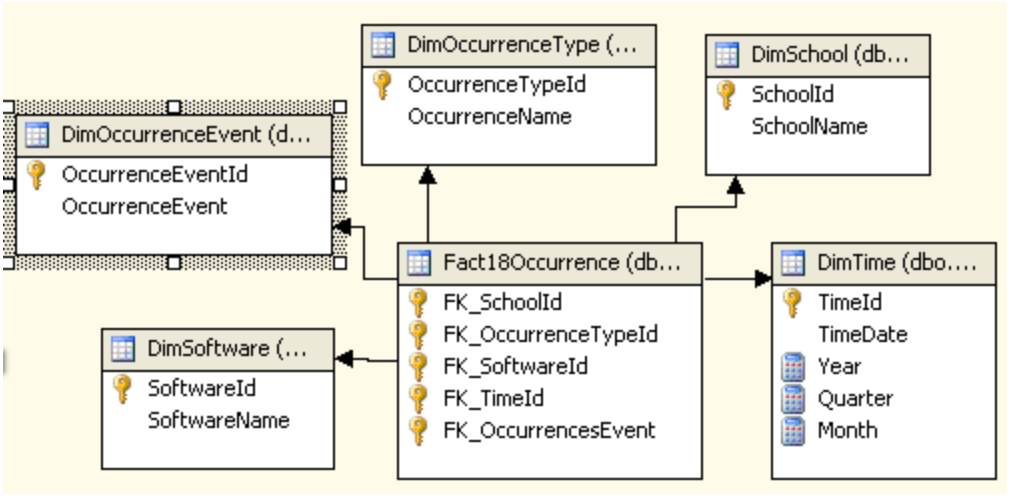

Figure 42 - Star model of IS occurrences

Figure 43 represents the fact table of IS incidents and its connections to the dimension tables. We have the following dimensions: schools, time, incidents and applications.

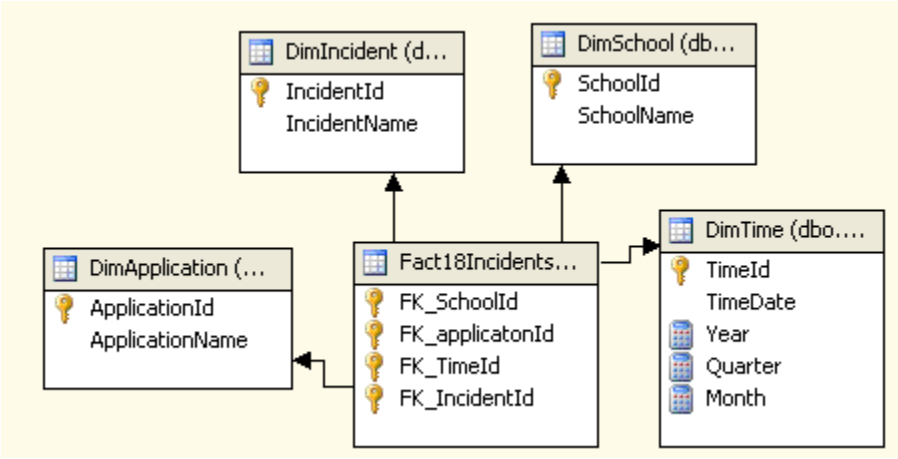

Figure 43 - Star model of IS incidents

Figure 44 represents the fact table of IS backups and its connections to the dimension tables. We have the following dimensions: schools, time critical levels, backup types and applications which are related to management information systems process.

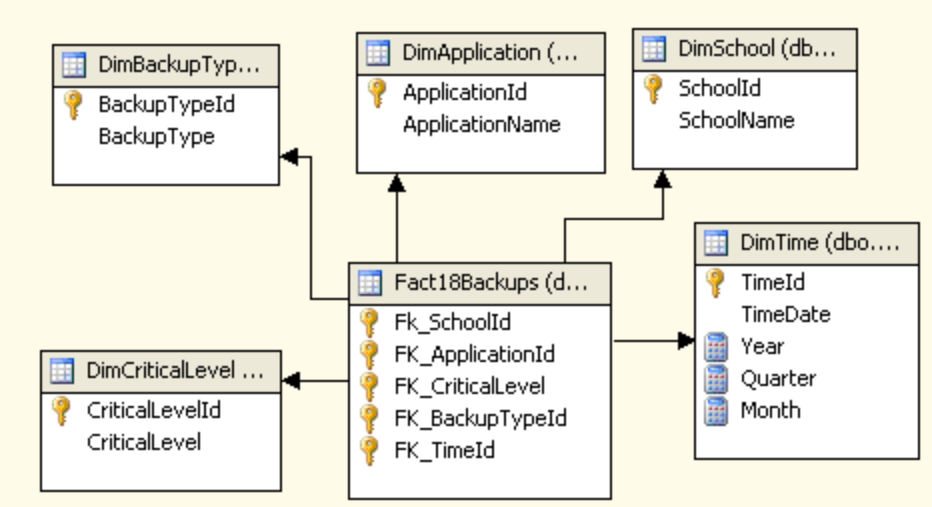

Figure 44 - Star model of IS backups

- **Observatory**

IPVC QMS staff would like to analyze Observatory process. They are interested in analyzing information about conducted questioners and surveys.

Table 17 represents accounting and treasury process KPI requirement.

Process	**Process/ Sub-process**	**Indicator**	**Calculation Formula**	**Unit of Measure**
Observatory	Observatory	Rate Answers to the Questionnaire for Assessment of Quality of Teaching and Organic unit	(Number of validated questionnaires / Total number of students) * 100	%
		Inquiry companies and institutions in the region	Number of companies and institutions surveyed / Total number of companies and institutions in the region	%
		Response Rate to Questionnaires to staff, by organizational unit	(Number of validated questionnaires / Total number of employees) * 100	%

Table 17 – Observatory KPI requirements

Figure 45 represents the fact table of teaching and its connections to the dimension tables. We have the following dimensions: schools, time, students, teachers and courses.

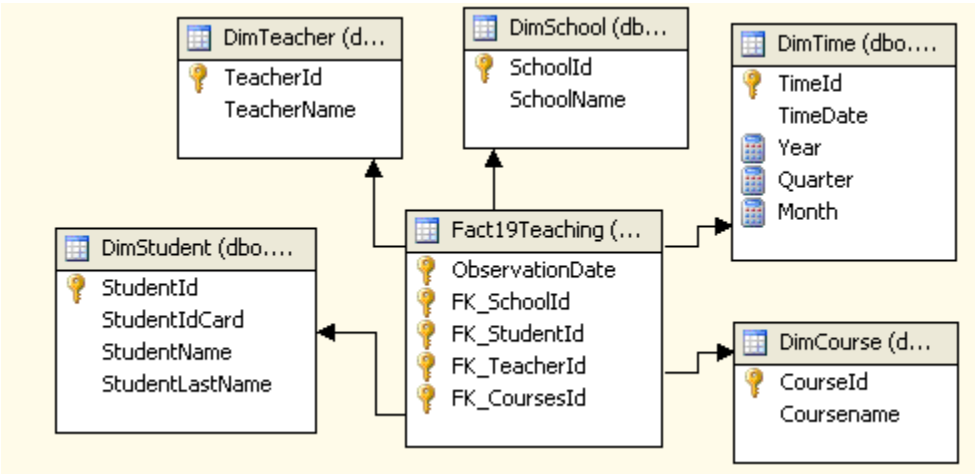

Figure 45 - Star model of teaching

Figure 46 represents the fact table of observing inquiry and its connections to the dimension tables. We have the following dimensions: locations, time and organization variety.

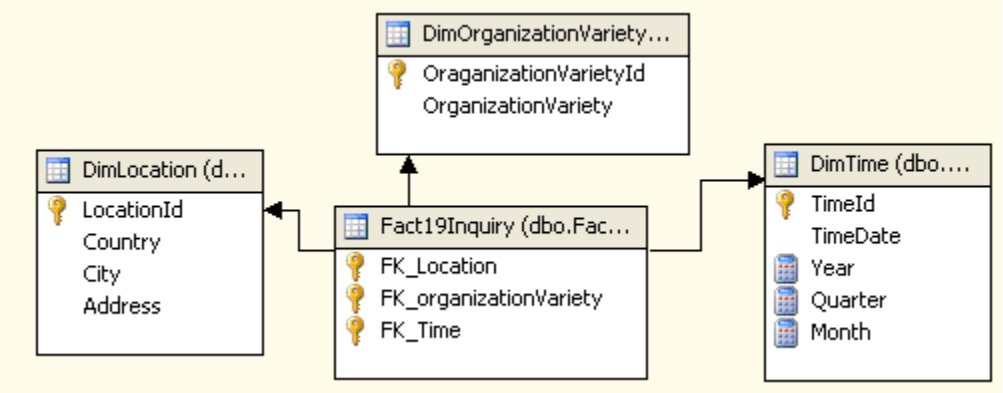

Figure 46 - Star model of inquiry

Figure 47 represents the fact table of questioners and its connections to the dimension tables. We have the following dimensions: questioner status, time, location and observation type which are related to Observatory process.

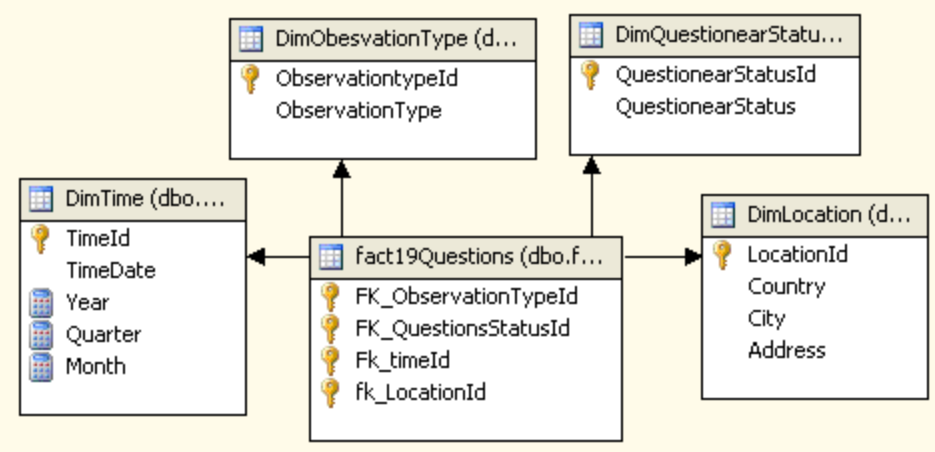

Figure 47 - Star model of questioners

Figure 48 represents the fact table of questioner responds and its connections to the dimension tables. We have the following dimensions: question responds, organization variety, question status and time which are related to Observatory process.

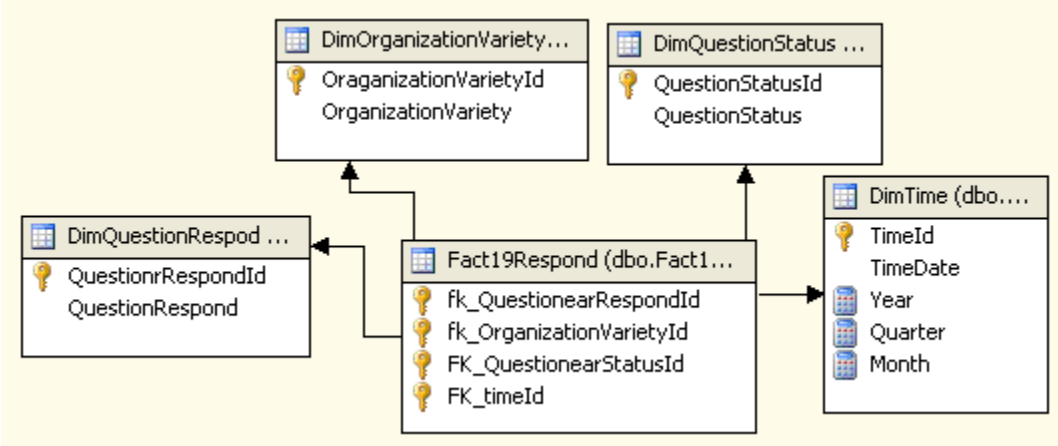

Figure 48 - Star model of Question Responds

- **Promotion and Image – Graphics Production and Audiovisual**

IPVC QMS staff would like to analyze graphics promotion and audiovisual process. They are interested analyzing information about compliance works and submitted complaints.

Table 18 represents Graphics production and audiovisual process KPI requirement.

Process	Process/ Sub-process	Indicator	Calculation Formula	Unit of Measure
PROMOTION AND IMAGE	Graphics production and audiovisual	Rate of work performed in accordance	(Number of studies conducted in compliance / total number of works)	records
		Rate complaint submitted	(Number of studies conducted in compliance / total number of works)	complaints register

Table 18 – Graphics production and audiovisual KPI requirements

Figure 49 represents the fact table of graphics production and its connections to the dimension tables. We have the following dimensions: time, schools, company types, study types, complaint, and students.

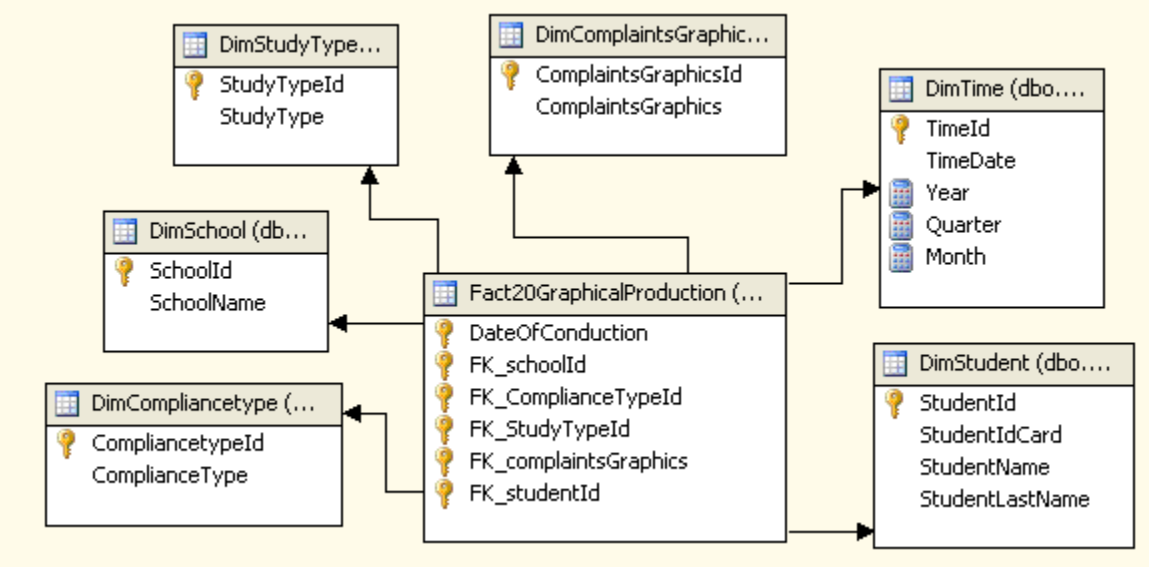

Figure 49 - Start model of graphical production

- **Promotion and Image – External and Internal Communication**

IPVC QMS staff would like to analyze External and Internal Communication process. They are interested in analyzing information about achievements, opportunities, proposals approvals and implementation, degree satisfaction, conducted training completeness, consultations and portals visits.

Table 19 represents External and internal communication KPI requirement.

Process	Process/ Sub-process	Indicator	Calculation Formula	Unit of Measure
PROMOTION AND IMAGE	Graphics production and audiovisual	Opportunity Disclosure	Number of achievements / Number of Opportunities	%
		Number of approved proposals	Number of approvals / Number of proposals	%
		Number of proposals implemented	Number of proposals used / Number of approvals	%
		Satisfaction degree	User surveys (%)	%
		Completeness	Number of demand training offer different Public	%
		Number of consultations / visits Portal	Number of visits daily and annual average	Number/Day
		Number of Publications and Communications (Student Guide, Revised IPVC, Getting Home)	Number of Publications Executed	%

Table 19 – External and internal communication KPI requirements

Figure 50 represents the fact table of disclosure and its connections to the dimension tables. We have the following dimensions: disclosure type, communication type, schools and time.

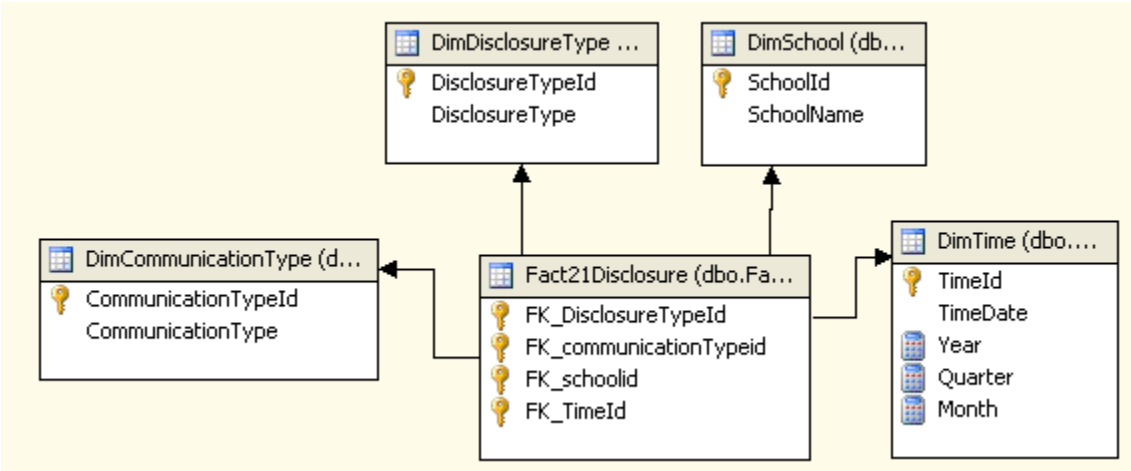

Figure 50 - Star model of disclosure

Figure 51 represents the fact table of proposals and its connections to the dimension tables. We have the following dimensions: proposals, improvements, schools, times and organization varieties.

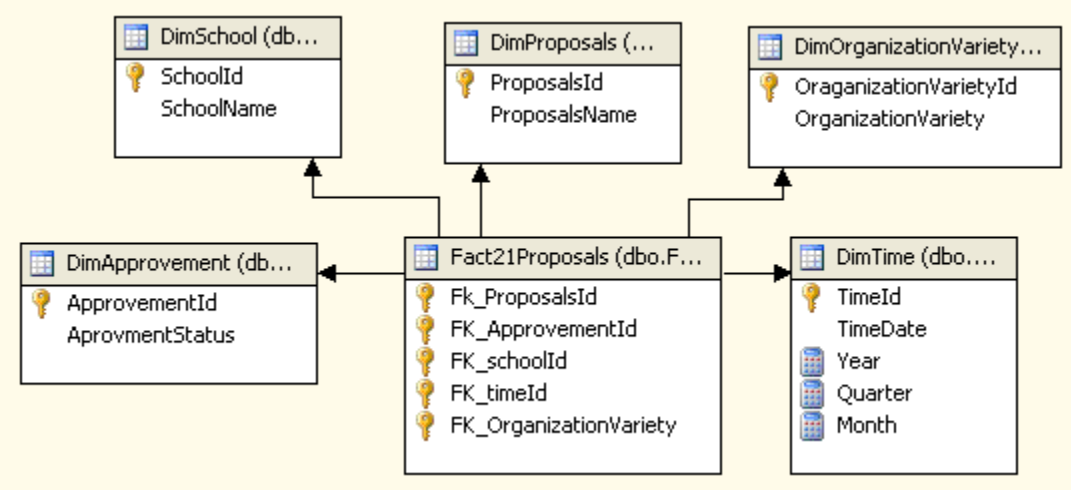

Figure 51 - Star model of proposals

Figure 52 represents the fact table of proposals implementation and its connections to the dimension tables. We have the following dimensions: schools, time, proposals, approves and proposals usages.

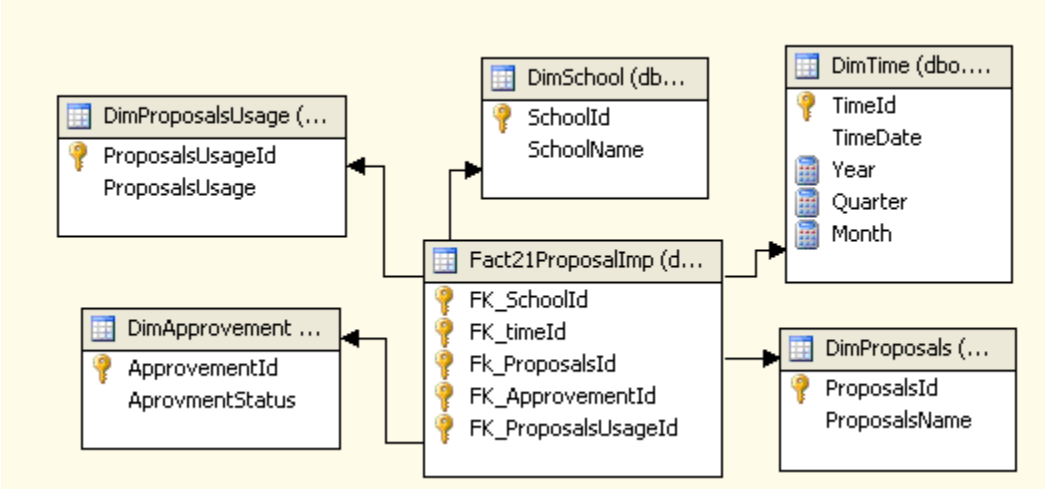

Figure 52 - Star model of proposals implementation

Figure 53 represents the fact table of communication satisfaction and its connections to the dimension tables. In dimensions tables are stored all information about schools, time,

questioner satisfaction and questioner types which are related to external and internal communication process.

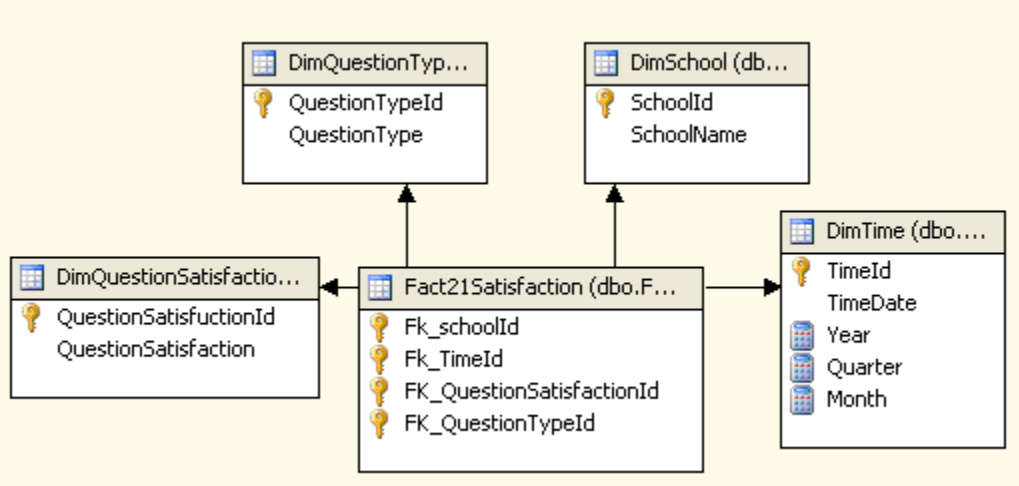

Figure 53 - Star model of communication satisfaction

Figure 54 represents the Fact Fact21Completeness table and its connections to the dimension tables. In dimensions tables are stored all information about schools, time, completeness types, trainings and organization varieties which are related to external and internal communication process.

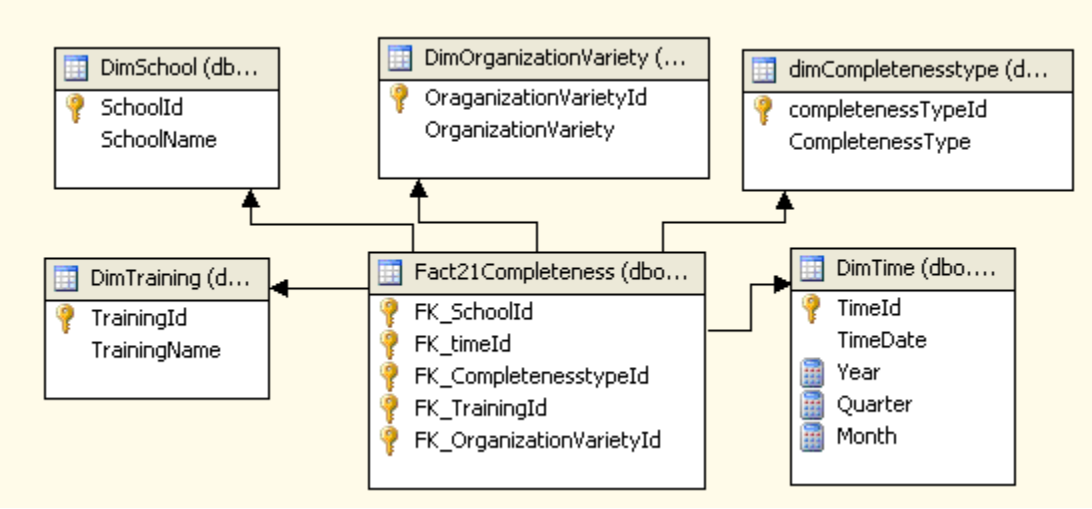

Figure 54 - Star model of Fact21completeness

Figure 55 represents the fact table of portal visits and its connections to the dimension tables. We have the following dimensions: schools, time, completeness types, trainings and organization varieties.

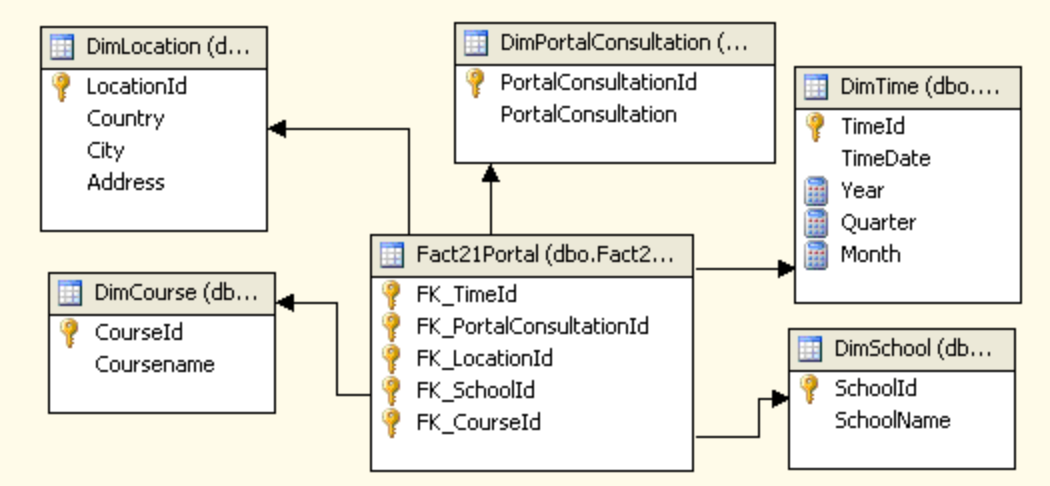

Figure 55 - Star model of visits portals

Figure 56 represents the fact tables of publications and its connections to the dimension tables. We have the following dimensions: schools, time, publication type and publication status.

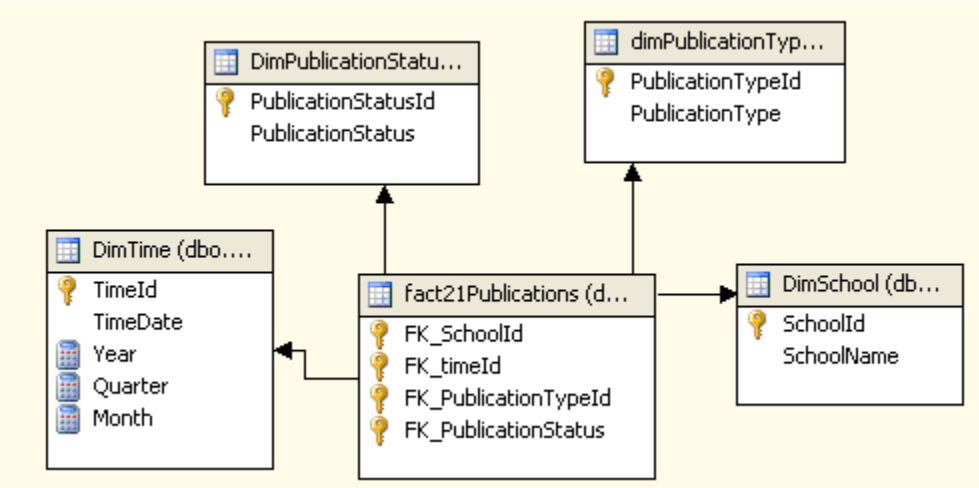

Figure 56 - Star model and publications

- **Human Resources**

IPVC QMS staff would like to analyze Human Resources process. They are interested in analyzing information about individuals' cases, conducted training hours, trainings pans, training efficiency and absentness rate.

Table 20 presents human resources KPI requirement.

Process	Process/ Sub-process	Indicator	Calculation Formula	Unit of Measure
Human Resources	Human Resources	Individual cases full rate	Number of complete dossiers / Number of employees	%
		Average number of hours of training per employee	Number of training hours / Number of employees	Hours
		Coverage rate of the training plan	(Number of employees covered by the training plan / Total number of employees)	%
		Efficacy rate of training	(Effective Number of shares / Total Number of training)	%
		Absenteeism Rate	(Number of . of hours of absence / Total Number of hours worked)	%

Table 20 – Human resources KPI requirements

Figure 57 presents the fact tables of dossiers and its connections to the dimension tables. We have the following dimensions: schools, time, employee, dossiers completeness and individuals' type.

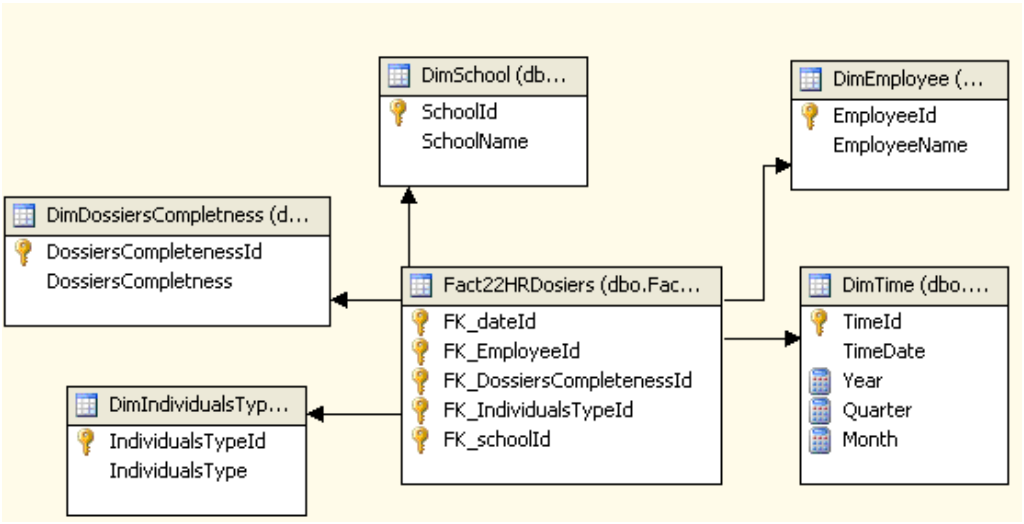

Figure 57 - Star model of Fact22HRDosiers

Figure 58 represents the fact table of HR trainings and its connections to the dimension tables. We have the following dimensions: employee, trainings, training hours, date, training types, training status, training coverage's and hour absence.

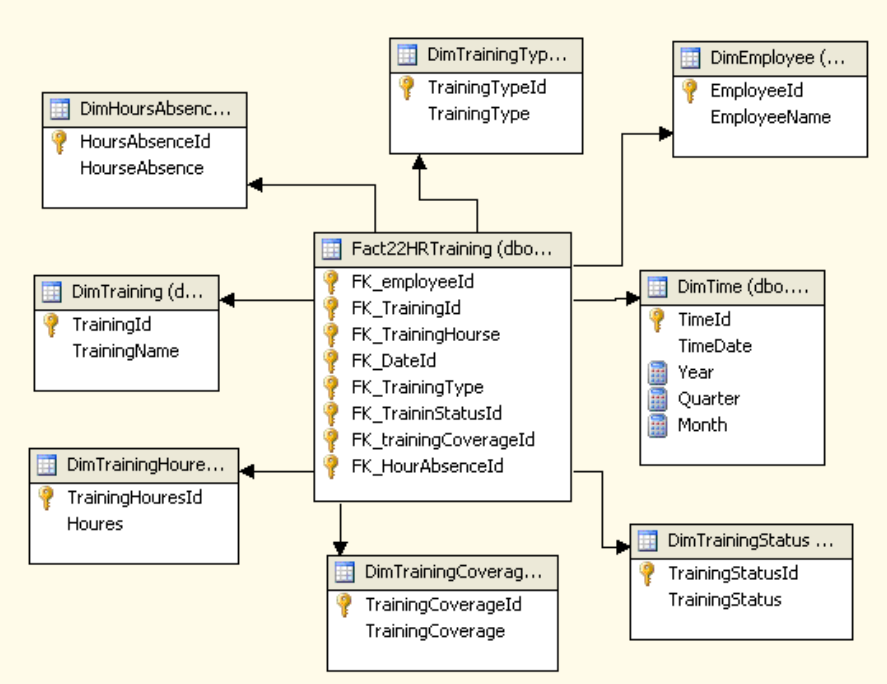

Figure 58 - Star model of HR Trainings

- **Educational Technical Resources - Library**

IPVC QMS staff would like to analyze Library process in schools. They are interested in analyzing information about borrowing books, internal library loans and customers complaints.

Table 21 presents library KPI requirement.

Process	**Process/ Sub-process**	**Indicator**	**Calculation Formula**	**Unit of Measure**
Educational technical resources	Library	Number of Register (MFN) made in the database per year	Number of of registrations in database	Number
		Number of loans / year	Number of loans made	Number
		Number of Interlibrary Loan / year	Number of requested loans - Number of Loan Number of t met	Number

		Number of complaints / year	Number of complaints received	Number

Table 21 – Library KPI requirements

Figure 59 represents the fact table of library and its connections to the dimension tables. We have the following dimensions: date, books, books MFN numbers, students, courses and schools.

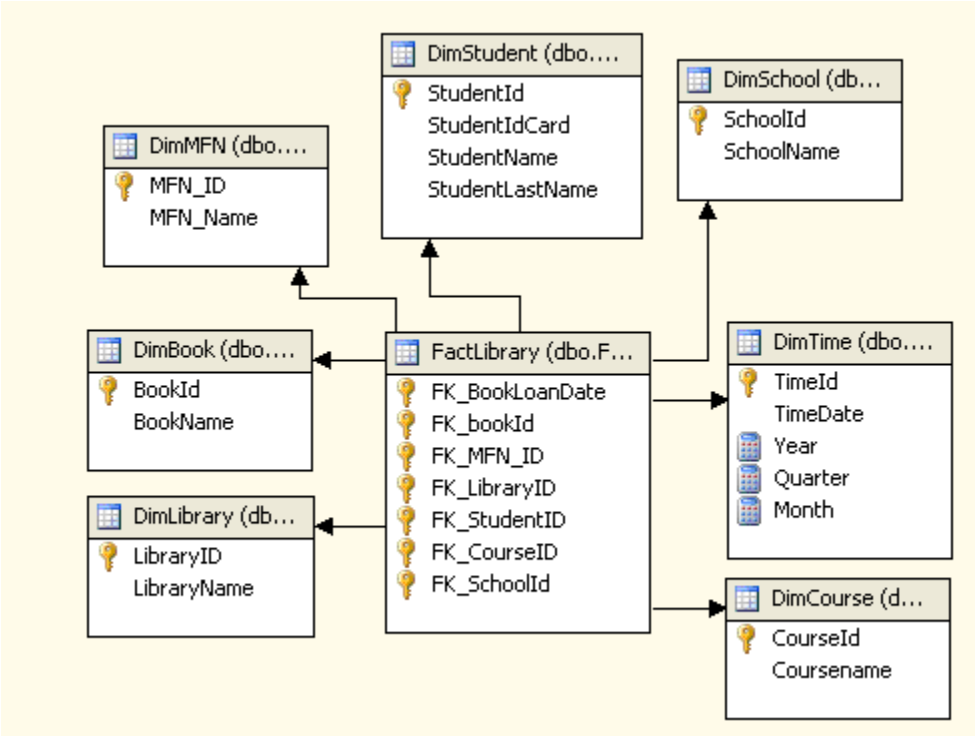

Figure 59 - Star model of library

Figure 60 represents the fact table of complaints in libraries and its connections to the dimension tables. We have the following dimensions: date, schools, libraries, customers and complaints.

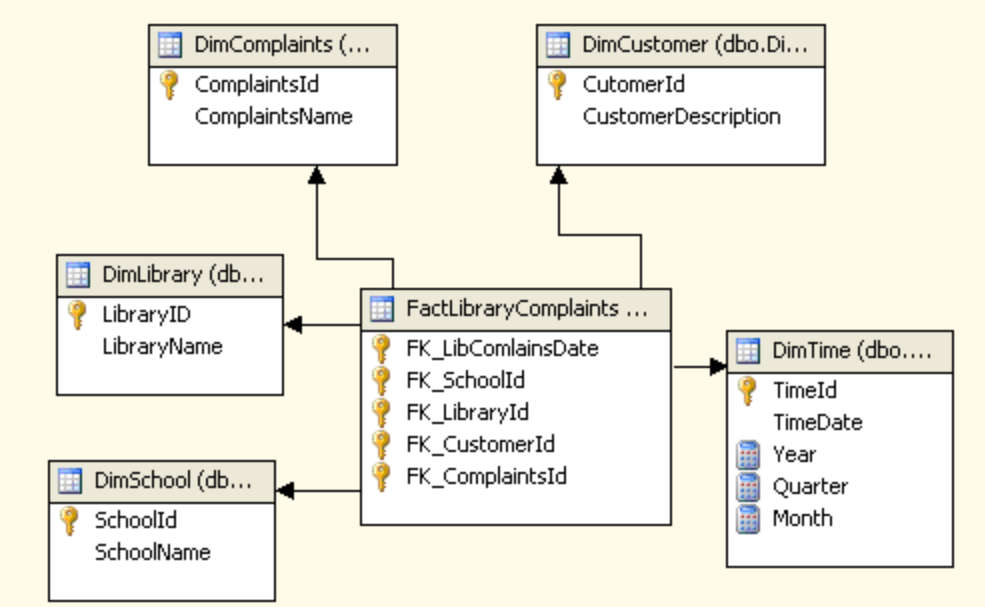

Figure 60 – Star model of complaints

Figure 61 represents the fact table of internal libraries process and its connections to the dimension tables. We have the following dimensions: date, Libraries, schools and books which are related to library process.

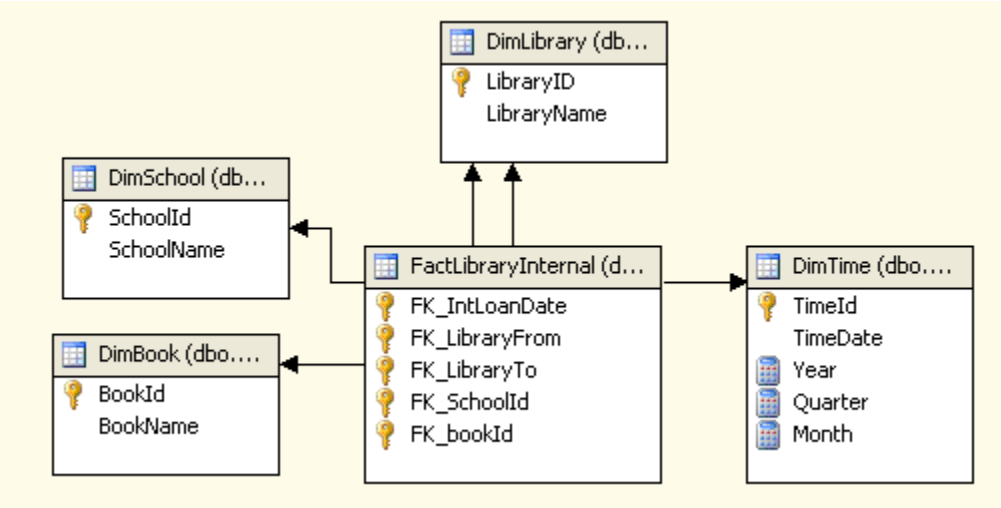

Figure 61 - Star model of internal libraries process

- **Educational technical resources - Management Education Spaces**

IPVC QMS staff would like to analyze Management Education Spaces process in schools.

Table 22 presents library KPI requirement.

Process	Process/ Sub-process	Indicator	Calculation Formula	Unit of Measure
Educational technical resources	Management Educational Spaces	Satisfaction of users	AVERAGE (listing questionnaire)	number
		Satisfaction Index Requests	Percentage of the total of requests	%
		Utilization rate of Spaces	% (Over max capacity)	%

Table 22 – Library KPI requirements

Figure 62 represents the fact table of education space and its connections to the dimension tables. We have the following dimensions: date, request types, capacities, schools, courses, labs, teachers, and books.

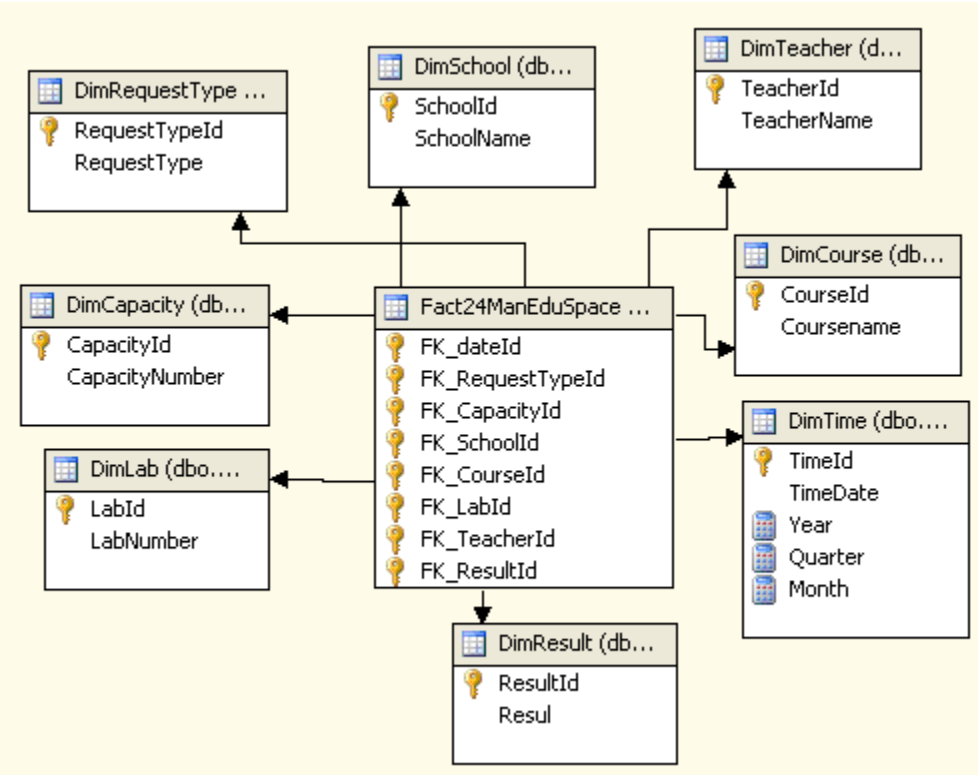

Figure 62 - Star model of education space

Figure 63 represents the fact table of space questioners and its connections to the dimension tables. We have the following dimensions: date, schools, questioner satisfactions, capacities, teachers and questioners filled status.

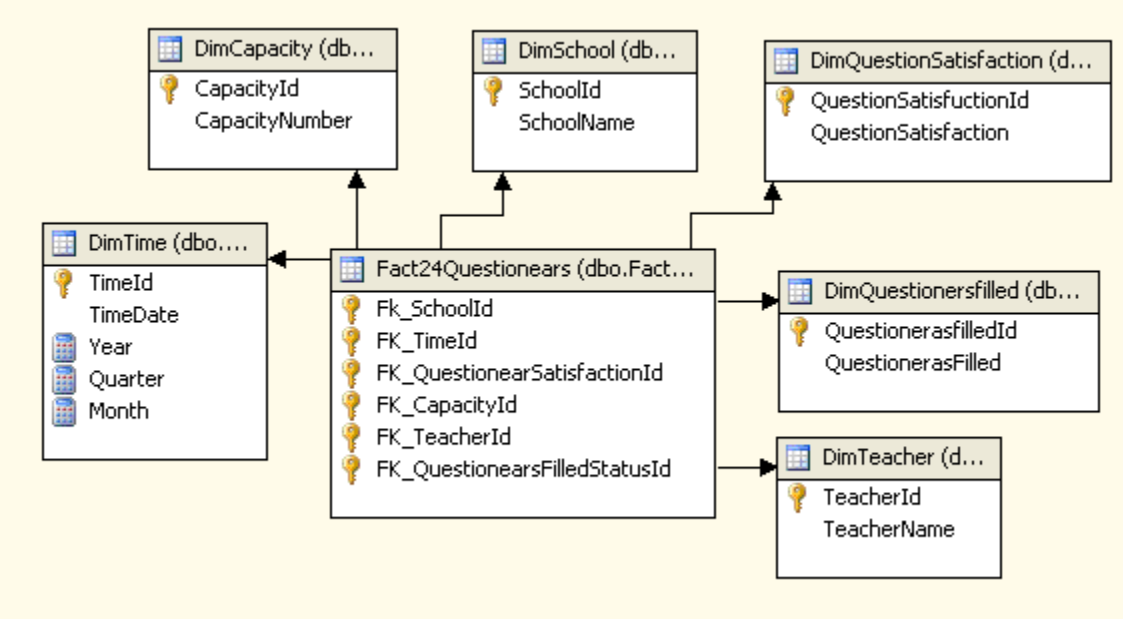

Figure 63 - Star model of space questioners