Faculty of Engineering of the University of Porto

Integrated Master in Informatics and Computation Engineering

CMMI Metrics Solution at Qimonda Portugal S.A.

MIEIC 2008 Internship Report

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Abstract

This report describes the internship project developed by André Filipe Lourenço Lessa on Qimonda Portugal S.A.

Porto Development Center is the unit responsible for developing software solutions to the world-wide semiconductor manufacturing facilities of Qimonda. Solutions developed in Portugal are installed and running productively in non-stop production facilities, covering a wide range of manufacturing areas in several different technological areas.

The Porto Development Center adopted a Quality Management System aiming the fulfillment of the Software Engineering Institute CMMI model goals. Every year, more than 40 projects involving over 100 software engineers, follow the quality management processes defined.

CMMI is on the leading edge of software methodologies, with an extremely fast adoption in all world-wide software industries. One key process area of CMMI is the Measurement Analysis. The main goal is to, based on the business objectives, define indicators and metrics to assess their fulfillment. In CMMI terms, it is also one enabler of higher maturity levels, particularly the ones requiring quantitative management.

The goal of this internship was then to define, design, build and deploy a software solution, integrated in the platform that manages the CMMI processes, that stores process metrics and indicators.

Acknowledgements

I would like to thank Raul Vidal for his determination in arranging the best possible internship experience for the MIEIC students, and also Francisco Lobo for providing me the opportunity of performing my internship at Qimonda.

My two supervisors were very important during the project. Teresa Carreiro with the guidance provided and João Pascoal Faria with the expertise and support given. The success of this project has to be shared with Hugo Magalhães because of his precious orientation and help.

I would also like to thank everyone at Qimonda who in any way contributed to this project's success, either by providing training, clearing some doubts or even giving feedback and suggestions which allowed me to better adapt it to Qimonda's and user's needs. A special part of it goes to the Quality Management team, who support me throughout the project and provided a great enviromenment to work in.

At last, I would like to thank to my family and friends for the support in my choices and the strenght given to pursuit my objectives.

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1 Introduction

The CMMI Metrics Solution project was developed at Qimonda as part of a curricular internship of the Integrated Master in Informatics and Computation Engineering Programme at the Faculty of Engineering of the University of Porto.

This chapter provides an introduction to this project's context, namely on the organization where it took place – Qimonda Portugal S.A. – and how it will contribute to Qimonda's own goals. It also provides a brief overview on this document's structure.

1.1 Qimonda Presentation

The project described in this document was developed at Qimonda Portugal S.A., which is part of the multinational Qimonda AG, one of the largest memory companies in the world (the world leading DRAM and 300mm wafer manufacturing company), with about 13,500 employees worldwide. **Figure 1-1** shows Qimonda's sites worldwide:

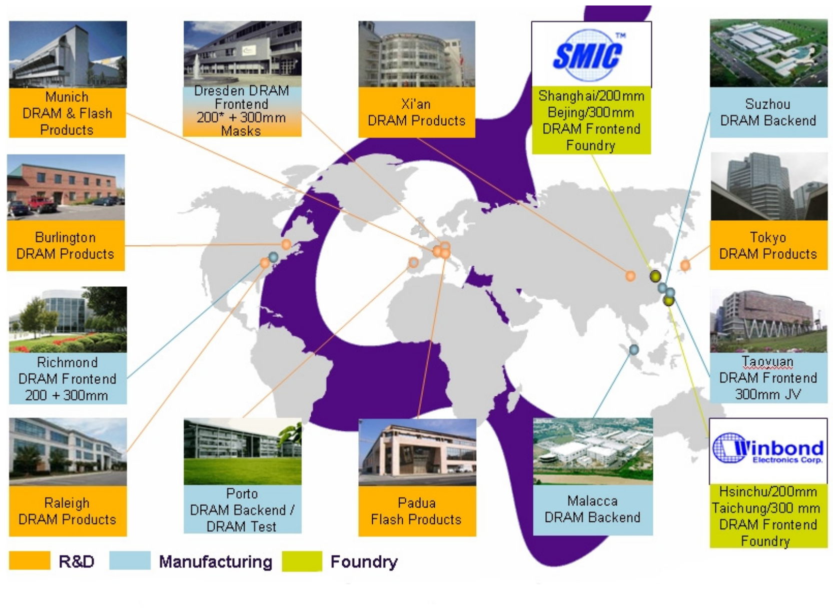


Figure 1-1 Qimonda worldwide

Qimonda started as a carve out of Infineon Technologies AG on May 2006, its roots go back to Siemens AG.

Siemens, a company with over 150 years, first carved out its semiconductor business in April 1999, thus creating Infineon, which has been an independent and successful memory company ever since.

Infineon Technologies focuses on the three main areas: energy efficiency, communications and security. Therefore it offers semiconductors and system solutions for automotive, industrial electronics, chip card and security as well as applications in communications. Furthermore, the company offered memory products trough its subsidiary Qimonda.

On May 1st, 2006 Qimonda carve out from Infineon and went public at the New York Stock Exchange on August 9th, 2006.

Based in Munich, Germany, Qimonda R&D and production facilities include sites all around the world, from Asia to Europe and North America. Porto's facilities (**Figure 1-2**) were founded in 1997 (while still part of Siemens Semiconductors AG) and now include a work force of over 1.600 employees.

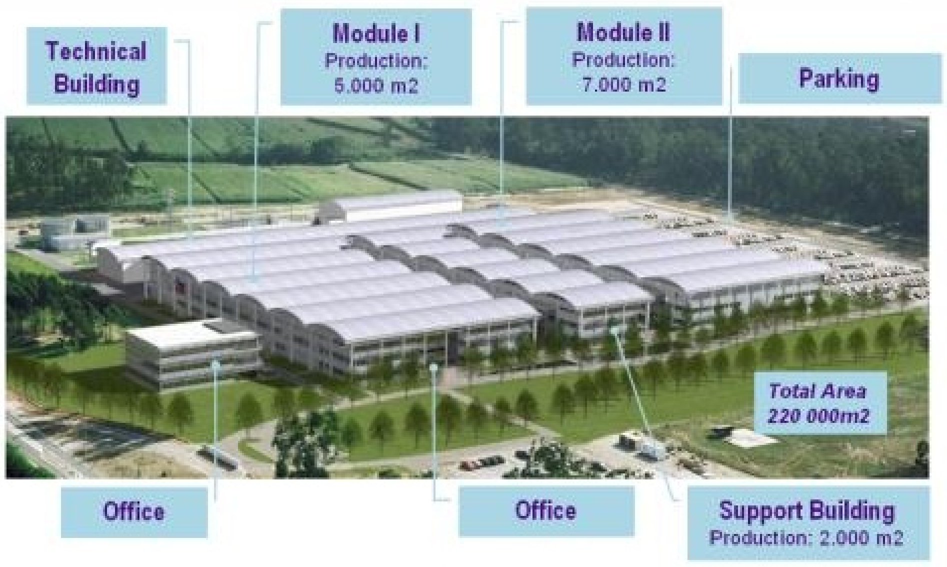

Technical Building
Module I Production: 5.000 m2
Module II Production: 7.000 m2
Parking
Total Area 220 000m2
Office
Office
Support Building Production: 2.000 m2

Figure 1-2 Qimonda production facilities in Porto

1.2 Porto DC at Qimonda

The Porto Development Center (DC) began its operations, on October 1st of 2005, as an autonomous organizational unit within IT Porto belonging to the Qimonda IT Manufacturing line.

IT Manufacturing has a complete software development supply chain, with identified organizational units owning each block of the chain.

The DCs are responsible for the technical design, implementation, testing and integration of solutions including the delivery to their direct customers, the Domain Functions (DF).

Internally, the Porto DC's organization follows a technical orientation and is therefore divided into the following technology oriented sections:

- Business Process Automation (BPA): focuses on developing automation of business processes between different manufacturing functional areas and also to provide software solutions for line automation, including equipments and materials.
- Cross-Platform Technologies (CPT): focuses developing applications to run on non-Windows platforms. Within this section development is also done in the middleware area, with focus on web and TIBCO based solutions.
- Database Technologies (DBT): focuses its work mainly in Oracle databases and tools. The activities include database design, modeling, development of database procedures, data marts and ETL (Extraction Transformation and Loading) procedures.

- Quality Management (QM): focuses on Quality Management processes and procedures, interacting directly with all other sections, namely ensuring adherence to defined processes, establishing Quality Assurance plans and acting as final gate before releases.
- Windows Technologies (WT): focuses on the development of Windows OS based Systems, Frameworks and GUIs.

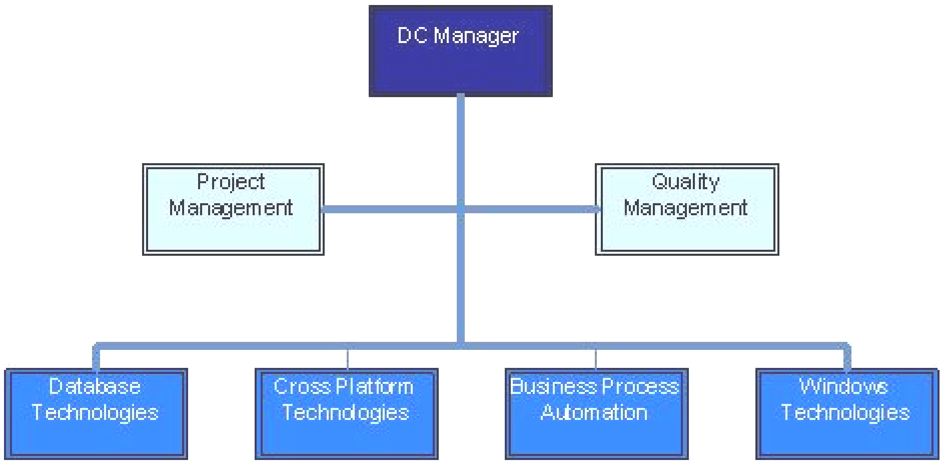


Figure 1-3 Porto DC organization chart

The CMMI Metrics Solution project was developed in the context of the Quality Management (QM) section.

1.3 CMMI Overview

Capability Maturity Model Integration [Chr07] (CMMI) is a process improvement approach, defined by the Software Engineering Institute (SEI), which provides organizations with the essential elements of effective processes. It can be used to guide process improvement across a project, a division, or an entire organization. CMMI helps integrate traditionally separate organizational functions, set process improvement goals and priorities, provide guidance for quality processes, and provide a point of reference for appraising current processes.

The CMMI Product Suite is at the forefront of process improvement because it provides the latest best practices for product and service development and maintenance. The CMMI models improve the best practices of previous models in many important ways. CMMI best practices enable organizations to do the following:

- more explicitly link management and engineering activities to their business objectives;
- expand the scope of and visibility into the product lifecycle and engineering activities to ensure that the product or service meets customer expectations;
- incorporate lessons learned from additional areas of best practice (e.g., measurement, risk management, and supplier management);
- implement more robust high-maturity practices;

- address additional organizational functions critical to their products and services;
- more fully comply with relevant ISO standards.

1.3.1 CMMI Measurement and Analysis Process Area

The purpose of the Measurement and Analysis (MA) process area is to develop and sustain a measurement capability that is used to support management information needs. This process involves the following:

- specifying the objectives of measurement and analysis such that they are aligned with identified information needs and objectives;
- specifying the measures, data collection and storage mechanisms, analysis techniques, and reporting and feedback mechanisms;
- implementing the collection, storage, analysis, and reporting of the data;
- providing objective results that can be used in making informed decisions, and taking appropriate corrective actions.

The Measurement and Analysis process area contains the following Specific Goals (SG) and Practices (SP):

- SG 1 – Align Measurement and Analysis Activities
  - SP 1.1 – Establish Measurement Objectives
  - SP 1.2 – Specify Measures
  - SP 1.3 – Specify Data Collection and Storage Procedures
  - SP 1.4 – Specify Analysis Procedures
- SG 2 – Provide Measurement Results
  - SP 2.1 – Collect Measurement Data
  - SP 2.2 – Analyze Measurement Data
  - SP 2.3 – Store Data and Results
  - SP 2.4 – Communicate Results

1.4 CMMI Metrics Solution at Qimonda

The goal of this internship was to define, design, build and deploy a software solution, integrated in the platform that manages the CMMI processes, that stores process metrics and indicators. The solution should be wide and dynamic enough to import and collect data from various sources (like Excel, Project Server, external databases, etc) and present it to the user in various formats (data tables, charts, indicators, etc).

The goal of the solution was to build a tool to help management trough the software and project development lifecycle. This way we can achieve a continuous improvement though regular reviews of the performance of our solutions and services against measurable targets.

1.5 Document Structure

This document is organized in 8 chapters.

Introduction (Chapter 1) gives the reader some background on Qimonda’s history, organization and business activities, and how this project aligns itself with these activities. A brief overview on the context in which this project took place and its main goals is provided in Objectives (Chapter 2).

Technological Review (Chapter 3) provides a review on the most relevant technologies used during the course of this project, covering both existing technologies used at Qimonda and technologies specific to this project’s domain (chosen after the appropriate research took place).

In Specification (Chapter 4) is described the solution designed to achieve the goals proposed for this project, covering all aspects from its requirements to the solution’s design. Some detail on its implementation (providing detail on lower level algorithms and data structures used where appropriate) is provided in Implementation (Chapter 5).

Results Evaluation (Chapter 6) provides some evaluation of the results achieved.

Finally, Evolution (Chapter 7) discusses some possible future enhancements on the solution developed and Conclusions (Chapter 8) has some final remarks about this internship and this project’s measurable success.

2 Objectives

2.1 Context

Porto DC has a strong commitment regarding software quality. The Software Quality Improvement (SQI) project was born to provide higher quality and user satisfaction levels on all of the DC's projects.

The Quality Management System (QMS) is part of this project and aims to provide products and services that meet or exceed the customer functional and non-functional requirements:

- On the agreed timeframes
- Within the agreed budget
- With high quality
- Using the agreed tools and software development processes

while achieving a continuous improvement through regular reviews of the performance of its solutions and services against measurable targets.

Figure 2-1 presents the QMS processes organization and their sub-processes.

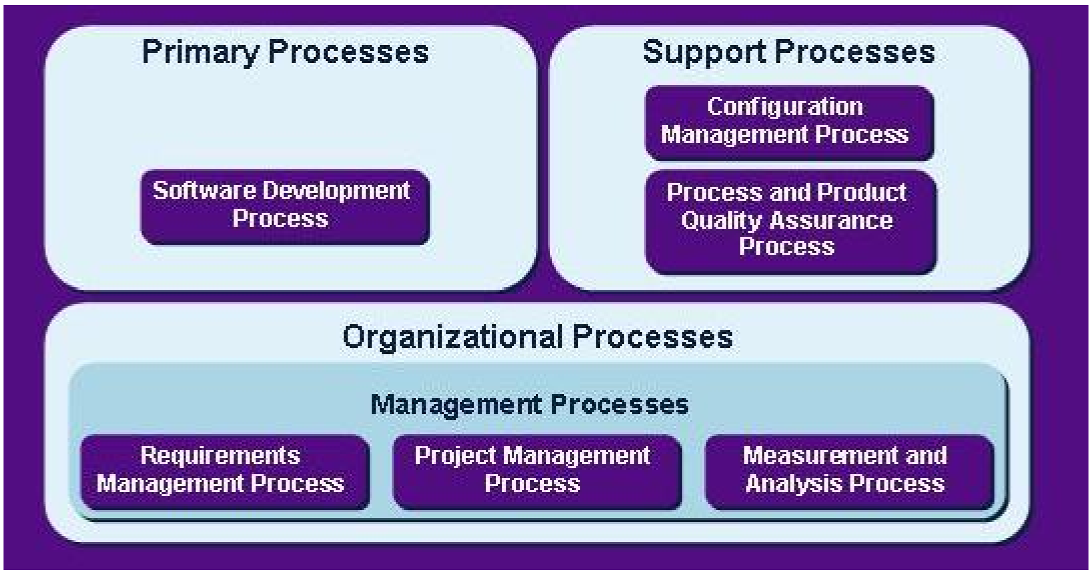

Primary Processes
Software Development Process
Support Processes
Configuration Management Process
Process and Product Quality Assurance Process
Organizational Processes
Management Processes
Requirements Management Process
Project Management Process
Measurement and Analysis Process

Figure 2-1 QMS Processes Organization

CMMI Metrics Solution project is included in Measurement and Analysis Process and it's an important tool to support the management and achievement of the QMS objectives.

The Measurement and Analysis process in Porto DC is used to measure project success against defined targets, like project progress, product size or quality, or process performance.

A metric is a quantitative value obtained from a measure which supports the calculation of indicators. An indicator is a calculated value, derived from one, two or more metrics that measures the extent of achievement of a given objective and allows the evaluation of trends.

A target is the value against which the actual value of an indicator will be compared. If the actual reaches or exceeds the target, this is considered achieved.

Its purpose is to develop and sustain a measurement capability that is used to support management information needs.

This process involves the following areas:

- The specification of the measures and analysis guaranteeing that these are aligned with the overall DC strategic objectives;
- The identification of the metrics, indicators, data collection, storage and calculation mechanisms;
- Identification of analysis and reporting mechanisms;
- Execution of defined data collection, indicators production, analysis and definition of improvement actions.

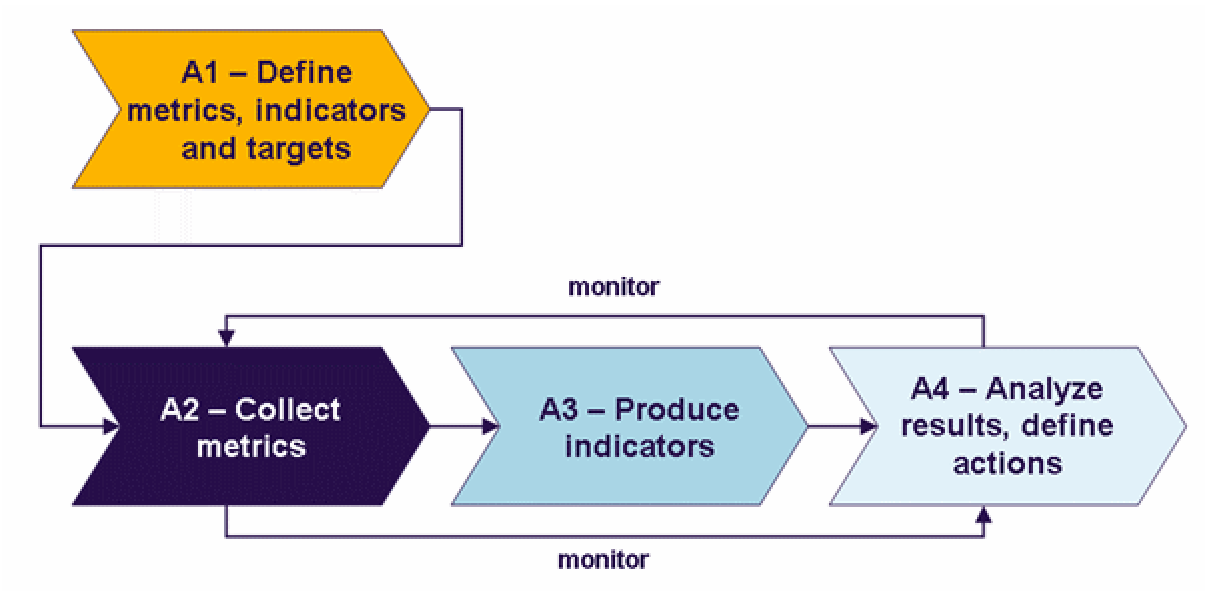

A1 – Define metrics, indicators and targets
monitor
A2 – Collect metrics
A3 – Produce indicators
A4 – Analyze results, define actions
monitor

Figure 2-2 Measurement and Analysis Process

2.2 Problem

As showed above (**Figure 2-2**), the Measurement and Analysis process has a defined number of activities. Although this process is well defined, data collection is difficult (done manually) and data visualization isn't systematic.

In the following paragraphs each activity will be presented and also its problems and improvements needed.

A1 – Define metrics, indicators and targets

This activity occurs on a yearly basis. Based on the inputs of DC targets, DC management needs and the past results of the process, a set of metrics and indicators are created, as well as target values for these indicators. Moreover, a drill-down to the section and individual level of these targets is also part of this process.

Problem

After defining new metrics and indicators new Excel files (where metrics data will be stored) should be created. These files should be filled several times for each metric defined, consuming time and reducing productivity.

A2 – Collect metrics

The metrics defined in A1 shall be collected on a monthly basis and stored, making them available for the A3 activity.

Problem

The process of collecting data for the metrics should be as automated as possible. Today, we have to go to several data sources and aggregate the results. It's a hard, manual and complex process. Considering that this process collects the results of hundreds of projects, we get to the main problem that CMMI Metrics Solution will solve.

A3 – Produce indicators

The indicators defined in A1 are produced, from the metrics collected in A2 and the results are stored and communicated, allowing the analysis and the definition of actions to be done within the scope of the A4 activity.

Problem

This task doesn't have important issues but can be improved. Microsoft Excel is a powerful application to implement formulas and data sheets but it's not the best way to present interactive results. Sometimes is complex to make the desired chart and present results in a user-friendly view. Other problem already referred is that data visualization isn't performed in a systematic way.

A4 – Analyze results, define actions

This activity occurs every half-year (semester). The purpose of this activity is to analyze the results and trends of indicators against the target values and derive improvement actions for the indicators that did not achieve the target value or that are significantly decreasing its performance.

Problem

For all the reasons and problems described in the previous activities, the analysis is difficult and the Measurement and Analysis is a long and complex process.

2.3 Main Goals

The following paragraphs will describe the improvements and solutions that this project implements for each of the problems described above.

A1 – Define metrics, indicators and targets

It will be possible to customize and create metrics and indicators. This application will be completely dynamic, allowing users to insert and edit metrics, change formula and chart to display the results, select sources to fetch data, manage scopes and default dates, among other functionalities presented in more detail in Specification (Chapter 4) and Implementation (Chapter 5).

A2 – Collect metrics

This project will improve this procedure, allowing the collection of the data to be done automatically (it's possible to collect data manually also), centralizing the data and calculating the metric results.

A3 – Produce indicators

CMMI Metrics Solution will present dynamic and fully customizable data tables and charts, helping reports and analysis of the metric results in a systematic way.

A4 – Analyze results, define actions

For all the improvements presented in the previous activities, analysis will become a lot more easy, interactive, safe and quick.

2.4 Planning

Due to its dimension, the project was divided in the following phases:

- Training: Qimonda provided training in various areas like structure and organization of Qimonda AG, *frontend* and *backend* processes, among others. CMMI and Development Center Quality Management System self-training was also done in this activity.
- Requirements: After analyzing the problem and objectives it was developed a Requirements Specification Document that was discussed several times and approved.
- Data Layer: In this phase was developed the database structure and its access classes and methods.
- User Interface: This phase contains the interface and data forms design. Was used AJAX to increase usability and interactivity.
- Business Logic Layer: This layer is the complete *core* of this application and contains all data and web page classes and its methods. It connects the Data Access Layer with the User Interface, providing the correct data fetching, transformation and visualization.
- Math Parser Tool: In this phase was investigated and implemented a Math Parser Tool to calculate metric results.
- Charting Tool: This activity contains the investigation and integration of a Charting Tool to present the metric results.
- Windows Service: This timer based module was created to automatically fetch data from external sources.
- Tests and Improvements: The application was fully tested, improving user interface, database access, and fixing some detected bugs.

- Documentation: The internship report, resumes, poster, website and code documentation were done in this phase.

	Duration (work days)	Start date	End Date
Training	5	10/9/2007	14/9/2007
Requirements	11	17/9/2007	1/10/2007
Data Layer	22	2/10/2007	31/10/2007
User Interface	27	2/10/2007	7/11/2007
Business Logic Layer	75	3/10/2007	15/1/2008
Math Parser Tool	3	22/11/2007	26/11/2007
Windows Service	3	30/11/2007	4/12/2007
Charting Tool	5	14/12/2007	20/12/2007
Tests and Improvements	29	24/12/2007	31/01/2008
Documentation	28	23/1/2008	29/2/2008

Table 2-1 Internship phases and its duration

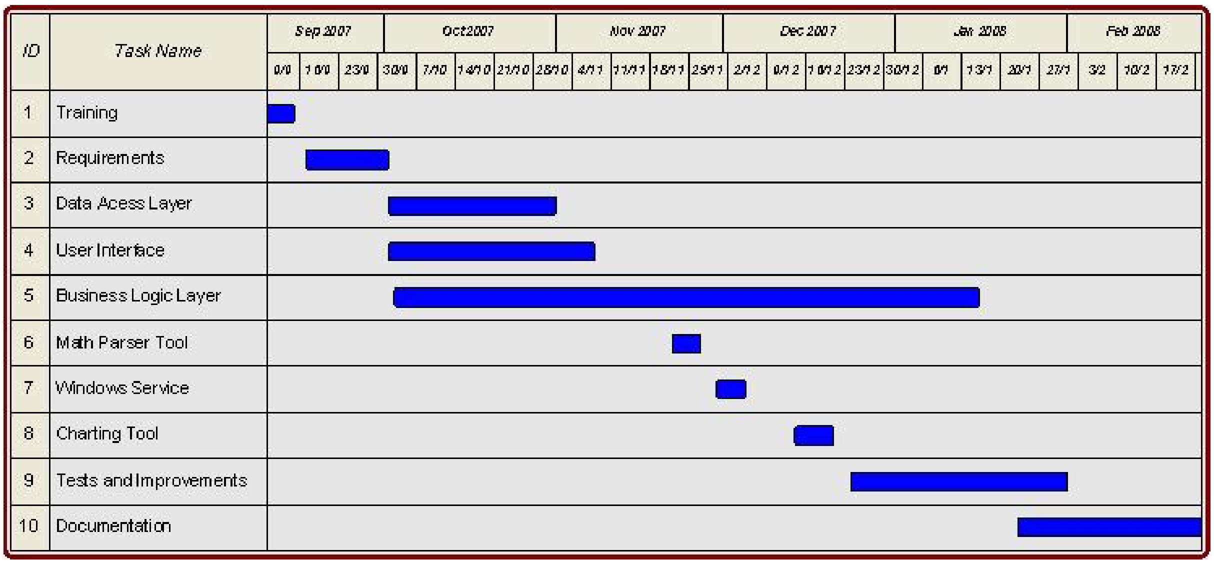


Figure 2-3 Internship plan *Gantt* diagram

3 Technological Review

This chapter contains information about all technological issues related to the CMMI Metrics Solution project. It is explained the most relevant technologies behind the project and the analysis done to some existing tools used in the development.

This application is completely dynamic, customizable and fully integrated to Qimonda Quality Management System metrics and data sources. For these reasons it wasn't compared with any available products in the market.

3.1 Existing Systems

It's important to mention some existent technologies and tools that are connected with this project.

3.1.1 TIBCO Rendezvous

TIBCO Rendezvous [Sof08] is a software product that provides a message bus for *enterprise application integration* (EAI). The basic message passing is conceptually simple:

- A message has a single subject composed of elements separated by periods. A message is sent to a single *daemon* (though it may end up being broadcast onto *daemons*).
- A listener announce its subjects of interest to a *daemon* (with a basic wildcard facility) and messages with matching subjects are delivered to it if the two *daemons* are connected to each other (or indeed the same *daemon*).

Messaging can be publish/subscribe or request/reply, point-to-point or multicast, synchronous or asynchronous, and delivered via the local-area network (LAN), wide-area network (WAN), or the internet. TIBCO Rendezvous messages are self-describing and platform-independent, with a user-extensible type system that provides support for data formats such as XML.

TIBCO provides messaging APIs in C, C++, Java, VB, Perl and .NET.

3.1.2 YODA

YODA (Your Own Data Adapter) [Gom07] is a technology and platform independent infrastructure developed at Qimonda, based on TIBCO Rendezvous, which provides a framework for developers to create their own distributed and load balanced applications, allowing the development to focus on business logic by providing an abstract communication layer through the use of its main library – IFXLib.

IFXLib provides encryption, load balancing, fault tolerance, logging and other features, and makes possible for a workflow to call services available in YODA by creating an IfxDoc (YODA's main data structure) and setting its fields accordingly, namely the *IFX_SERVICE* which holds the name of the service to be called.

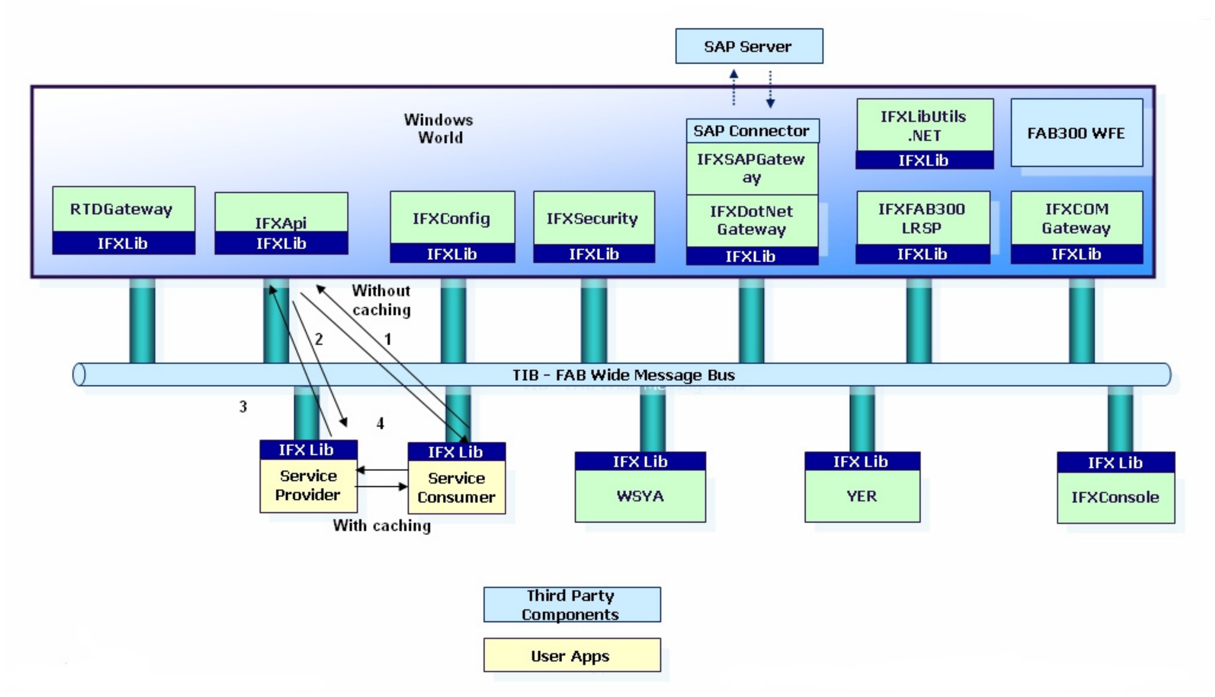


Figure 3-1 YODA Architecture

3.1.3 *Microsoft Project*

Microsoft Project [Cor08] is a project management software program developed and sold by Microsoft which is designed to assist project managers in developing plans, assigning resources to tasks, tracking progress, managing budgets and analyzing workloads.

Additionally, Project can recognize different classes of users. These different classes of users can have differing access levels to projects, views, and other data. Custom objects such as calendars, views, tables, filters and fields are stored in an enterprise global template which is shared by all users.

All Qimonda's project data and user tasks are stored in Project Server.

3.1.4 *Event Viewer*

Event Viewer [Cor05] is a component of Microsoft's Windows NT line of operating systems that lets administrators and users view the event logs on a local or remote machine.

Event logs have been a feature of Windows NT since its original release in 1993. Applications and operating system components can make use of this centralized log service to report events that have taken place, such as a failure to start a component or complete an action.

CMMI Metrics Solution has a component that consists in a Windows Service and Event Logs are the better way of debugging this service.

3.2 Math Parser Tool

An important component of this application is a mathematic formula parser and calculator. This sort of tool is available in all sorts of formats, with several different implementations but no one was wide enough to fit the problem. The solution was to find a simple extensible calculator implementation that could be integrated in the code and changed by our needs.

As such, it became necessary to analyze the different alternatives to find the one that best suited the requirements in mind.

3.2.1 Tools Evaluated

The tools presented here were chosen based on criteria such as their simplicity, extensibility, code integration and free open-source solutions.

Lundin Mathparser Assembly

This math parser developed by Patrik Lundin [Lun04] it's a simple .NET assembly written in C# that evaluates a mathematical expression.

The parser supports the most common mathematical operators and functions such as:

- Operators: +, -, *, /, ^, %
- Functions: sqrt, sin, cos, tan, atan, acos, asin, acotan, exp, ln, 10log, fac, sinh, cosh, tanh, abs, ceil, floor, sfac, round, fpart
- Logical: !, ==, !=, ||, &&, >, < , >=, <=

It provides a class library that can simply be included in the project and, it's also flexible enough to allow the development of new functions and operators.

CodeDom Calculator

CodeDom [Gol05] was developed by Mike Gold and gives the ability to dynamically build C# code into a string, compile it, and run it all inside the program. The calculator evaluates expressions (and even lines of C# code) inside a Windows Form. It primarily uses the *System.Math* class to do the calculations.

CodeDom opens up a world of possible dynamic coding that can be conjured on the fly.

This is a powerful tool but the formula has to be written in a specific syntax (not always user-friendly) and that brings an important issue.

G^{2}DS Calculator

G^{2}DS [Fol07] is an application developed in the Windows Technologies section at Qimonda with the objective of providing a generic disposition system configurable and extensible in order to be used for different disposition scenarios (e.g. automated/user triggered).

It has a Calculator module integrated but was too complex and doesn't have all the operations needed. This complexity was an important issue blocking the learning process. To insert new functions I had to change the core of the tool and was like developing a completely different tool from the start.

Excel Formula Parsing

This tool [Bac07] was developed in C# and parses Excel formulas into tokens and "constructs" a token tree. It supports all expressions and operations available in Excel but it doesn't implement the calculation of those formulas, what makes me abandon this option.

3.2.2 Conclusions

After studying the features provided by each of the previous tools and their examples, it was concluded that the best choice for this project would be Lundin Mathparser. Its flexibility, simplicity and ease integration and management make it an overall best choice.

G^{2}DS Calculator also seemed like a good choice, however the complexity issue and less operations supported determined the final choice.

Table 3-1 summarizes the results found (main features) for all tools analyzed.

	Simplicity	Operations and functions	Extensibility	Level of integration	Overall
Lundin Mathparser	High	Many	High	High	Very Good
CodeDom Calculator	Medium	Many	Low	Medium	Medium
G^{2}DS Calculator	Low	Basic	Medium	High	Good
Excel Formula Parser	High	Many	Low	Low	Incomplete

Table 3-1 Math parsing tools comparison

3.3 Charting Tool

Another important component of this application is a charting tool. The application business logic could be perfect but if it doesn't present the results it will be useless. The solution was to find a charting tool fully customizable, which presents different kinds of charts to help understanding the results returned by the Math Parser Tool (Section 3.2).

As such, it became necessary to analyze the different alternatives to find the one that best suited the requirements in mind.

3.3.1 Tools Evaluated

The tools presented here were chosen based on criteria such as their extensibility, customization, code integration and free open-source solutions.

ZedGraph

ZedGraph [Wik07] is a set of classes, written in C#, for creating 2D line and bar graphs of arbitrary datasets. The classes provide a high degree of flexibility – almost every aspect of the graph can be user-modified. At the same time, usage of the classes is kept simple by providing default values for all of the graph attributes. The classes include code for choosing appropriate scale ranges and step sizes based on the range of data values being plotted.

ZedGraph also includes a UserControl interface, allowing drag and drop editing within the Visual Studio forms editor, plus access from other languages such as C# and VB. ZedGraph is licensed under the LGPL.

Open Flash Chart

Open Flash Chart [Gla07] is an open-source project. It offers 35 chart variations; among them a number of bar charts, pie charts and line charts. Provided tutorials explain how the script can be extended with further functionality such as mouse-over effects and how the database can be queried for some values and the results then displayed in a graph. Open Flash Chart uses Flash and PHP. Data can also be stored in plain text. Actually there is support for .NET but it still has some performance and support issues.

3.3.2 Conclusions

Most of the tools found were developed under Windows Forms and don't support Web Forms and Controls. I presented the two best tools that could fit the problem.

Open Flash Chart makes more beautiful and interactive charts but the support for .NET is starting development so it still has some problems.

ZedGraph makes only 2D charts but is completely stable and efficient under the development environment of this project and it makes it and overall best choice. Additionally, ZedGraph has tutorials and examples, allowing a fluid and quick integration and learning process.

Table 3-2 summarizes the results found (main features) for all tools analyzed.

	Customization	**Number of charts**	**Extensibility**	**Integration and support**	**Overall**
ZedGraph	High	Medium	High	High	Good +
Open Flash Chart	High	High	High	Low	Good -

Table 3-2 Charting tools comparison

3.4 Other Technologies

Besides the technologies previously mentioned, several others were used. I will present a short description of the most relevant

3.4.1 .NET Framework 2.0

The *Microsoft .NET Framework* [Cor06] is a software component that is a part of the Microsoft Windows operating systems. It provides a large body of pre-coded solutions to common program requirements, and manages the execution of programs written specifically for the framework. The *.NET Framework* is a key Microsoft offering, and is intended to be used by most new applications created for the Windows and Web platforms.

This project was implemented in C# for several reasons, inherent both to the language itself (rapid application development, for instance) and to this project's context (better integration with existing components and also because Qimonda's *web servers* work on Windows Server 2003 and Internet Information Services (IIS) platforms).

3.4.2 ASP.NET AJAX

AJAX (Asynchronous JavaScript and XML), or Ajax [Cor07a], is a group of inter-related Web development techniques used for creating interactive Web applications. A primary characteristic is the increased responsiveness and interactiveness of Web pages achieved by exchanging small amounts of data with the server "behind the scenes" so that the entire Web page does not have to be reloaded each time the user performs an action. This is intended to increase the Web page's interactivity, speed, functionality, and usability.

AJAX is asynchronous in that extra data is requested from the server and loaded in the background without interfering with the display and behavior of the existing page. JavaScript is the scripting language in which AJAX function calls are usually made.

AJAX is a cross-platform technique usable on many different operating systems, computer architectures, and Web browsers as it is based on open standards such as JavaScript and the DOM. There are free and open source implementations of suitable frameworks and libraries.

This asynchronous data loading solution was the best approach because of the large amounts of data to be loaded by the application.

3.4.3 Excel Interop Assembly

COM *interop assemblies* allow *unmanaged* (COM) code to be called from *managed* (.NET) code by using the Microsoft .NET Framework and the common language runtime. COM interop assemblies allow managed applications to bind to unmanaged types at compile time and provide information to the common language runtime about how the unmanaged types should be marshaled at run time.

While any number of COM interop assemblies may exist, only one COM interop assembly is designated as the *primary interop assembly* (PIA). The PIA contains the official description of the unmanaged types as defined by the publisher of those unmanaged types. The PIA usually also contains certain customizations that make the types easier to use from managed code and is always digitally signed by the publisher of the original unmanaged type.

Microsoft has created several PIAs that contain the official description of commonly-used Microsoft Office XP type libraries for products such as Microsoft Access 2002, Microsoft Excel 2002, Microsoft FrontPage 2002, and so on.

In this project was used the *.NET Framework* namespace *Microsoft.Office.Interop.Excel* [Cor07b] to import and export data from Excel files.

3.4.4 Regex

In computing, regular expressions provide a concise and formal means for specifying text of interest, such as text that contains particular characters, words, or patterns of characters. Regular expressions are written in a formal language that can be interpreted by a regular expression processor, a program that examines text and identifies parts of the text that match the specification provided by the regular expression.

The *System.Text.RegularExpressions* namespace [Cor07c] contains classes (for example *Regex* and *Match*) that provide access to the *.NET Framework* regular expression engine. It was used with the math parser to extract the new operations implemented.

3.4.5 Selenium

Selenium [Pro07] is a test tool for web applications. Selenium tests run directly in a browser, just as real users do and run in Internet Explorer, Mozilla and Firefox on Windows, Linux, and Macintosh. No other test tool covers such a wide array of platforms.

Selenium IDE is an integrated development environment for Selenium tests. It is implemented as a Firefox extension, and allows recording, edition, and debugging tests. Selenium IDE includes the entire Selenium Core, allowing the easy and quick record and play back tests in the actual environment that they will run.

Selenium IDE is not only a recording tool, but a complete IDE. Its recording capability can be used, or the scripts can be edited by hand. With autocomplete support and the ability to move commands around quickly, Selenium IDE is the ideal environment for creating Selenium tests no matter what the style of tests preferred.

3.4.6 Firebug

Firebug [Hew07] is one of the most popular Mozilla Firefox's extensions. Firebug is both an inspector and an editor, including a lot of features such as debugging *JavaScript*, *HTML* inspecting and edition, logging, tracing, *CSS* edition, which are very useful for web development.

All objects in the *HTML*, *CSS* and *JavaScript* files can be edited with a single or double click. As they are typed, the changes are immediately applied in the browser window providing instant feedback. The DOM inspector allows full in-place editing of document structure, not just text nodes.

4 Specification

The system requirements specification process started at 17th September and lasted until the start of October. During this process took place several meetings, in order to obtain a realistic vision of objectives and needs.

Based on the information and feedback received, was created a Requirements Specification Document that was subject to several reviews and was finally approved in 1st October. This document contains a description of all features to be implemented, activity diagrams and an interface prototype. It provided a solid start of the project, allowing the correct project planning and effort estimation. This chapter gives a detailed description of the system requirements.

4.1 Requirements

This project had an exploratory nature so part of the work was finding out if the requirements defined in the Requirements Specification Document could satisfy the project main goals. During the development phase some requirements changed and new ones were introduced, but the project main goals were never modified.

These changes weren't included in the initial Requirements Specification Document because of time constraints. The Document dated 1st October [Les07] is referenced to present the evolution of this project from the initial draft to the solution delivered, which is described in detail in the following sections.

4.1.1 Functional Requirements

The application should contain four distinct areas:

- Main: the application main page where we can view the actual target values and indicators.
- Metrics: this is the visualization area where metric results and charts are presented by scope.
- Data Lists: in this area we can upload and list metric raw data, which is stored in the database and used to calculate metrics.
- Admin: where the administrator can manage the entire application properties.

The Main Area contains the application start page and has only one use case identified – view the actual target values and indicators. The other three areas will be presented in more detail in the next sub-sections and supported by use case diagrams, providing a wide vision of the solution and its activities.

Before explaining them, it's necessary to introduce the roles of different users that will use the application.

4.1.1.1 Authentication

The application should be layered into access groups. This feature was not implemented because it will receive the authentication from another application but the following profile types were identified:

- Administrator: has access to all application areas and features.
- Manager: has access to all features except the ones in Admin area.
- User: can only see metric and target results.

Figure 4-1 presents a high level use case diagram representing the actions allowed to each of the actors identified.

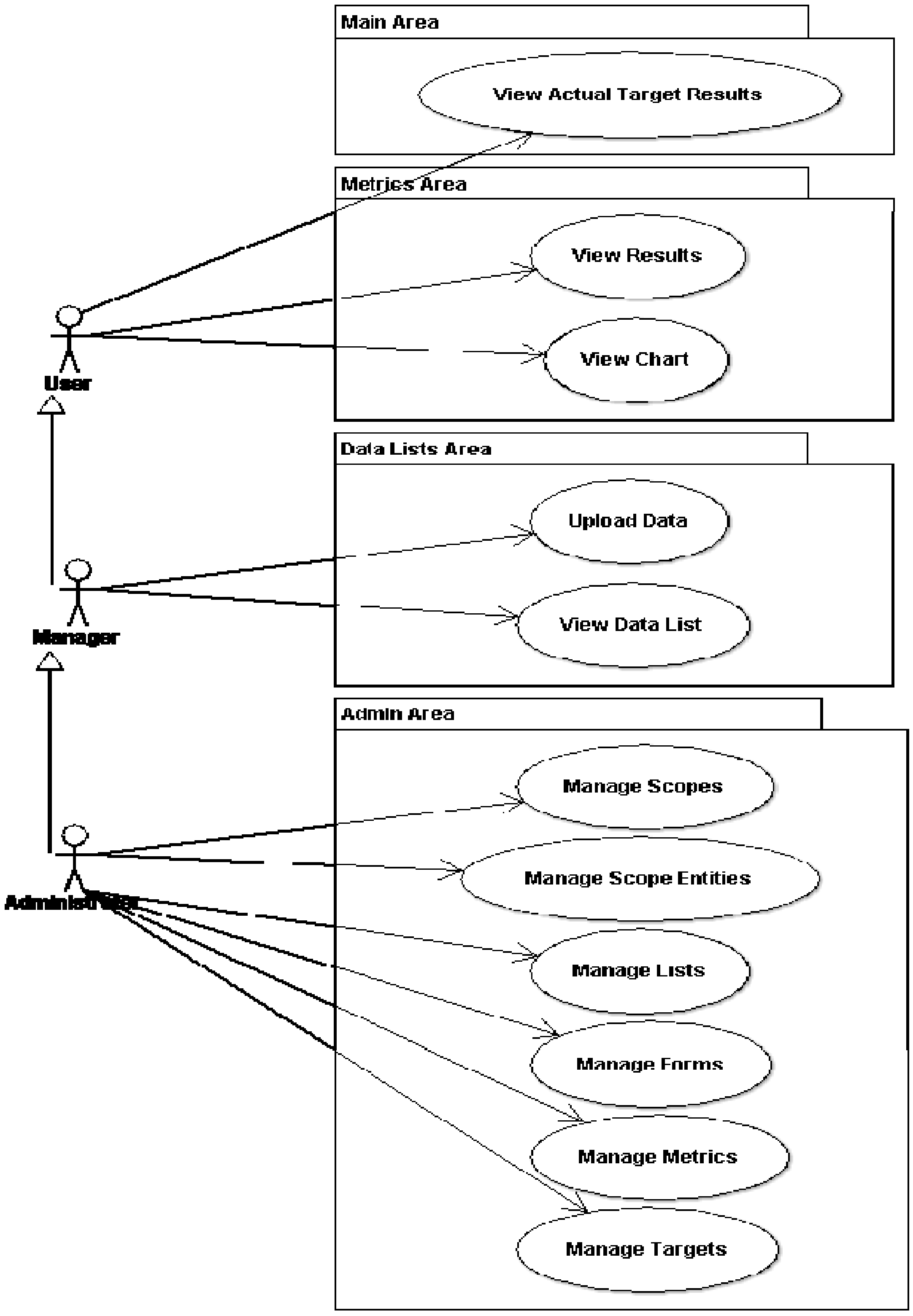


Figure 4-1 CMMI Metrics Solution use case diagram

4.1.1.2 Metrics Area

One of the project's main goals is to present metrics and indicators in an interactive and user-friendly way. The user can view a table with the current values against the defined targets, and also a chart with metric values evolution along time.

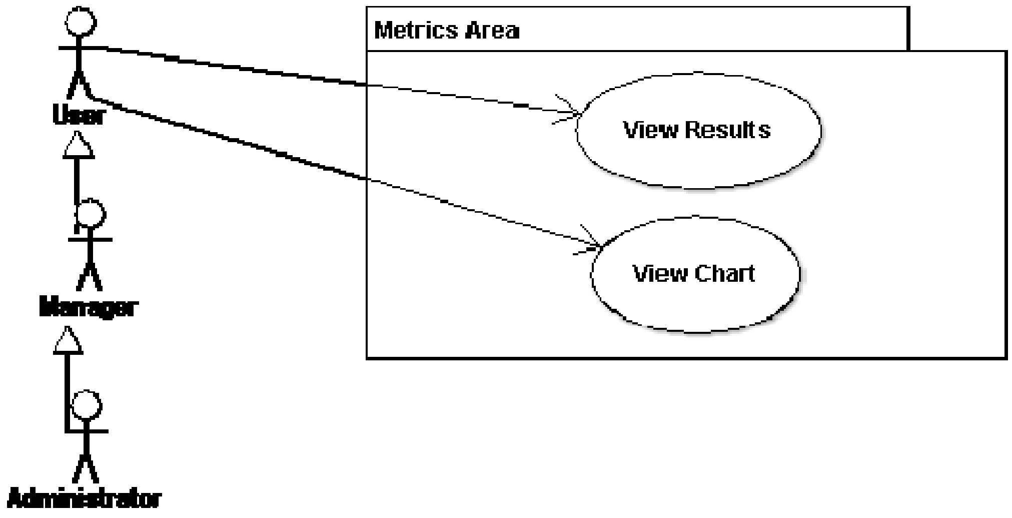


Figure 4-2 Metrics Area use case diagram

4.1.1.3 Data Lists Area

This area should permit the upload and list of raw data, which is stored in the database and used to calculate metrics.

All QMS metric data is stored in three sources: Excel files, Project Server or databases of different applications. The application should fetch data from this data sources and store it in the local database. This way we can have a central metric data repository, easily managed and accessible.

Also manual insertion of data will be possible, in order to correct a wrong value and because, in the future, Excel files may be discontinued and the user can fill directly the application forms.

Figure 4-3 presents a use case diagram of this area.

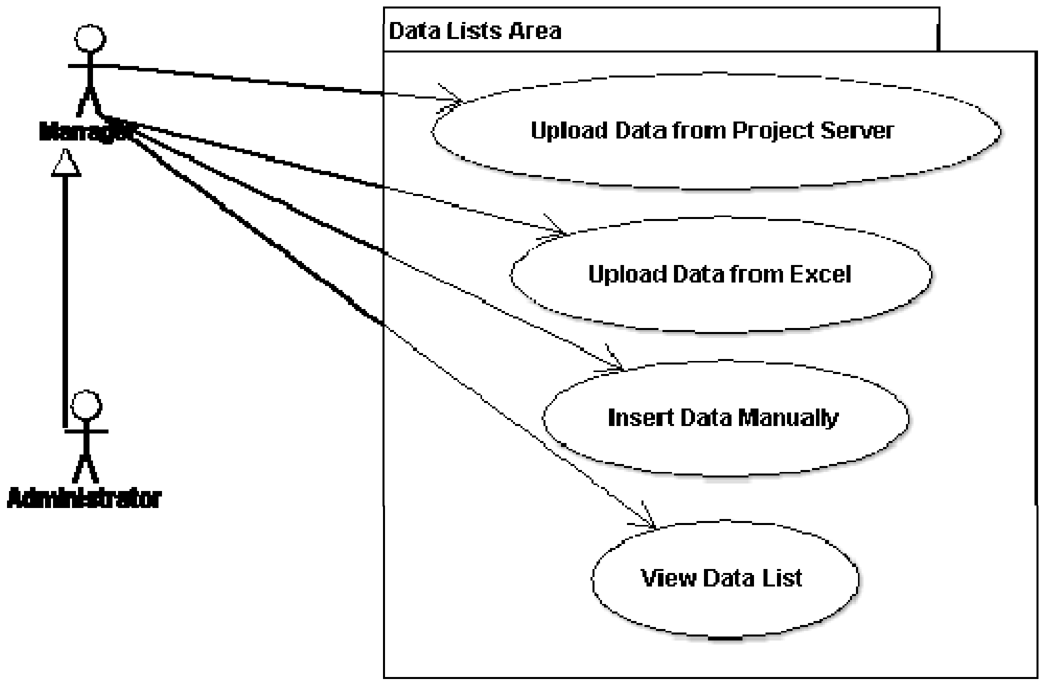


Figure 4-3 Data Lists Area use case diagram

With the objective of integrating all this different data sources we need to customize Forms and Lists, which will be presented below in the Admin Area.

4.1.1.4 Admin Area

In order to avoid recompiling the code when a change or a different configuration needs to be implemented, the application should have an administration area where its parameters and configurations could be managed. This customization assures dynamism and the response of future needs.

Manage Metrics

The application should be extensible to support and manage an initial number of metrics already defined, and also new ones in the future. For that reason, operations like add, edit, remove and list the existing metrics are essential.

Metrics have the following attributes:

- Name: name of the metric.
- Description: a short text explaining the meaning of the metric.
- Acronym: short name or acronym of the metric.
- Scope: represents a group of entities to which the metric is defined and is detailed in the next topic.
- Formula: it is introduced by the administrator and it should be intuitive and user-friendly. This means that formulas defined in C#, SQL or Excel have a particular syntax and are too complex and difficult to understand for a non-developer. It would be much better if we could write formulas in common and universal math and then the application would interpret and convert it to the desired format.

- Chart: different kinds of charts can be chosen when creating or editing the metric.

Figure 4-4 shows the actions in metric management.

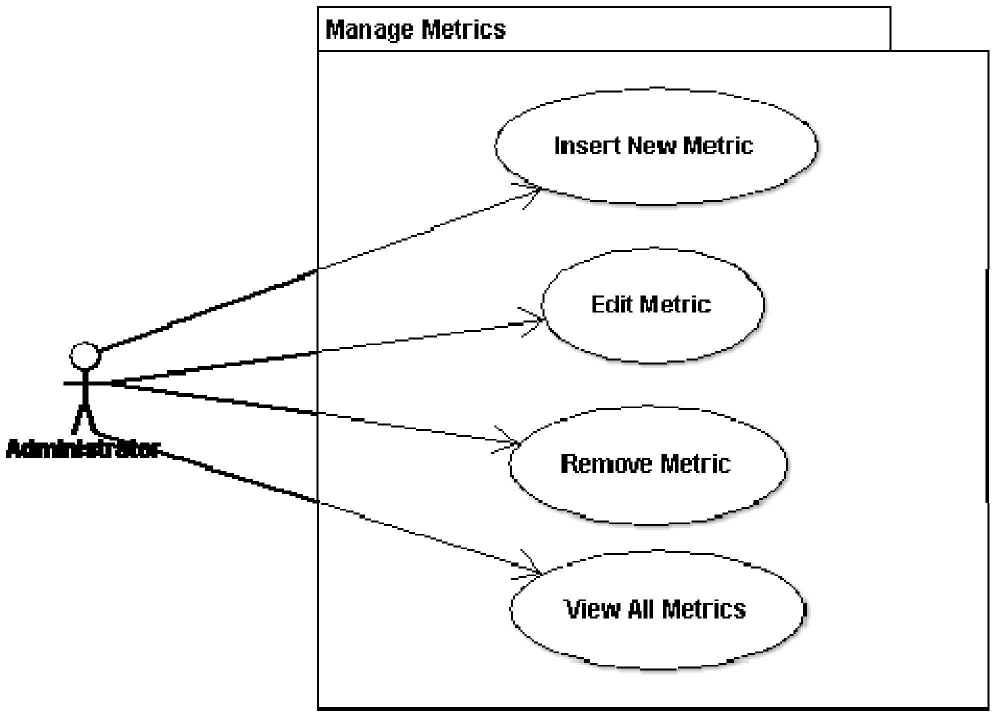


Figure 4-4 Manage Metrics use case diagram

Manage Scopes

The application should allow managing (add, edit, remove and list) scopes for organizing metrics. A scope is a group of entities as shown in **Figure 4-5**. It contains attributes like name, description, and a parent. A parent is another scope that contains this one in its definition. For example *Projects* contain *Releases*, *Sections* contain *Projects* and a *DC* contains *Sections*.

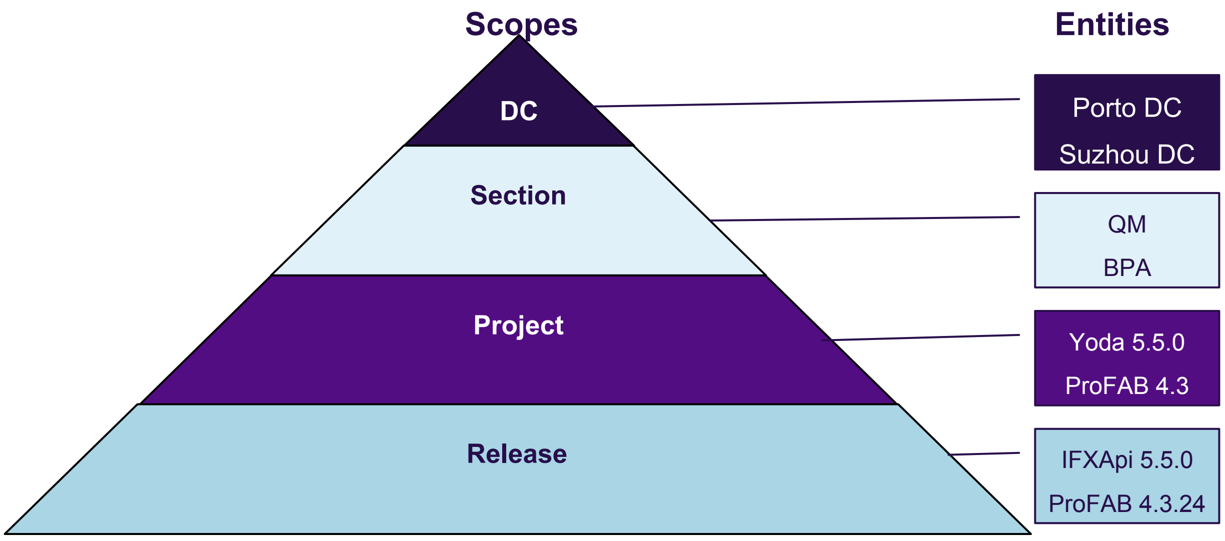


Figure 4-5 Scopes and Entities Organization

This approach is necessary because we can add or remove scopes without changing any aspect of the implementation. For example, if this application is implemented in Suzhou DC (located in China), its organization doesn't contain *Sections* and we can simply remove this scope by changing the *Project* parent directly to *DC*. If we need another scope *Sub-Project* is also possible changing the *Release* parent to this one, and its parent will be *Project*.

Figure 4-6 represents the use case diagram over the scope management.

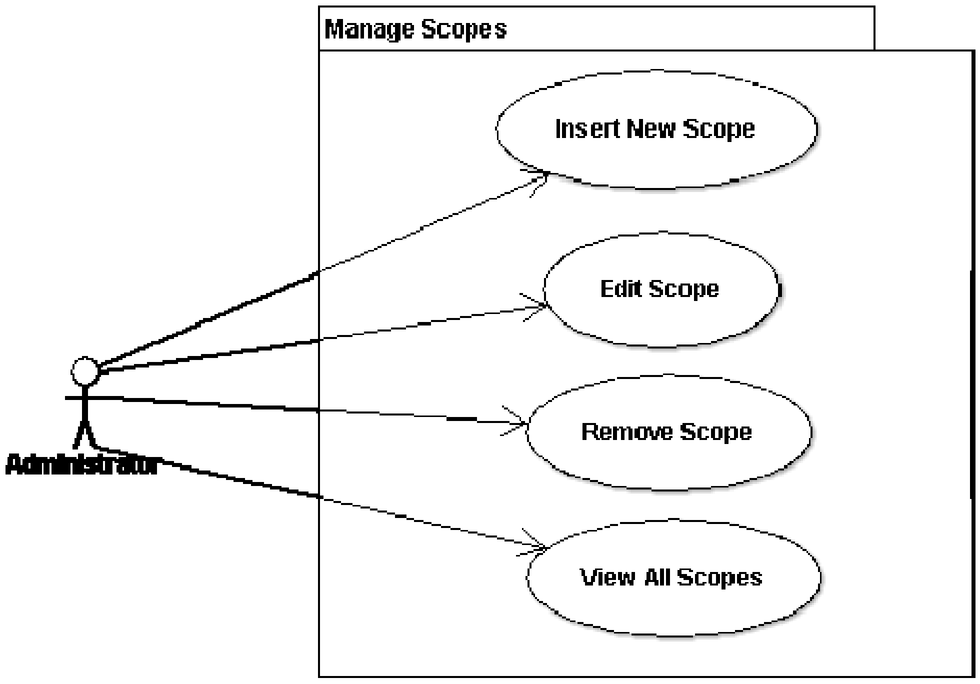


Figure 4-6 Manage Scopes use case diagram

Manage Scope Entities

As shown in **Figure 4-5** entities are "specific objects" of a scope. For example *Porto DC* contains the section *QM*, which contains the project *ProFAb 4.3*. *Porto DC* is an entity of the scope *DC*, *QM* is an entity of the scope *Section* and *ProFab 4.3* is an entity of the scope *Project*.

Entities are important because metric data is always inserted to an entity and defined to a scope. This means, when we create a metric to the scope *Release*, the data is always inserted to one release (which is an entity).

The application should also allow add, edit, remove and list entities. An entity has attributes like:

- Name: name of the entity.
- Description: short text containing what this entity represents.
- Scope: group where the entity is inserted.
- Parent: represents another entity that this one belongs.
- Manager: the person responsible for the entity.

Figure 4-7 presents the actions in scope entities management.

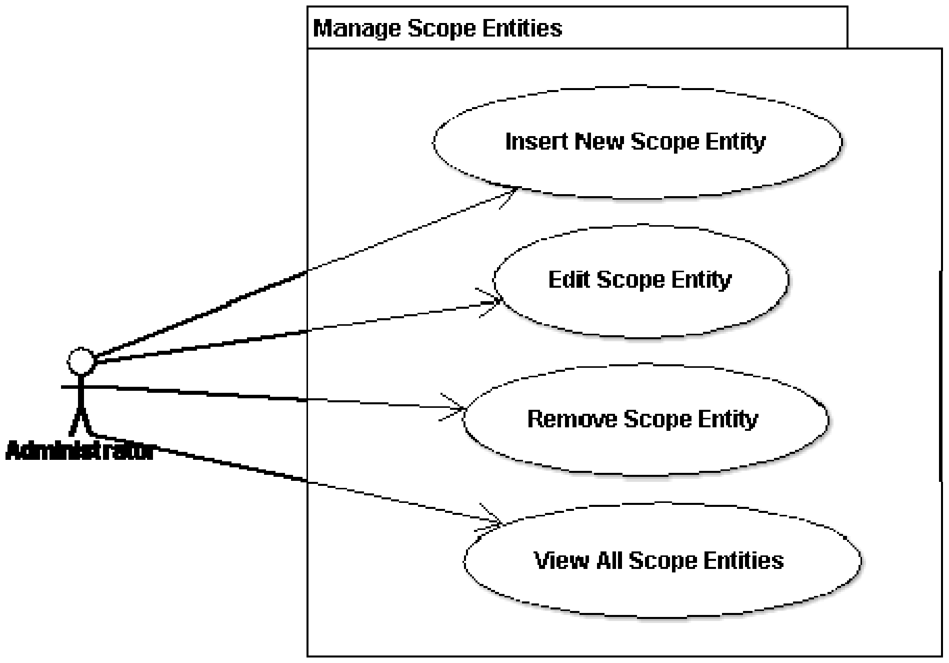


Figure 4-7 Manage Scope Entities Area use case diagram

Manage Lists

A data list is where we can see the raw data (like it was inserted and is stored in the database). Lists are fully customizable because we can choose what we want to list and how.

Imagine that we inserted an Excel file to the *Release X* and it contains five units inserted in the database. Then we want to list this data but only the units 1, 2 and 4. This is the objective of lists. We give a list of units and it should return all data that contains these units.

Management operations over lists are presented in **Figure 4-8**.

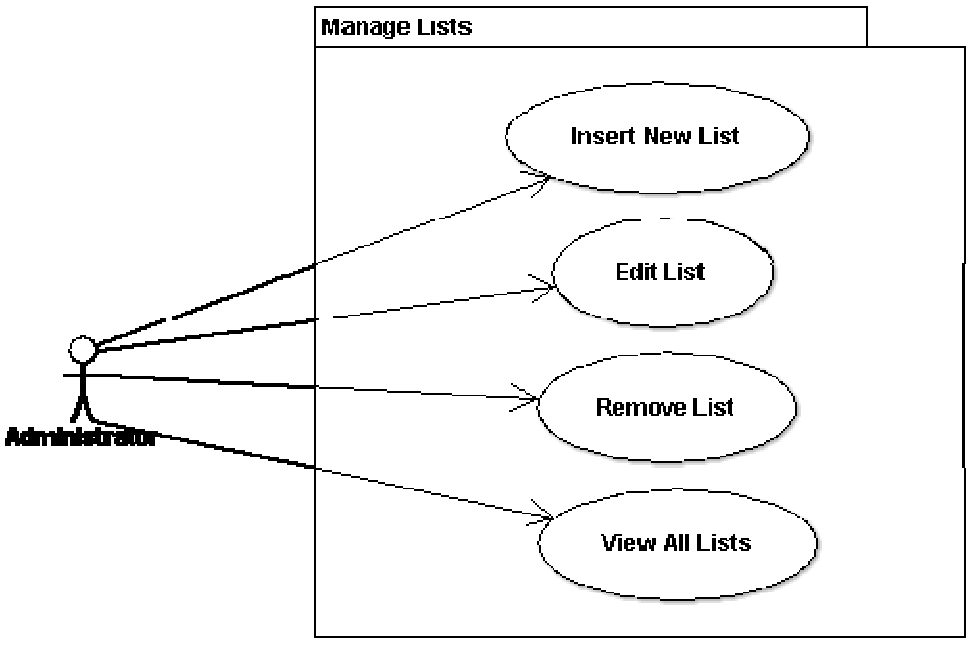


Figure 4-8 Manage Lists Area use case diagram

Manage Forms

As already referred, a form is where we can insert metric data for an entity. This insertion can be done from three external sources: Excel, Project Server and manual.

In this area we manage forms that will be available in the Data Lists Area (already described).

Forms contain properties like:

- Name: name of the form.
- Units: units to fetch from the source. We can have an Excel file with ten columns but want to import only the columns 1, 3 and 4.
- Source: the source of data (Excel, Project Server or manual).
- Data list: which list will present the data uploaded.
- Validation: if duplicate values are allowed in the database.
- Excel attributes: for example, the range of cells to import.

The application should permit configure and manage (add, edit, remove and list) forms as shown in **Figure 4-9**.

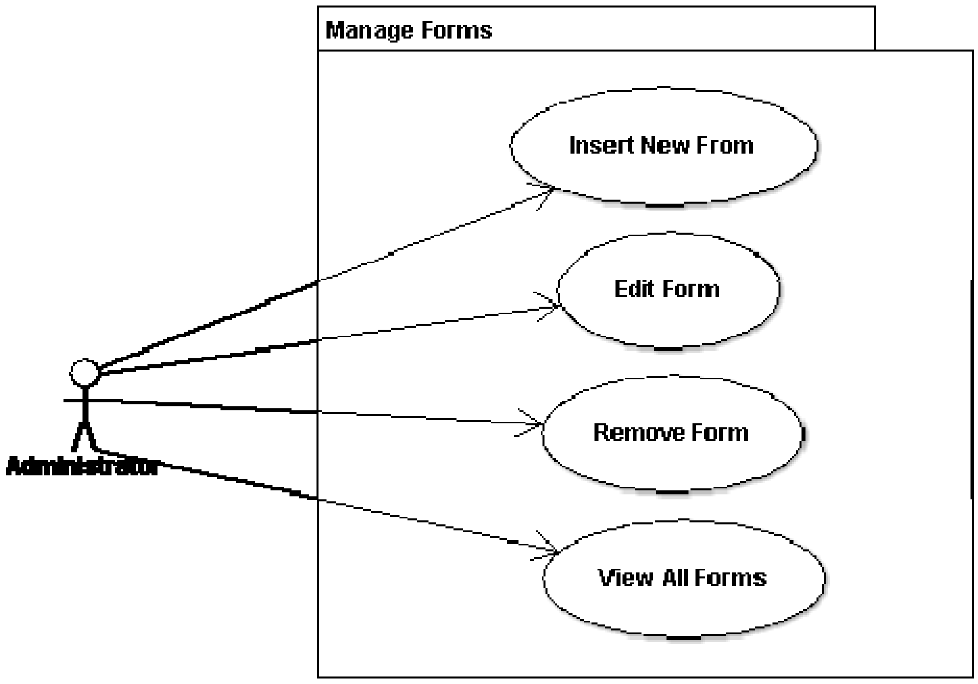


Figure 4-9 Manage Forms Area use case diagram

Manage Targets

A target is the value against which the actual value of an indicator will be compared. If the actual value reaches or exceeds the target, this is considered achieved. There are six levels of achievement (0%, 50%, 100%, 150%, 200% and 250%) and four color indicators:

- White: if the value it’s not applicable.
- Red: if the value is lower than the expected and the achievement is at risk.

- Yellow: if the value is near achievement but can be improved.
- Green: if the target value is achieved.

The application should allow the management activities presented in **Figure 4-10**.

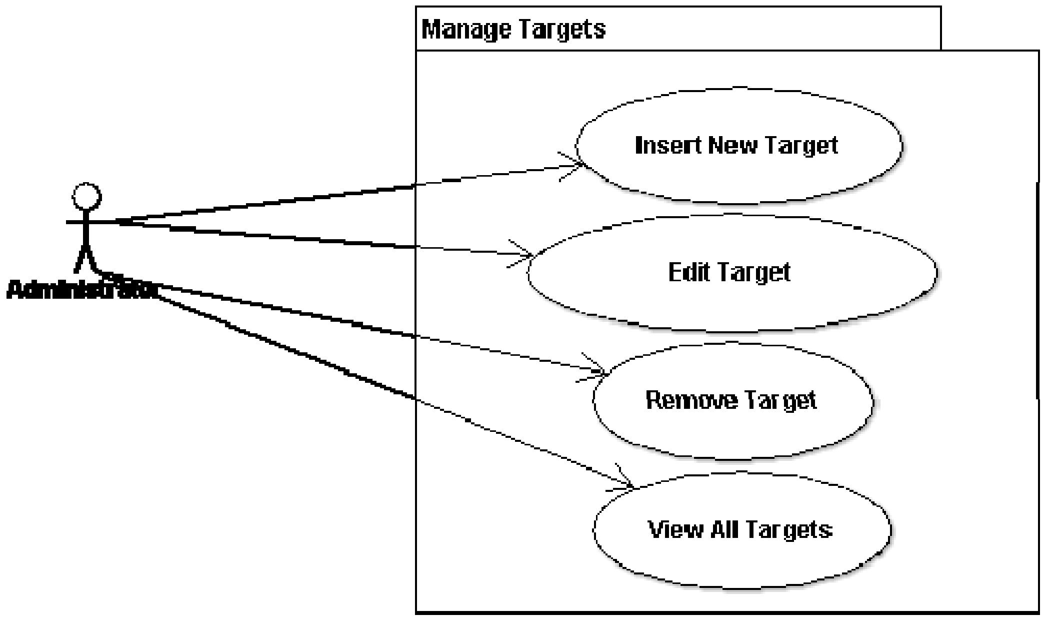


Figure 4-10 Manage Targets Area use case diagram

4.1.2 Non-functional Requirements

Documentation

The tool should be properly documented in English, with a user manual, documenting all of the application's features (screenshots and descriptions on how to use them), and an API with the classes and functions implemented.

Safety

Especially when adding and editing metrics and other data, the application should generate messages to prevent human errors and data inconsistencies, and the user is responsible to deal with them.

Usability

This tool should be designed to help the user complete the tasks proposed with success and increase efficiency. It should be intuitive, providing comprehensible menus, options and informative help messages.

Extensibility

The system should be architected to include mechanisms for expanding and enhancing it with new capabilities without making major changes in the infrastructure. Code should be a dynamic linkable library (*DLL*), so system's behavior could be modifiable at runtime, without recompiling or changing the original source code.

Interface

The design should be aligned with the colors and layout of the common Qimonda's web applications, providing to the users a known work environment.

4.1.3 Technological Requirements

The application should be developed with *Microsoft Framework 2.0* in *C#* language. The web application should be in *Microsoft ASP .NET* and the database implemented in *Oracle 9i*.

The web interface should support the official Qimonda's web browser, *Internet Explorer*, but it will also be tested and debugged in *Mozilla Firefox*.

4.2 Conceptual Model

The conceptual model (**Figure 4-11**) presents the system structure by showing the system classes, their attributes and relationships.

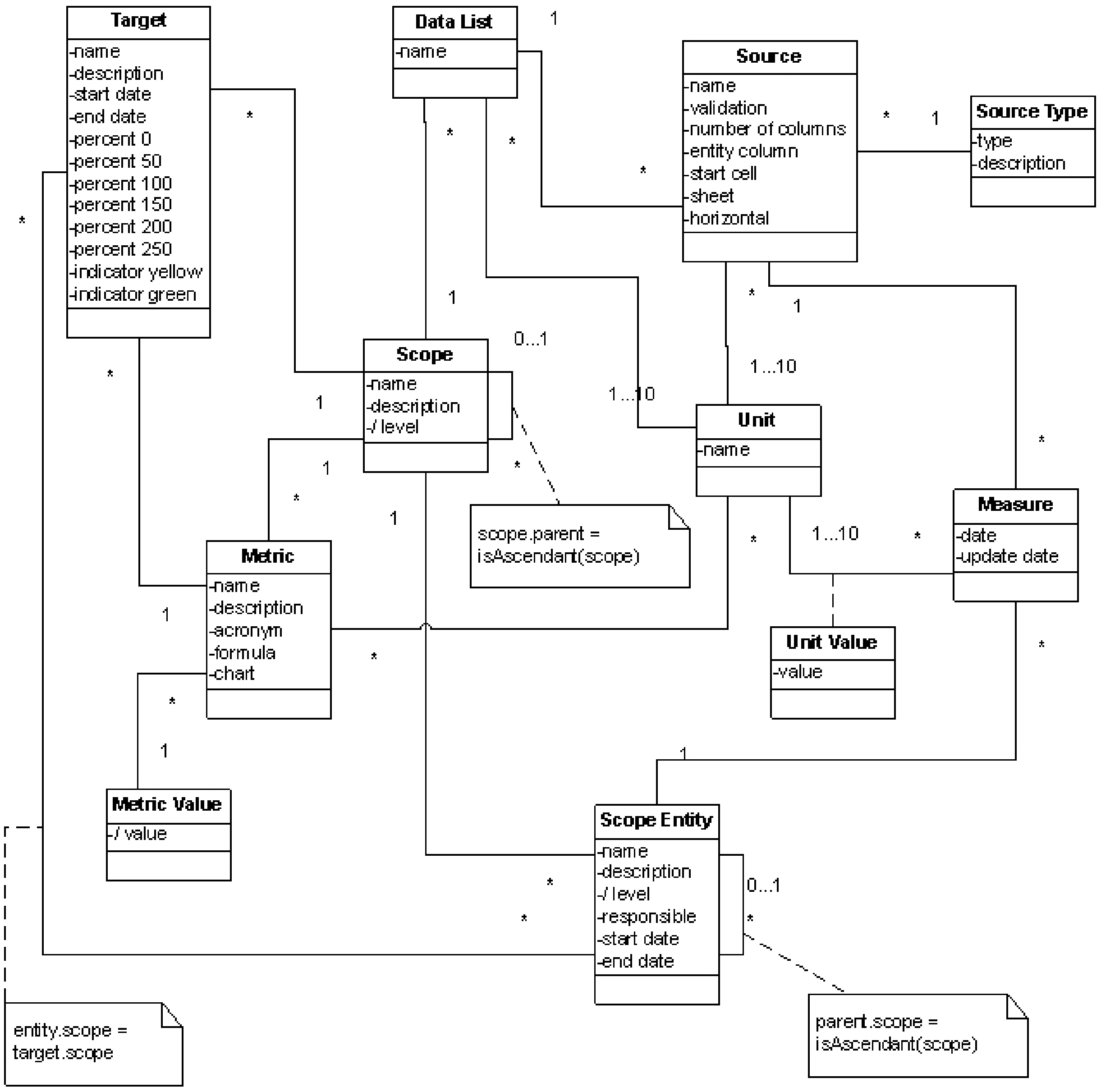


Figure 4-11 Conceptual model

5 Implementation

CMMI Metric Solution was developed incrementally in various phases. The first development done in this internship project was related to the technology analysis and architecture definition.

This chapter focuses on the development of the requirements defined in the last chapter and it is divided in four sub-sections. First will be explained the system architecture and then, each of the layers of the solution (Data Layer, Business Logic Layer and User Interface).

5.1 Architecture

It's extremely important to define a detailed and correct system architecture.

Logically, the application follows a *layered model*, in order to increase quality and extensibility levels. This model organizes the system in different layers, in each layer acts as a client of the lower layer and provides services to the higher one.

With this approach, the system becomes completely modular and portable (layers can be changed and replaced as long we respect communication between them).

Physically, these logical layered components are located in different servers and machines, increasing system performance and maintenance.

In the next sections will be defined these two architecture models.

5.1.1 Logical Architecture

Logically, the system was divided into three different layers. A lower layer to access, manage and store data, a middle layer with all the application's business logic and a web interface layer completely *dummy* (without business logic) for user interaction.

The next diagram shows this organization.

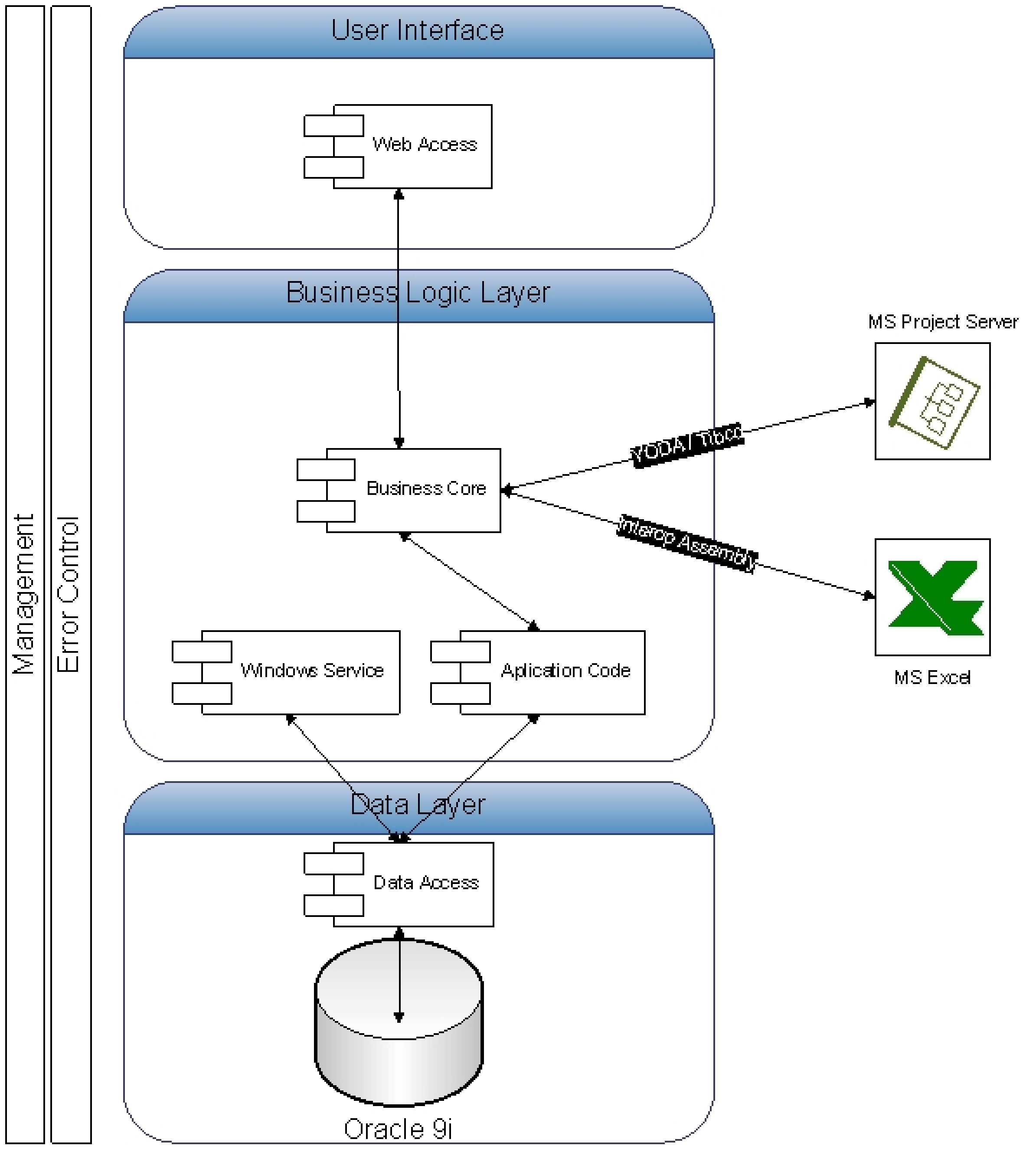


Figure 5-1 Logical Architecture

The Data Layer contains two modules. The lower module, the database, was implemented in *Oracle 9i* as referred in Technological Requirements (Section 4.1.3). Next we have the Data Access component, which was developed in C# with the .NET Framework Data Provider for Oracle.

The Business Logic Layer is the application core and implements all classes and functions from the data access to the user interface, besides the communication with external sources (Excel and Project Server). It was implemented in C#.

At last we have the *web based* layer, User Interface, developed in .NET with the usual *web controls*, plus the ones available in the AJAX Toolkit.

5.1.2 Physical Architecture

Physically, the main component is the *Web Server* that stores all logic layers of this solution, except the databases which are stored in the *Oracle Server*, as presented in **Figure 5-2**.

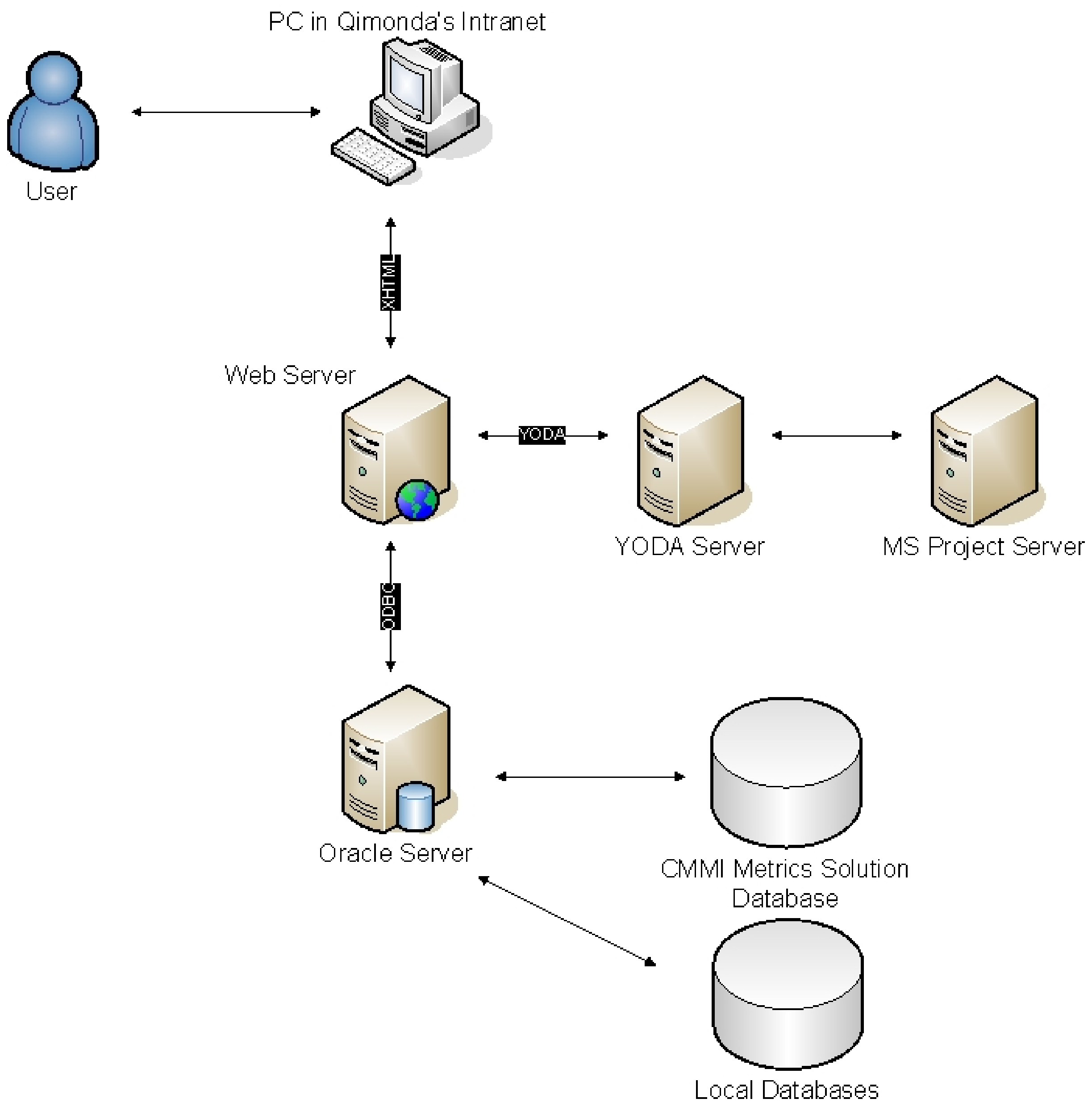


Figure 5-2 Physical Architecture

During the development and test phases, all the layers (except the databases) were stored in my computer that was acting as a server. The server where the application will run was analyzed in the beginning of the implementation to avoid future migration issues.

5.2 Data Layer

The implementation started by the Data Layer, which contains the database definition and data access classes and methods. This chapter provides description and diagrams for each one of these components, starting with the database model and, at last, the classes and methods that establish the connection between the application and data.

5.2.1 Database

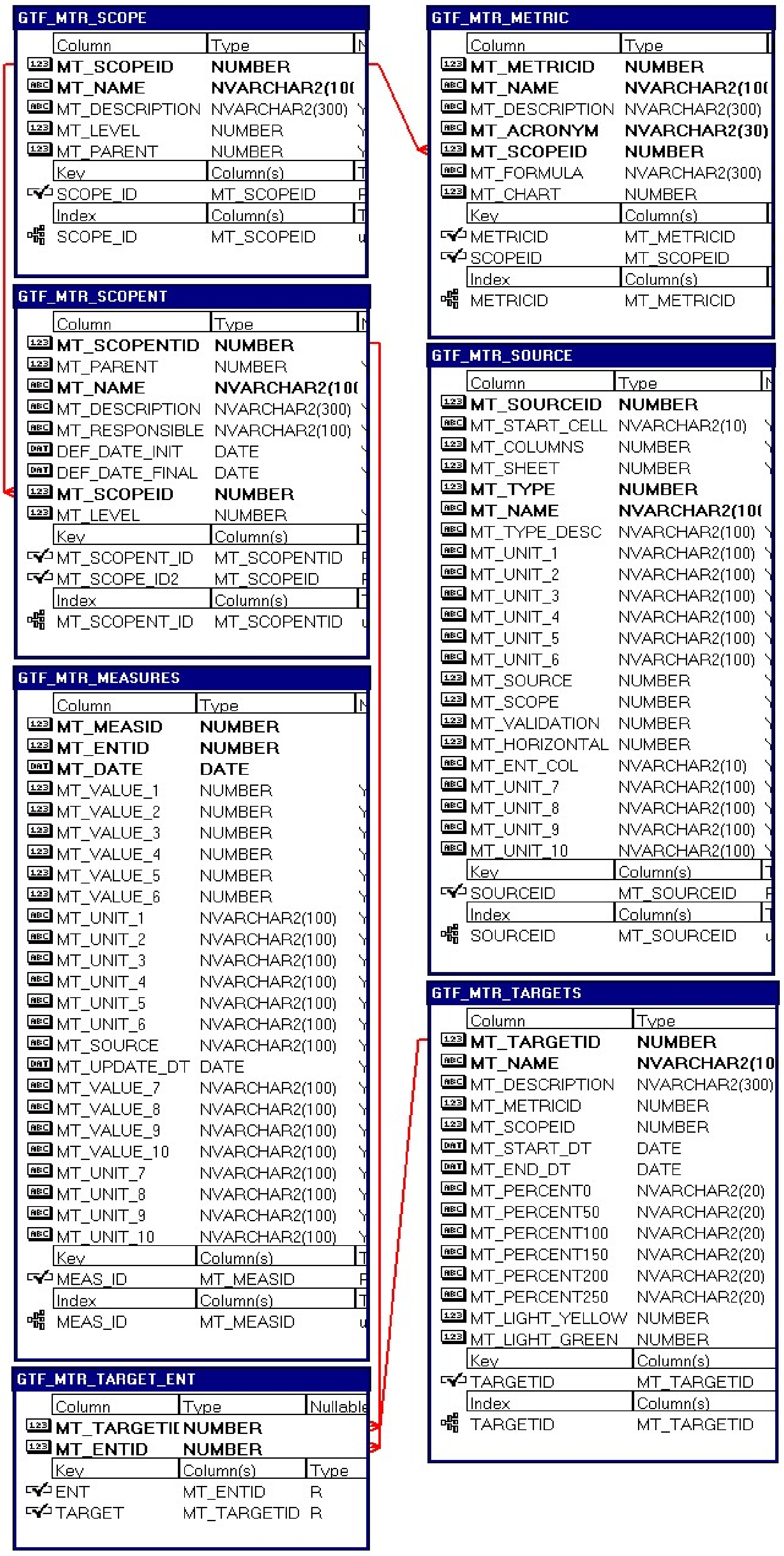
The database model was defined after the approval of the Requirements Specification Document.

Initially it was defined a model that contained several data tables to store metric and measure data. During development we realized that it wasn't as dynamic as we liked it to be because if we need to insert new metrics with different data (one of the main requirements), a new database table should be created. After analyzing the problem, was suggested a new model that contains only one data table (*GTF_MTR_MEASURES*) to store all metric data, which fields could be reutilized.

This approach could bring a performance issue because of the large amount of different data this table would store. After analyzing the problem, we concluded that it was the best choice and the access time didn't increase substantially, even with thousands of lines from different metrics.

This model allows creating and managing new metrics inside the application without needing to change the database or a single code line.

Figure 5-3 shows the final database model diagram.



GTF_MTR_SCOPE

Column	Type	N
MT_SCOPEID	NUMBER	
MT_NAME	NVARCHAR2(10(	
MT_DESCRIPTION	NVARCHAR2(300)	Y
MT_LEVEL	NUMBER	Y
MT_PARENT	NUMBER	Y
Key	Column(s)	T
SCOPE_ID	MT_SCOPEID	P
Index	Column(s)	T
SCOPE_ID	MT_SCOPEID	u

GTF_MTR_SCOPENT

Column	Type	N
MT_SCOPENTID	NUMBER	
MT_PARENT	NUMBER	Y
MT_NAME	NVARCHAR2(10(	
MT_DESCRIPTION	NVARCHAR2(300)	Y
MT_RESPONSIBLE	NVARCHAR2(100)	Y
DEF_DATE_INIT	DATE	Y
DEF_DATE_FINAL	DATE	Y
MT_SCOPEID	NUMBER	
MT_LEVEL	NUMBER	Y
Key	Column(s)	T
MT_SCOPENT_ID	MT_SCOPENTID	P
MT_SCOPE_ID2	MT_SCOPEID	F
Index	Column(s)	T
MT_SCOPENT_ID	MT_SCOPENTID	u

GTF_MTR_MEASURES

Column	Type	N
MT_MEASID	NUMBER	
MT_ENTID	NUMBER	
MT_DATE	DATE	
MT_VALUE_1	NUMBER	Y
MT_VALUE_2	NUMBER	Y
MT_VALUE_3	NUMBER	Y
MT_VALUE_4	NUMBER	Y
MT_VALUE_5	NUMBER	Y
MT_VALUE_6	NUMBER	Y
MT_UNIT_1	NVARCHAR2(100)	Y
MT_UNIT_2	NVARCHAR2(100)	Y
MT_UNIT_3	NVARCHAR2(100)	Y
MT_UNIT_4	NVARCHAR2(100)	Y
MT_UNIT_5	NVARCHAR2(100)	Y
MT_UNIT_6	NVARCHAR2(100)	Y
MT_SOURCE	NVARCHAR2(100)	Y
MT_UPDATE_DT	DATE	Y
MT_VALUE_7	NVARCHAR2(100)	Y
MT_VALUE_8	NVARCHAR2(100)	Y
MT_VALUE_9	NVARCHAR2(100)	Y
MT_VALUE_10	NVARCHAR2(100)	Y
MT_UNIT_7	NVARCHAR2(100)	Y
MT_UNIT_8	NVARCHAR2(100)	Y
MT_UNIT_9	NVARCHAR2(100)	Y
MT_UNIT_10	NVARCHAR2(100)	Y
Key	Column(s)	T
MEAS_ID	MT_MEASID	P
Index	Column(s)	T
MEAS_ID	MT_MEASID	u

GTF_MTR_TARGET_ENT

Column	Type	Nullable
MT_TARGETII	NUMBER	
MT_ENTID	NUMBER	
Key	Column(s)	Type
ENT	MT_ENTID	R
TARGET	MT_TARGETID	R

GTF_MTR_METRIC

Column	Type
MT_METRICID	NUMBER
MT_NAME	NVARCHAR2(10(
MT_DESCRIPTION	NVARCHAR2(300)
MT_ACRONYM	NVARCHAR2(30)
MT_SCOPEID	NUMBER
MT_FORMULA	NVARCHAR2(300)
MT_CHART	NUMBER
Key	Column(s)
METRICID	MT_METRICID
SCOPEID	MT_SCOPEID
Index	Column(s)
METRICID	MT_METRICID

GTF_MTR_SOURCE

Column	Type	N
MT_SOURCEID	NUMBER	
MT_START_CELL	NVARCHAR2(10)	Y
MT_COLUMNS	NUMBER	Y
MT_SHEET	NUMBER	Y
MT_TYPE	NUMBER	
MT_NAME	NVARCHAR2(10(	
MT_TYPE_DESC	NVARCHAR2(100)	Y
MT_UNIT_1	NVARCHAR2(100)	Y
MT_UNIT_2	NVARCHAR2(100)	Y
MT_UNIT_3	NVARCHAR2(100)	Y
MT_UNIT_4	NVARCHAR2(100)	Y
MT_UNIT_5	NVARCHAR2(100)	Y
MT_UNIT_6	NVARCHAR2(100)	Y
MT_SOURCE	NUMBER	Y
MT_SCOPE	NUMBER	Y
MT_VALIDATION	NUMBER	Y
MT_HORIZONTAL	NUMBER	Y
MT_ENT_COL	NVARCHAR2(10)	Y
MT_UNIT_7	NVARCHAR2(100)	Y
MT_UNIT_8	NVARCHAR2(100)	Y
MT_UNIT_9	NVARCHAR2(100)	Y
MT_UNIT_10	NVARCHAR2(100)	Y
Key	Column(s)	T
SOURCEID	MT_SOURCEID	P
Index	Column(s)	T
SOURCEID	MT_SOURCEID	u

GTF_MTR_TARGETS

Column	Type
MT_TARGETID	NUMBER
MT_NAME	NVARCHAR2(10
MT_DESCRIPTION	NVARCHAR2(300)
MT_METRICID	NUMBER
MT_SCOPEID	NUMBER
MT_START_DT	DATE
MT_END_DT	DATE
MT_PERCENT0	NVARCHAR2(20)
MT_PERCENT50	NVARCHAR2(20)
MT_PERCENT100	NVARCHAR2(20)
MT_PERCENT150	NVARCHAR2(20)
MT_PERCENT200	NVARCHAR2(20)
MT_PERCENT250	NVARCHAR2(20)
MT_LIGHT_YELLOW	NUMBER
MT_LIGHT_GREEN	NUMBER
Key	Column(s)
TARGETID	MT_TARGETID
Index	Column(s)
TARGETID	MT_TARGETID

Figure 5-3 Database model

Next, will be explained the tables and fields from the relational model in **Figure 5-3**. These tables have a common prefix (GFT_MTR_) in the name and its fields the prefix (MT_). The prefixes allow the distinction of different application's tables inside the database.

GTF_MTR_SCOPE: scopes introduced in Admin Area (Section 4.1.1.4).

- *MT_NAME*: name of the scope.
- *MT_DESCRIPTION*: short description about the scope.
- *MT_LEVEL*: scope depth from the root.
- *MT_PARENT*: scope parent.

GTF_MTR_SCOPENT: scope entities introduced in Admin Area (Section 4.1.1.4).

- *MT_PARENT*: scope entity parent.
- *MT_NAME*: name of the entity.
- *MT_DESCRIPTION*: short description about the entity.
- *MT_RESPONSIBLE*: person responsible or that manages the entity.
- *DEF_DATE_INIT*: start of the time span to visualize results.
- *DEF_DATE_FINAL*: end of the time span to visualize results.
- *MT_SCOPEID*: ID of the scope this entity belongs.
- *MT_LEVEL*: scope entity depth from the root.

GTF_MTR_METRIC: metrics introduced in Admin Area (Section 4.1.1.4).

- *MT_NAME*: name of the metric.
- *MT_DESCRIPTION*: short description about the metric.
- *MT_ACRONYM*: acronym or the metric short name.
- *MT_SCOPEID*: ID of the scope the metric was defined.
- *MT_FORMULA*: formula of the metric.
- *MT_CHART*: type of chart to display metric results.

GTF_MTR_SOURCE: sources and lists introduced in Admin Area (Section 4.1.1.4). These two objects have almost the same properties. It allows grouping them in the same table.

- *MT_START_CELL*: start cell when the source is an Excel file.
- *MT_COLUMNS*: number of columns to import when the source is an Excel file.
- *MT_SHEET*: sheet when the source is an Excel file.
- *MT_TYPE*: ID of the type (1 for Excel, 2 for Project Server, 3 for Manual and 4 for Data List).
- *MT_NAME*: name of the source.
- *MT_TYPE_DESC*: description of the type of the source.
- *MT_UNIT_(1-6)*: name of the numeric units of the source.
- *MT_SOURCE*: list parent of the source.

- *MT_SCOPE*: scope the source was defined.
- *MT_VALIDATION*: if the source validates data (don't allow duplicate values).
- *MT_HORIZONTAL*: direction to get Excel data.
- *MT_ENT_COL*: column that contains the entities (Excel source only).
- *MT_UNIT_(7-10)*: name of the text units of the source.

GTF_MTR_MEASURES: single table to store all metric raw data, as explained below.

- *MT_ENTID*: entity to which this data was inserted.
- *MT_DATE*: date of the data.
- *MT_VALUE_(1-6)*: numeric values of the measure.
- *MT_UNIT_(1-6)*: name of the numeric values of the measure.
- *MT_SOURCE*: source from where the data was inserted.
- *MT_UPDATE_DT*: date of the last update of data.
- *MT_VALUE_(7-10)*: text values of the measure.
- *MT_UNIT_(7-10)*: name of the text values of the measure.

GTF_MTR_TARGETS: targets introduced in Admin Area (Section 4.1.1.4).

- *MT_NAME*: name of the target.
- *MT_DESCRIPTION*: short text about the target and its objectives.
- *MT_METRICID*: metric to which values will be compared and present indicators.
- *MT_SCOPEID*: group of entities to which the target will be compared and present indicators.
- *MT_START_DT*: start date of the target time frame.
- *MT_END_DT*: end date of the target time frame.
- *MT_PERCENT0*: value that represents 0% of achievement.
- *MT_PERCENT50*: value that represents 50% of achievement.
- *MT_PERCENT100*: value that represents 100% of achievement.
- *MT_PERCENT150*: value that represents 150% of achievement.
- *MT_PERCENT200*: value that represents 200% of achievement.
- *MT_PERCENT250*: value that represents 250% of achievement.
- *MT_LIGHT_YELLOW*: if the metric value is lower that this, a red light is displayed, a yellow light is displayed otherwise.
- *MT_LIGHT_GREEN*: if the metric value is higher or equal to this, a green light is displayed.

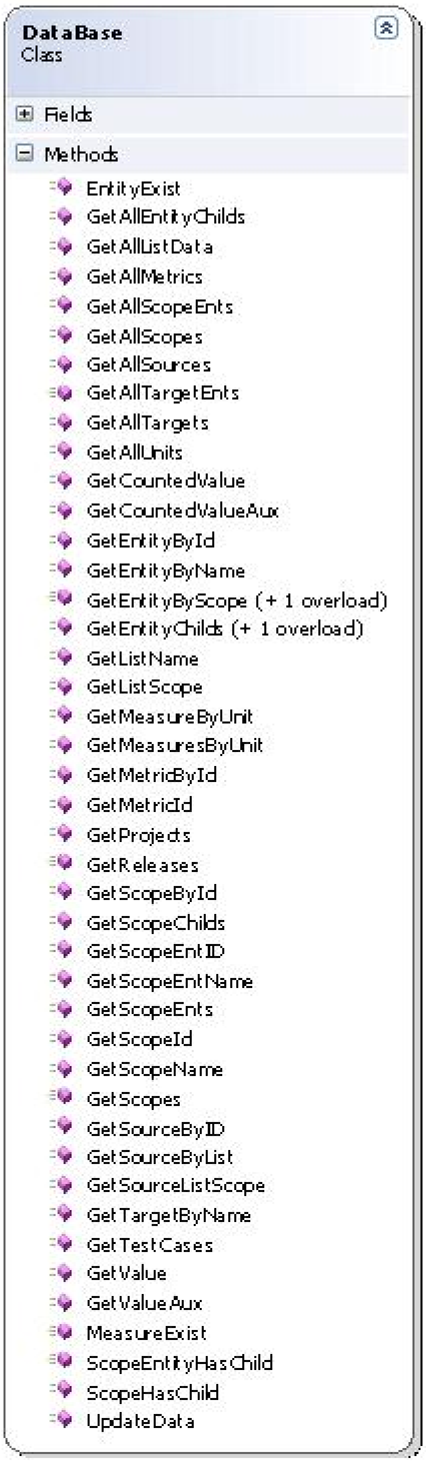
GTF_MTR_TARGET_ENT: this table establishes the connection between targets and entities.

- *MT_TARGETID*: ID of the target.
- *MT_ENTID*: ID of the entity.

5.2.2 Data Access Class and Methods

Only the *DataBase* class and its methods access directly the database defined in the previous section. This class contains several methods to retrieve data (*getters*) but only the method `UpdateData()` writes in the database. It's used to insert, update and remove data, depending on the query received by argument.

The list of methods in this class is presented in **Figure 5-4**.



DataBase
Class

Fields

Methods

- EntityExist
- GetAllEntityChilds
- GetAllListData
- GetAllMetrics
- GetAllScopeEnts
- GetAllScopes
- GetAllSources
- GetAllTargetEnts
- GetAllTargets
- GetAllUnits
- GetCountedValue
- GetCountedValueAux
- GetEntityById
- GetEntityByName
- GetEntityByScope (+ 1 overload)
- GetEntityChilds (+ 1 overload)
- GetListName
- GetListScope
- GetMeasureByUnit
- GetMeasuresByUnit
- GetMetricById
- GetMetricId
- GetProjects
- GetReleases
- GetScopeById
- GetScopeChilds
- GetScopeEntID
- GetScopeEntName
- GetScopeEnts
- GetScopeId
- GetScopeName
- GetScopes
- GetSourceByID
- GetSourceByList
- GetSourceListScope
- GetTargetByName
- GetTestCases
- GetValue
- GetValueAux
- MeasureExist
- ScopeEntityHasChild
- ScopeHasChild
- UpdateData

Figure 5-4 Methods of the *DataBase* class

5.3 Business Logic Layer

This layer implements, as the name says, all the business logic of the application. It connects the database and other external sources, transforms data and presents results to the user interface. It was developed in .NET Framework 2.0 (C#), following the object-oriented programming paradigm. The next subsections will describe the critical and important details of this implementation.

5.3.1 *Object Classes*

All these names and classes were introduced in Admin Area (Section 4.1.1.4) when describing the application requirements. They represent the objects that will map data from the database in order to organize and retrieve the information. Data encapsulation and hiding are the two fundamental characteristics of any object oriented programming language. Inside these classes, data fields were declared as private and provided a set of public *set/get* methods to access the data fields (*Properties*). This is a good programming practice, since the data fields are not directly accessible outside the class.

5.3.1.1 Scope

The object Scope contains the same fields of the database table described in Database (Section 5.2.1). It maps the scopes, the main organization to structure and view data.

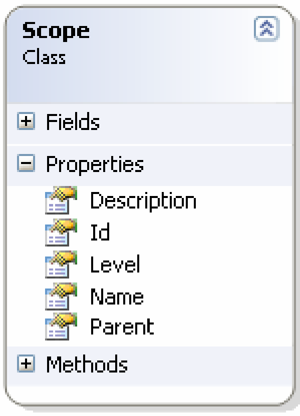


Figure 5-5 *Scope* class Properties

5.3.1.2 Scope Entity

The object Scope Entity also contains the same database fields described in Database (Section 5.2.1) and represents the entities explained in Admin Area (Section 4.1.1.4).

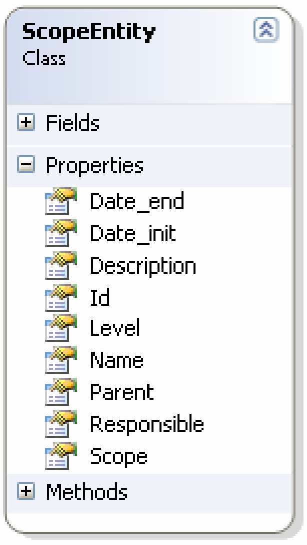


Figure 5-6 *Scope Entity* class Properties

5.3.1.3 Metric

This is the only object class that contains Methods, besides Properties. They are used to calculate metric results.

We call `CalculateChilds()` that calls recursively `Calculate()` to return the result of each entity child. If the entity don't have children it simply returns the result of `Calculate()`.

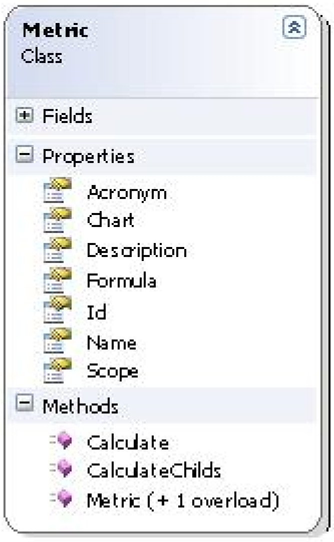


Figure 5-7 *Metric* class Methods and Properties

5.3.1.4 Data List and Data Source

These two object classes are stored in the same database table (*GTF_MTR_SOURCE*), described in Database (Section 5.2.1), but in the code are separate. The distinction between them was also explained in Admin Area (Section 4.1.1.4), and it's done by the database field (*MT_TYPE*).

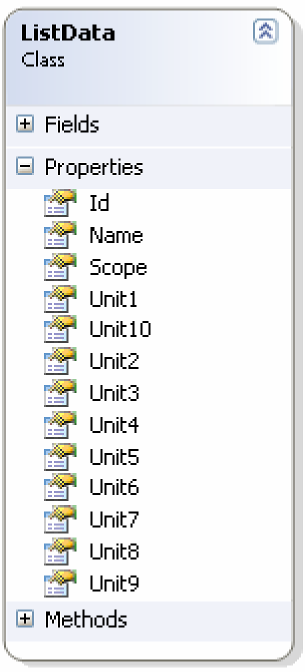


Figure 5-8 *ListData* class Properties

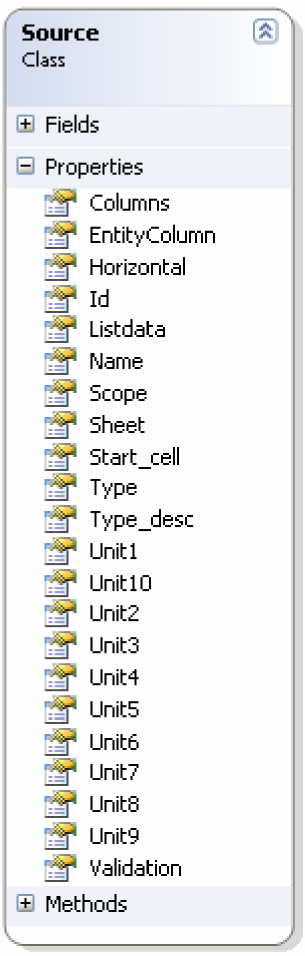
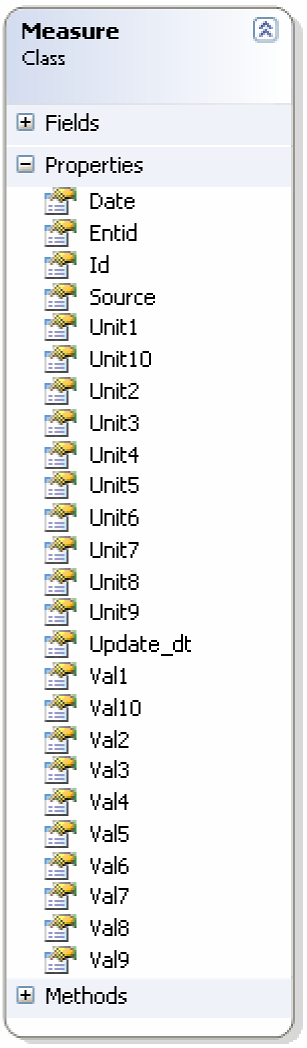


Figure 5-9 *Source* class Properties

This group was done because physically, they have almost the same properties and fields, which can be reutilized, avoiding the creation of a new database table. Logically they're completely different because Data Sources represent the inputs of the application and Data Lists one of its outputs.

5.3.1.5 Measure

This is the elementary object class of the application. A Measure object represents the raw data like it was inserted in the database (table *GTF_MTR_MEASURES* defined in Database – Section 5.2.1). The data of this table is used in Data List and Data Sources to display the existent metric data that will be calculated to present metric results in the visualization area.



Date
Entid
Id
Source
Unit1
Unit10
Unit2
Unit3
Unit4
Unit5
Unit6
Unit7
Unit8
Unit9
Update_dt
Val1
Val10
Val2
Val3
Val4
Val5
Val6
Val7
Val8
Val9

Figure 5-10 *Measure* class Properties

5.3.1.6 *Target*

This object contains the same fields presented in the Database section (table *GTF_MTR_TARGETS*) and represents the targets that will be presented in the start page, which were explained in Admin Area (Section 4.1.1.4).

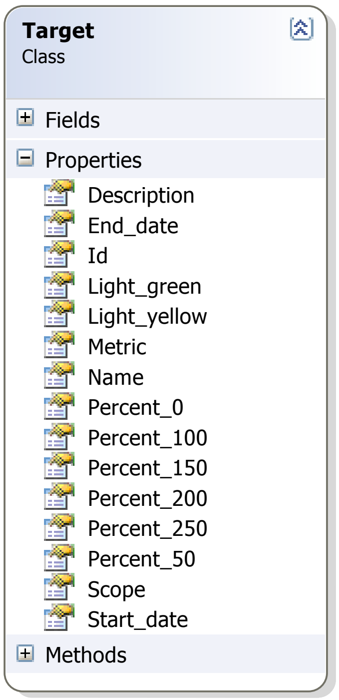


Figure 5-11 *Target* class Properties

5.3.1.7 *Target Entity Pair*

This class represents a pair target-entity like presented in the relationship table (*GTF_MTR_TARGET_ENT*) in the Database (Section 5.2.1).

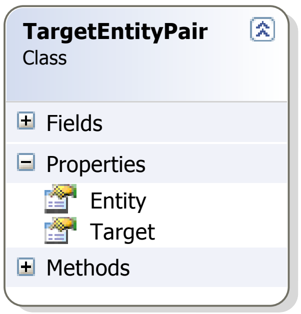


Figure 5-12 *Target Entity Pair* class Properties

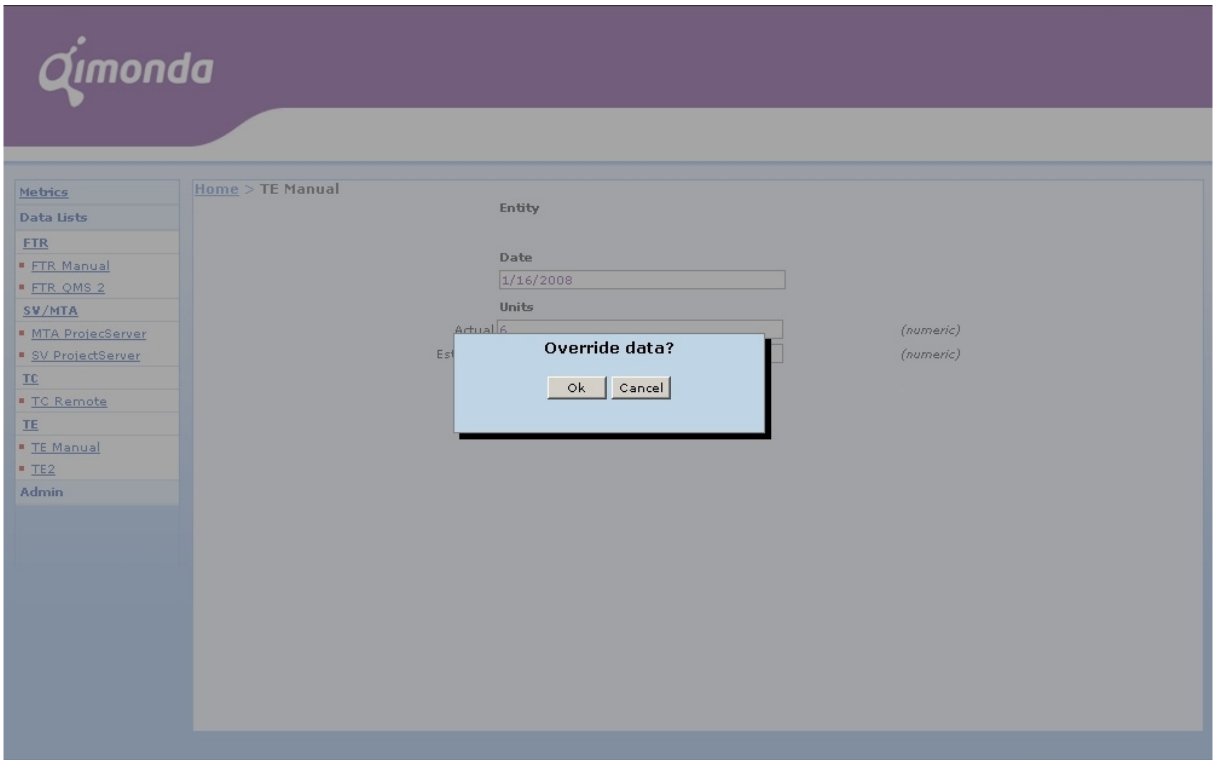
5.3.2 *Excel Import*

One important requirement was the import of Excel files. There are several different files defined in QMS and the application should be customizable to import data from all of them.

The following different cases were identified and are supported by the application:

- Some files have the header in the top of the sheet and the data is aligned vertically, but others have the header in the left column and data is filled to the right.
- The entities were another issue analyzed. Some files are filled for a project but others contain data for several projects, which are defined in a column of the file (or line, depending of the direction).
- The date inserted in the database can also be imported from the file. If it has a column with the word “date” in its name, the date will be automatically imported.

- In some cases it's also necessary to validate the data uploaded, namely, do not allow duplicate results for the same entity. If the file was already uploaded, even if with different data, the application alerts and asks the user if he wants to override the data, as shown in **Figure 5-13**.



Entity

Date
1/16/2008

Units
Actual 6 (numeric)
Est (numeric)

Override data?

Figure 5-13 Data validation example

For those reasons, the parameters needed are the range of data (start cell, number of columns and the sheet), the data direction (horizontal or vertical), the entity column (or none if it will be selected in the upload), if it should validate and the units to import. When analyzing the file, only the known columns are imported. If the application detect an unknown unit it alerts the user that the column was not imported.

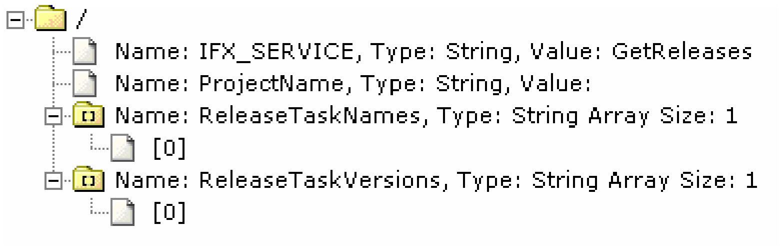
The implementation of this feature was done with the Excel Interop Assembly, developed by the Microsoft, which is very poor in documentation. The examples and documentation gathered came from discussion forums about ASP .NET and other people with the same problems and doubts on how to use the library. The learning process was a little hard but at the end it became easy to implement and integrate with the existing project. The performance was also a great surprise because the application can import and parse thousands of Excel lines in less that one second, which was better than we expected.

5.3.3 Project Server Import

Microsoft Project is the official tool to manage projects and individual tasks, reports and work progress in Qimonda. Project Server contains, this way, a central repository of data this application needs to present results. If we could fetch it, we would avoid the need of manually filling more forms or Excel sheets.

The Windows Technologies section has already implemented a service that could fetch this project information. In this area we had the collaboration of Antero Ferreira to understand how this could be integrated in the application and if it returns the needed results.

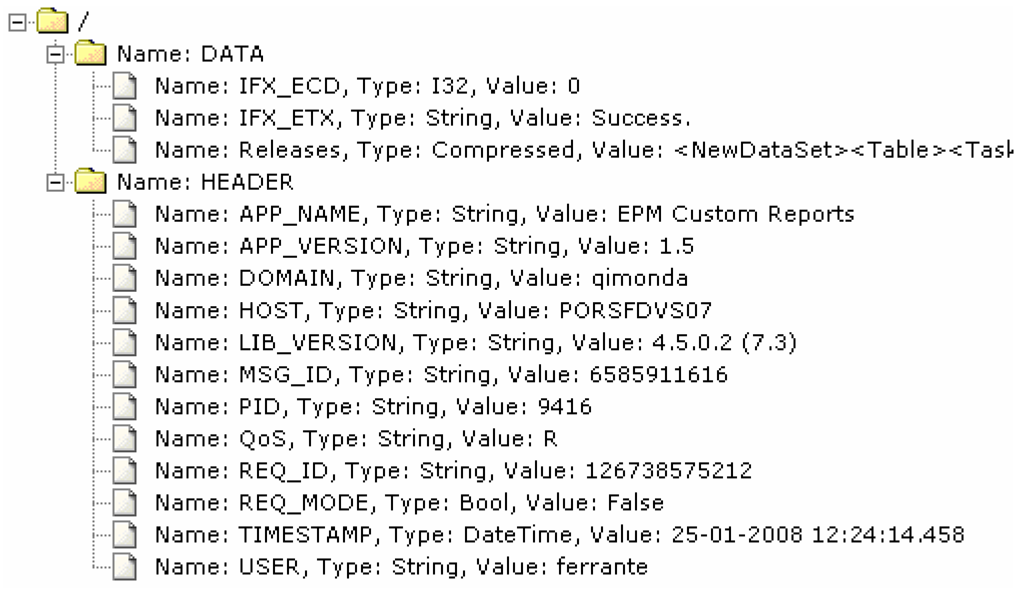
This service implements several YODA Services which get information from Project Server, and return it viaYODA, using a compressed dataset based interface, which can be reused by other applications. In the next figure we can see an example of querying the service database trough a console.



```
/
  Name: IFX_SERVICE, Type: String, Value: GetReleases
  Name: ProjectName, Type: String, Value:
  Name: ReleaseTaskNames, Type: String Array Size: 1
    [0]
  Name: ReleaseTaskVersions, Type: String Array Size: 1
    [0]
```

Figure 5-14 Querying the service GetReleases

The next figure shows the dataset returned by the service trough the console.



```
/
  Name: DATA
    Name: IFX_ECD, Type: I32, Value: 0
    Name: IFX_ETX, Type: String, Value: Success.
    Name: Releases, Type: Compressed, Value: <NewDataSet><Table><Tasl
  Name: HEADER
    Name: APP_NAME, Type: String, Value: EPM Custom Reports
    Name: APP_VERSION, Type: String, Value: 1.5
    Name: DOMAIN, Type: String, Value: qimonda
    Name: HOST, Type: String, Value: PORSFDVS07
    Name: LIB_VERSION, Type: String, Value: 4.5.0.2 (7.3)
    Name: MSG_ID, Type: String, Value: 6585911616
    Name: PID, Type: String, Value: 9416
    Name: QoS, Type: String, Value: R
    Name: REQ_ID, Type: String, Value: 126738575212
    Name: REQ_MODE, Type: Bool, Value: False
    Name: TIMESTAMP, Type: DateTime, Value: 25-01-2008 12:24:14.458
    Name: USER, Type: String, Value: ferrante
```

Figure 5-15 Dataset returned by the service

There exists also a C# library to call the services from the code. The dataset returned by the service was converted to a XML document and then parsed to the desired structure and inserted in the database.

5.3.4 *Math Parser*

In Math Parser Tool (Section 3.2) it was described the tools evaluated and the reasons why the Lundin Mathparser Assembly was chosen to be integrated in the application. The next figure shows its methods and classes.

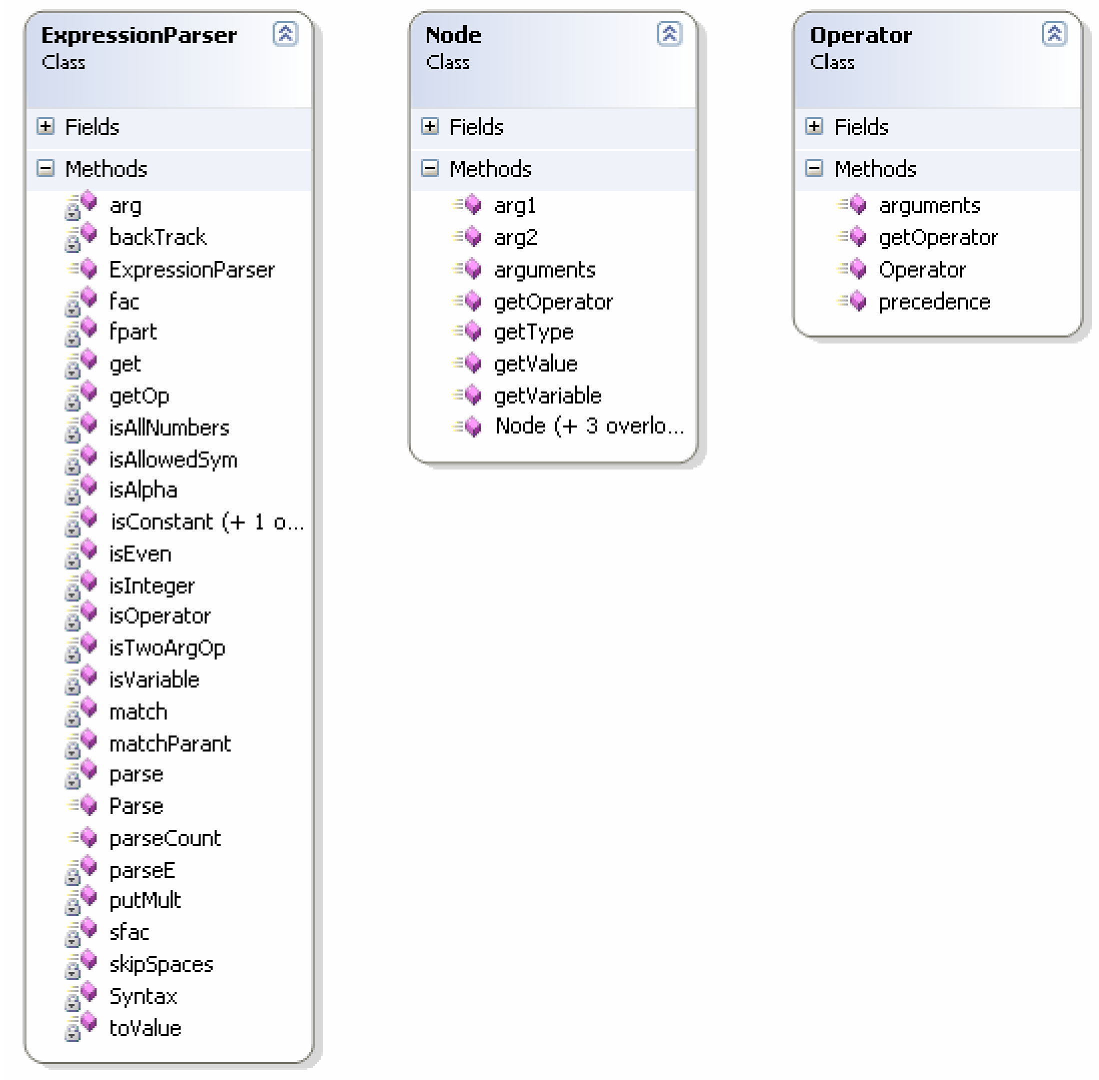


Figure 5-16 *Math Parser* Classes and Methods

This library is very complete and implements almost all the functions needed. The only operation implemented was to count values in the database (function `parseCount()` in the figure above). Originally, to get results we just needed to call the function `Parse()` with two arguments: the formula (in *string*) and a *Hashtable* with the values of the variables (pair key-value). For example the formula:

```
(X + Y) * Z where X=2 and Y=5 and Z=3
```

could be calculated:

```
string formula = “(X + Y) * Z”;
Hashtable htable = new Hashtable();
htable.add(“X”, 2);
htable.add(“Y”, 5);
htable.add(“Z”, 3);

Parse(formula, htable);
```

and it would return the *double* value 21.

In the example we know what the values of the variables are, but in our case these values are stored in the database. The representation of the data in the database is similar (see Measure object and *GTF_MTR_MEASURES* table in **Figure 5-3**) where we have the pair *unit-value*.

The solution was then to match this pair *unit-value* with the pair *key-value* in the *Hashtable*. This way the formula is able to find the values of the variables and calculate the results.

The main difficulty was to include two new operations (*`count()`* and *`countdist()`*), that should count the values of a unit in the database. For example the formula `count(X > 2)` should get the number of values greater than two from the units X.

The solution was found with regular expressions (*regex* for short), presented next.

5.3.4.1 Regex

Regular expressions are a compact way of describing complex patterns in texts. They can be used to search for patterns and, once found, to modify the patterns in complex ways.

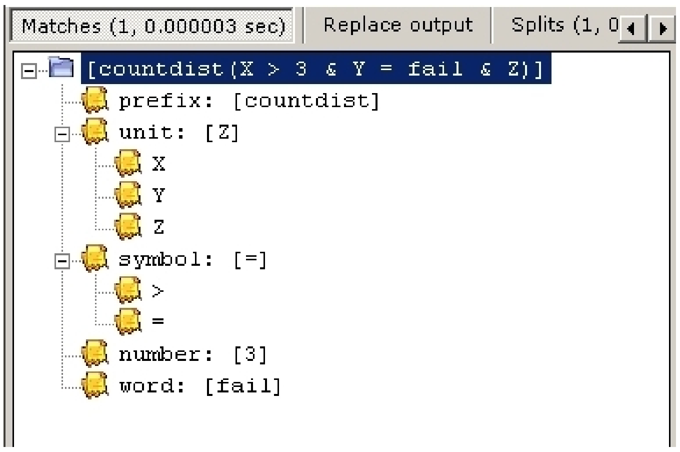
Regex offers an extremely powerful way to search, replace, format and extract text data inside a string using sophisticated search criteria. For example, we can search for whole words, or find a match with some pattern (e-mails, phone numbers, postal codes, HTML or XML tags, etc.), and can quickly locate, count, and extract all the occurrences from the searched string.

As we saw the formula is a string and we need to search all occurrences of *`count()`* and *`countdist()`* in order to deal with them before sending the formula to the parser. The expression *`countdist()`* should return the number of distinct values from a unit and *`count()`* only the number of values. They could have conditionals inside the brackets and a value to compare with, which could be numeric or text, depending on the unit. Examples of these operations could be as follow:

```
1. count(X)
2. count(days != 8)
3. countdist(X > 3 & Y = 'fail' & Z)
```

The first example should return the number of values from the unit "X". The second expression should return the number of values different of eight from the unit "days". At last we have the more complex expression, which should return the distinct values of units "X", "Y" and "Z", where the value of "X" is greater than three and the value of "Y" is equal to "fail". The regular expression that can extract the desired patterns is presented next, as also, the result for this example.

```
((?<prefix>count)?|(?<prefix>countdist)?)\s*\
(\s*(\s*(?<unit>([A-Z]+\s*[A-Z]*\s*))
((?<symbol>\>|\<|\>=|\<=|=|\!=)\s*
((?<number>\d+)|(?<word>[a-zA-Z]+)))?\s*\&?\s*)+\)
```

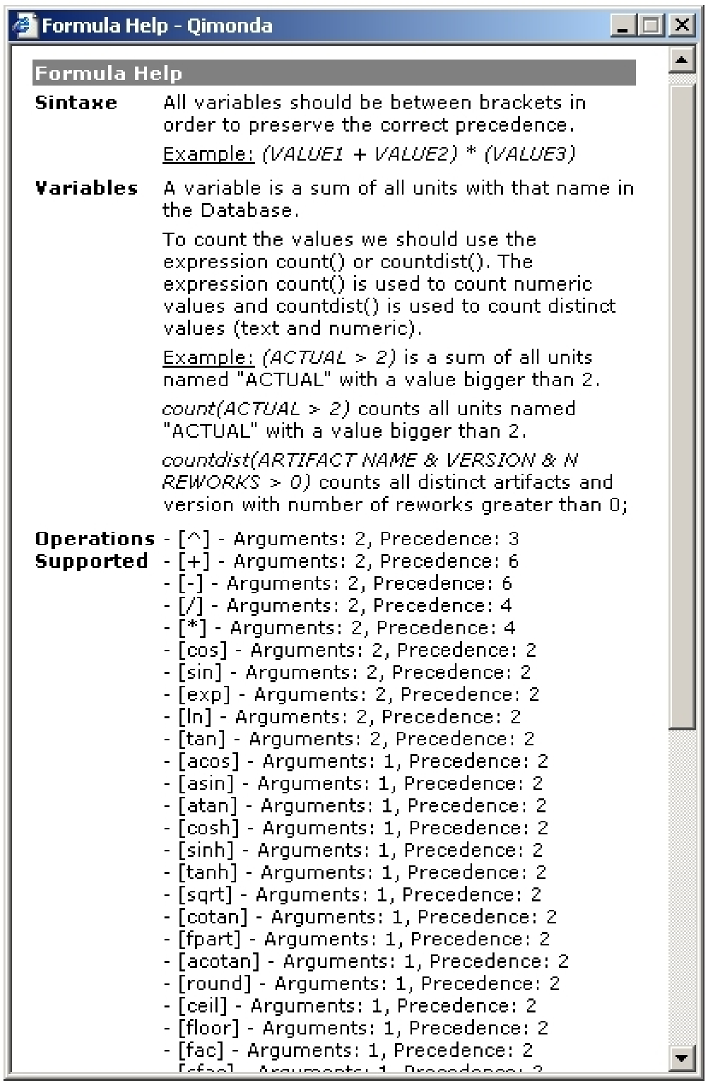


```
[countdist(X > 3 & Y = fail & Z)]
    prefix: [countdist]
    unit: [Z]
        X
        Y
        Z
    symbol: [=]
        >
        =
    number: [3]
    word: [fail]
```

Figure 5-17 Regular expression result

With this approach we were able to extract the patterns, get these values from the database and then replace them in the formula. All the expressions needed are now calculated and interpreted by the math parser.

To support the user, was created a help page with syntax and operation information [Appendix A: Math Parser Syntax], as showed in **Figure 5-18**.



Formula Help

Sintaxe All variables should be between brackets in order to preserve the correct precedence.

Example: *(VALUE1 + VALUE2) * (VALUE3)*

Variables A variable is a sum of all units with that name in the Database.

To count the values we should use the expression count() or countdist(). The expression count() is used to count numeric values and countdist() is used to count distinct values (text and numeric).

Example: *(ACTUAL > 2)* is a sum of all units named "ACTUAL" with a value bigger than 2.

count(ACTUAL > 2) counts all units named "ACTUAL" with a value bigger than 2.

countdist(ARTIFACT NAME & VERSION & N REWORKS > 0) counts all distinct artifacts and version with number of reworks greater than 0;

Operations Supported
- [^] - Arguments: 2, Precedence: 3
- [+] - Arguments: 2, Precedence: 6
- [-] - Arguments: 2, Precedence: 6
- [/] - Arguments: 2, Precedence: 4
- [*] - Arguments: 2, Precedence: 4
- [cos] - Arguments: 2, Precedence: 2
- [sin] - Arguments: 2, Precedence: 2
- [exp] - Arguments: 2, Precedence: 2
- [ln] - Arguments: 2, Precedence: 2
- [tan] - Arguments: 2, Precedence: 2
- [acos] - Arguments: 1, Precedence: 2
- [asin] - Arguments: 1, Precedence: 2
- [atan] - Arguments: 1, Precedence: 2
- [cosh] - Arguments: 1, Precedence: 2
- [sinh] - Arguments: 1, Precedence: 2
- [tanh] - Arguments: 1, Precedence: 2
- [sqrt] - Arguments: 1, Precedence: 2
- [cotan] - Arguments: 1, Precedence: 2
- [fpart] - Arguments: 1, Precedence: 2
- [acotan] - Arguments: 1, Precedence: 2
- [round] - Arguments: 1, Precedence: 2
- [ceil] - Arguments: 1, Precedence: 2
- [floor] - Arguments: 1, Precedence: 2
- [fac] - Arguments: 1, Precedence: 2

Figure 5-18 Formula help page

5.3.5 ZedGraph

The reasons behind the use of this charting library were already explained in Charting Tool (Section 3.3). It is available in a DLL that can be simply included in the project and implements all methods and controls to develop and manage the chart.

To use the component, we just need to initialize it by the function `InitializeComponent()` and then implement the methods to render the graph.

The X axis contains the time span and the Y axis the metric values. The method to calculate the metric results receives as a parameter the start date and the end date. This way we can parse the time span and present the evolution chart. When the time span is defined to a year, it was parsed by months, when defined to a month was parsed by weeks and when defined to weeks was parsed by days. These parsed values are the intervals in the X axis. The Y axis was divided in ten intervals, based on the maximum value of the chart.

Five types of chart were implemented (bar vertical, bar horizontal, line, high-low bar and stick) that can be chosen when creating the metric. When navigating to the visualization area the user sees the desired chart with the default time span.

In the chart page (**Figure 5-25**) the time span can be changed as referred, and also there's an option to show vertical and/or horizontal grid lines.

5.3.6 Windows Service

The application has to fetch data from databases of other applications and insert in its database to calculate and present the results. To do this work, it was implemented a timer based *Windows Service* that runs once a week and synchronizes this data. This service class is presented in **Figure 5-19**.

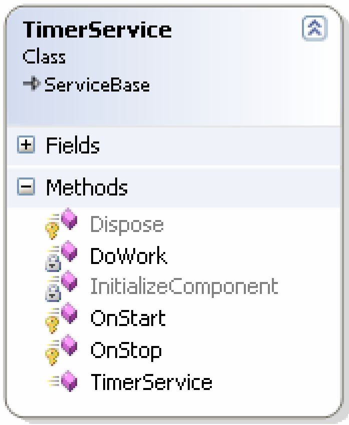


Figure 5-19 *Timer Service* Class Methods

The timer approach is the most common method and is probably the simplest to write and understand. The timer is created in the `OnStart()` event and the worker function attached to the timer. `DoWork()` is the method that contains the code to do the synchronization of data periodically, when the timer fires.

To install/uninstall the service was necessary the creation of an installer class (**Figure 5-20**). When launched, this class installs the service and calls the *Timer Service* class that fires the timer.

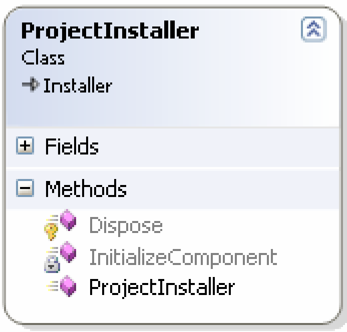
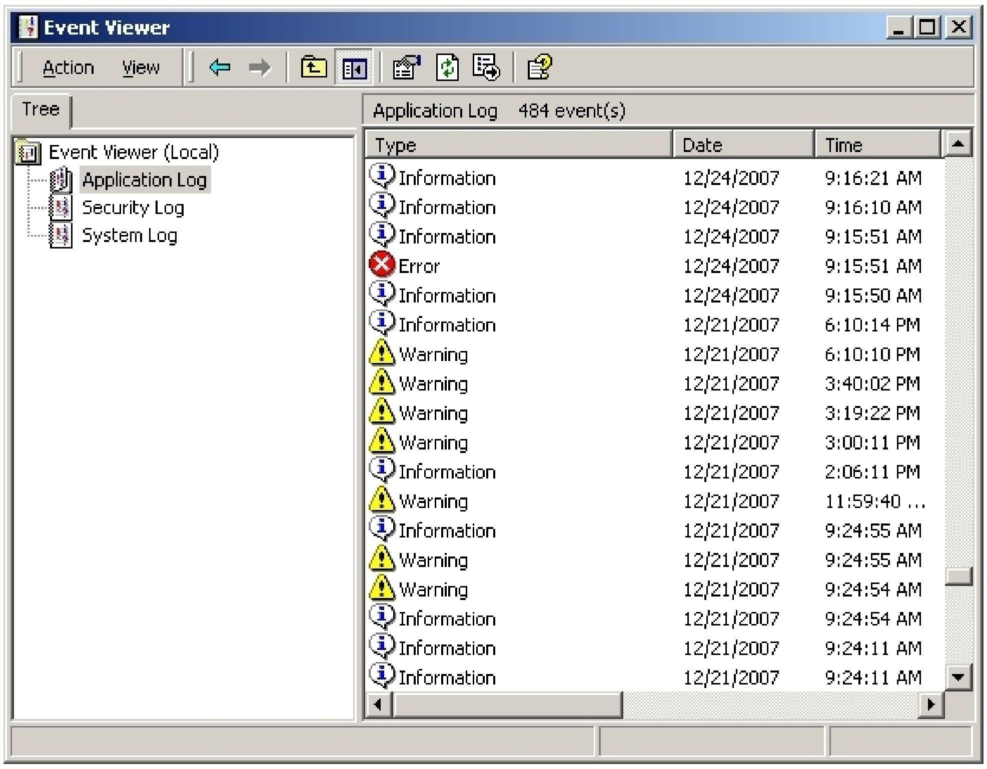


Figure 5-20 Service Installer Class

An important factor to have in mind is the error handling around the "work". If exceptions are not handled, we'll never know that an error happened, the worker thread will simply die and the service will keep running normally, unaware that the worker thread has terminated.

The service is working in background and we can't launch a message to the user if anything goes wrong. The only way to give some feedback about the work status is logging in the Event Viewer. There are three types of Event Log messages (*Information*, *Warning* and *Error*), as we can see in **Figure 5-21**.

When completed the work successfully, the service writes an information log with the actions done and the time the work finished. Otherwise, it writes an error message with the time occurred and the actions not completed.



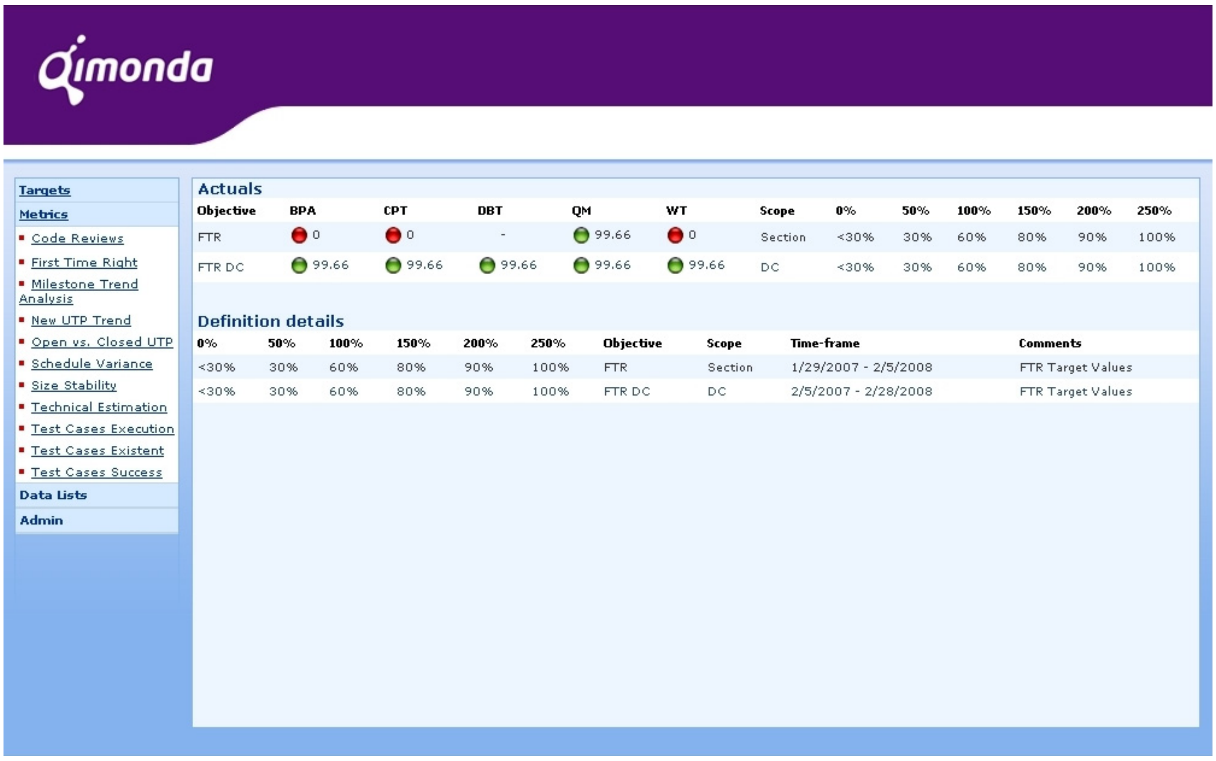
Type	Date	Time
Information	12/24/2007	9:16:21 AM
Information	12/24/2007	9:16:10 AM
Information	12/24/2007	9:15:51 AM
Error	12/24/2007	9:15:51 AM
Information	12/24/2007	9:15:50 AM
Information	12/21/2007	6:10:14 PM
Warning	12/21/2007	6:10:10 PM
Warning	12/21/2007	3:40:02 PM
Warning	12/21/2007	3:19:22 PM
Warning	12/21/2007	3:00:11 PM
Information	12/21/2007	2:06:11 PM
Warning	12/21/2007	11:59:40 ...
Information	12/21/2007	9:24:55 AM
Warning	12/21/2007	9:24:55 AM
Warning	12/21/2007	9:24:54 AM
Information	12/21/2007	9:24:54 AM
Information	12/21/2007	9:24:11 AM
Information	12/21/2007	9:24:11 AM

Figure 5-21 Event Viewer Logs

5.4 User Interface

Remembering Functional Requirements (Section 4.1.1), the application contains four distinct areas as we can see in the start page (**Figure 5-22**) left menu:

- Main: the application main page where we can view the actual target values and indicators.
- Metrics: this is the visualization area where metric results and charts are presented by scope.
- Data Lists: in this area we can upload and list metric raw data, which is stored in the database and used to calculate metrics.
- Admin: where the administrator can manage the entire application properties.



Actuals

Objective	BPA	CPT	DBT	QM	WT	Scope	0%	50%	100%	150%	200%	250%
FTR	🔴 0	🔴 0	-	🟢 99.66	🔴 0	Section	<30%	30%	60%	80%	90%	100%
FTR DC	🟢 99.66	🟢 99.66	🟢 99.66	🟢 99.66	🟢 99.66	DC	<30%	30%	60%	80%	90%	100%

Definition details

0%	50%	100%	150%	200%	250%	Objective	Scope	Time-frame	Comments
<30%	30%	60%	80%	90%	100%	FTR	Section	1/29/2007 - 2/5/2008	FTR Target Values
<30%	30%	60%	80%	90%	100%	FTR DC	DC	2/5/2007 - 2/28/2008	FTR Target Values

Figure 5-22 Targets Page (Application Start Page)

The application main page shows the defined targets, the current metric value for each one of these targets, the color semaphore indicating the level of achievement and the target description.

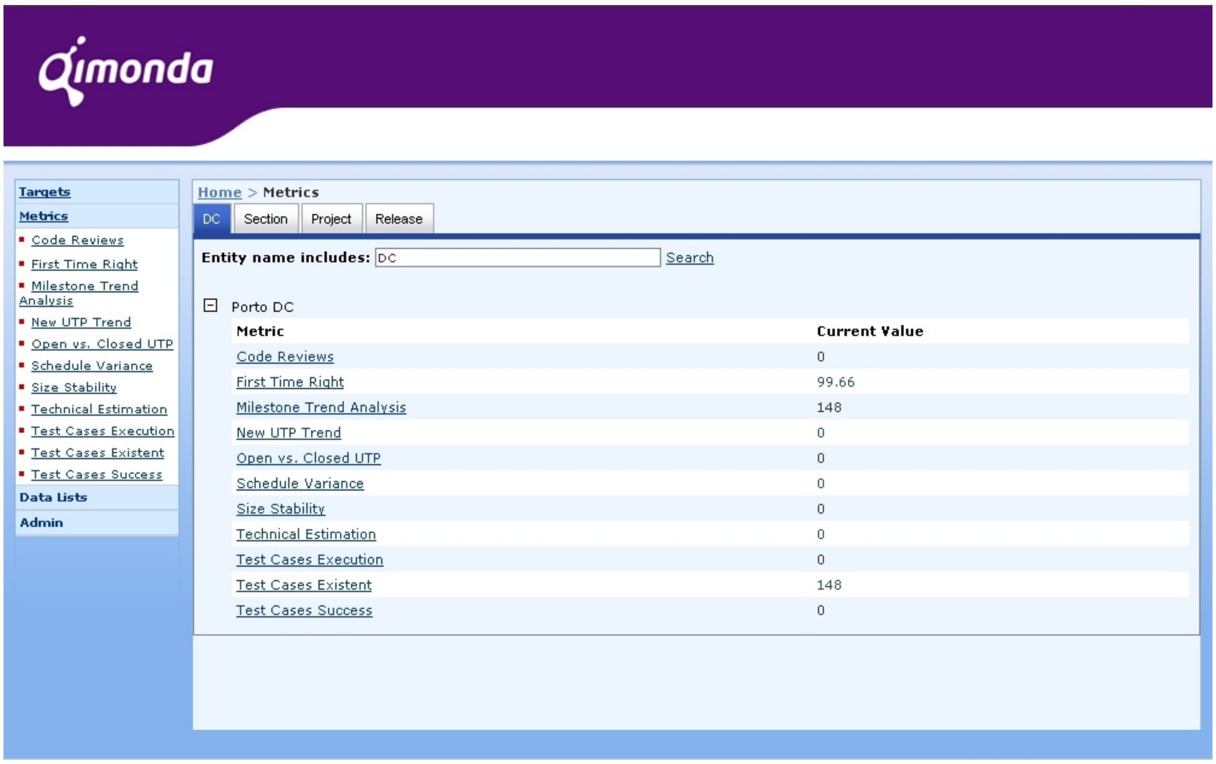
The other three main areas will be presented in more detail in the following subsections.

5.4.1 Metrics Area

This is the main visualization area, where we can see metric results and time evolution charts. These two cases will now be described with more detail.

5.4.1.1 View Results

Results can be viewed by scope or by metric. When viewed by scope, each scope entity contains the list of metrics defined and its values. The metrics main page screenshot (**Figure 5-23**) shows this example, where we can see all the metric values for the entity *Porto DC*.



Entity name includes: DC

Porto DC

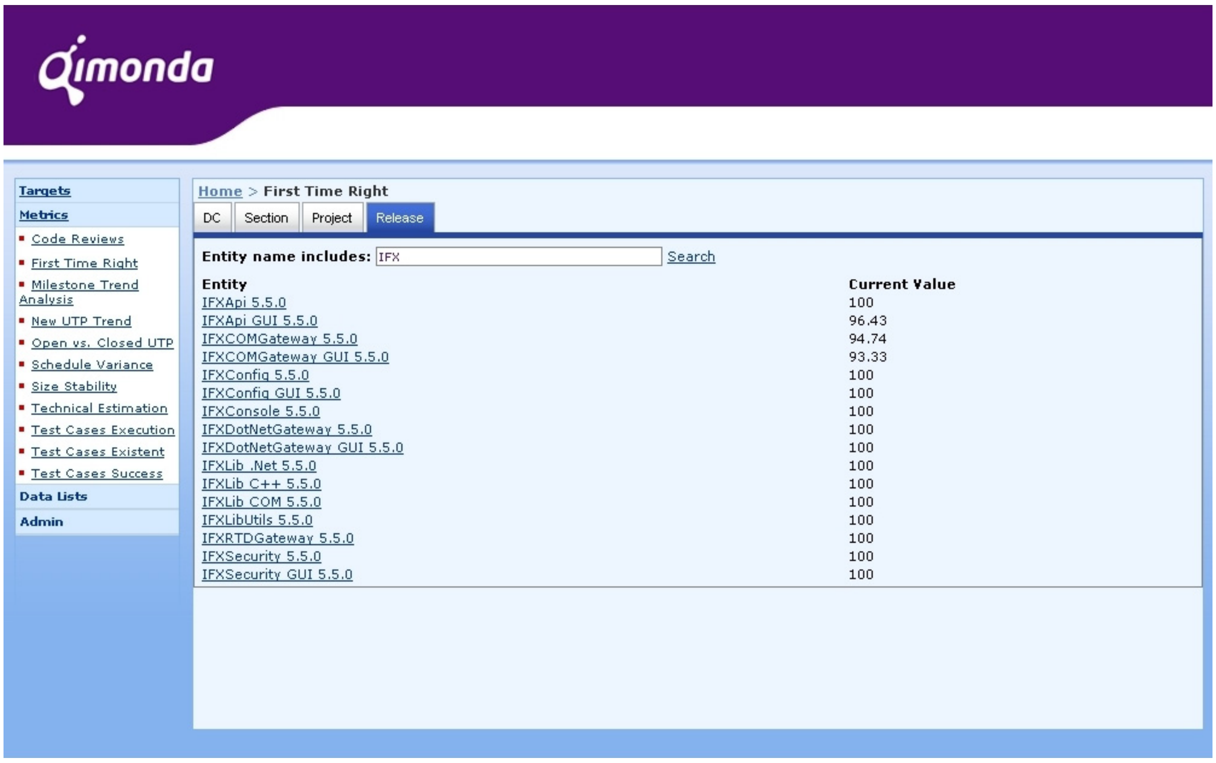
Metric	Current Value
Code Reviews	0
First Time Right	99.66
Milestone Trend Analysis	148
New UTP Trend	0
Open vs. Closed UTP	0
Schedule Variance	0
Size Stability	0
Technical Estimation	0
Test Cases Execution	0
Test Cases Existent	148
Test Cases Success	0

Figure 5-23 Metrics Main Page

This page shows all metrics for the selected scope (tab menu in the top) and its current value. The design is aligned with the colors and layout of the common Qimonda's web applications. Was also implemented a search field where the user can filter the results by the *Entity* name.

The top tab menu and the left menu are constructed dynamically and automatically from the data in the database. The tab menu gets the list of scopes from the database and sorts them by level. In the left menu we get the list of existing metrics, lists and forms, also dynamically and always updated. If we remove a metric, for example, it automatically leaves the list in the menu. These menus were implemented with TabContainer and Accordion Ajax controls, respectively.

Figure 5-24 shows the other example (by metric) where we can see only the value of one metric (in this case the metric *First Time Right*) for all the entities Release.



Entity name includes: IFX

Entity	Current Value
IFXApi 5.5.0	100
IFXApi GUI 5.5.0	96.43
IFXCOMGateway 5.5.0	94.74
IFXCOMGateway GUI 5.5.0	93.33
IFXConfig 5.5.0	100
IFXConfig GUI 5.5.0	100
IFXConsole 5.5.0	100
IFXDotNetGateway 5.5.0	100
IFXDotNetGateway GUI 5.5.0	100
IFXLib .Net 5.5.0	100
IFXLib C++ 5.5.0	100
IFXLib COM 5.5.0	100
IFXLibUtils 5.5.0	100
IFXRTDGateway 5.5.0	100
IFXSecurity 5.5.0	100
IFXSecurity GUI 5.5.0	100

Figure 5-24 Results viewed by metric

5.4.1.2 View Chart

The application support five different types of chart: horizontal bars, vertical bars, line, high-low bars and stick lines.

As described above, results can be seen by scope or by metric. This is also true for the time evolution chart. In the example of the **Figure 5-24** we only need to follow the *link* in the release name and we navigate to the chart page (**Figure 5-25**).

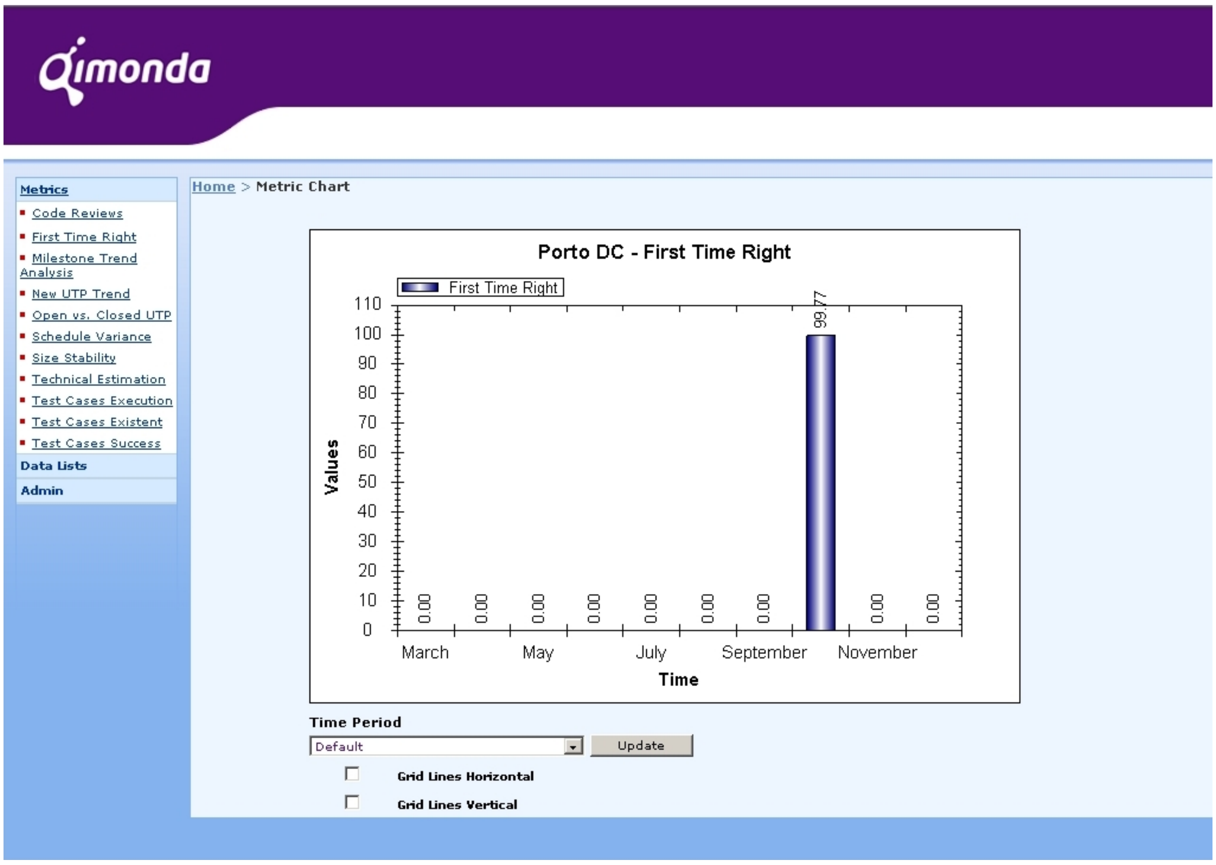


Figure 5-25 Chart page

In this page we can change the data range of the chart and select to show grid lines horizontal or/and vertical. The chart is assigned to a metric and its properties can be changed in the Admin Area (Section 5.4.3).

5.4.2 Data Lists Area

In this area we can upload and list metric raw data, which is stored in the database and used to calculate metrics. This menu is constructed automatically from the Lists and Forms in the database. Because of the feature to upload from different sources, it became necessary to create different pages to perform these actions, which will be presented next as well as the data list visualization pages.

5.4.2.1 Import from Excel

As described in Excel Import (Section 5.3.2), when importing data from an Excel file we should provide the entity to which data will be uploaded (optional if the entity is defined in the file), the date of the data (also optional if the file has a column namely “date”) and then browse and select the file to upload as shown in **Figure 5-26**.

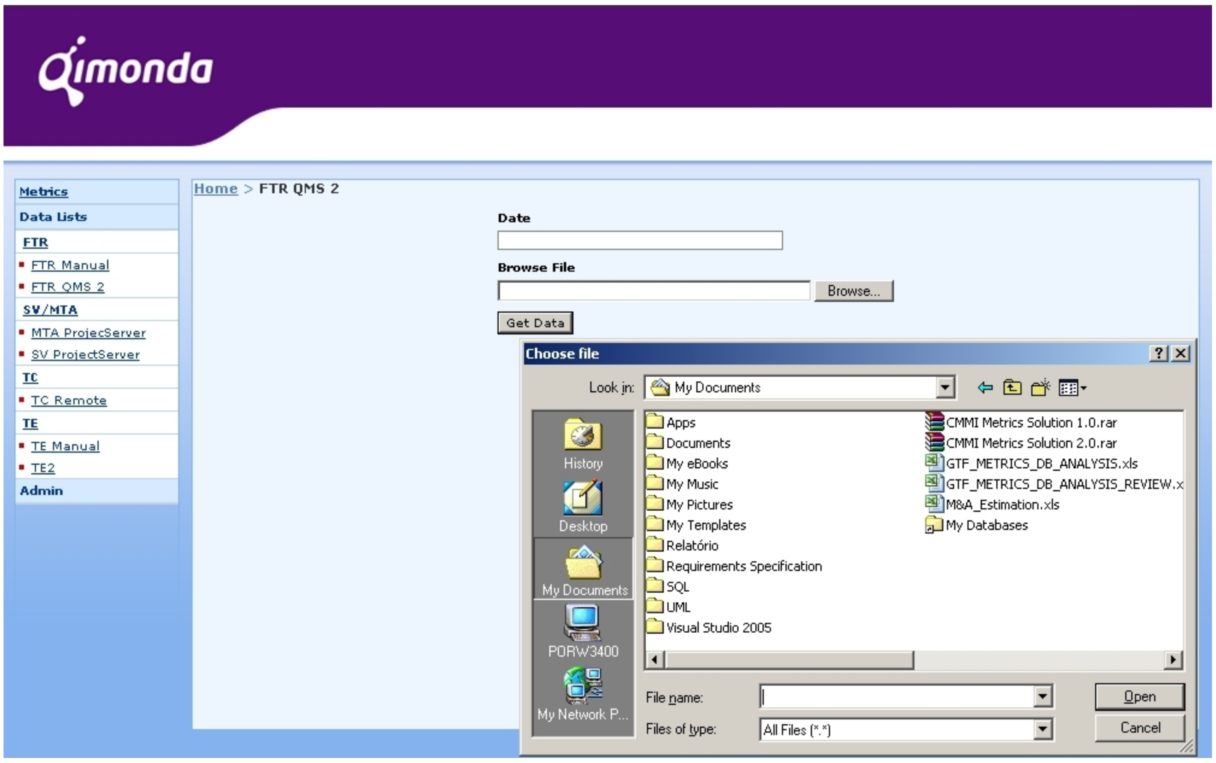


Figure 5-26 Upload Excel file page

5.4.2.2 *Import from Project Server*

When importing data from Project Server, the user only needs to provide the project to fetch data and, optionally, its releases. Additionally, was implemented a button to update all project data. It gets all projects and releases from the database and then fetches all the information from the Project Server, as presented in **Figure 5-27**.

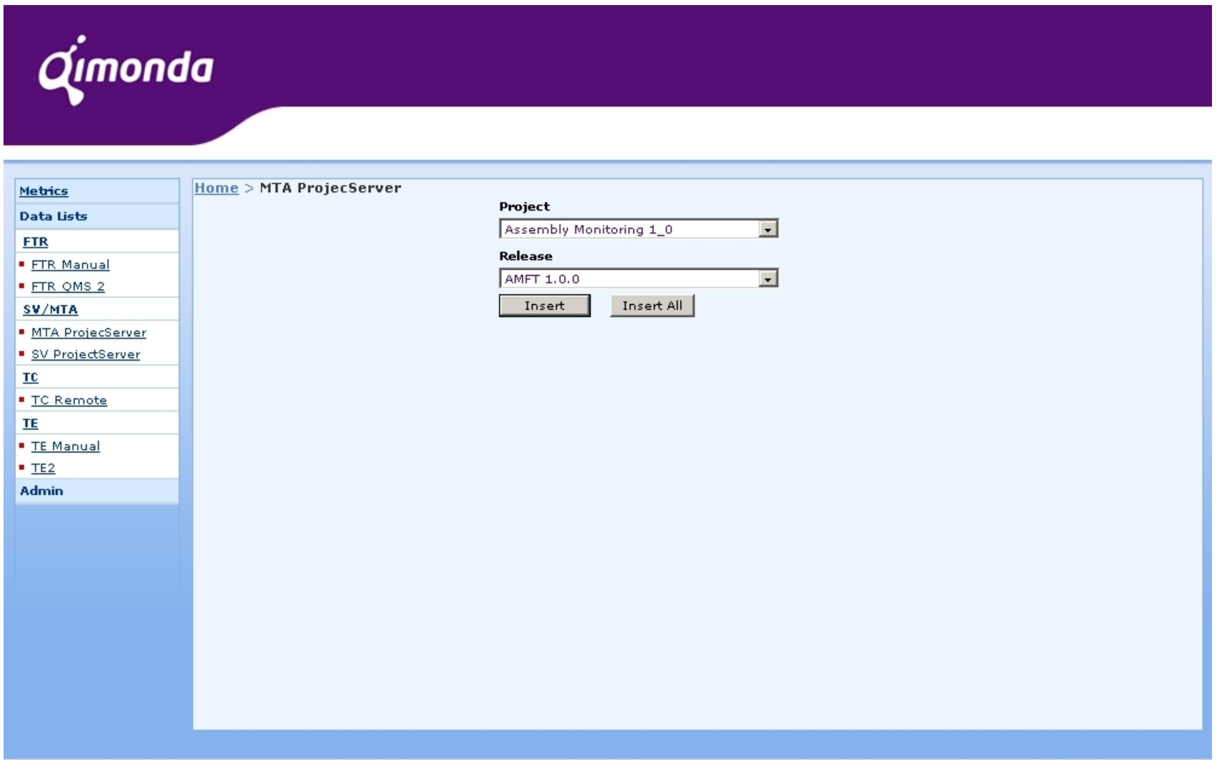


Figure 5-27 Import from Project Server page

5.4.2.3 *Manual Insertion*

The page that implements the manual insertion of data is the same for all the metrics and is dynamically constructed. The fields where the user can insert the values are fetched dynamically from the units defined in the database. In the next figure, we can see an example of this page where the units defined are “N reworks”, “Artifact name” and “Version”. The data type to be inserted is also in front of each text box.

The *Entity* and *Date* fields are mandatory for all the forms.

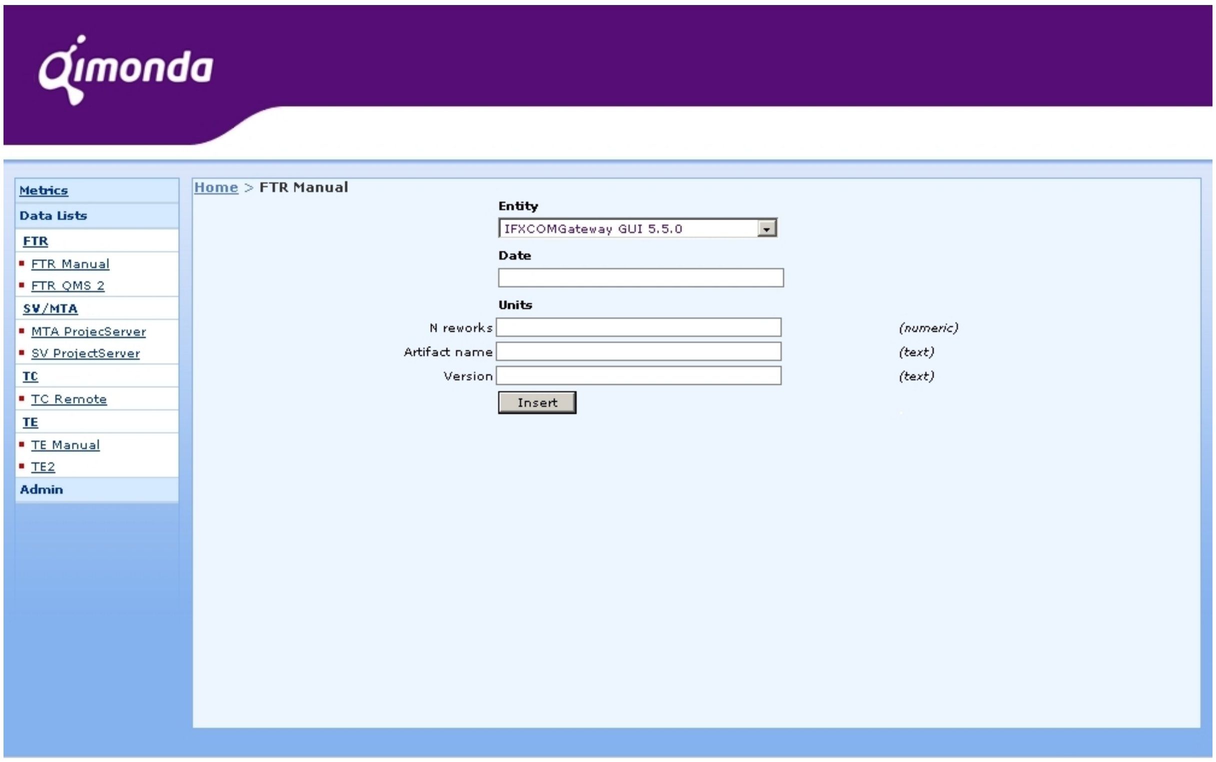
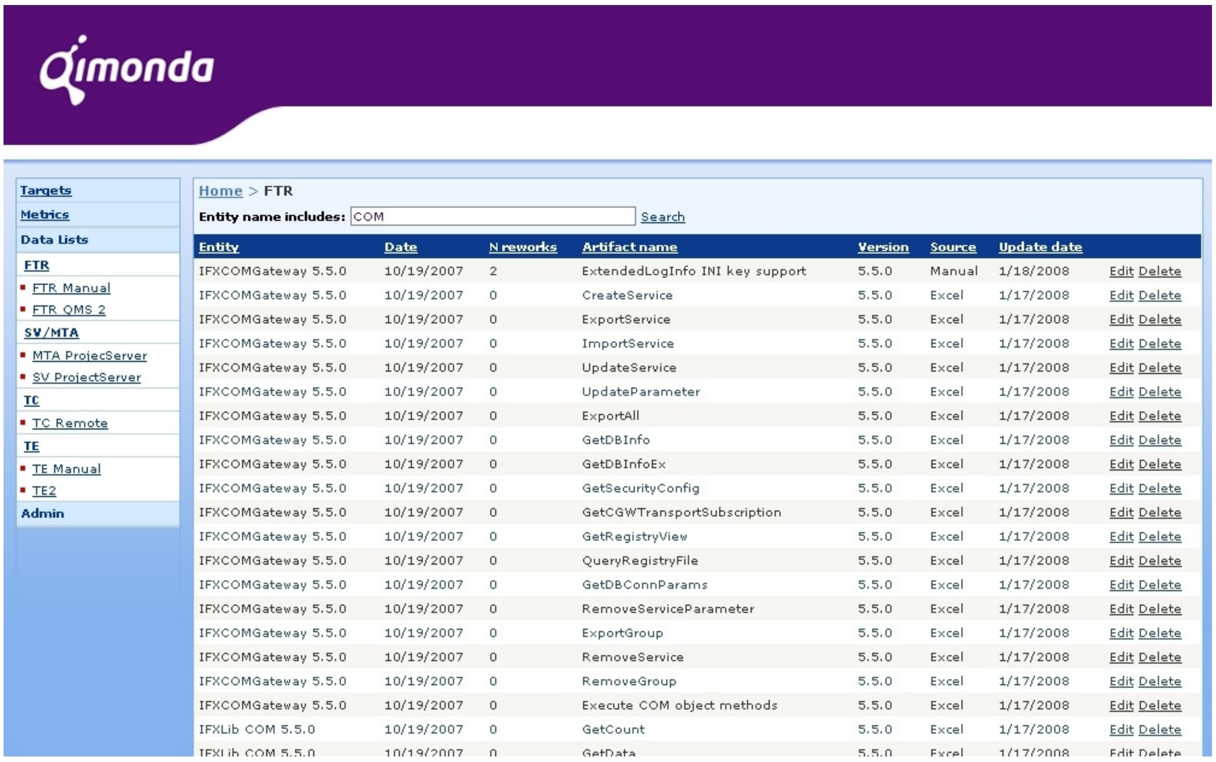


Figure 5-28 Manual insertion page

5.4.2.4 *Data List Visualization*

The visualization of the metric raw data inserted is also constructed dynamically. This page implements a GridView control and the columns to show are the units defined for the Data List. The following figure shows an example of a list created with the same units of the **Figure 5-28**. The fields *Entity*, *Date*, *Source* and *Update date* are mandatory for all the Data Lists.

It was implemented a search field where the user can filter the Data List by the *Entity* name and all tables and data grids of the application can be sorted, simply selecting the link in the header of each column.



Home > FTR

Entity name includes: COM Search

Entity	Date	N reworks	Artifact name	Version	Source	Update date	
IFXCOMGateway 5.5.0	10/19/2007	2	ExtendedLogInfo INI key support	5.5.0	Manual	1/18/2008	Edit Delete
IFXCOMGateway 5.5.0	10/19/2007	0	CreateService	5.5.0	Excel	1/17/2008	Edit Delete
IFXCOMGateway 5.5.0	10/19/2007	0	ExportService	5.5.0	Excel	1/17/2008	Edit Delete
IFXCOMGateway 5.5.0	10/19/2007	0	ImportService	5.5.0	Excel	1/17/2008	Edit Delete
IFXCOMGateway 5.5.0	10/19/2007	0	UpdateService	5.5.0	Excel	1/17/2008	Edit Delete
IFXCOMGateway 5.5.0	10/19/2007	0	UpdateParameter	5.5.0	Excel	1/17/2008	Edit Delete
IFXCOMGateway 5.5.0	10/19/2007	0	ExportAll	5.5.0	Excel	1/17/2008	Edit Delete
IFXCOMGateway 5.5.0	10/19/2007	0	GetDBInfo	5.5.0	Excel	1/17/2008	Edit Delete
IFXCOMGateway 5.5.0	10/19/2007	0	GetDBInfoEx	5.5.0	Excel	1/17/2008	Edit Delete
IFXCOMGateway 5.5.0	10/19/2007	0	GetSecurityConfig	5.5.0	Excel	1/17/2008	Edit Delete
IFXCOMGateway 5.5.0	10/19/2007	0	GetCGWTransportSubscription	5.5.0	Excel	1/17/2008	Edit Delete
IFXCOMGateway 5.5.0	10/19/2007	0	GetRegistryView	5.5.0	Excel	1/17/2008	Edit Delete
IFXCOMGateway 5.5.0	10/19/2007	0	QueryRegistryFile	5.5.0	Excel	1/17/2008	Edit Delete
IFXCOMGateway 5.5.0	10/19/2007	0	GetDBConnParams	5.5.0	Excel	1/17/2008	Edit Delete
IFXCOMGateway 5.5.0	10/19/2007	0	RemoveServiceParameter	5.5.0	Excel	1/17/2008	Edit Delete
IFXCOMGateway 5.5.0	10/19/2007	0	ExportGroup	5.5.0	Excel	1/17/2008	Edit Delete
IFXCOMGateway 5.5.0	10/19/2007	0	RemoveService	5.5.0	Excel	1/17/2008	Edit Delete
IFXCOMGateway 5.5.0	10/19/2007	0	RemoveGroup	5.5.0	Excel	1/17/2008	Edit Delete
IFXCOMGateway 5.5.0	10/19/2007	0	Execute COM object methods	5.5.0	Excel	1/17/2008	Edit Delete
IFXLib COM 5.5.0	10/19/2007	0	GetCount	5.5.0	Excel	1/17/2008	Edit Delete
IFXLib COM 5.5.0	10/19/2007	0	GetData	5.5.0	Excel	1/17/2008	Edit Delete

Figure 5-29 Data List page

5.4.3 Admin Area

In this area, the administrator can customize the application, creating, editing and removing all the objects referred in Object Classes (Section 5.3.1). All parameters can be edited inside the application, avoiding the need to rewrite code if some parameter or configuration has to change. In the next subsections are presented in more detail these application management operations.

5.4.3.1 Scope Management

Starting with the insertion of a new scope, the user should introduce the *Name*, *Parent* and *Description* in the text boxes like in **Figure 5-30**.

When listing all the scopes, the user can view a table with all the scopes, sorted by its level. An example of this table is provided in **Figure 5-31**. The last two columns contain *link buttons* to edit and remove the scopes.

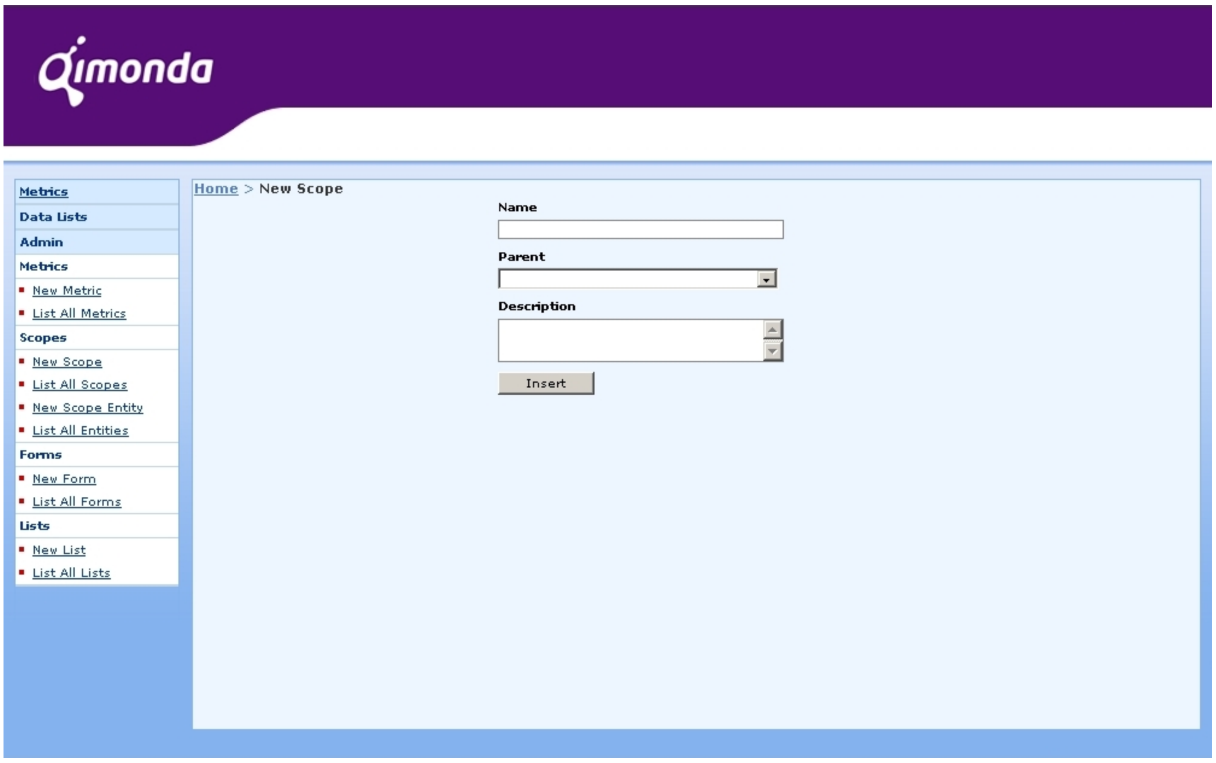
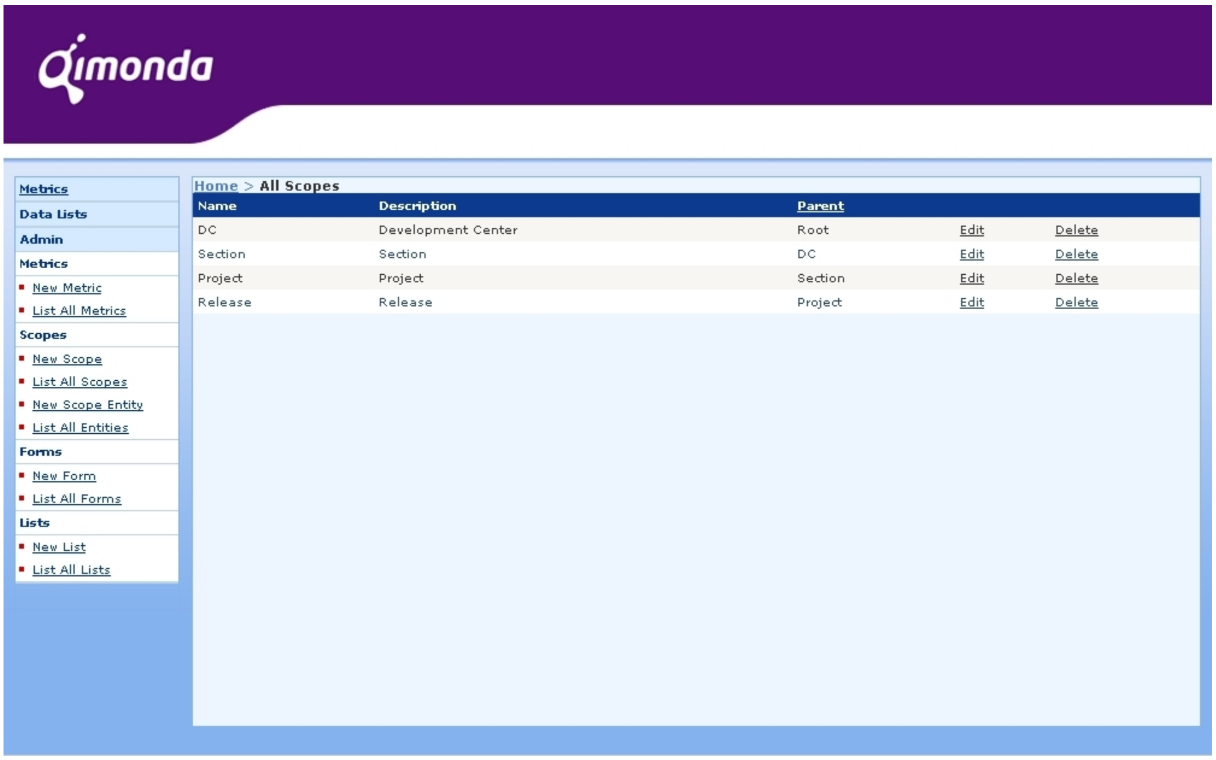


Figure 5-30 New Scope page

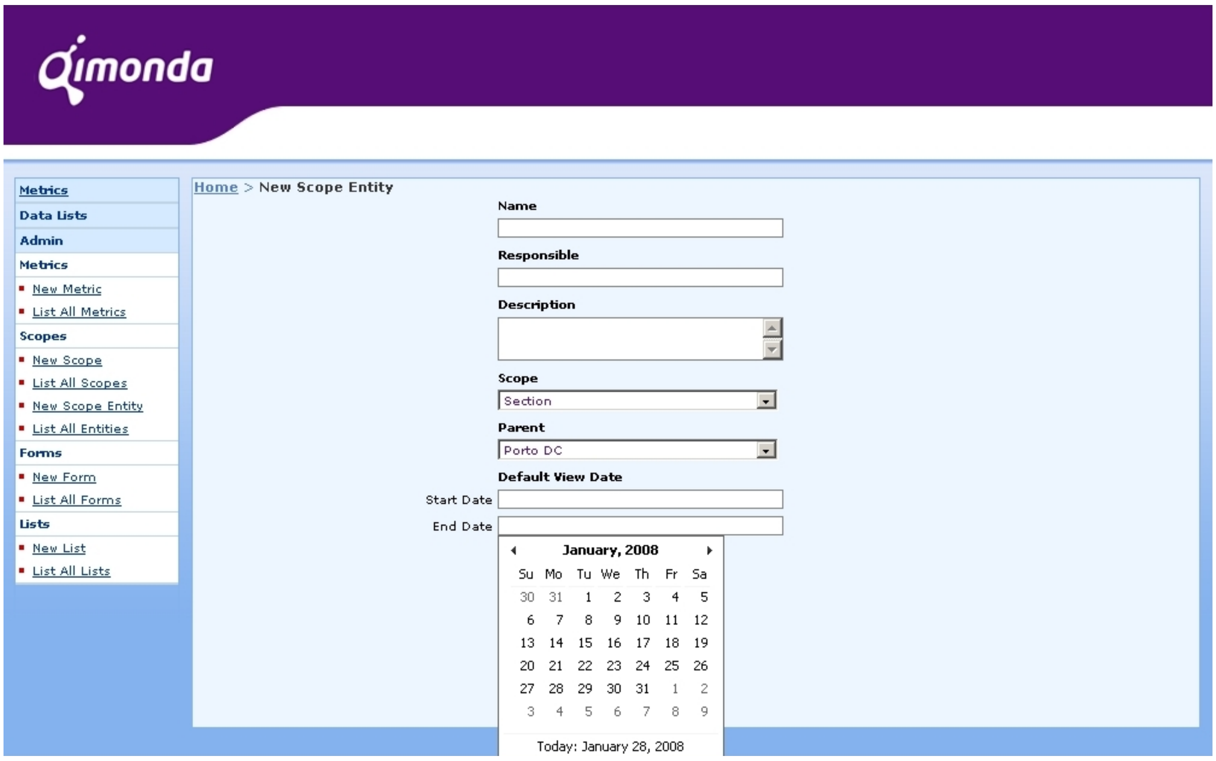


Name	Description	Parent		
DC	Development Center	Root	Edit	Delete
Section	Section	DC	Edit	Delete
Project	Project	Section	Edit	Delete
Release	Release	Project	Edit	Delete

Figure 5-31 List Scopes page

5.4.3.2 *Scope Entity Management*

The scope entity management operations are similar to scope management. Adding a new scope entity, the user provides the *Name*, *Responsible*, *Description*, *Scope*, *Parent* and *Default View Date*. This last input is the default date span to visualize data. When choosing the scope, the field parent is automatically updated, displaying only the possible parents from the selected scope, avoiding human errors and inconsistencies.



Home > New Scope Entity

Name

Responsible

Description

Scope: Section

Parent: Porto DC

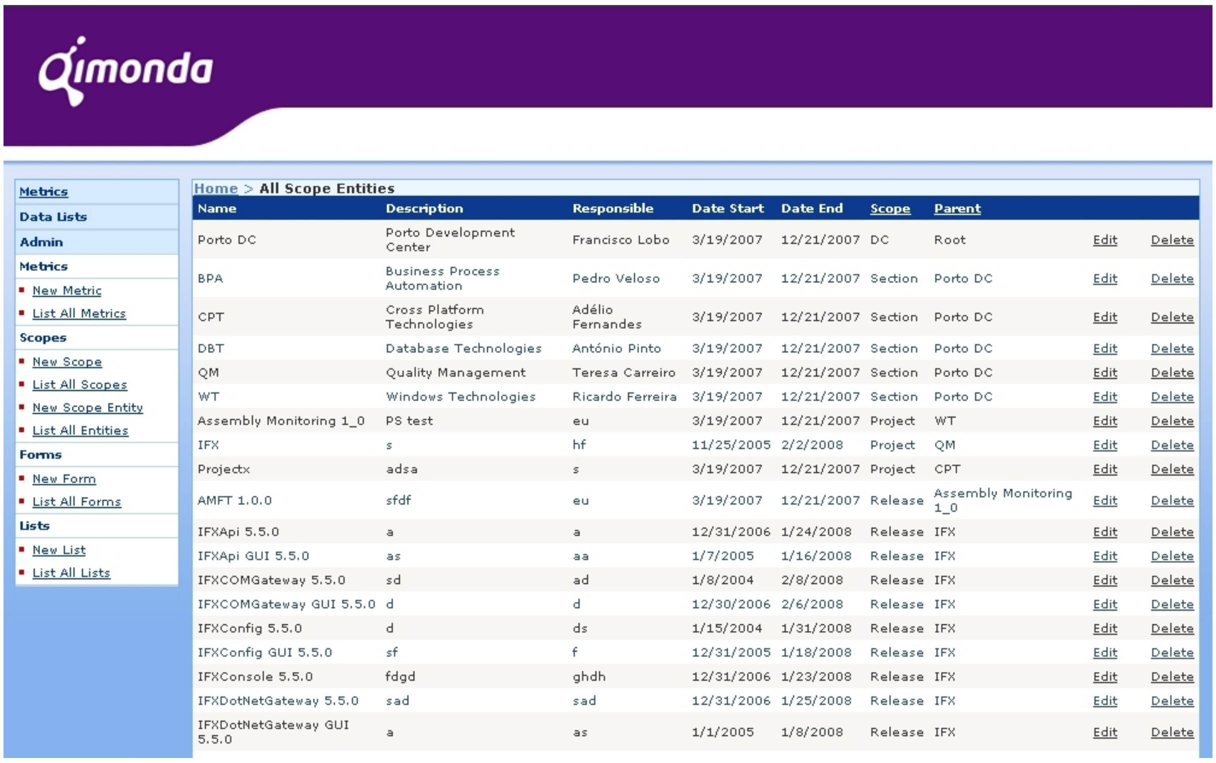
Default View Date

Start Date

End Date

Figure 5-32 New Scope Entity page

The table where the entities are listed (**Figure 5-33**) contains these attributes, plus two columns to allow edition and removal.



Home > All Scope Entities

Name	Description	Responsible	Date Start	Date End	Scope	Parent		
Porto DC	Porto Development Center	Francisco Lobo	3/19/2007	12/21/2007	DC	Root	Edit	Delete
BPA	Business Process Automation	Pedro Veloso	3/19/2007	12/21/2007	Section	Porto DC	Edit	Delete
CPT	Cross Platform Technologies	Adélio Fernandes	3/19/2007	12/21/2007	Section	Porto DC	Edit	Delete
DBT	Database Technologies	António Pinto	3/19/2007	12/21/2007	Section	Porto DC	Edit	Delete
QM	Quality Management	Teresa Carreiro	3/19/2007	12/21/2007	Section	Porto DC	Edit	Delete
WT	Windows Technologies	Ricardo Ferreira	3/19/2007	12/21/2007	Section	Porto DC	Edit	Delete
Assembly Monitoring 1_0	PS test	eu	3/19/2007	12/21/2007	Project	WT	Edit	Delete
IFX	s	hf	11/25/2005	2/2/2008	Project	QM	Edit	Delete
Projectx	adsa	s	3/19/2007	12/21/2007	Project	CPT	Edit	Delete
AMFT 1.0.0	sfdf	eu	3/19/2007	12/21/2007	Release	Assembly Monitoring 1_0	Edit	Delete
IFXApi 5.5.0	a	a	12/31/2006	1/24/2008	Release	IFX	Edit	Delete
IFXApi GUI 5.5.0	as	aa	1/7/2005	1/16/2008	Release	IFX	Edit	Delete
IFXCOMGateway 5.5.0	sd	ad	1/8/2004	2/8/2008	Release	IFX	Edit	Delete
IFXCOMGateway GUI 5.5.0	d	d	12/30/2006	2/6/2008	Release	IFX	Edit	Delete
IFXConfig 5.5.0	d	ds	1/15/2004	1/31/2008	Release	IFX	Edit	Delete
IFXConfig GUI 5.5.0	sf	f	12/31/2005	1/18/2008	Release	IFX	Edit	Delete
IFXConsole 5.5.0	fdgd	ghdh	12/31/2006	1/23/2008	Release	IFX	Edit	Delete
IFXDotNetGateway 5.5.0	sad	sad	12/31/2006	1/25/2008	Release	IFX	Edit	Delete
IFXDotNetGateway GUI 5.5.0	a	as	1/1/2005	1/8/2008	Release	IFX	Edit	Delete

Figure 5-33 List Scope Entities page

5.4.3.3 *Metric Management*

Adding new metrics has two steps. In the first page the user inserts the *Name*, *Acronym*, *Description* and *Scope*, as presented in **Figure 5-34**.

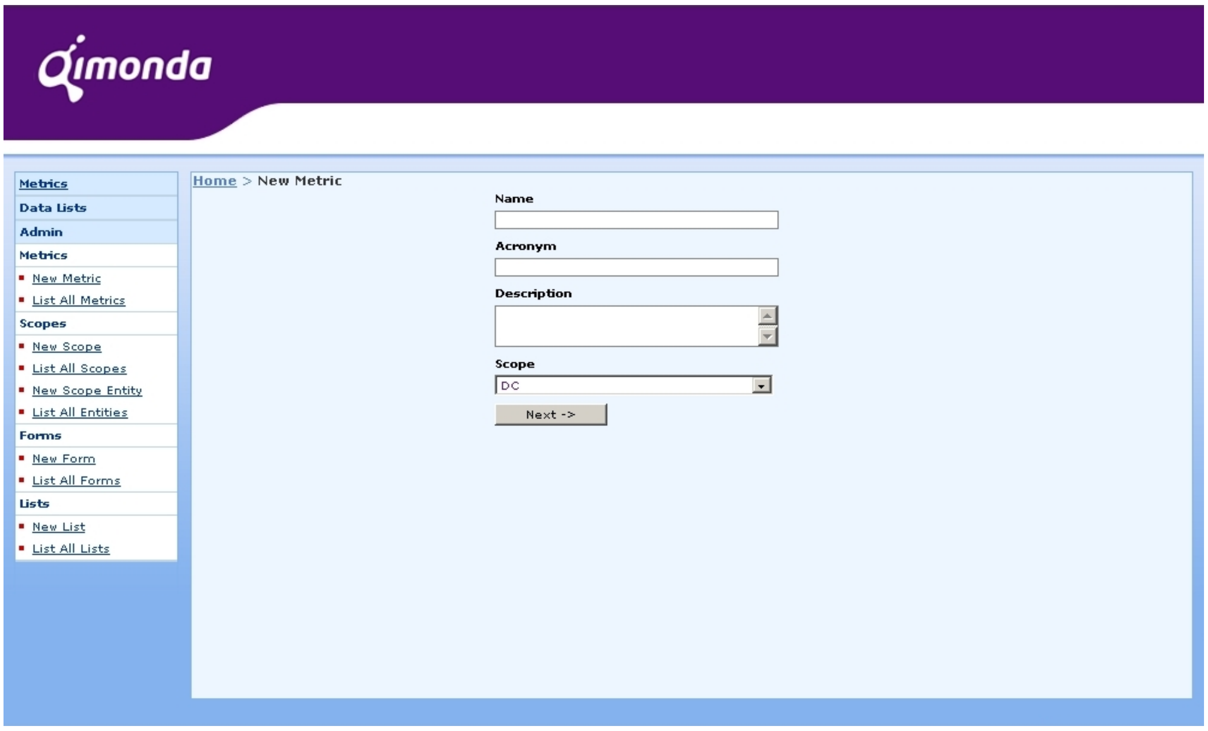
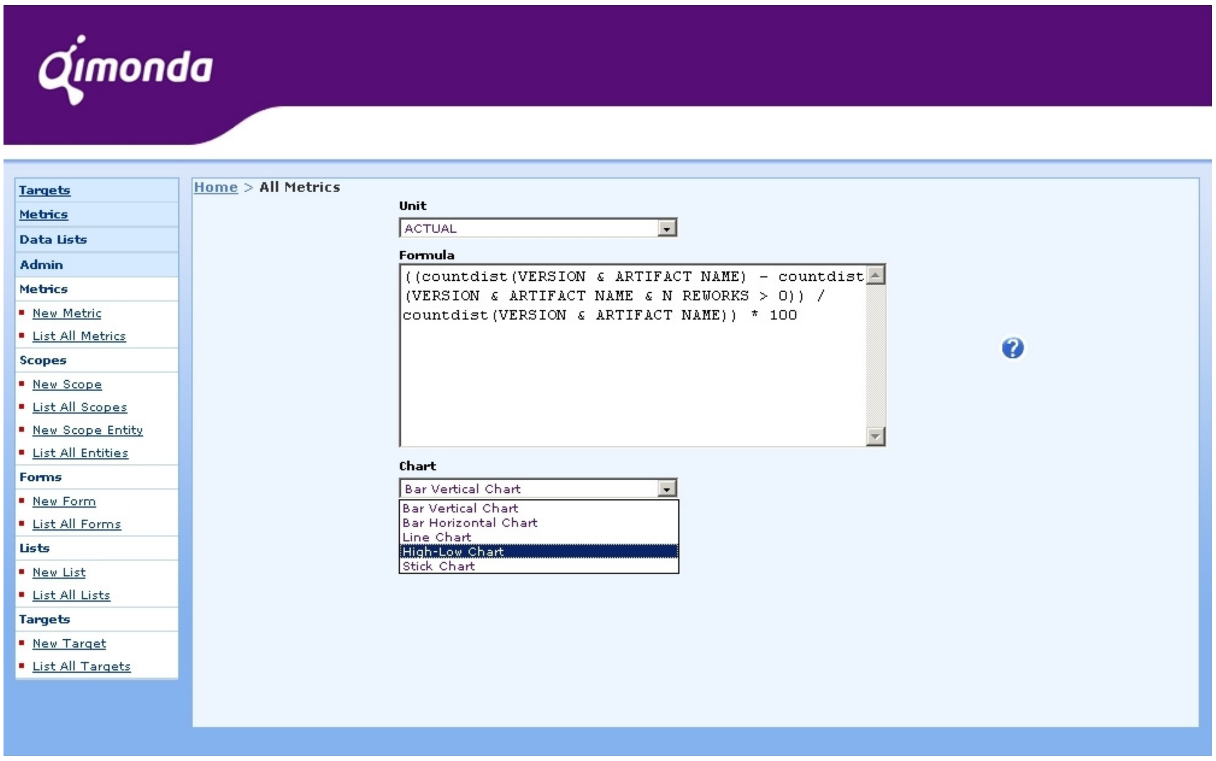


Figure 5-34 New Metric page

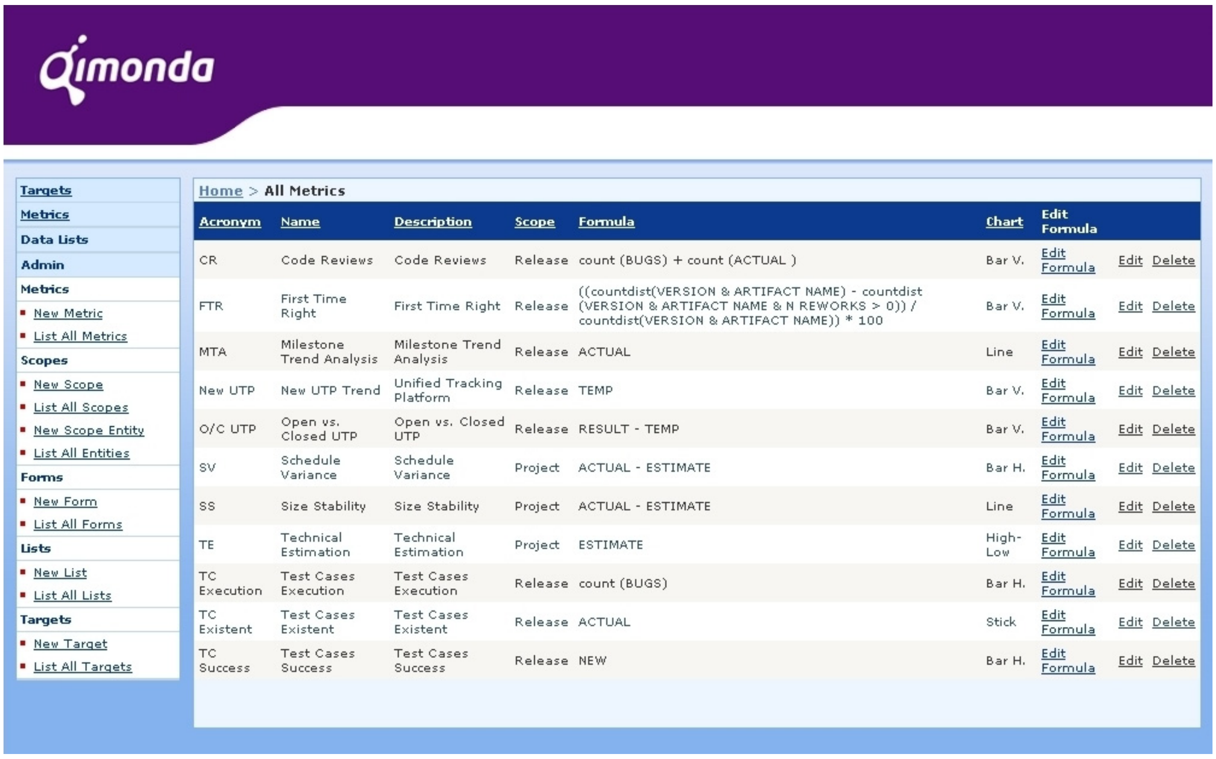
After these actions, another page where the user can insert other type of metric attributes (*Formula* and *Chart*) is displayed. In the right side of the formula text box, the user can view the formula help page presented in **Figure 5-18**.



```
((countdist(VERSION & ARTIFACT NAME) - countdist
(VERSION & ARTIFACT NAME & N REWORKS > 0)) /
countdist(VERSION & ARTIFACT NAME)) * 100
```

Figure 5-35 Add Formula page

The table to list metrics (**Figure 5-36**) has three additional columns (*Edit Formula*, *Edit* and *Remove*). When selecting *Edit Formula*, the user is redirected to the *Add Formula* page with the previous values to edit. This way he doesn't have to fill all the values again.

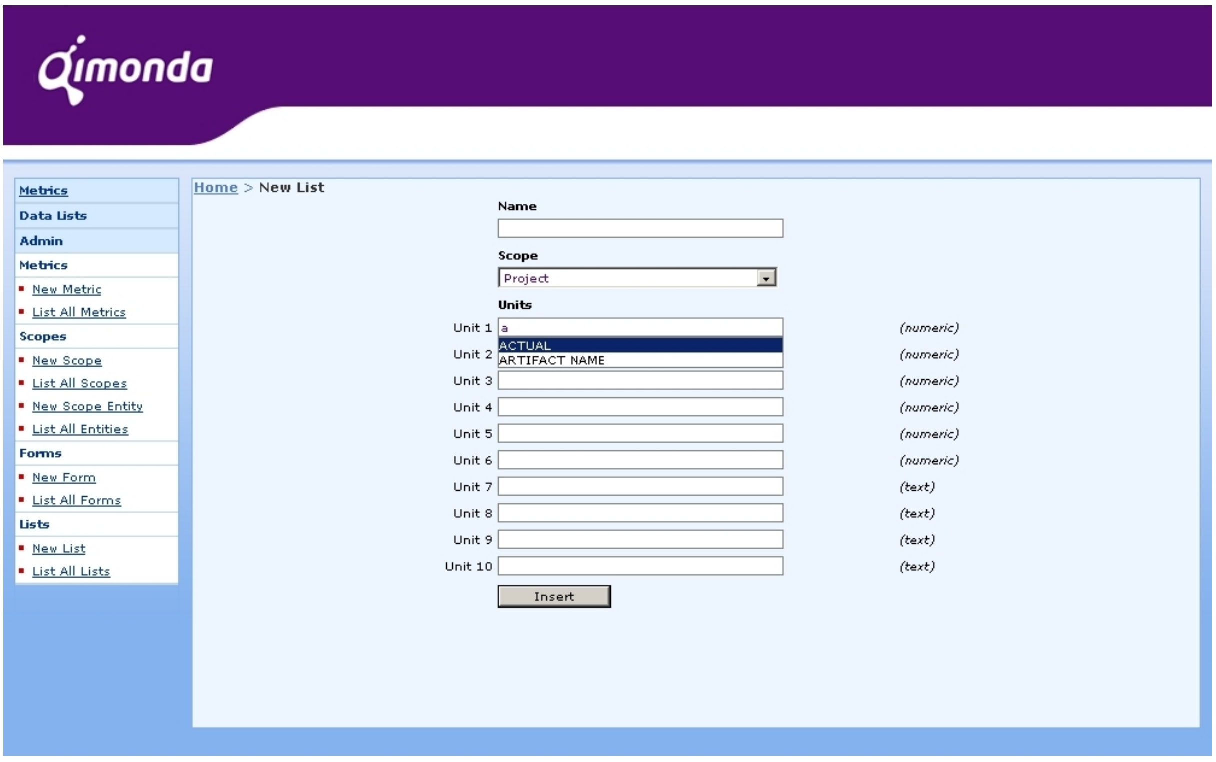


Acronym	Name	Description	Scope	Formula	Chart	Edit Formula		
CR	Code Reviews	Code Reviews	Release	count (BUGS) + count (ACTUAL)	Bar V.	Edit Formula	Edit	Delete
FTR	First Time Right	First Time Right	Release	((countdist(VERSION & ARTIFACT NAME) - countdist (VERSION & ARTIFACT NAME & N REWORKS > 0)) / countdist(VERSION & ARTIFACT NAME)) * 100	Bar V.	Edit Formula	Edit	Delete
MTA	Milestone Trend Analysis	Milestone Trend Analysis	Release	ACTUAL	Line	Edit Formula	Edit	Delete
New UTP	New UTP Trend	Unified Tracking Platform	Release	TEMP	Bar V.	Edit Formula	Edit	Delete
O/C UTP	Open vs. Closed UTP	Open vs. Closed UTP	Release	RESULT - TEMP	Bar V.	Edit Formula	Edit	Delete
SV	Schedule Variance	Schedule Variance	Project	ACTUAL - ESTIMATE	Bar H.	Edit Formula	Edit	Delete
SS	Size Stability	Size Stability	Project	ACTUAL - ESTIMATE	Line	Edit Formula	Edit	Delete
TE	Technical Estimation	Technical Estimation	Project	ESTIMATE	High-Low	Edit Formula	Edit	Delete
TC Execution	Test Cases Execution	Test Cases Execution	Release	count (BUGS)	Bar H.	Edit Formula	Edit	Delete
TC Existent	Test Cases Existent	Test Cases Existent	Release	ACTUAL	Stick	Edit Formula	Edit	Delete
TC Success	Test Cases Success	Test Cases Success	Release	NEW	Bar H.	Edit Formula	Edit	Delete

Figure 5-36 Metric List page

5.4.3.4 Lists Management

When adding a new list, the user should insert the *Name*, *Scope*, and the name of all *Units*, as presented in **Figure 5-37**. *Units 1* to *6* are numeric and *Units 7* to *10* are textual. In these text boxes were implemented, as we can see, the Ajax AutoCompleteExtender for the user to know if a unit exists or to help inserting an existing unit.



Name

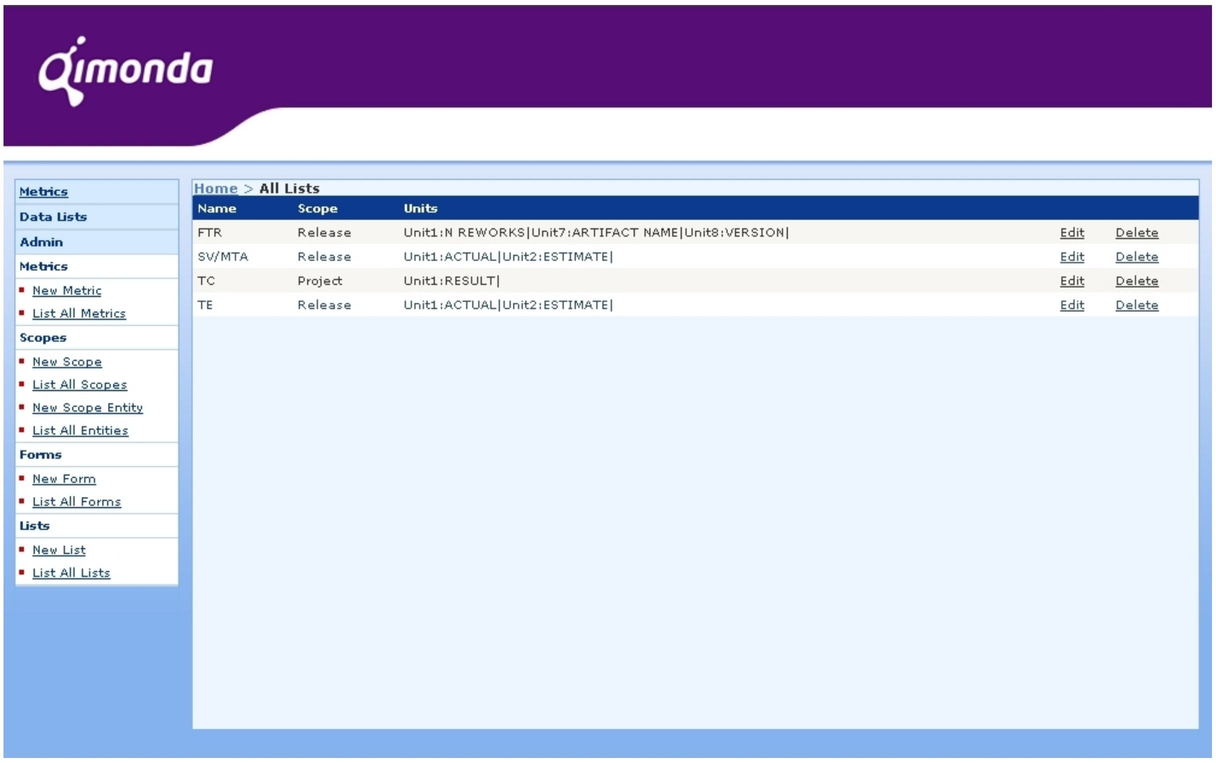
Scope: Project

Units

Unit 1	a	(numeric)
Unit 2	ACTUAL ARTIFACT NAME	(numeric)
Unit 3		(numeric)
Unit 4		(numeric)
Unit 5		(numeric)
Unit 6		(numeric)
Unit 7		(text)
Unit 8		(text)
Unit 9		(text)
Unit 10		(text)

Figure 5-37 New List page

The table to list all the *Lists* follows the usual layout and presents its attributes, plus the field *Edit* and *Remove*.



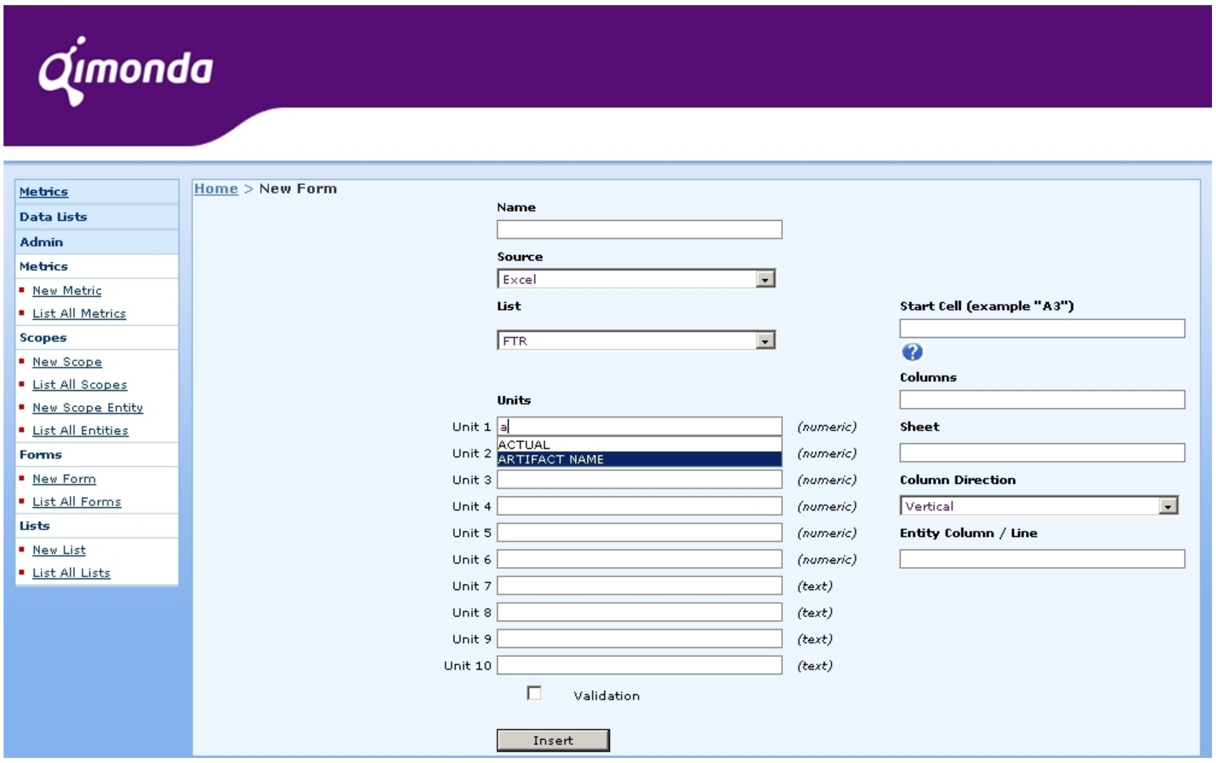
Name	Scope	Units		
FTR	Release	Unit1:N REWORKS|Unit7:ARTIFACT NAME|Unit8:VERSION|	Edit	Delete
SV/MTA	Release	Unit1:ACTUAL|Unit2:ESTIMATE|	Edit	Delete
TC	Project	Unit1:RESULT|	Edit	Delete
TE	Release	Unit1:ACTUAL|Unit2:ESTIMATE|	Edit	Delete

Figure 5-38 All Lists page

5.4.3.5 Forms Management

When adding a new Form, the user has to provide the *Name*, *Source* (Excel, Project Server or Manual), *List*, *Units* and check if we want data validation when inserting data using this *Form*. The insertion of *Units* in *Forms* is done like in *Lists*, presented before.

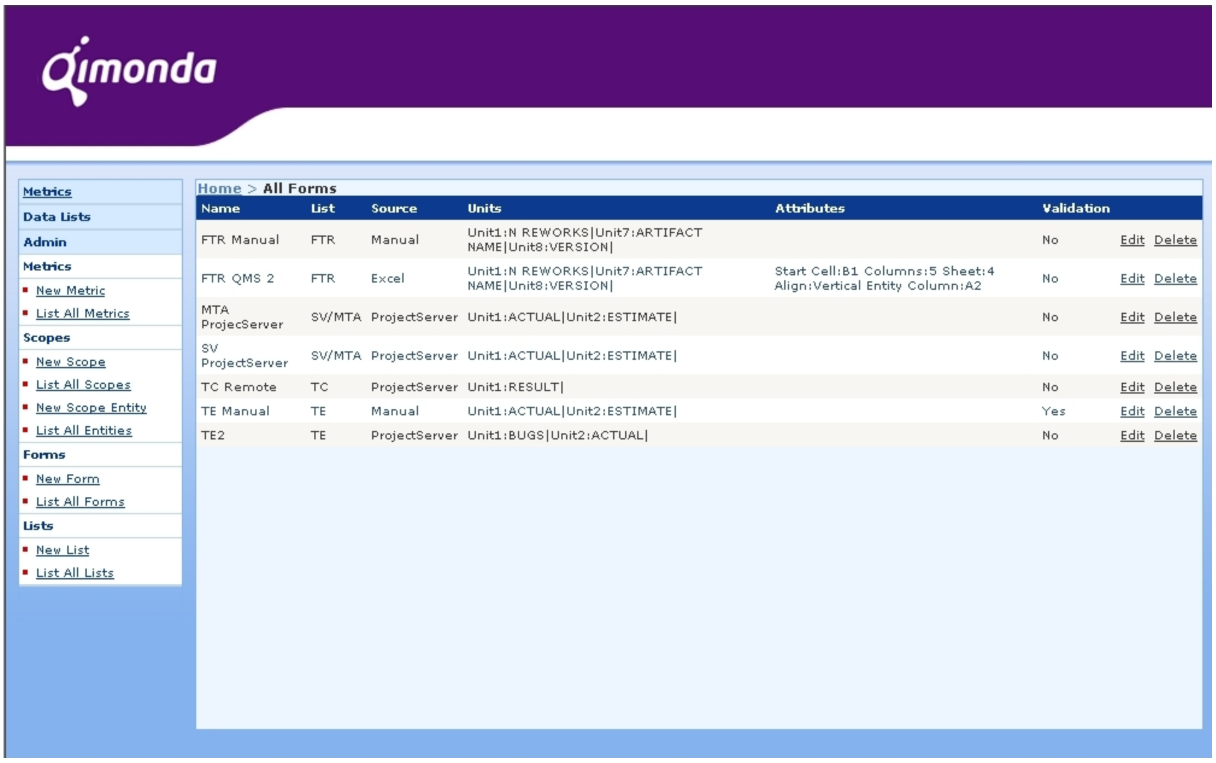
When selecting the Excel value to the Source, additional fields appear (**Figure 5-39**). These are the attributes of the *Excel* import, defined in Excel Import (Section 5.3.2).



Name		
Source	Excel	
List	FTR	
Start Cell (example "A3")		
Columns		
Sheet		
Column Direction	Vertical	
Entity Column / Line		
Units		
Unit 1	a (ACTUAL / ARTIFACT NAME)	(numeric)
Unit 2		(numeric)
Unit 3		(numeric)
Unit 4		(numeric)
Unit 5		(numeric)
Unit 6		(numeric)
Unit 7		(text)
Unit 8		(text)
Unit 9		(text)
Unit 10		(text)
Validation	☐	

Figure 5-39 New Excel Form page

Figure 5-40 presents the *Form* listing and shows all these attributes in a table.

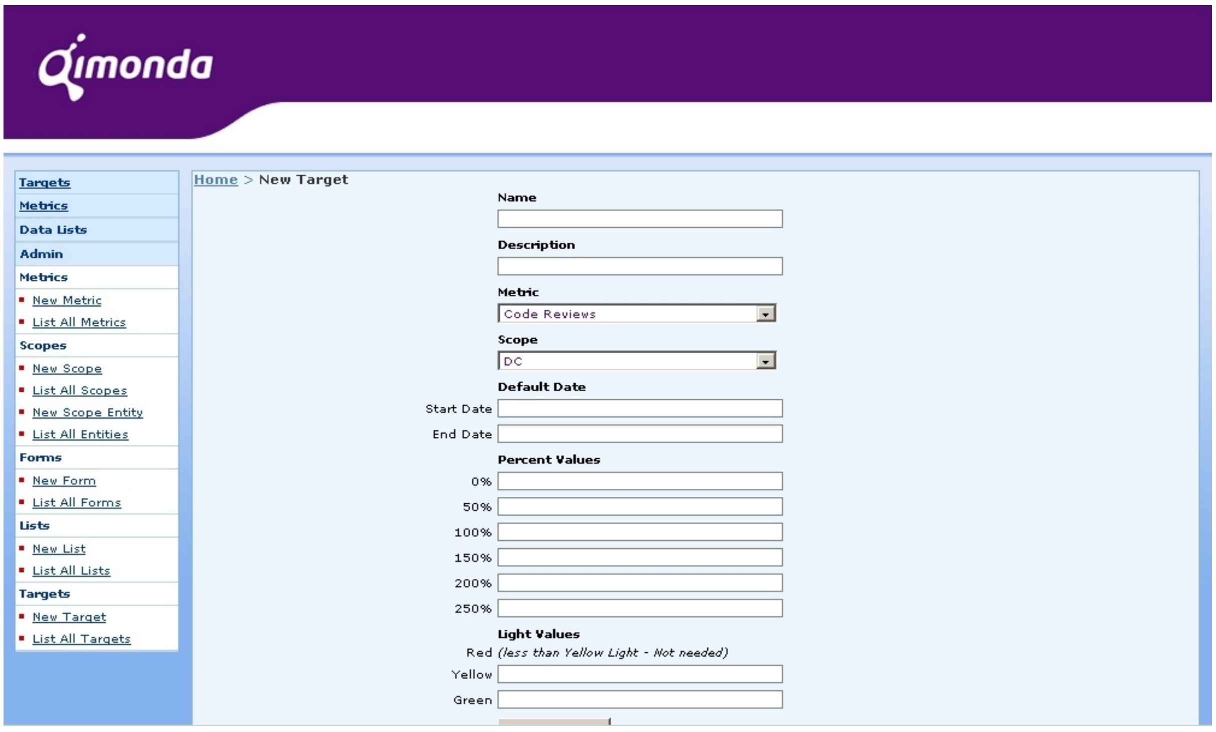


Name	List	Source	Units	Attributes	Validation		
FTR Manual	FTR	Manual	Unit1:N REWORKS|Unit7:ARTIFACT NAME|Unit8:VERSION|		No	Edit	Delete
FTR QMS 2	FTR	Excel	Unit1:N REWORKS|Unit7:ARTIFACT NAME|Unit8:VERSION|	Start Cell:B1 Columns:5 Sheet:4 Align:Vertical Entity Column:A2	No	Edit	Delete
MTA ProjecServer	SV/MTA	ProjectServer	Unit1:ACTUAL|Unit2:ESTIMATE|		No	Edit	Delete
SV ProjectServer	SV/MTA	ProjectServer	Unit1:ACTUAL|Unit2:ESTIMATE|		No	Edit	Delete
TC Remote	TC	ProjectServer	Unit1:RESULT|		No	Edit	Delete
TE Manual	TE	Manual	Unit1:ACTUAL|Unit2:ESTIMATE|		Yes	Edit	Delete
TE2	TE	ProjectServer	Unit1:BUGS|Unit2:ACTUAL|		No	Edit	Delete

Figure 5-40 All Forms page

5.4.3.6 *Targets Management*

When inserting a new Target, the user has to provide the *Name*, *Description*, *Time frame*, *Percent values* (0%, 50%, 100%, 150%, 200% and 250%) and *Light values* (Yellow and Green) and also associate the Target with a *Metric* and a *Scope*. The *Red Light value* is not needed because it is inferred if the actual value is lower than the *Yellow Light value*.



Name

Description

Metric
Code Reviews

Scope
DC

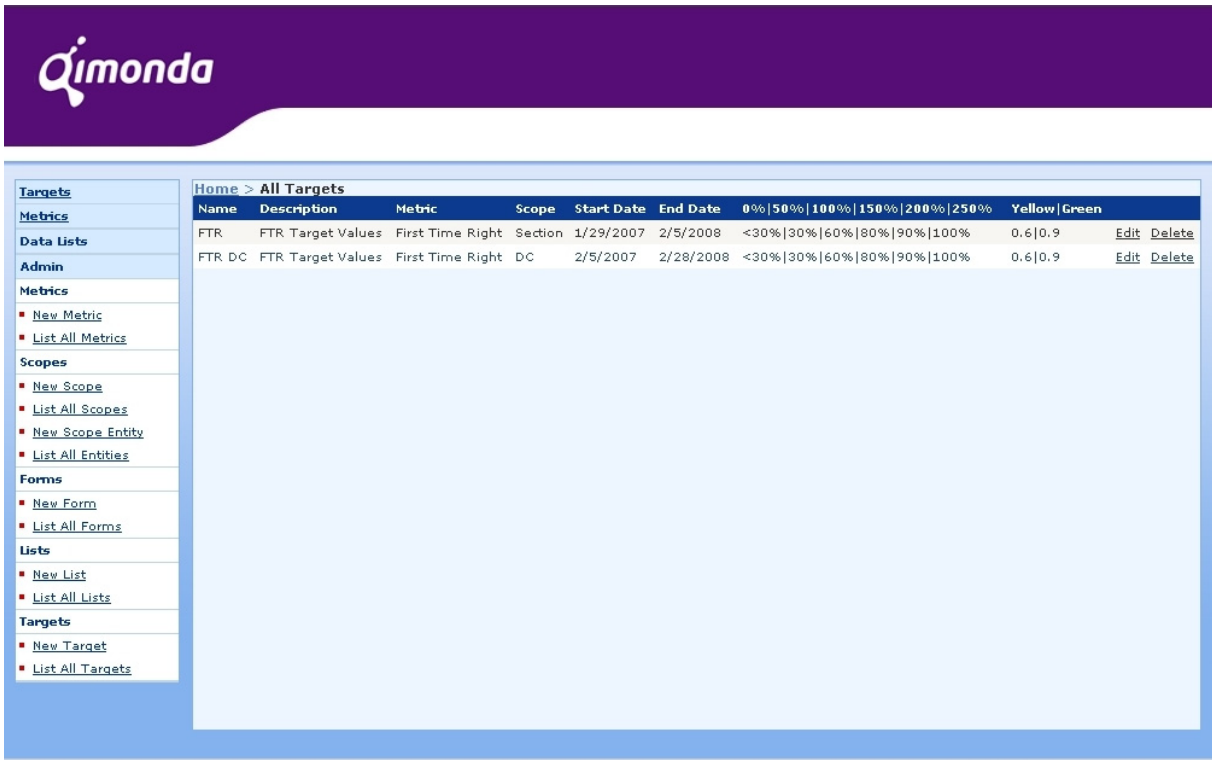
Default Date
Start Date
End Date

Percent Values
0%
50%
100%
150%
200%
250%

Light Values
Red *(less than Yellow Light - Not needed)*
Yellow
Green

Figure 5-41 New Target page

When listing all Targets, is presented a table with all the Target attributes, plus the field to *Edit* and *Remove* (**Figure 5-42**).



Name	Description	Metric	Scope	Start Date	End Date	0%|50%|100%|150%|200%|250%	Yellow|Green		
FTR	FTR Target Values	First Time Right	Section	1/29/2007	2/5/2008	<30%|30%|60%|80%|90%|100%	0.6|0.9	Edit	Delete
FTR DC	FTR Target Values	First Time Right	DC	2/5/2007	2/28/2008	<30%|30%|60%|80%|90%|100%	0.6|0.9	Edit	Delete

Figure 5-42 All Targets page

5.4.4 Data Validation

In order to avoid unnecessary server requests and human errors, the application validates data in the interface side.

Besides the validation implemented in *Forms* to insert data (**Figure 5-13**) the application have other validations like:

- All text boxes to insert date have the CalendarExtender Ajax control, inserting the date in the correct format (**Figure 5-32**).
- All required text boxes have the web control RequiredFieldValidator, alerting the user when some mandatory information needs to be supplied.
- All the text boxes to insert numeric values have the FilteredTextBoxExtender Ajax control that only allow the insertion of numbers.
- All the dropdown lists filter only the possible values, avoiding inconsistencies.

6 Results Evaluation

In this section, are analyzed the main results for each of the application layers.

The final results are evaluated in performance, flexibility and user interactivity.

6.1 Data Access

When analyzing the requirements, we realize that if the database model wasn't completely dynamic, the success of the application could be compromised. Creating a table, whose fields could be reused, allowed the complete control of data inside the application, without the need to create new tables when new metrics are defined.

This approach made the business logic layer development a little more complex but was an important step to complete all the requirements and to assure that it will respond to the future needs.

6.2 Business Logic

The main critical points of this layer are the calculation of metric results and the import of Excel files.

Initially, the calculation of the results was made entirely in the application code. When the volume of data in the database started to grow, the application became slower and heavy, processing all the information. One important approach to avoid this was the creation of dynamic database queries which would perform the bigger calculations and aggregate the results. When comparing performances of these two approaches, we verified that the calculation of the results inside the code took several seconds to complete, but a query to the database was returned in a few milliseconds, even with tables with thousands of lines.

Importing and parsing an Excel file was thought that could have a performance issue but it was never verified. The application was tested with the biggest file we have, with thousands of lines, which it has to upload, parse, validate the data and insert in the database. These tasks were completed in less than a couple of seconds, better than we expected.

6.3 User Interface

The main objective in the development of this layer was the interactivity with the user. For this reason it was designed to be simple, efficient, intuitive and like the common Qimonda's web applications, providing a known work environment. Some of these were only possible because of the use of *Ajax* technologies.

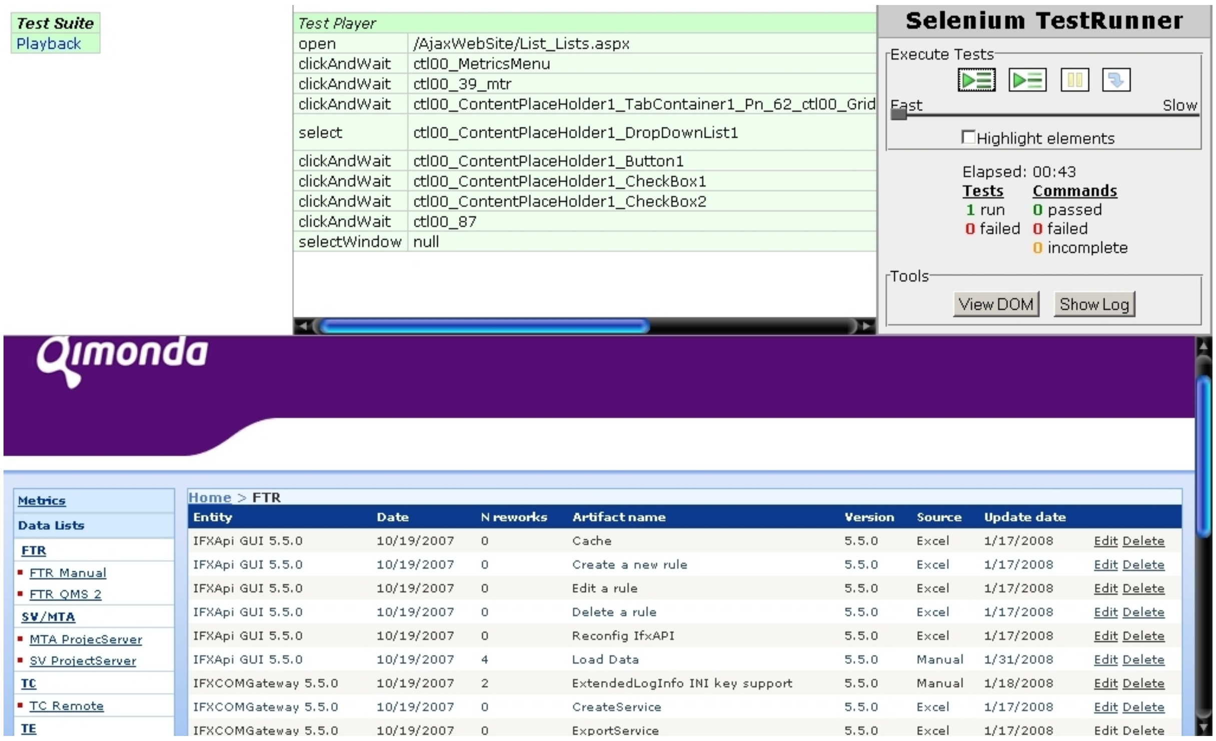
The web forms were designed following the best design practices defined by Luke Wroblewski [Wro08].

The labels are top-aligned, permitting users to capture both labels and inputs with a single eye movement, resulting in fastest completion times. Only in cases that the vertical screen space is a constraint, the labels are right-aligned.

The field length provides enough space for the inputs and the content is grouped, using the minimal visual elements necessary to communicate useful relationships.

When an error occurs, it is clearly communicated with a message in top, with visual contrast, referring which action launched the fault.

The interface was tested with Selenium IDE (Section 3.4.5). This tool records the user actions and label values displayed. When we run the test, it does the playback (execute all the actions recorded) and compares the label values with the recorded ones. If these results are the same, the test passes (**Figure 6-1**).



Test Player	
open	/AjaxWebSite/List_Lists.aspx
clickAndWait	ctl00_MetricsMenu
clickAndWait	ctl00_39_mtr
clickAndWait	ctl00_ContentPlaceHolder1_TabContainer1_Pn_62_ctl00_Grid
select	ctl00_ContentPlaceHolder1_DropDownList1
clickAndWait	ctl00_ContentPlaceHolder1_Button1
clickAndWait	ctl00_ContentPlaceHolder1_CheckBox1
clickAndWait	ctl00_ContentPlaceHolder1_CheckBox2
clickAndWait	ctl00_87
selectWindow	null

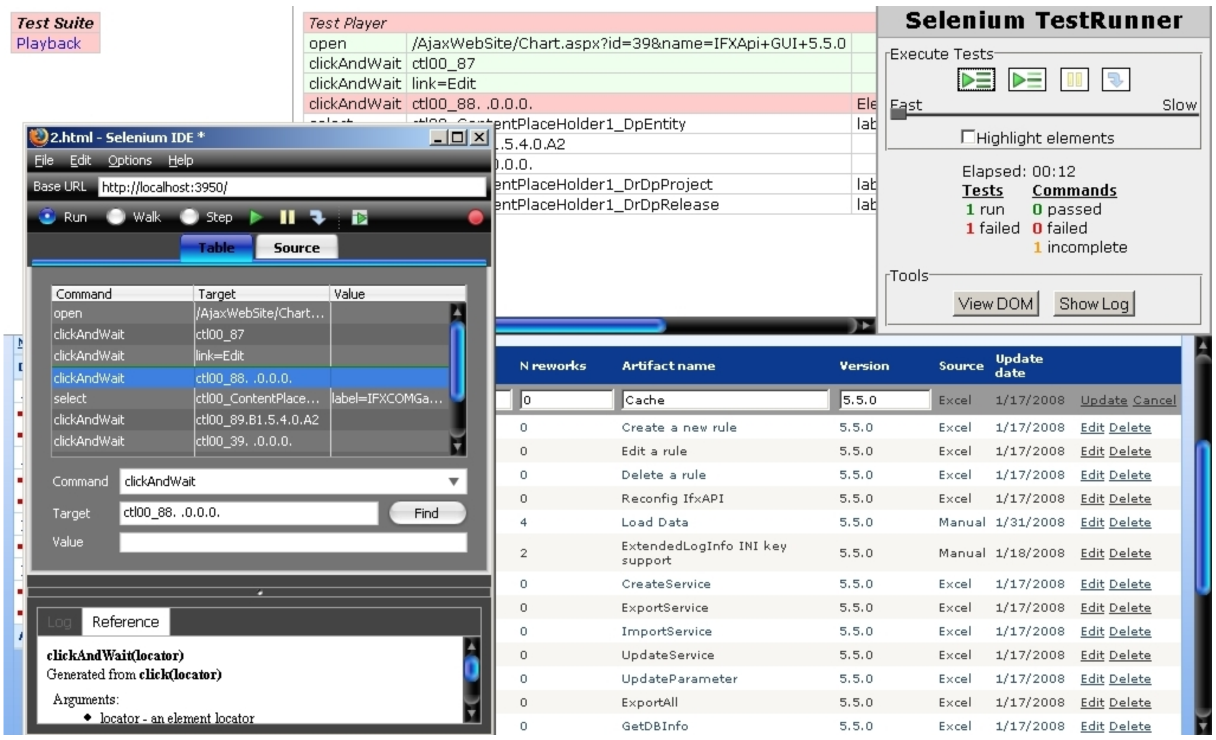
Elapsed: 00:43
Tests: 1 run, 0 failed
Commands: 0 passed, 0 failed, 0 incomplete

Home > FTR

Entity	Date	N reworks	Artifact name	Version	Source	Update date	
IFXApi GUI 5.5.0	10/19/2007	0	Cache	5.5.0	Excel	1/17/2008	Edit Delete
IFXApi GUI 5.5.0	10/19/2007	0	Create a new rule	5.5.0	Excel	1/17/2008	Edit Delete
IFXApi GUI 5.5.0	10/19/2007	0	Edit a rule	5.5.0	Excel	1/17/2008	Edit Delete
IFXApi GUI 5.5.0	10/19/2007	0	Delete a rule	5.5.0	Excel	1/17/2008	Edit Delete
IFXApi GUI 5.5.0	10/19/2007	0	Reconfig IfxAPI	5.5.0	Excel	1/17/2008	Edit Delete
IFXApi GUI 5.5.0	10/19/2007	4	Load Data	5.5.0	Manual	1/31/2008	Edit Delete
IFXCOMGateway 5.5.0	10/19/2007	2	ExtendedLogInfo INI key support	5.5.0	Manual	1/18/2008	Edit Delete
IFXCOMGateway 5.5.0	10/19/2007	0	CreateService	5.5.0	Excel	1/17/2008	Edit Delete
IFXCOMGateway 5.5.0	10/19/2007	0	ExportService	5.5.0	Excel	1/17/2008	Edit Delete

Figure 6-1 Selenium test passed

If the results aren't the expected or it can't find the control (link, button, text box…), the test fail (**Figure 6-2**) and it presents intuitive logs and debug information. *HTML*, *CSS* and *JavaScript* (including Ajax) were also tested and debugged with Firebug (Section 3.4.6).



Test Player

open	/AjaxWebSite/Chart.aspx?id=39&name=IFXApi+GUI+5.5.0	
clickAndWait	ctl00_87	
clickAndWait	link=Edit	
clickAndWait	ctl00_88. .0.0.0.	Ele
	entPlaceHolder1_DpEntity	lab
	.5.4.0.A2	
	.0.0.	
	entPlaceHolder1_DrDpProject	lab
	entPlaceHolder1_DrDpRelease	lab

Elapsed: 00:12

Tests	Commands
1 run	0 passed
1 failed	0 failed
	1 incomplete

Base URL http://localhost:3950/

Command	Target	Value
open	/AjaxWebSite/Chart...	
clickAndWait	ctl00_87	
clickAndWait	link=Edit	
clickAndWait	ctl00_88. .0.0.0.	
select	ctl00_ContentPlace...	label=IFXCOMGa...
clickAndWait	ctl00_89.B1.5.4.0.A2	
clickAndWait	ctl00_39. .0.0.0.	

Command: clickAndWait
Target: ctl00_88. .0.0.0.
Value:

clickAndWait(locator)
Generated from **click(locator)**

Arguments:
- locator - an element locator

N reworks	Artifact name	Version	Source	Update date	
0	Cache	5.5.0	Excel	1/17/2008	Update Cancel
0	Create a new rule	5.5.0	Excel	1/17/2008	Edit Delete
0	Edit a rule	5.5.0	Excel	1/17/2008	Edit Delete
0	Delete a rule	5.5.0	Excel	1/17/2008	Edit Delete
0	Reconfig IfxAPI	5.5.0	Excel	1/17/2008	Edit Delete
4	Load Data	5.5.0	Manual	1/31/2008	Edit Delete
2	ExtendedLogInfo INI key support	5.5.0	Manual	1/18/2008	Edit Delete
0	CreateService	5.5.0	Excel	1/17/2008	Edit Delete
0	ExportService	5.5.0	Excel	1/17/2008	Edit Delete
0	ImportService	5.5.0	Excel	1/17/2008	Edit Delete
0	UpdateService	5.5.0	Excel	1/17/2008	Edit Delete
0	UpdateParameter	5.5.0	Excel	1/17/2008	Edit Delete
0	ExportAll	5.5.0	Excel	1/17/2008	Edit Delete
0	GetDBInfo	5.5.0	Excel	1/17/2008	Edit Delete

Figure 6-2 Selenium test failed

7 Evolution

Although this project's scope was limited by the fact that this was an internship project (with limited time span), it was still possible to achieve an extensible solution, which can easily cope with future changes and enhancements.

Some features (not included in the initial requirements) were identified but due to the time constraints not all of them could be implemented.

7.1 Enhancements

Throughout the development, several improvements were identified and implemented. The first was the possibility of adding a search functionality to the application. We predict that the amount of data in the database will grow exponentially and the existence of a search field to improve information access time it's very useful.

From the database model to the usability of the user interface, all aspects were discussed, reviewed and tested. The first concern was to deliver a solution with high quality, usability and performance.

All these factors only were achieved due to enhancements. The database model became completely dynamic, metric calculations were improved to be performed in less than half of the time, and the user interface was designed to encourage communication.

7.2 Extensibility

The implementation took in consideration future growth and due to the high modularity achieved, this project can easily be extended in several of its features.

One such feature, whose extensibility was a requirement for CMMI Metrics Solution, was the calculation of results. The math library used supports several functions and operations and other were implemented. For all the existing metrics, it's possible to define a calculation formula that presents the correct results. I think it is wide enough to support future calculations but if other different expressions need to be implemented, it requires a minimal effort.

All the other aspects of this application are parameterized and can be added and edited inside the application (Admin Area).

Code is a dynamic linkable library (*DLL*), which is shared by the User Interface and the Windows Service.

This modularity permits the modification of system's behavior at runtime, without needing to recompile the source code, and also the implementation of new extensions with the minimal effort required.

7.3 Future Work

There are two identified features that could improve the value and usability of the application. To avoid the deprecation of performance, the *caching* of results is an approach that needs to be carefully analyzed.

Another feature, included in the initial project definition was the export of data to Excel. This feature was out of the project scope due to the time constraints but was identified as a future improvement.

8 Conclusions

After discussing this project's objectives, its entire development (from specification to implementation, results and future work perspectives), some conclusions should be drawn, not only about the project as a software development project but also as part of a curricular internship program.

8.1 Project

The development of CMMI Metrics Solution was an interesting challenge. It allowed me to implement the project throughout all phases of the software development process, and verify the importance of each one of these phases to achieve a solution with the desired quality.

The first phases of this project (Technological Review and Specification, Sections 3 and 4, respectively) allowed a better understanding on how this project's main goals could be achieved and the best planning of activities.

The project's implementation (Section 5) began shortly after the two previously mentioned phases, and only a month after this project started there was already a working prototype (with no calculations and low performance). This prototype was presented to receive some feedback and discuss if the approach followed was the best way to achieve the main goals. Some improvements were suggested, which turned out to be very useful to the project's success.

The final version of CMMI Metrics Solution fulfilled all the requirements previously defined. I consider this a successful project that will integrate the new version of QMS (version 2.0), helping and improving the Measurement & Analysis process.

8.2 Internship

Finishing the undergraduate program at a big international enterprise like Qimonda was a rewarding experience. It gave me the opportunity to adapt to the enterprise and business culture as the last step of the Integrated Master in Informatics and Computing Engineering course at FEUP.

On the first weeks of the internship I had a training program. Qimonda provided an initial introduction to its organization, factory and manufacturing process. In this period occurred also a self-training and studying phase about the CMMI model, the QMS and the development process and tools used at Porto DC. This period allowed me to have a better understanding of Qimonda's activities and the DC's role as part of a larger multinational organization.

During the requirements definition, several meetings took place to a better understanding on the project's scope and specification. Every week during the implementation, I had a meeting with my supervisor to analyze the status of the project and plan the next steps.

The QM section had several meetings (on a biweekly basis), where I was able to better understand the nature of its work within the DC's context. A "team building" activity was also promoted to help the integration process and allow us to know each other.

During the development of the project, the people from different sections at the DC were always very helpful and open, whenever their help was requested.

As the project came to an end, I presented the solution to Porto DC, discussed some aspects concerning to its usage and usefulness, and received some very positive feedback.

The internship project was a learning and rewarding experience, and one with which I hope to have been able to contribute to Qimonda's Porto DC continued success and development.

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Glossary

AJAX: *Asynchronous JavaScript and XML* is a group of inter-related web development techniques used for creating interactive web applications.

API: Stands for *Application Programming Interface*. It provides a set of routines that extend a language's functionality.

ASP: Acronym for *Active Server Pages*. It is Microsoft's web server-side scripting language. It allows the creation of dynamic web pages.

BPA: *Business Process Automation*.

CMMI: *Capability Maturity Model Integration* is a process improvement approach, defined by the Software Engineering Institute (SEI).

COM: *Component Object Model* is a platform for developing software in components used to enable inter-process communication and dynamic object creation in any programming language that supports the technology.

CPT: *Cross Platform Technologies*.

CSS: *Cascading Style Sheets* is a stylesheet language used to describe the presentation of a document written in a markup language.

DBT: *Database Technologies*.

DC: *Development Center*, usually used when referring to Porto DC.

DF: Acronym for *Domain Functions* (area). The Domain Functions are the main clients of Porto DC.

DLL: *Dynamic Link Library* is Microsoft's implementation of the shared library concept in the Microsoft Windows and OS/2 operating systems.

DOM: *Document Object Model*, a description on how an HTML or XML document is represented in a tree structure.

DRAM: Acronym for *Dynamic Random Access Memory*. It's a type of random access memory that stores each bit of data in a separate capacitor. As real-world capacitors are not ideal and hence leak electrons, the information eventually fades unless the capacitor charge is refreshed periodically.

EAI: Acronym for *Enterprise Application Integration*. Is a technology that integrates various applications that an enterprise has, like Manufacturing execution, Customer Relation Systems, between others.

ETL: *Extraction Transformation and Loading* is a process in data warehousing that involves extracting data from outside sources, transforming it to fit business needs and loading it into the end target.

GUI: Acronym for *Graphical User Interface*. It refers to program front-end that allows the users to manipulate it using different graphical components like buttons and menus.

HTML: *HyperText Markup Language* is a markup language designed for the creation of web pages with hypertext and other information to be displayed in a web browser.

IDE: *Integrated Development Environment* is a software application that provides comprehensive facilities to computer programmers for software development.

IIS: *Internet Information Services*, the Microsoft Web Server.

IT: *Information Technologies*.

LAN: *Local Area Network* is a computer network covering a small geographic area, like a home, office, or group of buildings.

LGPL: *GNU Library General Public License* is a free software license published by the Free Software Foundation.

MA: *Measurement and Analysis*.

MS: Acronym for *Microsoft*.

ODBC: *Open Database Connectivity* provides a standard software API method for using database management systems.

OS: *Operative System*.

PIA: *Primary Interop Assembly*, a type of .NET assembly dealing with interaction between managed code and COM objects.

QM: *Quality Management*.

QMS: *Quality Management System*.

R&D: *Research and Development*.

Regex: Shorthand for *Regular Expression*.

SEI: *Software Engineering Institute*.

SG: *Specific Goal*.

SP: *Specific Practice*.

SQI: *Software Quality Improvement*.

WAN: *Wide Area Network* is a computer network that covers a broad area.

WT: *Windows Technologies*.

XHTML: *eXtensible HyperText Markup Language* is a markup language that has the same expressive possibilities as HTML, but a stricter syntax, being an application of XML.

XML: Acronym for *eXtensible Markup Language* which is used to describe the structure of data. It is widely used to interchange data between applications.

YODA: Stands for *Your Own Data Adapter* and is the Manufacturing Integration Baseline backbone. Is the EAI system of Qimonda.

Appendix A: Math Parser Syntax

The following table contains the complete list of operations and constants supported by the Math Parser:

Syntax	All variables should be between brackets in order to preserve the correct precedence. Example: `(VALUE1 + VALUE2) * (VALUE3)`	
Variables	A variable is a sum of all units with that name in the Database. To count the values we should use the expression `count()` or `countdist()`. The expression `count()` is used to count numeric values and `countdist()` is used to count distinct values (text and numeric). Examples: `(ACTUAL > 2)` is a sum of all units named "ACTUAL" with a value bigger than 2. `count(ACTUAL > 2)` counts all units named "ACTUAL" with a value bigger than 2. `countdist(ARTIFACT NAME & VERSION & N REWORKS > 0)` counts all distinct artifacts and version with number of reworks greater than 0;	
Operations Supported	^	Arguments: 2, Precedence: 3
	+	Arguments: 2, Precedence: 6
	-	Arguments: 2, Precedence: 6
	/	Arguments: 2, Precedence: 4
	*	Arguments: 2, Precedence: 4
	cos	Arguments: 2, Precedence: 2
	sin	Arguments: 2, Precedence: 2
	exp	Arguments: 2, Precedence: 2
	ln	Arguments: 2, Precedence: 2
	tan	Arguments: 2, Precedence: 2
	acos	Arguments: 1, Precedence: 2
	asin	Arguments: 1, Precedence: 2
	atan	Arguments: 1, Precedence: 2
	cosh	Arguments: 1, Precedence: 2
	sinh	Arguments: 1, Precedence: 2
	tanh	Arguments: 1, Precedence: 2
	sqrt	Arguments: 1, Precedence: 2
	cotan	Arguments: 1, Precedence: 2
	fpart	Arguments: 1, Precedence: 2
	acotan	Arguments: 1, Precedence: 2
	round	Arguments: 1, Precedence: 2
	ceil	Arguments: 1, Precedence: 2
	floor	Arguments: 1, Precedence: 2
	fac	Arguments: 1, Precedence: 2

	sfac	Arguments: 1, Precedence: 2
	abs	Arguments: 1, Precedence: 2
	log	Arguments: 2, Precedence: 5
	%	Arguments: 2, Precedence: 4
	>	Arguments: 2, Precedence: 7
	<	Arguments: 2, Precedence: 7
	&&	Arguments: 2, Precedence: 10
	==	Arguments: 2, Precedence: 8
	!=	Arguments: 2, Precedence: 8
	||	Arguments: 2, Precedence: 11
	!	Arguments: 1, Precedence: 1
	>=	Arguments: 2, Precedence: 7
	<=	Arguments: 2, Precedence: 7
	count	Arguments: 1 or 3, Precedence 0
	countdist	Arguments: N, Precedence 0
Constants Supported	euler pi nan infinity true false	

Table A-1 Math Parser Syntax

Appendix B: Regular Expression Syntax

The following table, from the .NET documentation [Cor07d], contains the complete list of metacharacters and their behavior in the context of regular expressions:

Character	Description
\	Marks the next character as a special character, a literal, a backreference, or an octal escape. For example, 'n' matches the character "n". '\n' matches a newline character. The sequence '\\' matches "\" and "\(" matches "(".
^	Matches the position at the beginning of the input string. If the RegExp object's Multiline property is set, ^ also matches the position following '\n' or '\r'.
$	Matches the position at the end of the input string. If the RegExp object's Multiline property is set, $ also matches the position preceding '\n' or '\r'.
*	Matches the preceding character or subexpression zero or more times. For example, zo* matches "z" and "zoo". * is equivalent to {0,}.
+	Matches the preceding character or subexpression one or more times. For example, 'zo+' matches "zo" and "zoo", but not "z". + is equivalent to {1,}.
?	Matches the preceding character or subexpression zero or one time. For example, "do(es)?" matches the "do" in "do" or "does". ? is equivalent to {0,1}
{*n*}	*n* is a nonnegative integer. Matches exactly *n* times. For example, 'o{2}' does not match the 'o' in "Bob," but matches the two o's in "food".
{*n*,}	*n* is a nonnegative integer. Matches at least *n* times. For example, 'o{2,}' does not match the "o" in "Bob" and matches all the o's in "foooood". 'o{1,}' is equivalent to 'o+'. 'o{0,}' is equivalent to 'o*'.
{*n*,*m*}	*m* and *n* are nonnegative integers, where *n* <= *m*. Matches at least *n* and at most *m* times. For example, "o{1,3}" matches the first three o's in "fooooood". 'o{0,1}' is equivalent to 'o?'. Note that you cannot put a space between the comma and the numbers.
?	When this character immediately follows any of the other quantifiers (*, +, ?, {*n*}, {*n*,}, {*n*,*m*}), the matching pattern is non-greedy. A non-greedy pattern matches as little of the searched string as possible, whereas the default greedy pattern matches as much of the searched string as possible. For example, in the string "oooo", 'o+?' matches a single "o", while 'o+' matches all 'o's.
.	Matches any single character except "\n". To match any character including the '\n', use a pattern such as '[\s\S]'.
(*pattern*)	A subexpression that matches *pattern* and captures the match. The captured match can be retrieved from the resulting Matches collection using the $0…$9 properties. To match parentheses characters ( ), use '\(' or '\)'.

(?:*pattern*)	A subexpression that matches *pattern* but does not capture the match, that is, it is a non-capturing match that is not stored for possible later use. This is useful for combining parts of a pattern with the "or" character (|). For example, 'industr(?:y|ies) is a more economical expression than 'industry|industries'.
(?=*pattern*)	A subexpression that performs a positive lookahead search, which matches the string at any point where a string matching *pattern* begins. This is a non-capturing match, that is, the match is not captured for possible later use. For example 'Windows (?=95|98|NT|2000)' matches "Windows" in "Windows 2000" but not "Windows" in "Windows 3.1". Lookaheads do not consume characters, that is, after a match occurs, the search for the next match begins immediately following the last match, not after the characters that comprised the lookahead.
(?!*pattern*)	A subexpression that performs a negative lookahead search, which matches the search string at any point where a string not matching *pattern* begins. This is a non-capturing match, that is, the match is not captured for possible later use. For example 'Windows (?!95|98|NT|2000)' matches "Windows" in "Windows 3.1" but does not match "Windows" in "Windows 2000". Lookaheads do not consume characters, that is, after a match occurs, the search for the next match begins immediately following the last match, not after the characters that comprised the lookahead.
x|*y*	Matches either *x* or *y*. For example, 'z|food' matches "z" or "food". '(z|f)ood' matches "zood" or "food".
[*xyz*]	A character set. Matches any one of the enclosed characters. For example, '[abc]' matches the 'a' in "plain".
[^*xyz*]	A negative character set. Matches any character not enclosed. For example, '[^abc]' matches the 'p' in "plain".
[*a-z*]	A range of characters. Matches any character in the specified range. For example, '[a-z]' matches any lowercase alphabetic character in the range 'a' through 'z'.
[^*a-z*]	A negative range characters. Matches any character not in the specified range. For example, '[^a-z]' matches any character not in the range 'a' through 'z'.
\b	Matches a word boundary, that is, the position between a word and a space. For example, 'er\b' matches the 'er' in "never" but not the 'er' in "verb".
\B	Matches a nonword boundary. 'er\B' matches the 'er' in "verb" but not the 'er' in "never".
\c*x*	Matches the control character indicated by *x*. For example, \cM matches a Control-M or carriage return character. The value of *x* must be in the range of A-Z or a-z. If not, c is assumed to be a literal 'c' character.
\d	Matches a digit character. Equivalent to [0-9].
\D	Matches a nondigit character. Equivalent to [^0-9].
\f	Matches a form-feed character. Equivalent to \x0c and \cL.

\n	Matches a newline character. Equivalent to \x0a and \cJ.
\r	Matches a carriage return character. Equivalent to \x0d and \cM.
\s	Matches any white space character including space, tab, form-feed, and so on. Equivalent to [\f\n\r\t\v].
\S	Matches any non-white space character. Equivalent to [^ \f\n\r\t\v].
\t	Matches a tab character. Equivalent to \x09 and \cI.
\v	Matches a vertical tab character. Equivalent to \x0b and \cK.
\w	Matches any word character including underscore. Equivalent to '[A-Za-z0-9_]'.
\W	Matches any nonword character. Equivalent to '[^A-Za-z0-9_]'.
\x*n*	Matches *n*, where *n* is a hexadecimal escape value. Hexadecimal escape values must be exactly two digits long. For example, '\x41' matches "A". '\x041' is equivalent to '\x04' & "1". Allows ASCII codes to be used in regular expressions.
\num	Matches *num*, where *num* is a positive integer. A reference back to captured matches. For example, '(.)\1' matches two consecutive identical characters.
\n	Identifies either an octal escape value or a backreference. If \n is preceded by at least *n* captured subexpressions, *n* is a backreference. Otherwise, *n* is an octal escape value if *n* is an octal digit (0-7).
\nm	Identifies either an octal escape value or a backreference. If \nm is preceded by at least *nm* captured subexpressions, *nm* is a backreference. If \nm is preceded by at least *n* captures, *n* is a backreference followed by literal *m*. If neither of the preceding conditions exists, \nm matches octal escape value *nm* when *n* and *m* are octal digits (0-7).
\nml	Matches octal escape value *nml* when *n* is an octal digit (0-3) and *m* and *l* are octal digits (0-7).
\u*n*	Matches *n*, where *n* is a Unicode character expressed as four hexadecimal digits. For example, \u00A9 matches the copyright symbol (©).

Table B-1 Regular Expression Syntax