

MESG

MESTRADO EM ENGENHARIA DE SERVIÇOS E GESTÃO

Requirements Maintenance

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Abstract

The present environment for businesses is on constant change and evolution which in turn complicates the task of businesses to go along with evolving costumers' trends. In the context of the services provided through software such as web services it gets even harder to monitor and manage all those changes. To overcome this difficulty, the activity of Requirements Management from Requirements Engineering plays a crucial role in providing means to decrease the instability and keep track of all kinds of changes during a software project development and its lifecycle. It is this activity that helps to perform a proper requirements maintenance and therefore helps to increase the product lifecycle and its overall quality. However, providing services that are always available and in permanent contact with costumers increase the importance of a better and on time maintenance so that the services keep up with the costumer's trends and needs. There are already tools to help requirements management but most tend to be too complex and fail to integrate with other tools such as web analytics tools that can provide insightful data on user's patterns. In this sense, it is evaluated a tool – REQAnalytics – that analyses the web usage data to provide recommendations to the software requirements specifications in order to support the requirements maintenance and improve the software quality. The evaluation was accomplished by conducting a case study on a website and the results attained demonstrate the capacity of REQAnalytics to provide useful recommendations to enhance requirements maintenance and improve a website quality. Further during the evaluation of the tool, there were detected some new features to REQAnalytics that may improve the tool but also may support the task of requirements maintenance of a web service during its lifecycle.

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List of Abbreviations

DOM	Document Object Model
HTML	Hypertext Markup Language
ISO	International Standards Organization
KPI	Key Performance Indicator
OWA	Open Web Analytics
RE	Requirements Engineering
RM	Requirements Maintenance
SaaS	Software as a Service
SQL	Structured Query Language
SRS	Software Requirements Maintenance
UML	Unified Modelling Language
URL	Uniform Resource Locator
WWW	World Wide Web
XML	eXtensible Markup Language
XSD	XML Schema Definition

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Chapter 1

Introduction

Software quality is a topic of extreme importance within the area of software engineering. In particular, the software requirements management throughout the life cycle of a software. This report consists on an analysis of the advantages of using a new approach (Garcia, 2016) to support the process of requirements maintenance on software web projects. In this chapter the project framework is presented followed with the main goals intended to achieve and the overall structure of the report.

1.1 Context

Currently companies are taking advantage from the growth of world wide web to provide their services and support business development. Doing it by the use of software tools such as web services, intranets and web applications. These tools must be always available, making grow its concern with (Garcia and Paiva, 2016c) the service overall quality and that it is updated with users needs. To do so, companies, need to maintain and improve these softwares throughout its lifecycle (April, 2010). For software projects that are websites evolving during its lifetime it is difficult to keep a software requirements specification up to date. Despite attempts to improve processes used to collect, analyze, document and maintain requirements in a structured requirements specification written in natural language. As seen on “The Chaos Report” published on 2009 (Dominguez, 2009) most software projects tend to fail due to a poor requirements elicitation, requirements changes and their uncontrolled evolution during the software project lifetime. These factors have a negative impact in software, leading to the increase of costs and ultimately to systems that do not fulfill stakeholders needs. Therefore, in order to ensure the quality of software project and its success it is crucial to begin with a

proper requirements elicitation and resort to requirements management tools that help to keep stability and agreement among stakeholders. Requirements management – one of the steps of Requirements Engineering (RE) – consists on a continuum process that enables this stability and agreement through the analysis of changes and its accompaniment through the project development.

1.2 Problem

On a context of continuous environment change it is very important to continuously evaluate software's capability to fulfill its user's goals. These constant changes and uncertainties make it essential to apply RE techniques not only on a software development stage but also throughout its entire lifecycle. Nowadays the most common methods used to support requirements maintenance are not very flexible and do not take in account data provided by websites usage data. Therefore, fail to evaluate pattern changes that may lead to new requirements, the elimination or modification of others and help determine new prioritization criteria's to the requirements. Only by keeping up with users needs changes it is possible to assertively propose improvements in order to increase a software lifecycle (Garcia, 2013). Taking advantage of the data gathered by web analytical tools it is possible to analyze patterns of usage and consequently improve the requirements maintenance process. As seen on the approach suggested (Garcia and Paiva, 2016d) this data can be a huge support for requirements maintenance. Regarding the context of services provided though web services, intranets or web applications it is intended to evaluate a tool that may support requirements maintenance through the usage of the data collected by a web analytical tool.

1.3 Research Questions

On this report it is intended to analyse and provide results on the following topics:

1. How can Requirements Management be supported by web usage data of a website;
2. How REQAnalytics allows to support Requirements Management;
3. What type of recommendations to requirements specifications may REQAnalytics offer;

4. In what way are the reports generated by REQAnalytics more supportive for businesses than traditional reports of web analytical tools;
5. How has the use of REQAnalytics in the IPVC case study has improved the Requirements Management task;
6. How does REQAnalytics allows to support management of a web service requirements throughout its lifecycle;
7. Analyse the advantages of creating traceability links between the functional requirements and pages and HTML elements of a web service.

1.4 Report Outline

This report is structured in five different chapters. The first one regards the scope of the project and its presentation. On the second chapter, designated as State of Art, it is presented the studies conducted in order to support and frame the work intended to do. It is briefly defined RE, its main characteristics and importance, focusing more on the process of requirements management. Web Analytical Tools are also addressed, by explaining what they are, the kind of data they can collect and what we can benefit from their use. The following chapter presents the tool under analysis – REQAnalytics – defining its scope and characteristics that are analysed on this report. For a better comprehension of the study carried out it is discussed the approach followed and justified its choice. On chapter 4, it is presented the case study conducted in order to formally validate the methodology proposed. According with the reports given by REQAnalytics it is suggested some improvements to the website in matter. For last, the conclusions of the work are presented on chapter 5 followed with some suggestions for future work.

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Chapter 2

State of the Art

Nowadays software is being seen as an essential part of every business, hoping that it may evolve in a way to help the business grow and not jeopardizing it. Therefore, the software overall quality should be a major concern. Software engineering enables to create complex systems in an organized way to achieve solutions with high quality and that meet the needs of those who will use it (Pressman, 2010). Every software project starts with the specification of the stakeholder's needs, representing what it should be. Those needs may vary according to each stakeholder interest so it is crucial to document and manage every requirement. The process of eliciting stakeholder's needs and specifying it into detailed, agreed requirements in a way that they can serve as the basis for all other system development activities is designated as requirements engineering (Pohl, 2010). The main activities for Requirements Engineering are:

- Requirements elicitation;
- Requirements specification;
- Requirements validation;
- Requirements management.

2.1 Requirements Definition

The term requirement has several definitions according to its application field. In this context a requirement may be defined as (ISO/IEC and IEEE, 2010):

- a condition or capability needed by a user to solve a problem or achieve an objective;

- a condition or capability that must be met or possessed by a system or system component to satisfy a contract, standard, specification, or other formally imposed document;
- a documented representation of a condition or capability as in the above definitions;
- a condition or capability that must be met or possessed by a system, product, service, result, or component to satisfy a contract, standard, specification, or other formally imposed document. Requirements include the quantified and documented needs, wants, and expectations of the sponsor, customer, and other stakeholders;

On a general way, requirements may be classified as functional or as non-functional requirements. Functional requirements describe an interaction between the software and its users. It refers on how the system should react to specific events and behave to certain situations. In some cases, it can also define what the system shall not do. Its specification should be complete and done on a consistent way. The non-functional requirements describe the software constraints that limit the implementations possibilities. It is related to the application use in terms of performance, usability, reliability, security, availability and technologies involved. Those kind of requirements have direct impact on the system architecture.

2.2 Requirements Engineering

Requirements Engineering may be described as a process, composed by a group of activities with the purpose to identify, validate and manage a requirements specification document. It aims to define the context of a project from the systematization of activities. Those activities have a clear objective becoming crucial to an efficient process of requirements engineering. Without any of those activities in the process may lead to delays, increase of maintenance costs and in the worst scenario, result on a system that does not fulfill the stakeholder's needs (Westfall, 2006).

As mentionend before, the process of requirements engineering involves several activities such as the elicitation, the analysis and negotiation of requirements, its specification and validation through the continuous involvement with stakeholders related to the system. Those activities occur on an iterative way and are included throughout the software lifecycle. Usually, the requirements elicitation is the first step on the process of RE. This is related to the activities of understanding the user's needs and constraints for the

system. It is essential to work directly with the different stakeholders related to the project in order to clearly understand and document the software specifications. Traditionally those stakeholders can be:

- Costumers, who contribute to the identification of the system needs and will pay for its development;
- Users who will use the system after being deployed;
- Domain specialists, who have specific knowledge on the context of the system
- Project Management, responsible of the system plan of development its time and costs restrictions;
- Development team, who will develop and maintain the system;
- Requirements engineers, responsible for the requirements specifications document.

The requirements specifications consists on documenting the need's and constraints elicited in a clearly and precise manner. In the document should be well described what the software system will do and how it is expected to work. The validation process (Requirements Validation) it is performed iteratively in order to make sure that the system requirements are complete, correct, consistent and clear. It is also mandatory to assure the requirements documented on a natural language are feasible, necessary, prioritized, unambiguous and verifiable.

2.2.1 Requirements Management

The process of managing changes in requirements during the requirements engineering process and system development it is designated as Requirements management. New requirements and needs may appear during the project development and/or after being delivered to the costumer. The management of requirements is an activity which aims to guarantee the traceability of requirements, analysis of maturity and stability as well as the observation of disposal needs, changing or adding requirements during the development phase or system maintenance (Guerreiro, 2015). Therefore, Requirements Management is a crucial process to support the system improvements over time. Its importance is being recognized in order to keep track on the system evolution throughout time. Despite being a crucial step for a high quality software and to project success there are still few studies and applications to

support this process in terms of proposing improvements to a system so that its lifecycle is improved.

Requirements Management Tools

There are several tools on the market to support the process of Requirements Management (Birk and Heller, 2016). Most of them aim to help to manage the entire software project, enabling the activities of Requirements Engineering. Those tools tend to be great to manage requirements changes and properly document it since they provide a way to efficiently communicate with stakeholders (Khatoun et al., 2013). However, such software solutions tend to be complex and expensive. Despite there are some great tools, most of them do not allow to integrate with other software solutions that could help enhance its features. Also, they are more oriented to solve problems identified instead of focusing in its improvements. These limitation may have to do with the fact that the tools do not have data about the users' website usage and therefore cannot provide suggestions to improve the quality of the website. Away to overcome these problem it would be to follow a methodology to track changes and develop ways to automatically approve change requests.

2.3 Web Analytics

Web analytics refers to the study of patterns and trends. It is used to collect, measure, report and analyze a website usage data. It can provide information such as the number of visitors to a website and the number of page views, among other metrics (Mcfadden, 2005). Typically, it is used to analyze the performance of a website and optimize it. Being commonly viewed as a powerful tool for businesses and marketers. But the study of this patterns can help to improve the user experience and making it more efficient. Businesses are moreover taking advantage of the data gathered by analytical tools to support the continuous improvement of their websites and therefore services provided to costumers. The process of web analytics – described in the Figure 1 – consists on setting the business goals, define the Key Performance Indicators (KPI) in order to track the goal achievement, collect the data and analyze it to extract reports, based on what is provided by the reports it can be tested alternative solutions and finally according with the analysis those solutions may be implement so that the website user experience may be improved.



Figure 1: Web Analytics Process

There are several tools available on the market to conduct this type of analysis. The tools differ from each other in terms of features offered and payment options, existing many free or open source choices. On the Table 1 it is presented a list with some of the most commonly used web analytics tools and their main features.

Table 1: List of Web Analytics Tools

Web Analytics Tools	Main features
Google Analytics	Free; Setting Goals; Funnel Visualization
Open Web Analytics	Free; DOM click tracking; Clicks Heatmap
Spring Metrics	Real time conversion; Print and click configuration
Piwik	Free; Block traffic; Segmentaiton of users
KISSmetrics	People tracking; User segmentation
Clicky	Heatmaps; Real time data
Crazy Egg	Heatmaps; Clicks heatmap
Mint	Visits
AWStats	Free; Number of hits; Country origin

It is the web analytics tools that may offer insights on performance of a website, visitors patterns and trends. Such tools can collect several metrics and KPI's important to measure if the goals are being fulfilled. Some of the metrics present in web analytical tools are (Burby et al., 2007):

- **Page** - A page is an analyst definable unit of content. litem Page Views -The number of times a page (an analyst-definable unit of content) was viewed.
- **Visits/Sessions** - A visit is an interaction, by an individual, with a website consisting of one or more requests for an analyst-definable unit of content (i.e. "page view"). If an individual has not taken another action (typically additional page views) on the site within a specified time period, the visit session will terminate.
- **Unique Visitors** - The number of inferred individual people (filtered for spiders and robots), within a designated reporting timeframe, with activity consisting of one or more visits to a site. Each individual is counted only once in the unique visitor measure for the reporting period.
- **New Visitor** - The number of Unique Visitors with activity including a first-ever Visit to a site during a reporting period.
- **Repeat Visitor** - The number of Unique Visitors with activity consisting of two or more Visits to a site during a reporting period.
- **Return Visitor** - The number of Unique Visitors with activity consisting of a Visit to a site during a reporting period and where the Unique Visitor also Visited the site prior to the reporting period.
- **Entry Page** - The first page of a visit.
- **Landing Page** - A page intended to identify the beginning of the user experience resulting from a defined marketing effort.
- **Exit Page** - The last page on a site accessed during a visit, signifying the end of a visit/session.
- **Visit Duration** - The length of time in a session. Calculation is typically the timestamp of the last activity in the session minus the timestamp of the first activity of the session.
- **Referrer** - The referrer is the page URL that originally generated the request for the current page view or object.

- **Internal Referrer** - The internal referrer is a page URL that is internal to the website or a web-property within the website as defined by the user.
- **External Referrer** - The external referrer is a page URL where the traffic is external or outside of the website or a web-property defined by the user.
- **Search Referrer** - The search referrer is an internal or external referrer for which the URL has been generated by a search function.
- **Visit Referrer** - The visit referrer is the first referrer in a session, whether internal, external or null.
- **Original Referrer** - The original referrer is the first referrer in a visitor's first session, whether internal, external or null.
- **Click-through** - Number of times a link was clicked by a visitor.
- **Click-through Rate/Ratio** - The number of click-throughs for a specific link divided by the number of times that link was viewed.
- **Page Views per Visit** - The number of page views in a reporting period divided by number of visits in the same reporting period.
- **Page Exit Ratio** - Number of exits from a page divided by total number of page views of that page.
- **Single-Page Visits** - Visits that consist of one page regardless of the number of times the page was viewed.
- **Single Page View Visits (Bounces)** - Visits that consist of one page-view.
- **Bounce Rate** - Single page view visits divided by entry pages.
- **Event** - Any logged or recorded action that has a specific date and time assigned to it by either the browser or server.
- **Conversion** - A visitor completing a target action.

Although being able to measure several metrics that cover all kind of actions executed by users, those web analytics tools do not consider them on the perspective of system improvement, especially on the context of requirements maintenance.

2.4 Final Considerations

There is a growing concern with software quality, making companies pursue solutions to help maintain their software's lifecycle and consequently increase the customer's satisfaction. The available tools to manage requirements tend to be complex what complicates the maintenance of software. Beyond that it fails to provide a way to collect stakeholder's feedback on time so that the software may be optimized and improved across its lifecycle. A way to overcome this is to use the data collected by analytics tools in order to generate recommendations to improve a website and improve the process of requirements maintenance.

Chapter 3

Problem Characterization

This chapter presents the tool analysed to solve the goals presented on this report and that will be applied on the case study (Chapter 4). Apart from it, will also be explained the method used on this dissertation.

3.1 REQAnalytics

This section presents REQAnalytics (APPENDIX A: REQAnalytics), a recommender system (Figure 2) that uses the web usage data of a website, and the information of the mapping of the functional requirements with the web pages and elements to suggest recommendations to the software requirements specification (Garcia and Paiva, 2016b).

The main characteristics of REQAnalytics are:

- **Integration with a Web Analytics Tool:** Taking advantage of the data gathered by a Web Analytics tool it correlates this data with the functional requirements. The system analyses the web usage data from the web analytics tool in order to formulate recommendations to the software requirements specifications (SRS);
- **Requirements Import:** Imports SRS files in a XML file into the system;
- **Mapping Tool:** Allows to relate functional requirements with the web pages and elements of the website;
- **Functional Requirements List Report:** Presents a list of the requirements with its mapping information;

- **Details of the Requirements Report:** Shows all the details related to the requirements in REQAnalytics;
- **Dashboard Visualization Report:** A report that shows information such as. Requirements that are already mapped, Number of mapping established, Charts indicating the percentage of the requirements of the priority ranking, Number of recommendations generated by REQAnalytics;
- **Requirements Dependencies Directed Chart:** A chart that displays the dependencies detected, with previous or following requirements.
- **Most used Requirements Navigation Paths Report:** Based on the functional requirements executed it shows the most frequent paths taken by users along the web application – instead of showing the path as sequences of web pages visited;
- **Traceability Matrix Report:** Correlate the links between the functional requirements and the web pages and elements of the websites;
- **Requirements Analytics (Statistics and Main Metrics) Report:** Lists the most accessed Requirements and other metrics like Entry Features, Exit Features and Requirements Bounce Rate.
- **Report of Recommendations to the Software Requirements Specification based on web usage data:** Present the main recommendations to the SRS, such as:
 - Create New Requirement
 - Requirements Prioritization Change
 - Delete existing Requirement
 - Split a Requirement in two or more Requirements
 - New Requirement Dependency
 - Delete Requirement Dependency

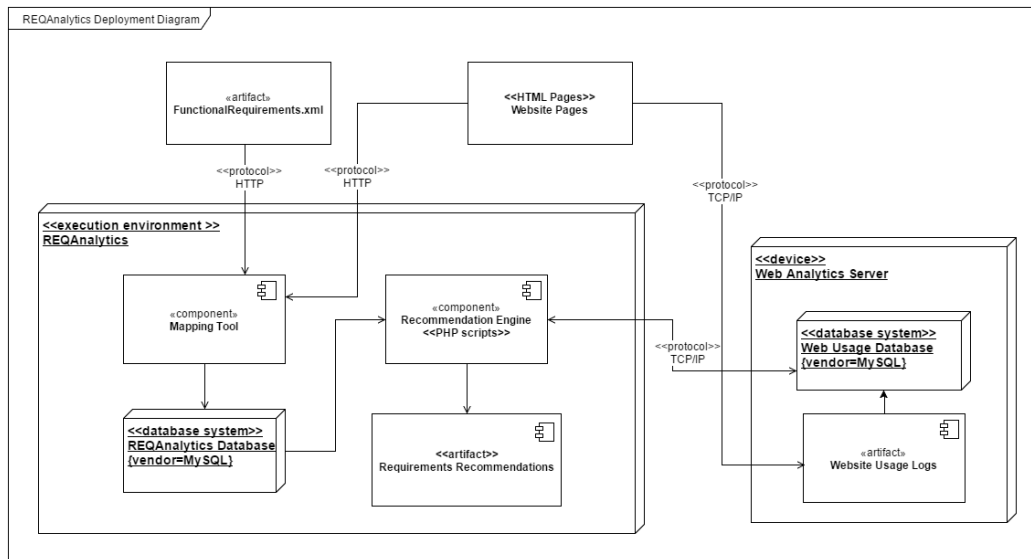


Figure 2: REQAnalytics Deployment Diagram

In order to generate those recommendations, the system uses a web based tool that enables to map functional requirements of a website with the web pages and elements of the features and functionalities of the website. The web usage data from the website is gathered through the use of a web analytical tool – Open Web Analytics (OWA) (APPENDIX B: OWA Results). The system is divided in four different main phases:

- Requirements Mapping: map the functional requirements with the web pages and elements of the website;
- Collect Web Usage Data: use of the web analytics tool for collecting web usage data;
- Analysis of the Data Collected: the data is gathered is analysed and related with the mapping information.
- Generation of Recommendation Report: it is generated a high level recommendations report with possible improvements of the requirements specification and of the website itself.

After collecting and analysing the data, the solution generates recommendations aimed at propose improvements to the website analysed. This reports generated by REQAnalytics are carefully built in a more business friendly language so that they can be easily interpreted. The recommendations given by the tool are:

- Show the most and least used website functionalities, mapped with the respective requirement
- Creation of new requirements
- Eliminate requirements whose functionality are not used
- Change the priority of the functional requirements
- Detect the most used navigation paths

The tool system is divided in nine different parts that belong to the phases presented above, being:

- Requirements Import (Figure 3): the first task to be done is to import the requirements list of the website in analysis to REQAnalytics so that the mapping can be done.

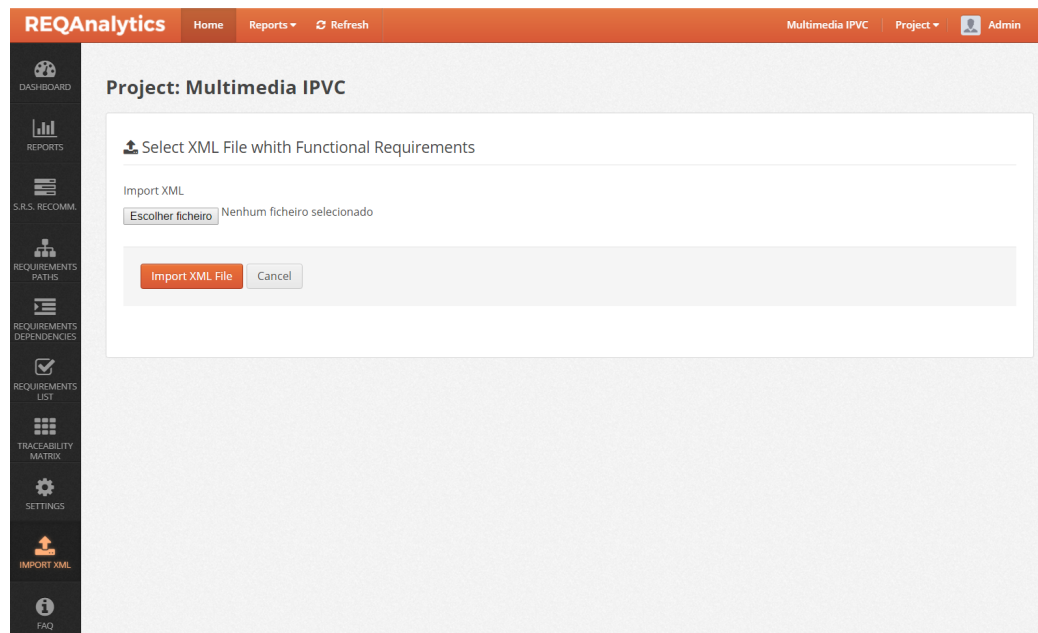
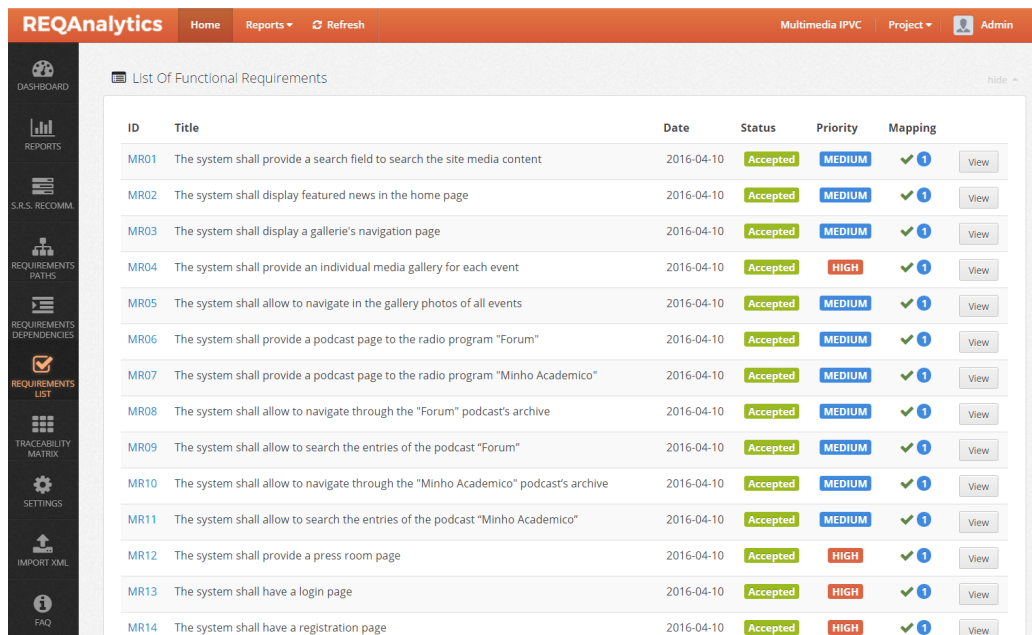


Figure 3: Screenshot of REQAnalytics - Requirements Import

- Functional Requirements List (Figure 4): List all the functional requirements that were imported, showing for each the attributes defined in the XML Schema (Date, Status, Priority).

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The screenshot shows the REQAnalytics interface with a sidebar on the left containing navigation options: DASHBOARD, REPORTS, S.I.S. RECOMM., REQUIREMENTS PATHS, REQUIREMENTS DEPENDENCIES, REQUIREMENTS LIST, TRACEABILITY MATRIX, SETTINGS, IMPORT XML, and FAQ. The main content area displays a table titled 'List Of Functional Requirements' with columns for ID, Title, Date, Status, Priority, and Mapping. The table lists 14 requirements (MR01 to MR14) with their respective details.

ID	Title	Date	Status	Priority	Mapping
MR01	The system shall provide a search field to search the site media content	2016-04-10	Accepted	MEDIUM	✓ 1 View
MR02	The system shall display featured news in the home page	2016-04-10	Accepted	MEDIUM	✓ 1 View
MR03	The system shall display a galerie's navigation page	2016-04-10	Accepted	MEDIUM	✓ 1 View
MR04	The system shall provide an individual media gallery for each event	2016-04-10	Accepted	HIGH	✓ 1 View
MR05	The system shall allow to navigate in the gallery photos of all events	2016-04-10	Accepted	MEDIUM	✓ 1 View
MR06	The system shall provide a podcast page to the radio program "Forum"	2016-04-10	Accepted	MEDIUM	✓ 1 View
MR07	The system shall provide a podcast page to the radio program "Minho Academico"	2016-04-10	Accepted	MEDIUM	✓ 1 View
MR08	The system shall allow to navigate through the "Forum" podcast's archive	2016-04-10	Accepted	MEDIUM	✓ 1 View
MR09	The system shall allow to search the entries of the podcast "Forum"	2016-04-10	Accepted	MEDIUM	✓ 1 View
MR10	The system shall allow to navigate through the "Minho Academico" podcast's archive	2016-04-10	Accepted	MEDIUM	✓ 1 View
MR11	The system shall allow to search the entries of the podcast "Minho Academico"	2016-04-10	Accepted	MEDIUM	✓ 1 View
MR12	The system shall provide a press room page	2016-04-10	Accepted	HIGH	✓ 1 View
MR13	The system shall have a login page	2016-04-10	Accepted	HIGH	✓ 1 View
MR14	The system shall have a registration page	2016-04-10	Accepted	HIGH	✓ 1 View

Figure 4: Screenshot of REQAnalytics - Requirements List

- Details of the Requirement (Figure 5): This component allows to view more data about a specific requirement chosen. The information available is:
 - Requirement
 - Recommendations
 - Requirement Dependencies
 - Mapping with the web pages and elements
 - Parameters
 - Number of visits
 - Most visited Page comparison
 - DOM Element Number of Clicks
 - TOP 5 DOM elements clicked on this page

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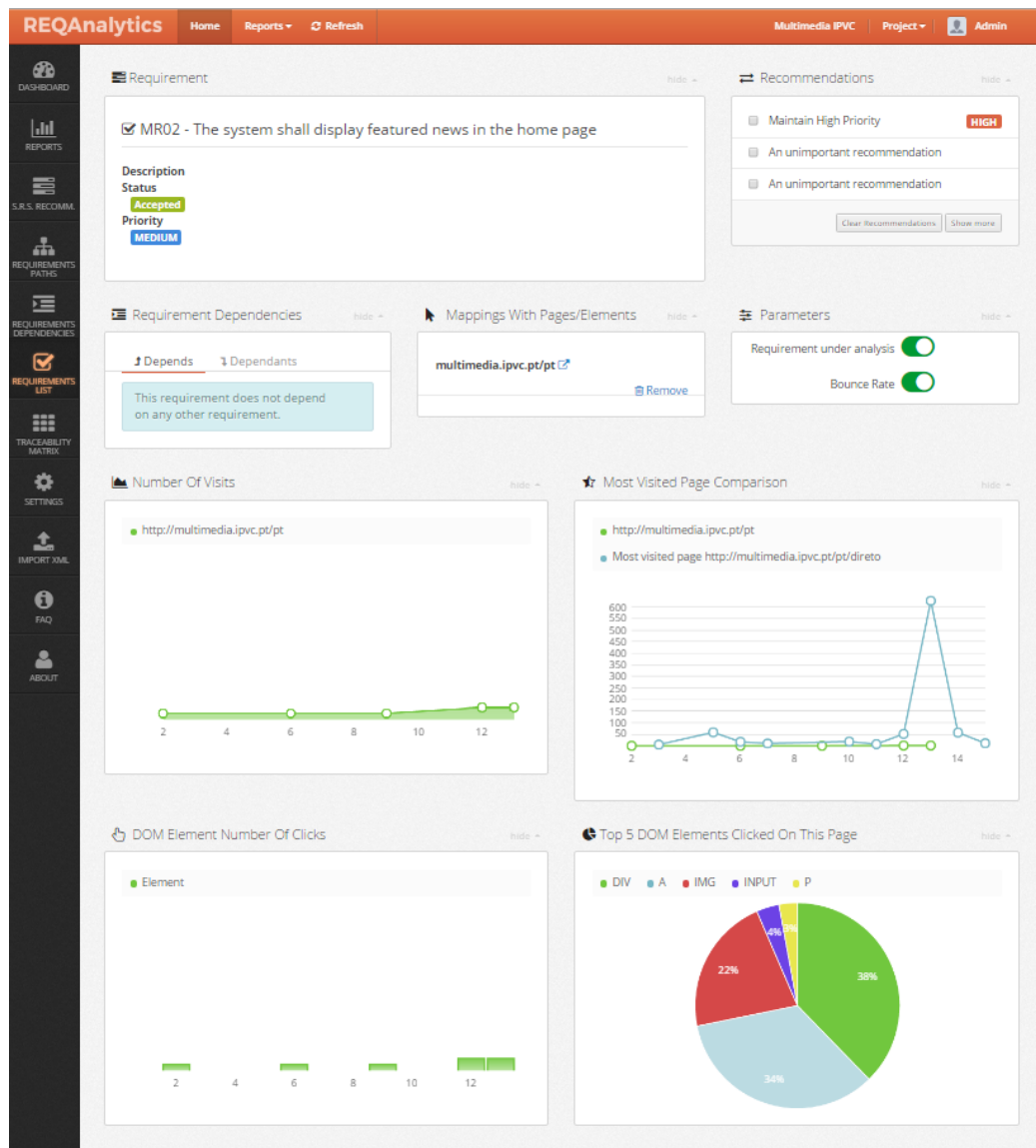


Figure 5: Screenshot of REQAnalytics - Requirement Details

- Dashboard Visualization (Figure 6): The main screen of REQAnalytics that displays the most relevant information about the website being analysed. Making it easy to read.

Requirements Maintenance

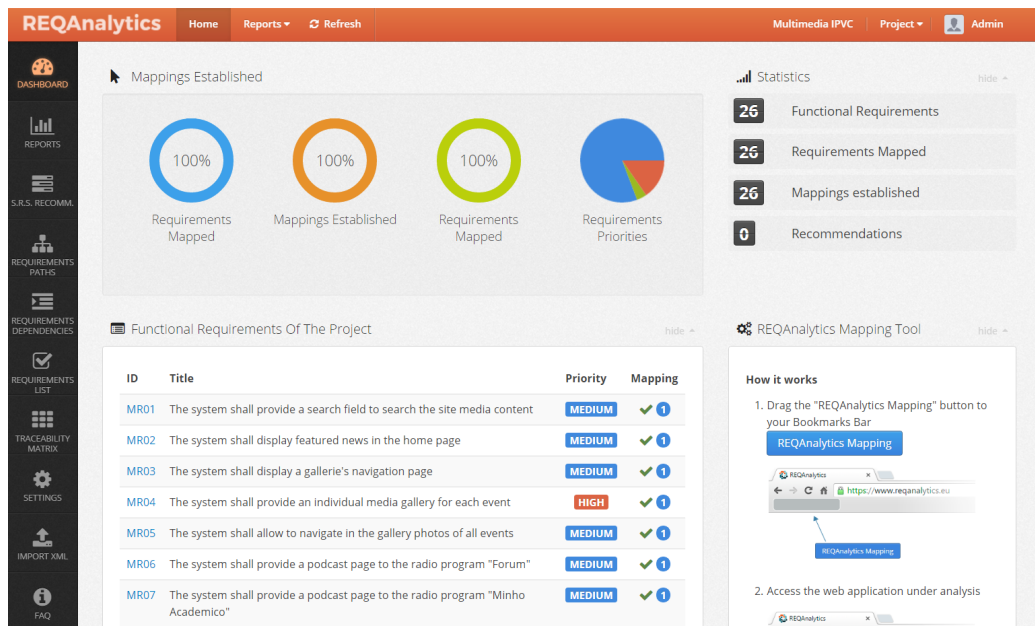


Figure 6: Screenshot of REQAnalytics - Dashboard

- Requirements Dependencies Network Chart: Displays a chart with the navigation paths taken by users of the website, taking in account the functionalities performed.
- Most used Navigation Paths (Figure 7): Shows the most usual paths taken by users of the website, associated with the requirements.

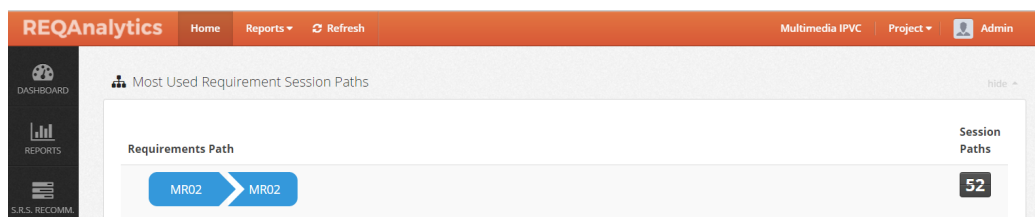


Figure 7: Screenshot of REQAnalytics - Navigation Paths

- Traceability Matrix (Figure 8): A matrix showing the traceability links between functional requirements and the website features.

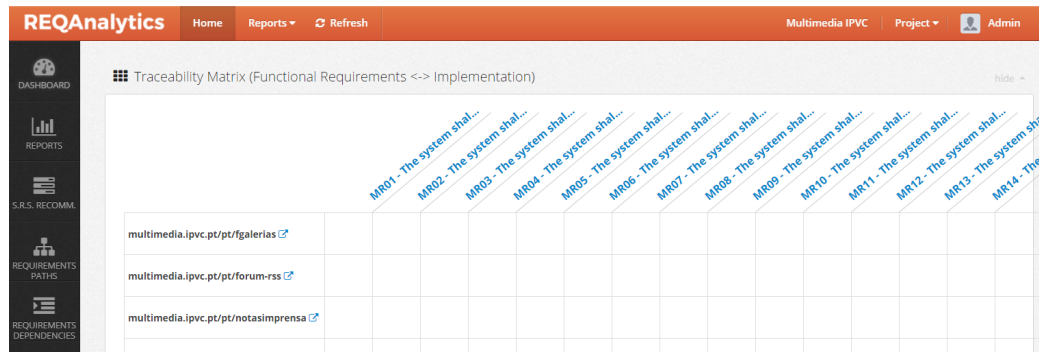


Figure 8: Screenshot of REQAnalytics - Traceability Matrix

- Requirements Analytics (Figure 9): Displays statics and metrics of the functional requirements under analysis, similar to the metrics provided by web analytics tools. Once REQAnalytics correlates web pages and elements with the requirements, it allows to analyse new metrics, such as:
 - Requirements Visits
 - Entry Requirements
 - Exit Requirements
 - Requirements Bounce Rate

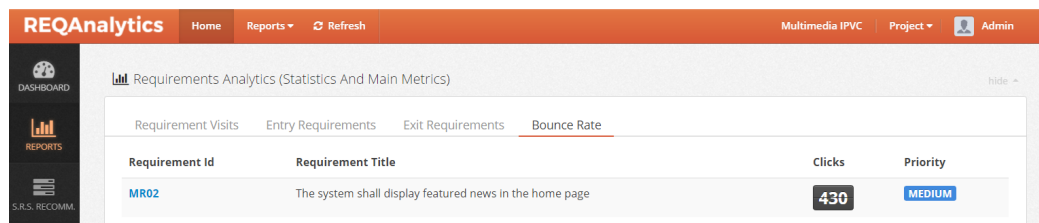


Figure 9: Screenshot of REQAnalytics - Requirements Analytics

- Recommendations to the Software Requirements Specification (Figure 10): From the web usage data collected by the web analytics tool and after correlating it with the functional requirements previously mapped, REQAnalytics generates recommendations that help the task of requirements maintenance. The recommendations may be:
 - Create New Requirements
 - Requirements Prioritization Change

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- Delete Existing Requirements
- Split a Requirement in two or more Requirements
- New Requirement Dependency
- Delete Requirement Dependency

The screenshot displays the REQAnalytics interface for 'Software Requirements Specification Recommendations'. The main section is titled 'Requirements Priority Change' and contains a table with the following data:

Rank	Requirement Id	Requirement Title	Clicks	Priority	Recommendation
1	MR16	The system shall provide a livestreaming page	555	MEDIUM	INCREASE TO HIGH
2	MR02	The system shall display featured news in the home page	255	MEDIUM	INCREASE TO HIGH
4	MR03	The system shall display a galerie's navigation page	147	MEDIUM	INCREASE TO HIGH
9	MR12	The system shall provide a press room page	78	HIGH	MAINTAIN HIGH
10	MR17	The system shall allow to navigate through the streaming records archive	73	MEDIUM	INCREASE TO HIGH
16	MR13	The system shall have a login page	46	HIGH	MAINTAIN HIGH
24	MR06	The system shall provide a podcast page to the radio program "Forum"	37	MEDIUM	MAINTAIN MEDIUM
33	MR07	The system shall provide a podcast page to the radio program "Minha Academico"	22	MEDIUM	MAINTAIN MEDIUM
57	MR15	The system shall have a recovery password page	9	MEDIUM	DECREASE TO LOW
78	MR14	The system shall have a registration page	6	HIGH	DECREASE TO LOW
80	MR23	The system shall display page with the rss feeds available	5	MEDIUM	DECREASE TO LOW
98	MR21	The system shall provide a website credits page	4	LOW	MAINTAIN LOW
101	MR22	The system shall provide a contact page	1	MEDIUM	DECREASE TO LOW
213	MR18	The system shall provide a FAQ page	1	MEDIUM	DECREASE TO LOW
221	MR19	The system shall provide a privacy policy page	1	MEDIUM	DECREASE TO LOW
232	MR20	The system shall provide a terms of use page	1	MEDIUM	DECREASE TO LOW

Below the table, there are sections for 'Create New Requirements' and 'Delete Requirements'. The 'Create New Requirements' section shows three entries with 'NEW REQUIREMENT' buttons. The 'Delete Requirements' section shows one entry with a 'DELETE REQUIREMENT' button.

Figure 10: Screenshot of REQAnalytics - SRS Recommendations

As stated above, there are several recommendations that REQAnalytics may generate in order to help improve and maintain a website, which can con-

tribute to the overall quality of the service provided. The type of analysis provided by REQAnalytics distinguishes itself from other analytics tools that only generate reports with navigation statics (APPENDIX B: OWA Results) and in a language closer to the business. Since during the lifecycle of a website its requirements are constantly changing and evolving, the task of requirements maintenance can profit with this approach. That is with the possibility to collect the web usage data, it is possible to generate recommendations that may help increasing the quality of the software requirements specification.

3.2 Methodology - Analyse Conducted

This report it is aimed to conduct an analysis on the software REQAnalytics. To do so it will be applied the software on a case study (Chapter 4). Not only is intended to discuss and validate the software features presented by (Garcia and Paiva, 2016a) but also to provide constructive criticism. It was chosen a case study to evaluate this approach efficacy on providing recommendations to the software requirements specification by using the web usage data. With the data collected by the web analytics tool it will also be analysed possible improvements to REQAnalytics.

The case study was conducted by following the guidelines of a qualitative case study method (Yin, 1994). Guided by the six activities of this method, the study begins with the identification of the research questions (Plan), followed by the definition of the data to be collected (Design). It continues by identifying who will be part of the case and how the data will be collected (Prepare). On the fourth stage the data is collected (Collect). The data gathered is then analysed (Analyse) and in the sixth (Share) the results and findings are reported.

Chapter 4

Case Study

On this section it is presented the results achieved by the application of the proposed methodology in order to validate the research goals. To do so, there were defined goals to analyse the data, following with the definition on how to collect it as the period it was gathered. Lastly the results and their analysis are presented.

4.1 IPVC Multimédia

The “IPVC Multimédia” website (Figure 11), owned by Instituto Politécnico de Viana do Castelo (IPVC), aims to provide the IPVC community with multimedia content related to the institute. Apart from that kind of contents it also provides a description of the events taken in place in the institute or with relevant interest. The website contents are coordinated by Gabinete de Comunicação e Imagem do Instituto Politécnico de Viana do Castelo (GCI-IPVC).

Being a service provided throughout time it is necessary to maintain its requirements during the project lifecycle what will help to improve the quality of the software requirements specification and consequently improving the service quality. Therefore this web service was chosen to conduct the case study.



Figure 11: IPVC Multimédia website

This case study is meant to evaluate REQAnalytics capacity to support the process of requirements maintenance. Above all, it is conducted to answer the research questions of this research work that are defined on section 1.3 (page 2).

4.1.1 Goals

The goals defined for this case study were:

- Analyse the recommendations provided by REQAnalytics
- Analyse the data collected from the usage of the website to provide new recommendations to the software requirements specification
- Identify users' navigation paths and suggest changes
 - Shortest path

- Identify users' duration time per website page
- Suggest recommendations to merge requirements
- Identify requirements attributes
- Analyse the traceability links between the functional requirements and pages and HTML elements of a web service

4.1.2 Data Collection and Analysis

The first step of the solution is to identify the list of functional requirements and its priority change criteria under analysis on the IPVC Multimedia case study. On Table 2, it is possible to view all the functional requirements identified on the requirements specification document of the website.

Table 2: IPVC Multimedia Functional Requirements

ID	Description	Priority
MR01	The system shall provide a search field to search the site media content	Medium
MR02	The system shall display featured news in the home page	Medium
MR03	The system shall display a gallery's navigation page	Medium
MR04	The system shall provide an individual media gallery for each event	High
MR05	The system shall allow to navigate in the gallery photos of all events	Medium
MR06	The system shall allow to navigate in the gallery photos of all events	Medium
MR07	The system shall provide a podcast page to the radio program "Minho Academico"	Medium
MR08	The system shall allow to navigate through the "Forum" podcast's archive	Medium
MR09	The system shall allow to search the entries of the podcast "Forum"	Medium
MR10	The system shall allow to navigate through the "Minho Academico" podcast's archive	Medium
MR11	The system shall allow to search the entries of the podcast "Minho Academico"	Medium
MR12	The system shall provide a press room page	High

Continued on next page

Table 2 – Continued from previous page

ID	Description	Priority
MR13	The system shall have a login page	High
MR14	The system shall have a registration page	High
MR15	The system shall have a recovery password page	Medium
MR16	The system shall provide a live streaming page	Medium
MR17	The system shall allow to navigate through the streaming records archive	Medium
MR18	The system shall provide a FAQ page	Medium
MR19	The system shall provide a privacy policy page	Medium
MR20	The system shall provide a terms of use page	Medium
MR21	The system shall provide a website credits page	Low
MR22	The system shall provide a contact page	Medium
MR23	The system shall display page with the RSS feeds available	Medium
MR24	The system shall provide RSS feed for press release	Medium
MR25	The system shall provide RSS feed for “Forum” podcast	Medium
MR26	The system shall provide RSS feed for the media galleries	Medium

After this identification, the list is then exported to an XML document to be inserted on REQAnalytics database, respecting the format allowed by it. Only, after this task finishes, the mapping between each requirement and the web pages and elements of the website under analysis is established. For collecting the web usage data of IPVC Multimedia it was used the web analytics tool Open Web Analytics (OWA). This tool provides REQAnalytics the data needed to generate recommendations. Studying the data collected using OWA it is possible to analyse the recommendations made by REQAnalytics and validate their usability to improve not only the activity of requirements maintenance but also the added value for business in measuring the improve of the website itself.

4.1.3 Results

During the analysis period, REQAnalytics linked the web usage data collected by the web analytical tool (Open Web Analytics) with the mapping information of the requirements in order to analyse the information and generate reports and recommendations to the software requirements specification. The recommendations generated by REQAnalytics are stated below in Figure 12.

Change the Priority of the Functional Requirements

Software Requirements Specification Recommendations

Requirements Priority Change hide

Rank	Requirement Id	Requirement Title	Clicks	Priority	Recommendation
1	MR16	The system shall provide a livestreaming page	869	MEDIUM	INCREASE TO HIGH
2	MR02	The system shall display featured news in the home page	269	MEDIUM	INCREASE TO HIGH
4	MR03	The system shall display a gallerie's navigation page	147	MEDIUM	INCREASE TO HIGH
9	MR12	The system shall provide a press room page	78	HIGH	MAINTAIN HIGH
10	MR17	The system shall allow to navigate through the streaming records archive	73	MEDIUM	INCREASE TO HIGH
16	MR13	The system shall have a login page	46	HIGH	MAINTAIN HIGH
24	MR06	The system shall provide a podcast page to the radio program "Forum"	37	MEDIUM	MAINTAIN MEDIUM
33	MR07	The system shall provide a podcast page to the radio program "Minho Academico"	22	MEDIUM	MAINTAIN MEDIUM
60	MR15	The system shall have a recovery password page	9	MEDIUM	DECREASE TO LOW
74	MR14	The system shall have a registration page	6	HIGH	DECREASE TO LOW
84	MR23	The system shall display page with the rss feeds available	5	MEDIUM	DECREASE TO LOW

Figure 12: Requirements Priority Change

Taking in account the information generated by the priority change suggestions and all the data gathered, the solution comes up with several observations that may support the process of improvement of the software requirements specifications, such as:

- Creation of new requirements

Create New Requirements hide

URL : http://multimedia.ipvc.pt/en/node/133?page=0,2 (Detected URL Pattern) : Different URL Pages with the same pattern (Similarity > 90%) Mapped Requirement: Not Found Suggested Priority: HIGH	NEW REQUIREMENT
URL: http://multimedia.ipvc.pt/en/node/133 Mapped Requirement: Not Found Suggested Priority: MEDIUM	NEW REQUIREMENT
URL: http://multimedia.ipvc.pt/en/live Mapped Requirement: Not Found Suggested Priority: MEDIUM	NEW REQUIREMENT

Figure 13: Create New Requirements

The data gathered suggests the need to have access to an English version of the live page. Therefore, and in line with the recommendations of new requirements, the website should have an English version available. It is suggested the specification of a requirement such as “The system shall display a language selection option”, with a medium priority.

- Eliminate requirements whose functionalities are not used

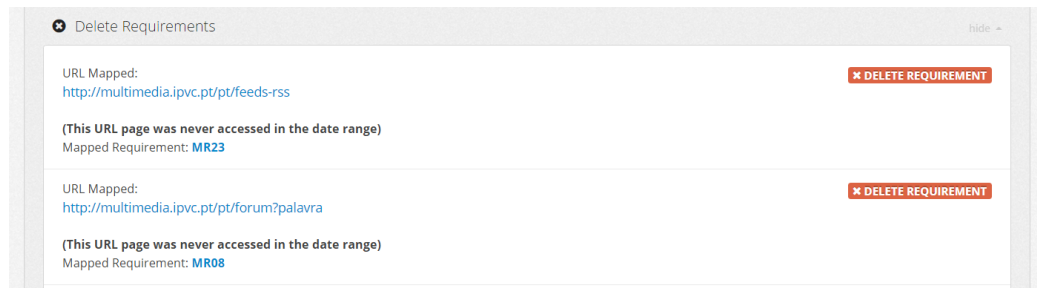


Figure 14: Delete Requirements

In REQAnalytics, it is necessary to previously define which are the requirements that even if they are never visited, they can not be removed, because they are important to the website. The results obtained suggest the removal of requirements MR23 (The system shall display page with the RSS feeds available) and MR08 (The system shall allow to navigate through the “Forum” podcast’s archive). According with the results users do not value those functionalities and removing it would improve the need for maintenance of the website.

- Most used pages/functionalities of the website (Figure 12)
- Analysis each requirement priority

According with the number of clicks for each web page – previously mapped with the requirements list – the application lists the requirements from the most to the least clicked one. If a requirement is highly accessed and has low or medium priority, REQAnalytics suggests the increase of its importance (example: MR16 – The system shall provide a live streaming page – Priority: Medium). In the same way, for requirements not much accessed but have a medium or high priority it suggests to decrease the priority (example: MR14 – The system shall have a registration page – Priority: High). These results show that users do not value the registration page as much

as was initially foreseen, because it is only visited to user registration. In this case there should be given more attention to improve the live streaming page, making it the top priority for maintenance to the detriment of registration page. REQAnalytics priority analysis take in account the most used pages/functionalities of the website to support requirements engineers establishing the priority for their work in line with user's needs.

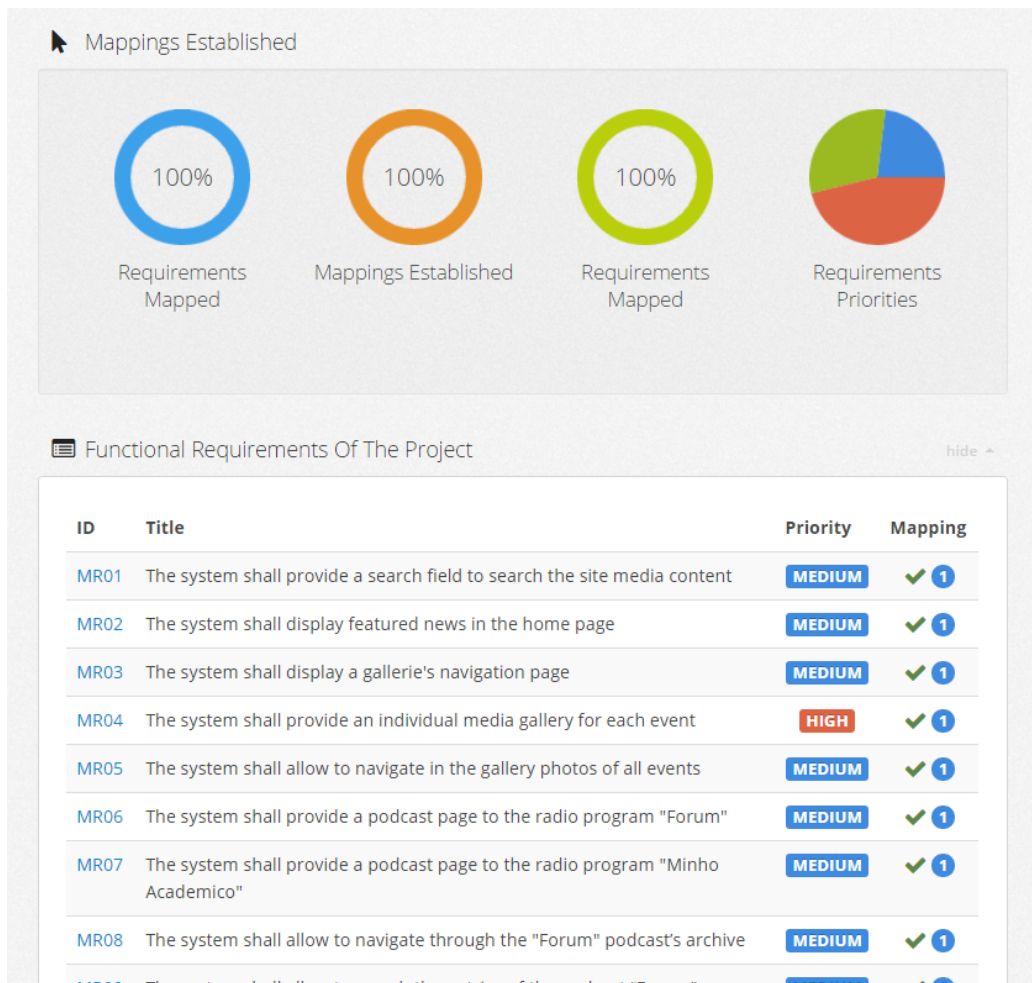


Figure 15: REQAnalytics Dashboard

As shown by the results presented, REQAnalytics provides several recommendations in order to improve the software requirements specification. By providing the list of requirements it allows to identify if all requirements are implemented in the website (Figure 15). This option aims to provide an understandable report so that any stakeholder can easily interpret it, which common web analytics tools, fail to provide..

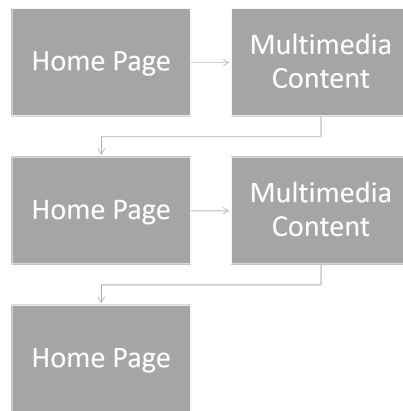


Figure 17: Representation of current multimedia content navigation

To improve the website usability there should be implemented a way to consult other multimedia contents from the current page. In Figure 18 is represented a possible navigation path to resolve the issue.

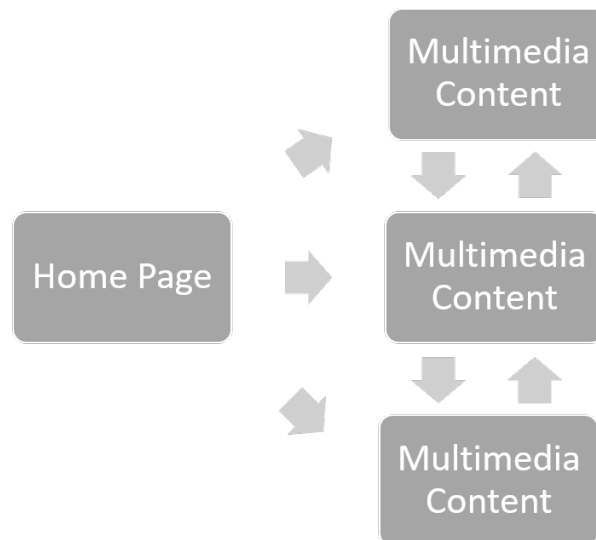


Figure 18: Multimedia Navigation Path Recommended

The suggestion was achieved on an empirically way, although REQAnalytics provides an useful support to conduct this analysis thanks to its graphic features such as the navigation and graphs path report.

Entry and Exit Requirements

Displays the top entry and top exit requirements. It is possible by correlating the visited pages with the web pages and elements mapped with each requirement. The page with the higher number of visits as first page is the top entry requirement (Figure 19) and the one with the highest visits as last page for each session makes the top exit requirement (Figure 20).

- Top Entry Requirements

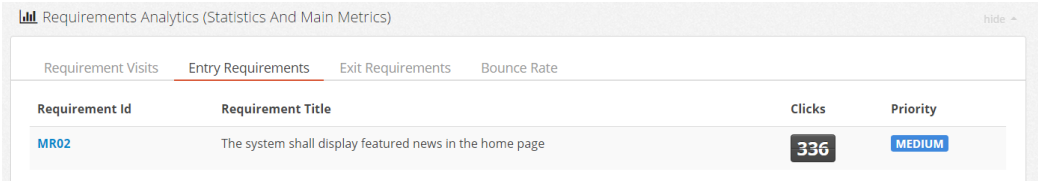


Figure 19: Entry Requirements

- Top Exit Requirements

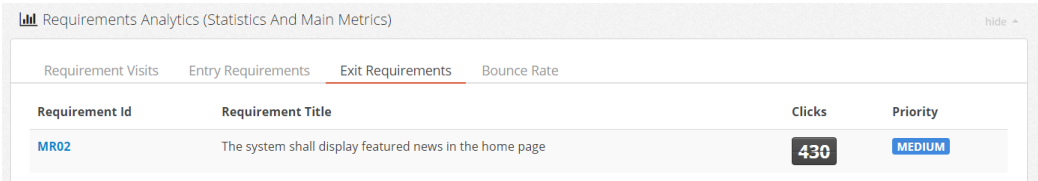


Figure 20: Exit Requirements

Being the requirement MR02 mapped with the homepage URL, the results show that most of the visits are accessing the website through the homepage. This top entry and top exit analysis help to identify the functionalities that should be enhanced in order to keep attracting users or to try making them not leave the website. For the case study presented, the top entry page already has some engaging options such as a direct access to the most used functionality (MR16: The system shall provide a live streaming page) and display option to become a social fan – Figure 11. But the website could be improved in order to keep visitors from leaving or ensure their return. One possible improvement, taking in account the livestream functionality, would be the implementation of a pop-up to suggest users to receive notifications on new livestream events as exemplified on the following mockup – Figure 21.

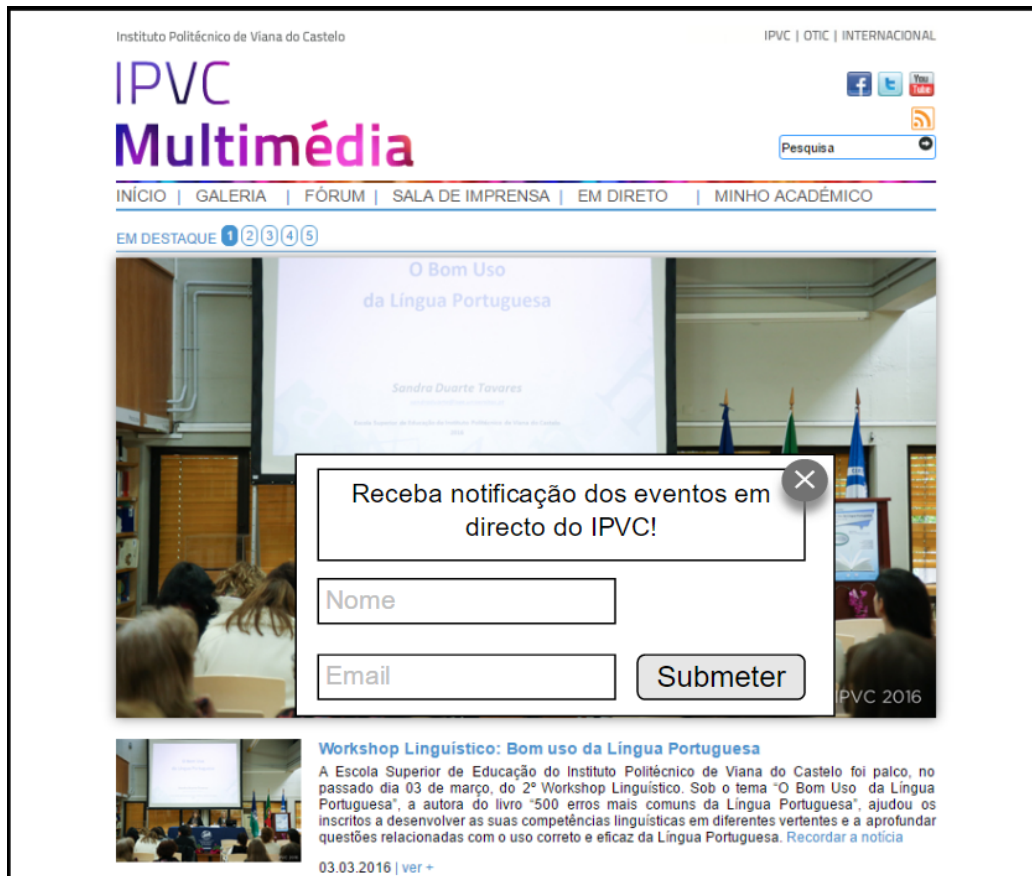


Figure 21: Mock-up of Livestream Notification Pop-up

Traceability Matrix

The data in the database allows REQAnalytics to generate a traceability matrix between functional requirements and web pages and elements (Figure 22). In this case study the traceability matrix shows that all requirements were covered.



Figure 22: Traceability Matrix

Split a Requirement in two or more

On Figure 23 is displayed the REQAnalytics recommendation to split a requirement in two or more requirements. This has to do with the feature of the solution that when detects a substantial number of visits for a page without leaving to another requirement of the website, it suggests that the requirement is split. This is another type of recommendations provided that help to better understand the web usage data. As seen on Figure 12, the requirement MR02 (The system shall display featured news in the home page) has 269 clicks and REQAnalytics suggests to split it. Taking in account the mapped the URL and the requirement there can be some ambiguity. For

that reason, MR02 should be split in two or more requirements to overcome this difficulty.

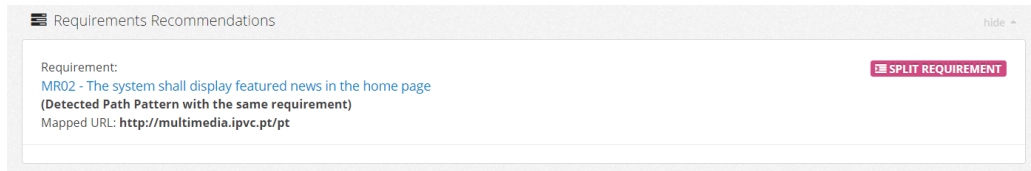


Figure 23: Split Requirement

The web usage data collected by the analytical tool – OWA – allows to verify which are the most and least used functionalities or pages accessed and therefore suggest the creation or the elimination of requirements (Figure 13, Figure 14). It is also possible to evaluate the most used navigation paths that can be helpful to improve the website user experience (Figure 16). It is understandable the importance (Figure 12) of the requirements MR16 and MR02 that were the most accessed URL addresses during the analysis period and therefore REQAnalytics suggests to increase their priority to high. All these recommendations provide a useful support to the requirements maintenance and help to update the software requirements specification closer with the users' needs.

4.2 Discussion

The case study helps to validate the initial proposal and the REQAnalytics features as a solution that may support the activity of Requirements Management on a web service during its lifecycle. With the achieved results it is possible to answer the first research question (How can Requirements Management be supported by web usage data of a website;) and verify the importance of the web usage data to properly understand the patterns of the website users and link it with the requirements specification.

As stated on Chapter 2, Requirements Management has to with the process of managing changes in requirements no only during the requirements during the requirements engineering process and system development but also during the system lifecycle. Once may appear new requirements and need during and/or after the project is delivered to the client. Therefore, the management of requirements aims to guarantee the traceability of requirements, analysis of maturity and stability as well as the observation of disposal needs, changing or adding requirements during the development phase or system maintenance. By what was shown with the application of the case

study the second research question (How REQAnalytics allows to support Requirements Management) is also answered by results attained.

In addition, it was also possible to answer the third research question (What types of recommendations to requirements specifications may REQAnalytics offer;). The results obtained show several recommendations of the solution to the requirements specifications, such as: the creation of new requirements, the deletion of requirements whose functionalities are not used and the priority change of requirements. The reports generated by REQAnalytics shown in the Chapter 4 can be easily understood allowing a better interpretation of the web usage data when comparing with the results of other tools. Thus addressing the fourth research question (In what way are the reports generated by REQAnalytics more supportive for businesses than traditional reports of web analytical tools;).

Regarding the IPVC case study and the reports generated by REQAnalytics it can be verified that those reports provide a huge support for the task of Requirements Management – answering the fifth research question number (How has the use of REQAnalytics in the IPVC case study has improved the Requirements Management task;) – However to better prove this question the recommendations should be implemented in the website and the new results compared with the ones previously obtained.

The sixth research question (How does REQAnalytics allows to support management of a web service requirements throughout its lifecycle;) may automatically be answered with the assumptions achieved with the research questions number 2 and 3.

Lastly, the last research question (7. Analyse the advantages of creating traceability links between the functional requirements and pages and HTML elements of a web service.) is concerned with the ability of REQAnalytics to easily map each functional requirement with the web pages and then generate a traceability matrix (Figure 22) that list the links between the functional requirements and the web pages and elements. This research work demonstrates to be a useful tool to requirements maintenance seeing that on a continuously evolving environment the need of taking trace of every change becomes essential.

Along the evaluation of REQAnalytics there were some improvements identified. Regarding the functional requirements list and the constant changes and evolution of services, by adding two more attributes (Status and Risk) to the existing ones would make REQAnalytics more supportive since the first stage of a software project development. Another feature that could be added to the tool would be the ability to suggest the merge of requirements on a similar way as the split recommendations already provided.

Chapter 5

Conclusion

5.1 Contributions

The research work aims to analyse the recommender system to support requirements maintenance and enhance the software requirements specification and the overall website. It basis on the information gathered by an analytical tool about the usage of a website to come up with recommendations to the website under analysis. Those recommendations intend to increase the website quality and its lifecycle and consequently the service provided.

All this research is grounded by the experimental evaluation conducted on a case study where several recommendations to improve the requirements of the website where obtained. REQAnalytics displays the list of all functional requirements mapped with the web pages, identifies the top entry and top exit functional requirements and shows the navigation paths followed by users. This analysis allows to study alternative navigation paths that may increase the user experience and the quality of the website. In terms of recommendations to the functional requirements, it is able to suggest the priority change, creation of new, supress of others and even to split requirements in two or more. In summary the findings achieved in this case study validate the approach that REQAnalytics can be a good support to requirements maintenance during the lifecycle of a website, improving its overall quality.

This type of analysis distinguishes from existing web analytic tools that can only provide reports with navigation statics. Apart from this, REQAnalytics differs from those tools in the way its reports are available on a language closer to business.

Although REQAnalytics proves to be a helpful tool to support requirements management, along the experimental evaluation elaborated there were some

aspects identified that could be addressed by the tool so that it can be more complete. In terms of the functional requirements list and taking in account the constant changes and evolution of the services, it is suggested to add two more attributes to the existing ones – id, description and priority. Attributes as status and risk are helpful to make REQAnalytics more supportive since the first software project delivery. A functional requirement not yet implemented would be listed by REQAnalytics as not mapped, but with the status attribute more easily it would be to understand why it was not mapped. The other attribute suggested, risk (evaluated as low, medium or high) would also provide a helpful information to manage requirements throughout the project lifecycle.

Other improvement would be to analyse which functional requirements could be merged. The solution already recommends to split requirements in two or more based on the number of visits for a page without leaving to another requirement of the website. In a similar way using the data gathered REQAnalytics could recommend to merge requirements that provide the same function to users.

Most web analytics tools, as OWA, have a feature that allows to define goals. It is commonly used by marketers to determine their campaigns income. But for requirements engineers this can be a way to determine a better user experience, increasing the website usability and therefore the overall quality of the service provided. This could be achieved by defining goals to better understand the users' navigation patterns

5.2 Future research work

The application of the recommendations obtained on the case study would be an interesting point to achieve so that then could be done a comparison analysis to measure the “IPVC Multimédia” website quality – before and after implementation of REQAnalytics recommendations. Taking in account the suggestions made to improve REQAnalytics, implementing them in the tool and analysing its impact would be an interesting research work.

It would also be interesting to evaluate REQAnalytics ability to support requirements maintenance of other kind of services such as web applications, intranets and business support applications.

The last proposed future research work is the development of a business plan for REQAnalytics.

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APPENDIX A: REQAnalytics

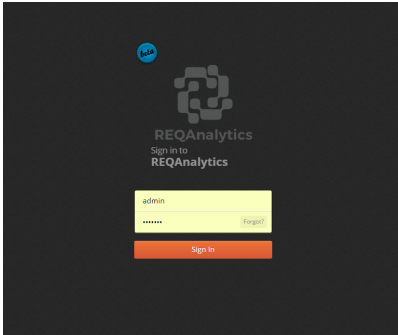


Figure 24: Screenshot of REQAnalytics entry page

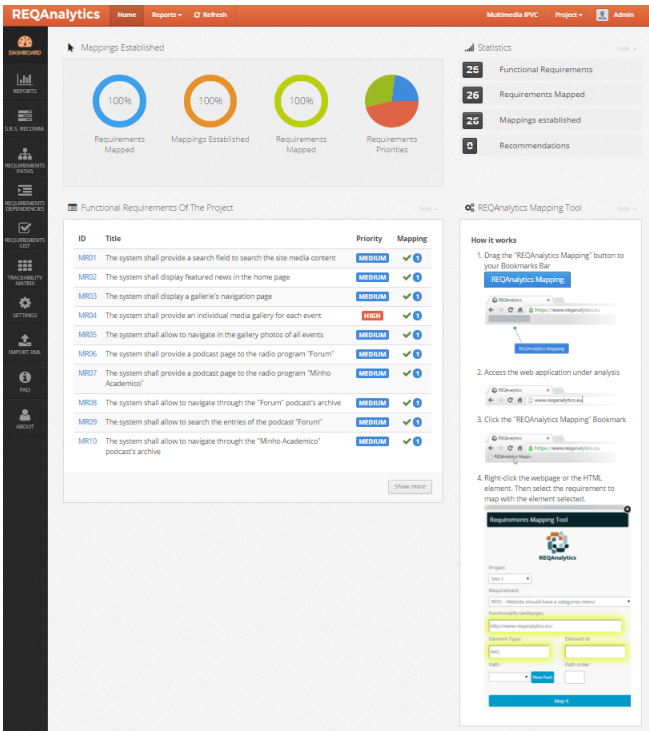


Figure 25: Screenshot of REQAnalytics landing page

