TÉCNICO LISBOA

BOAv3/DashVis: Visualization Dashboard applied to Learning Objects Repository

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Abstract

As the learning community evolves, it is necessary to track its users activities in order to provide improved solutions. Not only is it important to monitor but also group and present that same information in a clear and concise way as both learners and educators rely on this data to measure performance, thus adapting behavior if needed.

Dashboards are an appropriate solution because they allow to aggregate information as necessary and provide with customizable visualizations.

This thesis analyses the current implemented technologies for information visualization in the social web environment such as Facebook, LinkedIn, ResearchGate, Picasa and Flickr. It proposes a set of dashboards for BOA's ("Bolsa de Objectos de Aprendizagem") social objects using visualization information technologies, i.e. User dasboard, Learning Objects dashboard, Group dashboard and Virtual Collection dashboard. These dashboards aim to motivate users interaction with the system providing an overview of their activities in BOA thus stimulating users towards obtaining boosts (or rewards).

Furthermore, these dashboards were tested on Usability and Performance concluding that the proposed solution is prepared to scale without affecting performance of the dashboards and also proposes a solution that pleases users allowing them to monitorize their activities in BOA as well as stimulate them to continually interact with it.

Keywords

BOA (Bolsa de Objectos de Aprendizagem), Learning Object Repositories, Social Objects, Information Visualization, Dashboards

Resumo

À medida que a comunidade de aprendizagem cresce é necessário que as actividades dos seus utilizadores sejam monitorizadas de forma a fornecer soluções incrementalmente melhoradas. É importante monitorizar, agrupar a informação e apresentá-la de uma forma clara e concisa pois tanto educadores como alunos dependem destes dados para medir a sua performance adaptando assim o seu comportamento, caso necessário.

Os dashboards são uma solução apropriada pois permitem a agregação da informação assim como a sua costumização, conforme a necessidade.

Esta tese analisa as tecnologias actuais para a visualização de dados em ambientes sociais web como o Facebook, LinkedIn, ResearchGate, Picasa e Flickr e propõe um conjunto de dashboards de visualização adaptado aos objectos sociais do BOA (Bolsa de Objectos de Aprendizagem) - mais especificamente os Utilizadores, Grupos, Objectos de aprendizagem e Colecções Virtuais- usando tecnologias de visualização de informação, ou seja Dashboard de Utilizador, Dashboard de Objecto de Aprendizagem, Dashboard de Grupo e Dashboard de Colecção Virtual. Estes dashboards têm como objectivo motivar os utilizadores a interagirem com o sistema dando uma visão global das suas actividades no BOA e dessa forma estimulando os utilizadores a obterem recompensas.

A solução proposta foi testada em Usabilidade e Performance concluíndo que a mesma se comporta correctamente com o constante e exponencial crescimento de dados assim como propõe uma solução que agrada aos utilizadores, permitindo-lhes monitorizar as suas actividades no BOA assim como estimulá-los a continuamente interagir com a mesma.

Palavras Chave

BOA (Bolsa de Objectos de Aprendizagem), Repositório de Objectos de Aprendizagem, Objectos Sociais, Visualização de informação, Dashboards

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Acronyms

BOA Bolsa de Objectos de Aprendizagem

BOA-GPI Bolsa de Objectos de Aprendizagem - Gestão de Projectos Informáticos

BOAv3 Bolsa de Objectos de Aprendizagem v3

DNN DotNetNuke

INESC-ID Instituto de Engenharia de Sistemas e Computadores - Investigação e Desenvolvimento

InfoVis Information Visualization

LO Learning Object

LOR Learning Objects Repository

VC Virtual Collection

1

Introduction

Contents

More and more society relies on efficient and simple ways to read and represent information, the simpler the better. Consequently the information presented to the user needs to be concise and easy to understand so that it makes the users' life much easier. This applies to learning, as the web arose and technology evolved, new and improved ways to represent knowledge and educational practices were offered [2]. Downes [3] assumes that there is repetition of content as there may be subjects that share the same contents. The world does not need thousands of similar descriptions, specially online.

Learning Objects (LO) are resources that produce and represent educational material which are stored in specific repositories denominated Learning Objects Repositories, which are similar to digital libraries as they catalogue and manage these educational resources. LOs properly described associated with metadata turn into reusable and interoperable resources in a variety of contexts [4] avoiding repetition and in a way helping creating order in chaos [5]. These resources are maintained in a repository, named Learning Objects Repository (LOR), that stores both LOs and their metadata allowing search and reuse of data in learning contexts [1].

1.1 Context

The BOA ("Bolsa de Objectos de Aprendizagem") is a collaborative web based application that supports user communities as part of the teaching and learning process [6]. BOA is essentially a Learning Objects Repository that promotes active collaboration between users in submission of LOs and submission of relevant information that contributes to its understanding.

The system works as a reputation based system calculating the level of users collaboration throught the level of their activities with the platform, rewarding the ones that collaborate the most and more actively participate and contribute for high quality creation LOs. Every action performed by the user is captured and quantified, positively influencing the user's reputation. Additionaly there is a time decaying function that verifies and updates the reputation in case of no interaction with the platform, this way users have a hidden incentive [1] to maintain engagement.

Figure 1.1 presents the BOA system overview containing its concept and features [1].

The BOA system has been developed by INESC-ID[1] research laboratory and was instantiated into two usage scenarios: the BOA-GPI [2] and VemAprender[3].

BOA is currently in its 3.0 version, being a result of the work of three MsC students namely Dinis [6], Carlota [7] and Gouveia [1].

[1] http://www.inesc-id.pt
[2] http://isg.inesc-id.pt/BOA-GPI
[3] http://vemaprender.net

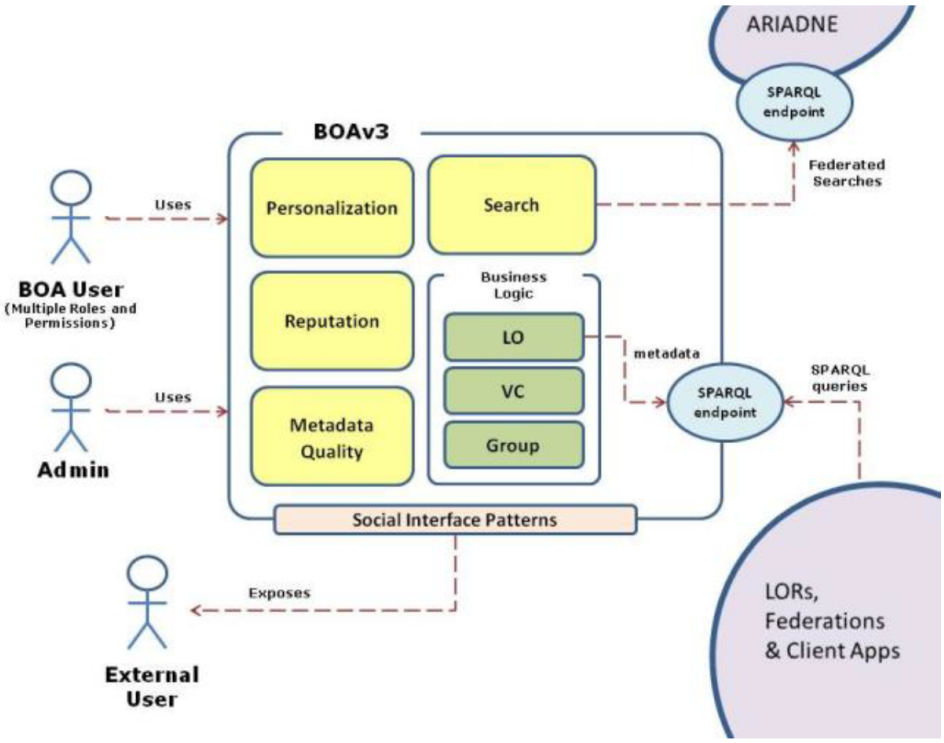


Figure 1.1: BOA System Overview [1]

BOA-GPI is the instance used at a university course at IST (Instituto Superior Técnico), more explicitly GPI (Gestão de Projectos Informáticos). This instance was designed to test a real scenario for the original BOA prototype. It contains documents, presentations, whichever material submitted by users belonging to this community and uniquely related to this subject. This way both students and teachers collaborate by belonging to the same sharing environment.

This instance also contains 5 different groups, separated by topic, GPI2008, GPI2009, GPI2010, GPI-Docents - uniquely for contents submitted by teachers and finally , which contains LOs that do not belong to any of the other groups. These groups can be differentiated by the definition of rules by the administrator of the system BOA.

VemAprender targets for K-12 education levels, i.e. any user that is in any way connected to these learning levels (from kindergarten to the 12th grade) has access to VemAprender and can actively collaborate with materials from all fields of education, related to K12. Unlike BOA-GPI which is directed to a more restrictive audience, this is a public access instance, as long as the user belongs to the target audience.

BOAv3 is an additional non public instance, more specifically an update and consequently an improved version of BOA developed by Bernardo Gouveia in his Master Thesis [1]. Unlike the previous

versions, BOAv3 does not yet target for a specific audience thus allowing the user to manage their groups more freely.

Amongst inumerous improvements in BOAv3's functionality one of the most important ones is the reputation system. This system monitors and rewards users for their actions on a daily basis [1] while the previous versions of BOA relied on a credit based system very similar to the stock exchange metaphor. That way users are constantly acknowledged for their positive actions increasing their score in BOA, but their reputation decreases gradually if there is no engagement from the user. This function aims to maintain user's interest and collaboration with the platform.

1.2 Problem Definition and Motivation

Understanding the aim of BOA and what it comprises there is the concern to improve users participation within the community considering current technological advances. Data can either be ignored, archived or it can be used in a way that is relevant to the users. Currently in the BOA platform the data is being used but it is not yet perceptible to the user.

It is not only important to keep the user interested in collaborating with the platform, but also design a way to give the users consciousness of their actions and what influence they have on their score and others.

This way the main concern of this thesis is to find an interface that aggregates and presents this data to the user in a way that the user does not feel lost and lose interest on the platform. The goal is to find a solution that allows the user to check all his data and all the actions made upon such data.

1.3 Proposed Solution

The BOA platform has three main assets [1], LOs, Groups and Virtual Collections, all of which are associated to a user and whose actions influentiate their score (or reputation). Until now users interact with these assets but are completely unaware of their reputation growth or their activities through time and in general.

Considering the concerns for improvement of the BOA platform and its users experience, the proposed solution is to use dashboard and information visualization technology to display most relevant information grouped in a significant, comprehensible and appealing way applied to the BOA context as it lacks interactive visualizations to help users gain insights into their data and identify patterns [8] in their behaviour, thus taking action into improving their performance and most relevant metrics in the platform.

Besides providing with a simple and concise view of the data, this solution as well improves users participation within the community as it will show specific data that encourages users to do so. As Silva refers in [9] what motivates users to remain in a certain community is a Social Object. Besides this

notion, it is as important to define the community's actions (or "verbs"). By defining these two objects, it is possible to design a usable solution.

This solution is not only applied to users (monitoring and presenting their activities and reputation) but also to LOs, Groups and Virtual Collections as these also have their own metrics and reputation, weighing in the user's reputation score.

1.4 Document Outline

This thesis divided into five chapters each organized in the following way:

- **Chapter 2** - Background and Related Work: this chapter presents important related subjects for topic comprehension particularly in the Learning Objects field, Information Visualization and Dashboard understanding. Additionally, analyses the current state of the art on dashboard technology particularly current dashboard implementation tools and selects the most common usability patterns for dashboard data presentation by studying social web communities such as Facebook, Picasa and others;

- **Chapter 3** - Requirements: analyses and defines the requirements associated to the proposed solution as well as present the metrics model and the proposed functionalities to implement the dashboard technologies;

- **Chapter 4** - Design and Implementation: presents an overview of the BOAv3 architecture as well as its data model and the steps for dahsboard implementation in the BOA platform taking into consideration the needed integration with the current architecture. ;

- **Chapter 5** - Evaluation: describes the evaluation methods applied to the solution testing its adequacy for production deployment;

- **Chapter 6** - Conclusions: presents main conclusions of the research and solution implementation and the main contributions and limitations of this work. It also suggests possible future work.

2

Background and Related Work

Contents

This chapter describes the research findings on the current state of the art regarding information visualization and dashboard technologies. For a better understanding on the theme, more contextualization is necessary, therefore this chapter is divided into subsections respectively Section 2.1.1 on Learning Objects and Section 2.1.2 on Information Visualization for a dashboard-related background.

In addition, this section presents an analysis on dashboard technology, more specifically dashboard concepts and design (Section 2.1.3), an analysis on available tools for dashboard implementation (Section 2.2.2) and a statistical dashboard investigation applied to the most common online social communities in order to propose a metrics and operations model applied to the BOA platform (Section 2.2.1).

2.1 Background

This section presents three different sections to provide the basic concepts needed to better understand the context and scope of this thesis.

2.1.1 Learning Objects Concepts

For a proper dashboard design it is important to understand its setting. Since the motivation for this thesis is to define, design and implement a user centered visualization dashboard integrated in the BOA model which is a LOR containing LOs, this section aims to give a fitting understanding on what Learning Objects are, as they are important components of BOA.

Learning Objects (LOs) are facilitators of the use of educational content online and when properly catalogued and standardized, they are interoperable and reusable in a vast number of learning environments [4]. Metadata allied to LOs allows the adequate cataloguing which consequently makes LOs ”be modular units that can be assembled together to form lessons or courses ” [4]. It addresses LOs since it describes their constituting features. Another perspective compares LOs with LEGO building blocks: small units that can be fitted together any number of ways to produce customized learning experiences [10].

LOs come in various shapes and sizes [11]. Their granularity should be such that it is possible to reuse the LO in the most variety contexts. The more granular the LOs, the more reusable [12]. This does not necessarily mean that it is best to have more granular LOs, some authors even defend that less granular LOs are more educational [13]. Rory McGreal also defends in [4] that depending on the level of granularity of the LOs, they interoperate accordingly.

According to [14] sharing is important for non repetition of LOs, he exemplifies this by referring to the fact that universities have courses and lessons with the same contents, which are adapted for online delivery. This adaptation process may become boring and time consuming leading to the concept of reusability (preventing content repetition). Work conducted by Meyer in [15] considers granularity as the

most relevant factor in reference to reusability.

In plainer language, LOs are essentially digital resources associated to a learning context, the metada is their systematic description (making LOs searchable, accessible and discoverable) and the repositories are collections of these resources. [16, 17].

2.1.2 Information Visualization

Visualization is everywhere namely in science, engineering, design, entertainment, learning and businesses. It has the ability not only to add value to existing data as well as to allow much faster data processing and data pattern recognition. ”Visualizations can make complex relationships easily understandable and stimulate visual thinking” [18].

As Chaomei refers in [19], information visualization is branched into two related aspects: 1) structural modeling and 2) graphical representation. The first one aims to ”detect, extract and simplify” existing relationships between the analyzed data. The purpose of the second one is the transformation of a structure’s representation into a graphical one. By doing so, the transformed structure will be more visually understandable and interactive. When referring to Information Visualization, one most of the times refers to graphical representation and that is the one we will be focusing on.

Charts reveal data, thus being more precise than statistical computations. Of course, this depends on the information they contain and how clear and concise it is presented [20]. Many visualizations are really appealing and beautiful, but it needs to have meaning and be true, in order to take actions upon the data. How data is presented, i.e. the layout of the data, defines how effectively the key features of the structure of the system are conveyed. Nachtwey [21] claims that well-defined data visualization improves the efficiency of information delivery.

2.1.3 Dashboards

This section presents the most relevant concepts for dashboard understanding, respectively the concepts for this technology (Section 2.1.3.A), metrics understanding (Section 2.1.3.B) and finally design (Section 2.1.3.C).

2.1.3.A Concept

The term dashboard is a metaphor for a vehicle’s dashboard, which presents the most important information the driver needs to safely operate and maintain the car (speedometer, mileage indicator, fuel gauge).

Tableau de Bord, which is its original term, was a measurement system created in France at the turn

of the last century [22]. They were designed as a way to improve production process by developing a better understanding on cause-effect relationships and later on applied at top management levels [23] A dashboard can improve a user's awareness towards their activities, by not only providing an overview of the activity (for at-glance analysis) but also enabling a more detailed view in order to let users identify the root causes of problems and take action on them.

Historically, dashboards appeared in the 1980s as Executive Information Systems when managers needed to aggregate their business information all-together in a way that could understandable. This idea did not result in proper adhesion because of the lack of adequate technology, making it costly to customize and maintain. Later, in the late 1990s with the emergence of the web, dashboards as known today appeared [24].

Dashboards have four major purposes: monitoring, consistency, planning and communication, according to [25]. A dashboard helps monitoring performance, this way it is possible for users to detect and diagnose problems that may occur in the daily analysis of the system. Consistency is enforced in measures and measurement procedures across department and business units, meaning that correlated data is gathered and presented facilitating data interpretation. It may be used for planning by analyzing what is presented at current time. And finally, communication, meaning that it conveys important values of an organization and its performance.

Modern dashboards have a certain number of prerequisites [24]:

- should define and present most important information or tasks and it should be comprehensible. This way, it is important to choose the right metrics;
- overview and detailed option, otherwise one of two situations could happen: the dashboard would have much information or too little. Either way, making the dashboard useless;
- provide the ability to act upon the data;
- highlight problems with alerts;
- show progress;
- should be customizable with colors, charts, key metrics

Overall, the dashboard needs to be built around the needs of a business and be adaptable to its needs. This may seem simple, but a poorly constructed dashboard is not useful and will not achieve the purposes it should.

2.1.3.B Metrics

Information presented in a dashboard needs to be carefully selected, not every piece of information is useful or understandable. It is a challenge to correctly select data and present it in a straightforward way. If the information within a dashboard is not perceptible, then what is the point of the dashboard? Noisy or distractive information will make the user feel overwhelmed, with too little information the user will not be able to understand the message it wants to transmit.

For instance, considering a dashboard built for a teacher that has many classes, it may be interesting to show data across each and every one of the classes, i.e. not only having a single chart that compares the classes but also other temporal charts for each class, so it is not only needed to measure general metrics from the classes but also more specific metrics for each one.

Key Performance Indicators are comparative indicators through which it is possible to determine whether a metric is far or not from a pre-determined goal or target [24, 26, 27] thus measuring performance. These indicators are very important metrics as they are the ones that alert the user on the achievement of their goals.

An example of a well designed dashboard is presented bellow in **Figure 2.1**.

Figure 2.1: Website Dashboard Example[1]

[1] http://www.responsivemiracle.com/best-responsive-html5-dashboard-template/

2.1.3.C Dashboard Design

In order to build a dashboard that combines utility and usability, the context in which it will be integrated must be defined. The questions that need to be answered are the following [24]:

1. Who is my target audience? Who will see the information I present?
2. What value will the dashboard add to the organization? What purpose will it serve?
3. What type of dashboard am I creating?

The answers to these questions are sufficient for the definition of the dashboard context, that way it is possible to define which data is important for the users to see. This data must be carefully selected, otherwise the dashboard will be a waste.

In terms of dashboard layout and information visualization, form and structure must be defined. A dashboard can come in many flavors depending on the nature of the information, the way the data is visually structured in the dashboard is relevant for how users look at the business. For instance, inserting a chart on the top of a page is different from inserting another one on the bottom, what it implies is that top charts are more important and the intention may not be to emphasize a certain chart.

There are multiple structure options defining how data is presented, that can be adopted like flow, relationships and grouping:

- **Flow** accentuates a sequence of actions through time;
- **Relationships** emphasize relationships between entities;
- **Grouping** groups related information or categories.

A dashboard can be separated into modules, where each module compacts information, making it easier for the viewer to better understand what is being presented [28]: As referred previously, it is a prerequisite that the dashboard overview and detailed options, it must be possible to reveal the information as the user inquires, having an overview of the most important data. Customizability is a feature that provides the user with flexibility to visualize what is important to them. This way, the operations that should be considered for any dashboard are:

- **Drill down** - Possibility to go to a more detailed view, providing additional detail;
- **Filters** - Possibility of only selecting the desired data;
- **Comparison** - Possibility to compare multiple related data in order to record evolution;
- **Alerts** - Possibility to display a signal when a metric goes over or below a certain threshold;

- **Export** - Possibility to export the information out of the dashboard, preferably to a xls (excel) format;
- **Text-based Summary** - Possibility to show more detailed descriptions of the visualizations;
- **Tagging** - Ability to configure the dashboard so that it only shows the desired data;
- **Annotations** - Ability to present with a small comment/note on the visualization;
- **Advanced Visualizations** - Ability to choose the different types of visualization boards namely area charts, bar charts, bubble charts, gauges, line charts, pie charts.

Everything matters in the design of a dashboard, the choice of the colors, typography, page organization, chart types and tables as they affect information presentation and the way data is conveyed. It is also important to remind that sometimes is not how many components are in the screen but their quality.

2.2 Related Work

This section presents the related work presenting the analysed systems and tools for data analysis and dashboard implementation currently available in order to enable the development of the proposed solution.

2.2.1 Social Collaboration Systems

In an environment of sharing and data access, users should be able to monitor their actions through time, being able to see their evolution and act upon them based on the past.

The process of dashboard implementation not only implies the choice of implementation software but it is also important to analyze similar platforms in order to correctly designate valuable metrics - without good metrics the dashboard may become idle.

This section describes the online communities chosen to perform this statistical metrics analysis and create a reference model containing the most common and important usability patterns for users as well as analysing the types of charts used that make these pages so simple and clear [29].

Facebook [2] is a very popular social networking system, mainly used for connection and sharing online. Although it may seem to be of personal use, it is possible for someone to create a page (mostly for businesses) and promote it to the world (or at worst to the closest group of friends). For each page there is a Statistical Tab that groups the most important information regarding the page. This Tab is separated into several others, each one regarding important things to be measured. The tabs are the following:

[2] https://www.facebook.com

- **Overview Tab** - Is essentially a snapshot for the last 7 days of available data on the page's performance. It contains metrics such as the number of likes of a page (new and total), post reach indicating whether a post and page has been popular or not and engagement pinpointing the number of people who engaged with the page and the type of engagement (whether it was through likes, comments or shares);
- **Likes Tab** - Displays the different types of likes obtained by the page, more specifically total number of page likes, net likes and where they come from. This data is presented using a temporal based chart presenting a more visual result to the user;
- **Reach Tab** - Contains the post reach, whether there is positive or negative engagement and also total reach, also through a time based chart allowing the administrator to understand post and page evolution;
- **Visits Tab** - Presents page and tabs visits, other pages activities and also external reference, meaning where was the page referenced from;
- **Actions Tab** - Shows action related information, such as the number of clicks that trigger certain actions such as getting the phone number or the address;
- **Posts Tab** - Shows when fans (people that like and follow the page) of the page are online, their post types and all posts published;
- **Videos Tab** - Contains measured metrics on video actions, for example the number of views;
- **People Tab** - Presents the fans more thoroughly (percentage of male and female followers), people reached and people engaged, also detailing their localization.;
- **Messages Tab** - Shows information on exchanged messages between the users.

Facebook displays a number of different visualization components such as Line Charts, for time based analysis, a number of widget Indicators,that show the user their current state and their growth relative to a certain date in the past, Filters and Drill Down, Alerts and Annotations and even Export component all of which allow the user to customize their search.

Figure 2.2 presents a Facebook Analytics page with some of the data referred previously.

Slideshare [3] is a slideshow sharing platform where registered users are allowed to view, comment, upload and share as many presentations as desired. It started as containing professional or educational contents for its goal is to encourage content sharing, and ultimately knowledge. This platform also

[3] http://www.slideshare.net

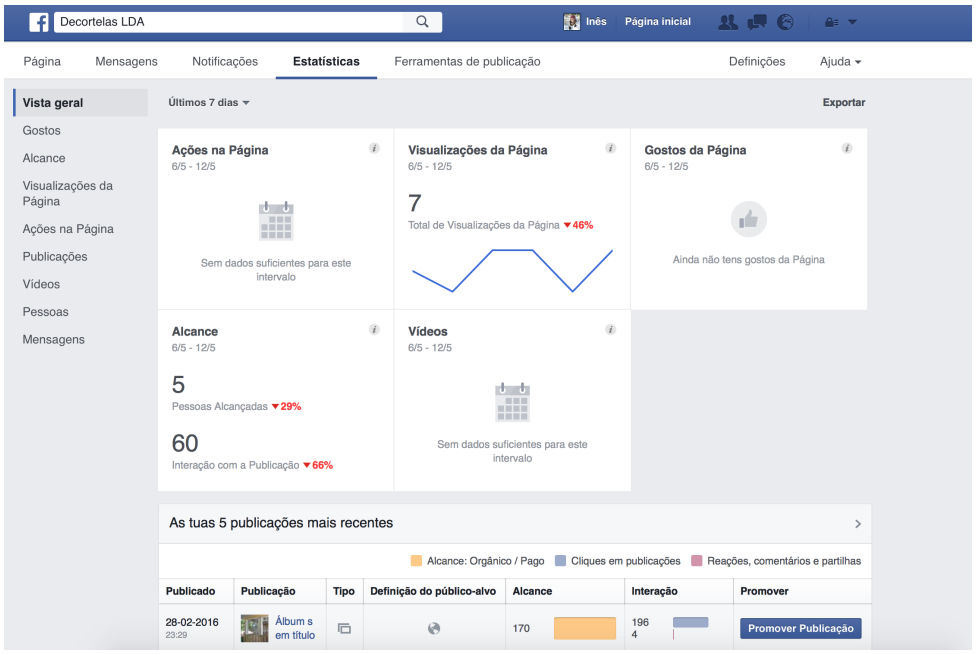


Figure 2.2: Facebook Analytics Page

encourages users to connect with other members that share similar interests. As for statistics measurement, the registered users have a dedicated area were they can visualize a certain number of relevant metrics on the uploaded contents respectively:

- **Summary Tab** - Contains general presentations information such as number of views evolution through time, total number of views and slideshare actions (i.e. comments, likes, favorites). It also contains a traffic sources pie chart, a list of top countries, a detailed view of slideshare actions and also a top contents list;

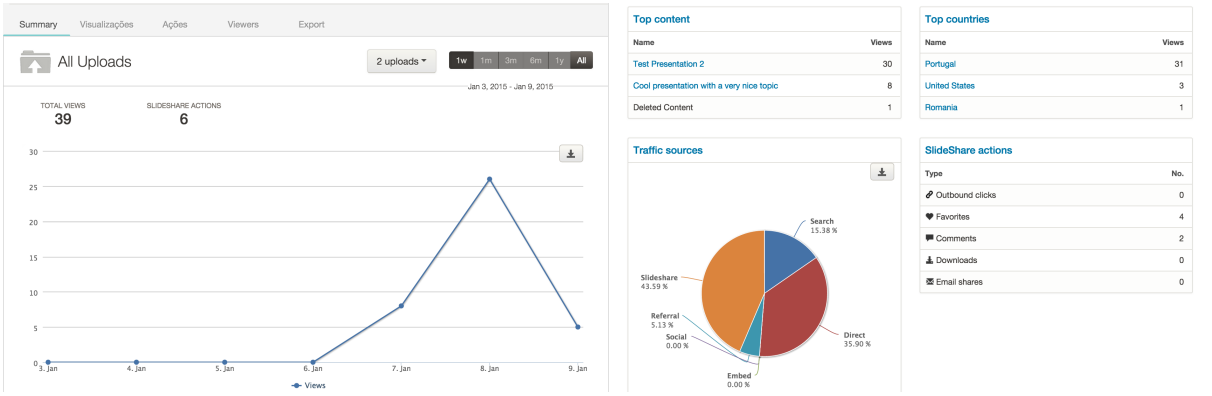
- **Views Tab** - Contains detailed data for the presentations' views, more specifically a chart with the number of views through time, a list of top content, a chart with the number of referrals for the presentations, e a geographic map that presents where the accesses were from;

- **Actions Tab** - Contains counters for each presentation, the number of likes, favorites, comments, downloads and e-mail shares;

- **Viewers Tab** - Presents a detailed list of users that viewed the presentations.

Slideshare provides the user with Pie Charts and Activities Counters for an overall view of the data and also a Line Chart for a time based analysis. Besides these components Drill Down, Filters and Export are also allowed.

Figure 2.3 presents a Slideshare Analytics page with some of the data referred previously.



(a) (b)

Figure 2.3: Slideshare Statistics Page

Flickr [4] is a web platform for photo sharing and management, thus an important metric is the number of visualizations. Flickr does not provide this option for non-PRO users.

Flickr, much like Slideshare, presents a Line Chart for time based analysis and counters for a more general view of the data.

Figure 2.4 presents a Flickr Stats page with some of the data referred previously.

Figure 2.4: Flickr Statistics first page[5]

[4] https://www.flickr.com
[5] http://workshop.evolutionzone.com/category/flickr/

Picasa [6]is an online photo organizer, allowing picture sharing. Regarding statistical information on published contents, it only allows the administrator of the page to visualize the number of likes and number of visualizations. Additionally it shows the number of groups the picture belongs to as qell as the number of comments, views and times it was marked as favourite.

Picasa is one of the most incomplete social collaboration tool in terms of visualizations, mainly because it is a repository of pictures, only allowing a certain number of actions upon these objects. It only presents counters for each object.

Figure 2.5 presents a Picasa Statistics page with some of the data referred previously.

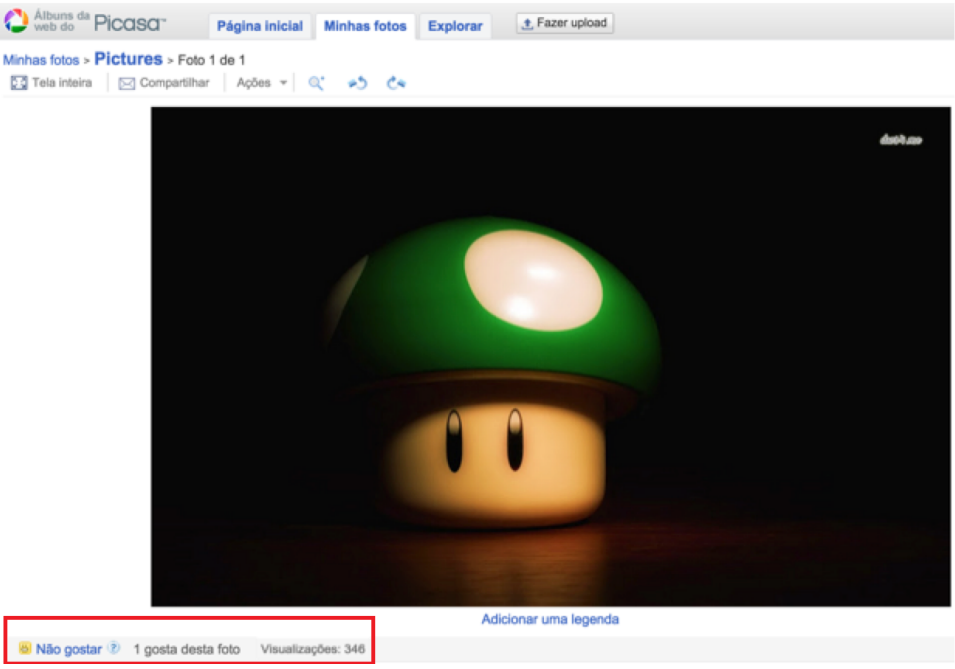


Figure 2.5: Picasa Statistics Page

LinkedIn [7] is a business social networking system, it is very similar to Facebook, but it serves the purposes of businesses. This platform allows users (both employers and workers) to create a profile and create connections stimulating the growth of one's professional network. These connections may serve a number of purposes such as finding jobs, seeking for potential employees, finding valuable connections for future references, basically anything that is business related. In terms of statistical information, the user can obtain the number of profile views as well as who viewed it. Currently it is also possible to go to a lower level of granularity by providing details on the viewers profile.

LinkedIn provides Line Charts for time based analysis and also counters for an overview of the measured metrics.

[6]http://picasa.google.com
[7]https://www.linkedin.com

(a) (b)

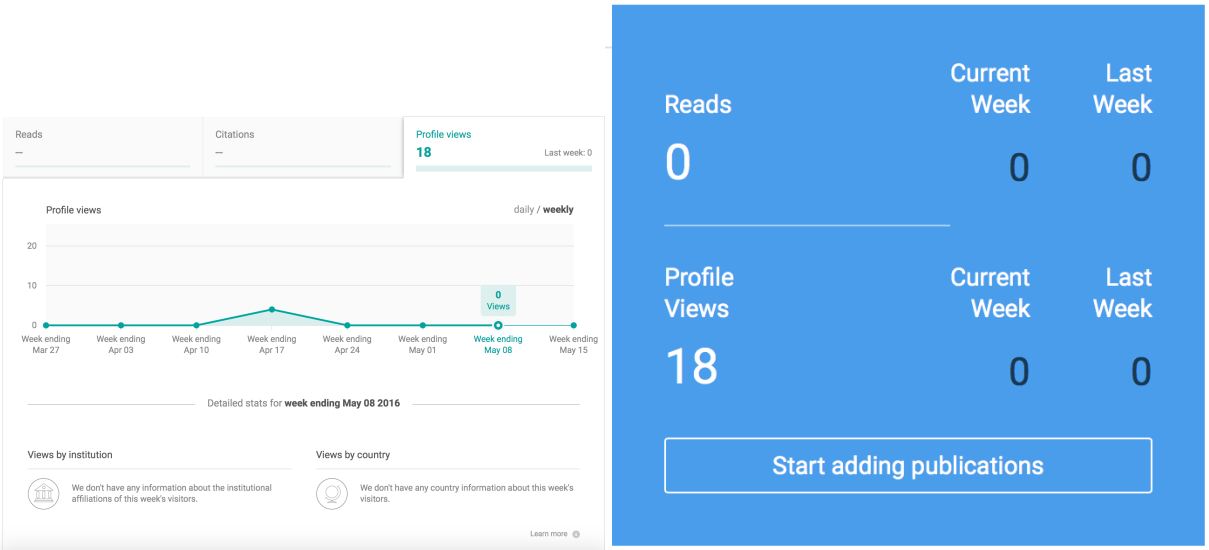
Figure 2.6: LinkedIn Statistics First Page

Figure 2.6 presents a LinkedIn Statistics page with some of the data referred previously.

ResearchGate [8], similarly to Facebook and LinkedIn, is a researchers and scientists social system, with the purpose of sharing publications, connecting with colleagues, seeking new collaborations and also job seeking or recruitment. Thus, the metrics measured are the number of profile views and publication referrals.

Reasearch Gate provides Indicators for data overview and a Line Chart for a time based analysis.

Figure 2.7 presents a ResearchGate Statistics page with some of the data referred previously.



(a) (b)

Figure 2.7: Research Gate Statistics Page

[8] http://www.researchgate.net

Evaluation After analyzing the previous online communities it is possible to compose a reference model, containing the measured metrics by each platform. Table 2.1 contains that reference model. Most of these online communities provide the users with a complete and clear vision of their actions in the community.

Online Community	Social Objects	Metrics	Operations
Facebook	Pages	- No. Likes - Reach - No. Visits - No. Posts - People	- Drill Down - Filters - Comparison - Alerts - Export - Annotations - Line Charts (based on time) - Bar Charts
Slideshare	Presentations	- No. Views - No. Comments - No. Likes - No. Shares - No. Downloads - No. Favorites	- Drill Down - Filters - Export - Annotations - Line Charts (based on time) - Bar Charts - Geographic Map - Pie Chart
Flickr	Photos	- No. Views	- Line Chart (based on time)
Picasa	Photos	- No. Views - No. Likes	None
LinkedIn	Personal Pages	- No. Views - No. Profile Viewers	- Line Chart (based on time) - Pie Chart - Filters - Annotations
ResearchGate	Researchers; Publications	- No. Views - No. Referrals	- Line Chart (based on time) - Annotations

Table 2.1: Overview of aggregated information in social platforms

2.2.2 Tools for dashboard implementation

In previous chapters important aspects regarding the context of this thesis were discussed, such as the dashboard theory and information visualization. The next task is to analyze dashboard software currently used in the industry in order to understand the available tools for users and organizations.

There are multiple solutions available that contain the sufficient tools to develop efficient dashboards. Most tools are Business Intelligence solutions, which transform data into useful information so that it can be presented in an intuitive manner. Business Intelligence solutions are not the only possible software that can be used to create dashboards. There are solutions such as Tools for data visualization [9] that

[9] http://www.fastcodesign.com/3029239/infographic-of-the-day/30-simple-tools-for-data-visualization

collect, analyze and render data.

As there are so many tools, we need to narrow down the analysis to only a few tools that are described and compared in the following subsections. The choice of tools is imposed by the scope of the project (further explained in Section 1.3). An overview of the analyzed tools is presented in Section 2.2.2. The list of platforms was obtained from 25 Open Source and Free Business Intelligence Solutions[10].

Palo/Jedox [11] is an easy-to-integrate-easy-to-use Business Intelligence suite for planning, reporting and analytics for performance management. It is licensed, meaning that it includes maintenance and integration costs. It aims to enhance planning, analytics, dashboards and reporting providing an architecture that does so. One of its features is that it has Excel integration because this is used in most businesses for planning and it can be very ineffective and confusing, so Palo simplifies the analysis presenting a cleaner visualization. Data for the analysis can be provided by a number of sources (Databases, Webpages and others) as Palo contains a tool that transforms data as needed. If included in the license, this data is kept in a provided ODBO (OLE DB for OLAP, which is basically a database for analytical processing).

Qlik [12] is a business intelligence software containing two major products: QlikSense and QlikView, the difference between them is that QlikView is used for specific business applications with predefined layouts and charts (organization defined) whereas QlikSense allows a freer and more flexible visualizations creation and customization. There is also a free QlikSense version - QlikSense Desktop for personal use only. QlikSense also contains a number of components that provide the dashboards with interactivity and innovative designs with interrelated data, thanks to QIX (Qlik Index), which is responsible for linking data among multiple data sets thus having more complex relationships and consequently more related data being beneficial for the users. QlikSense can be fully customizable due to the use a standard API also allowing to embed visualizations into other solutions as long as developers have HTML5, CSS3 and .NET skills. Data has to be provided and can be loaded from multiple sources (such as OLE DB, Spreadsheets, ERP - Enterprise Resource Planning - and also Web sources).

D3.js [13] is a javascript library that manipulates HTML documents based on data supporting the creation of interactive and smooth visualizations. It is very customizable as it contains a wide range of components and plugins. It can be easily integrated within a webpage and with technologies such as HTML5, CSS3 and SVG (Scalable Vector Graphics which is a graphics definition in XML).

[10] http://www.predictiveanalyticstoday.com/open-source-free-business-intelligence-solutions/
[11] http://www.jedox.com/en/
[12] http://www.qlik.com
[13] http://d3js.org

Google Charts [14] is a simple javascript library that can be embed within a website (thus being integrated with HTML and CSS). The provided data can be of any source such as a database, directly from a webpage or a data provider that supports Chart Tools Datasource protocol (implemented by Google Fusion Tables and Google Spreadsheets).

Highcharts [15] is a free for non-commercial use Javascript library running on any server supporting HTML. Allows customization with the high number of chart types and features and since the source code is public it provides flexibility and allows much more customization. Data for visualization can be loadedd from sources such as CSV files and HTML tables.

Telerik UI for ASP.NET AJAX [16] is a control and widget suite for HTML5 and .NET to allow the creation of web apps. It is compatible with PHP and JS technologies as well. Due to its modular characteristics it is easy to cutomize and integrate controls as needed.

Evaluation

The choice of dashboard implementation tools encompasses certain aspects that were analyzed in this section and that are compared in order to subsequently choose a proper tool for the proposed solution, those are: License - the cost of usage of the tool, System Integration - how is the tool integrated with the system in study, Customization - whether it is possible to customize its objects, Data Collection and Storage - how the data is collected and saved. These aspects are important to decide which is the best tool for infovis dashboard implementation in the current BOA architecture. There are three kinds of licenses available namely free, paid and freemium, this last one is a combination of free and paid i.e. a free software is available for download but there may be certain features that are paid. For the purpose of this thesis it is preferable to get a platform that is free, not excluding the ones that are freemium (depending on its cost).

In dashboard implementation it is quite important that customization is present since most of its value relies on data presentation. It is also important to get and store data in adequate infrastructures. Considering that BOA has a pre-defined structure, the data storage is not as relevant as the other analyzed features.

Table 2.2 contains a summary of all the tools and their most relevant characteristics, analyzed previously.

[14] https://developers.google.com/chart/
[15] http://www.highcharts.com/
[16] http://www.telerik.com/products/aspnet-ajax.aspx

	License	System Integration	Customization	Data Collection	Data Storage
Palo/ Jedox	Freemium	Software suite - either on the cloud or on premise (business must provide an infra-structure - according to supported hardware)	Allowed and provided by the tool	Provided - by many sources (DB, webpages, spreadsheets)	If license covers it, data stored in ODBO
QlikSense	Freemium	Application integrated on a specific infra-structure (according to supported hardware)	Allowed with a specific standard API	Provided - multiple sources (DB, ERP, web sources)	In memory
QlikView	Paid	Application integrated on a specific infra-structure (according to supported hardware)	Allowed and within the application	Provided - multiple sources (DB, ERP, web sources)	In memory
D3.js	Free	Javascript integrated within webpage's code (with HTML5, CSS3 and SVG)	Allowed - containing many components and plugins	Provided - DB	Not included
Google Charts	Free	Javascript integrated within webpage's code (HTML and CSS)	Allowed	Provided - any source (DB, webpage or data provider)	Not included
HighCharts	Free	Javascript integrated within webpage's code (HTML and CSS)	Allowed - contains many chart types and features; source code is public allowing changes	Provided	Not included
Telerik UI for ASP.NET AJAX	Paid	.NET Controls integrated in code	Allowed	Provided - multiple sources	Not included

Table 2.2: Implementation Dashboard Tools Overview

3

BOAv3/DashVis - Requirements

Contents

This chapter analyses and defines the requirements associated to the proposed solution as well as present the metrics model and the proposed functionalities to implement the dashboard technologies.

3.1 Requirements

BOA as a social community defines a set of objects associated uniquely to BOA - social objects - which are the following: LO, Group, VC and User.

The relationship between them is as follows:

A Group contains 0 or more LOs, Users and VCs; VCs are exclusivelly grouped LOs, which can be 1 or more; Users can create LOs, Groups and VCs as well as to only be members of 1 or more Groups. The Figure 3.1 presents such relationships.

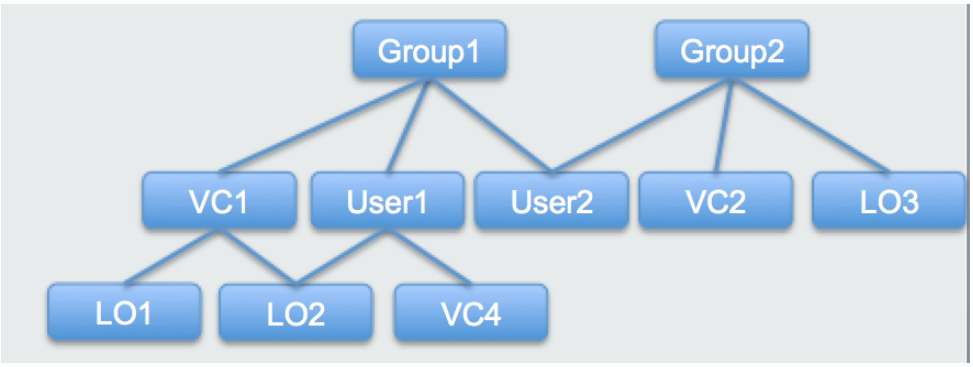


Figure 3.1: Social Objects Relationships in BOA

The social objects and their relationships influence the requirements definition, design and implementation of the proposed solution. Understanding that these objects are the intervenients of the BOA platform and that all these objects influence actively in each others' scores - through actions made upon them - the solution is to design a specific dashboard for each social object offering a number of functionlities for the visualization of these social objects.

3.2 Proposed Metrics

As described in Section 2.1.3.B, metrics selection are the most efficient ways to alert the users of the status of the system. It is possible to determine such metrics by analyzing the current architecture and studying similar applications and their metrics, presented in Table 2.1, understanding which kind of metrics could be relevant in this case.

As such there are four definitions that we must take into account when analysing BOA's structure, they are Learning Objects - entities that are mainly used in learning environments-, users - the consumers of the information, groups - aggregators of users and consequently LOs and Virtual Collections,

which are collections of LOs. They are all related to one another such that the actions made upon them also affect each others scores. This is defined as reputation and it is calculated on a 24 hour basis and it is influenced by the actions made upon that object. Users are now automatically rewarded for their positive behaviour and interactions with the platform. If the users do not collaborate their reputation gradually decreases with a time decaying function [1] in order to maintain the engagement levels.

For instance, the reputation of an LO is calculated based on the actions made upon it, such as updates, views, rates, reviews and even adding it to a Group or VC. The same happens with the other components, but metrics may vary.

The metrics model is intended to define a base model for chosen metrics that are the most relevant for each social object as well as the functionalities that allow building a dashboard comprising these metrics and considering the studied dashboard functionalities available.

The most important metrics for each social object are quite similar, having small nuances from one to another. The list of the metrics is the following:

- Reputation Score - one of the most important metrics as it defines the level of interaction of the social object in the platform (measured by the number of actions made upon other objects, in case of a user, or made upon itself, in case of any other object;
- Number of Views - number of times the social object was viewed;
- Number of Reviews - number of times the social object was reviewed;
- Number of Rates - number of times the social object was rated;
- Number of Searches - number of times the social object was searched using the available search mechanisms in the platform;
- Number of Updates - number of times the social object was updated;
- Number of Additions in a Group and VC - only for Groups and VCS;
- Number of Created Elements - only for Users;
- More specific metrics for each social object such as the number of groups a certain LO belongs to or the number of LOs a Group contains;

To create usable dashboards we need a certain number of functionalities, such as Line Charts (which are time-based), Indicators (showing current status and comparing with the past), Exportation options, Annotations, Filters and Pie Charts (for an overall view of the data).

3.2.1 Summary

Adapting that information to BOA, the metrics that should be shown to the users are presented in Table 3.1.

Each of these metrics are aggregated and presented in a unified visualization dashboard, that is presented in Section 4.4.

Social Objects	Metrics	Functionalities
LO	- Reputation Score - N. of Views - N. of Reviews - N. of Rates - N. of Searches - N. of Updates - N. of Groups LO belongs to - N. of VCs LO belongs to	- Line Chart (time-based) - Indicators (with comparison to the past) - Export - Annotations - Filter - Pie Chart
User	- Reputation Score - N. of Views - N. of Reviews - N. of Rates - N. of Searches - N. of Updates - N. of Created Elements (LOs, VCs & Groups) - N. of Groups User belongs to - N. of Followers - N. of Friends	- Line Chart (time-based) - Indicators (with comparison to the past) - Export - Annotations - Filter - Pie Chart
Group	- Reputation Score - N. of Views - N. of Updates - N. of Additions to the Group (LOs, VCs) - N. of Users it contains - N. of VCs it contains - N. of LOs it contains	- Line Chart (time-based) - Indicators (with comparison to the past) - Export - Annotations - Filter - Pie Chart
VC	- Reputation Score - N. of Views - N. of Reviews - N. of Searches - N. of Updates - N. of Additions to the VC (LOs)	- Line Chart (time-based) - Indicators (with comparison to the past) - Export - Annotations - Filter - Pie Chart

Table 3.1: BOA Metrics Model

4

BOAv3/DashVis - Design and Implementation

Contents

This chapter presents an overview of the BOAv3 architecture as well as its data model and the steps for dahsboard implementation in the BOA platform taking into consideration the needed integration with the current architecture.

4.1 System architecture

As referred previously in Section 1.1, BOA is a web based application supporting user communities in the teacher-learner process [6].

Currently there is a work in progress developed by the student Bernardo Gouveia [1] that proposed and implemented an improved BOA framework for community and users participation and engagement stimulation. These improvements maintain the modularity in the BOA architecture and are implemented over DNN (Dot Net Nuke) [1]. Dot Net Nuke is a Web Content Management System for online content publication, it is open source and built over a Microsoft ASP.NET platform. It uses modules to present functionality to the user.

More thoroughly the BOA platform consists of three layers:

- Presentation Layer - for User Interface purposes, presenting the information to the user;
- Business Layer - contains the bulk of BOA v3 functionalities;
- Data Layer - for data storage, more specifically in relational DB (SQL Server), Lucene Index, file storage and the triplestore.

It is important to consider the implications of developing visualization dashboards taking this architecture into account, specifically how to get the data and present it to the user, for that reason it was important to analyse a number of tools with specific pre-defined specs and choose one that could accomplish this thesis goal.

Figure 4.1 presents the overall architecture of the system, showing integration of these three layers

4.2 Data model

The data needed for presentation and thus associated to the interactions with the platform is already stored in a SQL Server Database enabling further use to group platform metrics for dashboard and visualizations consumption. Figure 4.3 presents the most relevant tables that were used to aggregate the information to feed the dashboards. The ¡socialObjectName¿Reputation tables contain the reputation scores measured through time; the ¡socialObjectName¿Actions define the scores for each action that is available for the social object, for example the View Action has a different score than the Update

[1] http://www.dnnsoftware.com

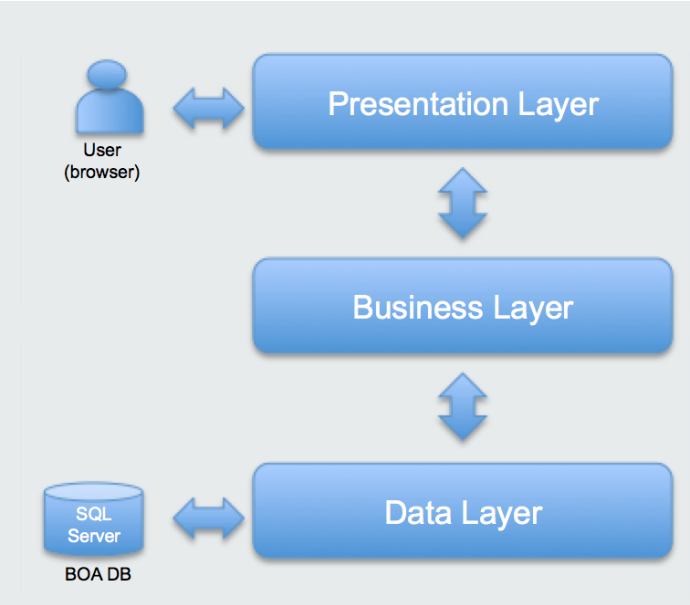


Figure 4.1: BOA Overall Architecture

Action affecting differently the calculated Reputation; the ¡socialObjectName¿UserActions tables log the actions performed upon that social object, as such it stores the action date, the performed action Id, the user Id that performed the action and other contextual parameters, taht depend on the performed actions.

Figure 4.2 presents a line of the LoUserActions Table as an example of the saved data. This example shows that a View action was performed (the ActionId = 7 corresponds to the View action) over an LO on the 18th May,2015.

	userActionId	userIdFk	loIdFk	actionIdFk	datePerformed	active	addContext	addContextFloat
1	47	1	1	7	2016-05-18 17:44:15.260	1	NULL	NULL

Figure 4.2: BOAv3 LoUserActions Logged Action - Example

For the matter of this thesis only certain metrics are necessary for information visualization use, those metrics are defined and presented in Section 3.2.

As there are four social objects, the actions associated to them are the ones needed for aggregation and presentation in the dashboard. Each action has a value associated to it that influences the reputation calculation, thus stimulating activities and collaboration in the platform. The list of possible performed actions are the following, by social object:

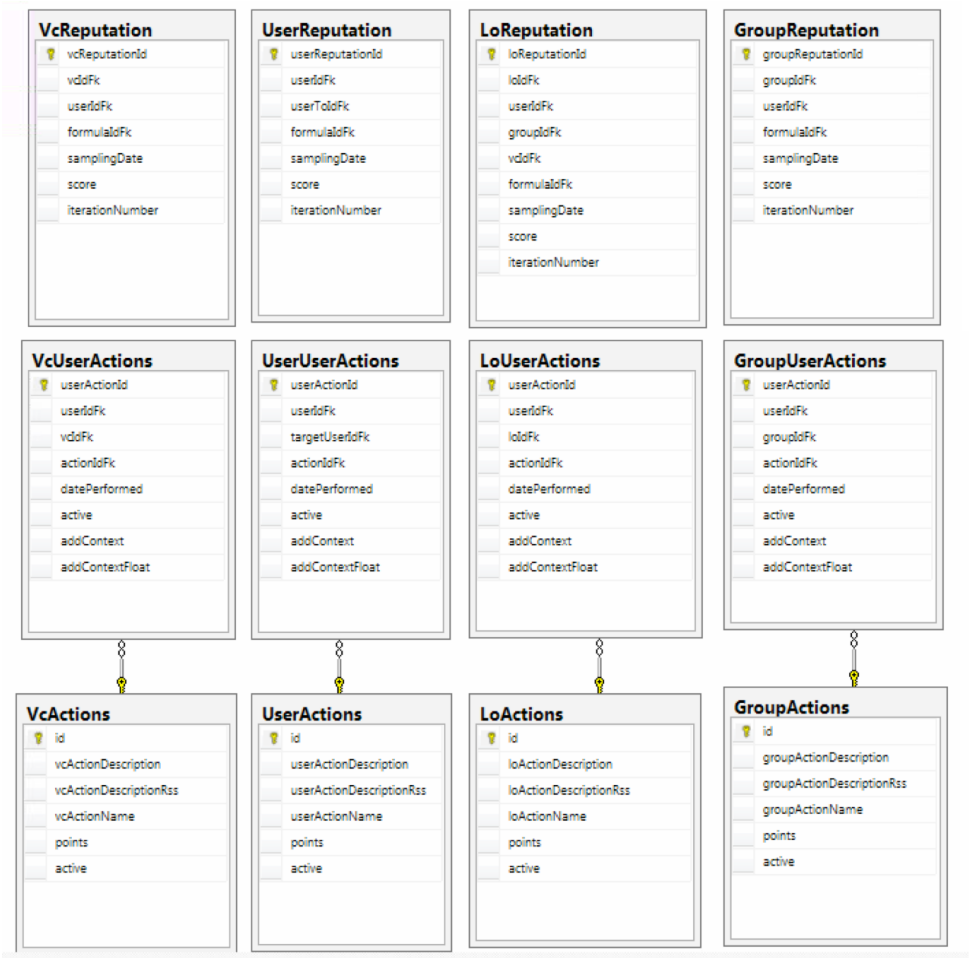


Figure 4.3: BOAv3 Data Model - relevant tables

4.3 Integration

The latest BOA version (BOAv3) was implemented using a Content Management System (CMS) named DNN (Dot Net Nuke). This is a modular framework and as such allows extensibility and functionality. As mentioned in Section 4.1 the BOA architecture has three main layers that communicate with each other depending on development requisites.

Each dashboard was developed in a control page (.ascx) for presentation to the user. For the data visualization and having considered and analysed the dashboard implementation tools in Section 2.2.2 Google Charts was the best fit for building effective, customizable charts with various important dashboard aspects such as annotations and filtering. To do so, it is necessary to load the Google Charts Library, associate the data and draw the charts, as shown in the code below. It presents an example of a visualization type integrated into the dashboard that creates the Reputation Charts. The Reputation Charts not only presents the reputation through time but also a filter option, in a smaller chart - this

LO	Group	VC	User
- View - Update - Search - Review - Rate	- View - Update - Added Object (LO,User, VC)	- View - Update - Added Object (LO) - Search - Review	- View - Update - Create Object (LO, VC, Group) - Review - Rate - Search

Table 4.1: Actions in BOA Social Objects

representation can be seen in Figure 4.4 (b).

```
<div id="LOReputation_dashboard">
    <div id="LOReputation_lineChart" style="margin-left: auto;margin-right: auto;"></div>
    <div id="LOReputation_filter"></div>
</div>

<!--Script-->
<script type="text/javascript" src="https://www.gstatic.com/charts/loader.js"></script>
<script type="text/javascript" src="http://www.google.com/jsapi"></script>

<script type="text/javascript">
    google.charts.load('current', { packages: ['corechart', 'controls'] });
    google.charts.setOnLoadCallback(drawCharts);

    function drawCharts() {
        // Get the Data
        /*Line Reputation*/
        var reputationData = new google.visualization.DataTable();

        reputationData.addColumn('date', 'Date');
        reputationData.addColumn('number', 'Reputation');

        for (var key in reputationArray) {
            reputationData.addRow([new Date(key.split("/")[2], key.split("/")[1] - 1, key.spli
        };

        var dashboardReputation = new google.visualization.Dashboard(document.getElementById('

```

```
28
29          // Create a range slider, passing some options
30          var dateRangeSlider_reputation = new google.visualization.ControlWrapper({
31              'controlType': 'ChartRangeFilter',
32              'containerId': 'LOReputation_filter',
33              'options': {
34                  filterColumnIndex: 0,
35                  ui: {
36                      chartOptions: {
37                          height: 50,
38                          width: 700,
39                          chartArea: {
40                              width: '65%'
41                          },
42                          series: {
43                              0: { color: '#3366cc' }
44                          },
45                          curveType: 'function'
46                      },
47                      chartType: 'LineChart',
48                      minRangeSize: 432000000, //5days
49                      snapToData: true
50                  }
51              }
52          });
53
54          var reputationSmallChart = new google.visualization.ChartWrapper({
55              'chartType': 'LineChart',
56              'containerId': 'LOReputation_lineChart',
57              'options': {
58                  title: 'Reputation Through Time',
59                  titleTextStyle: { fontSize: 20 },
60                  tooltip: { trigger: 'focus', showColorCode: true },
61                  curveType: 'function',
62                  chartArea: { width: '65%', height: '50%' },
63                  animation: { startup: true, easing: 'in' },
64                  hAxis: { title: 'Date', slantedText: true, slantedTextAngle: 20, viewWindowMod
65                  vAxis: { title: 'Score', viewWindowMode: 'maximized' },
```

```
                legend: { position: 'none' },
                height: 300,
                width: 700,
                series: {
                    0: { color: '#3366cc' }
                }
            }
        });

        dashboardReputation.bind(dateRangeSlider_reputation, reputationSmallChart);
        dashboardReputation.draw(reputationData);
```

In order to populate the charts DNN has a controller-provider mechanism to allow database connection configuration, thus creating a bridge between the Data Layer and Business Layer for data fetching and functionality creation. The data is fetched from the database using Stored Procedure functions that return the information needed. Using Controller and Provider classes it is possible to create a bridge of communication between the database and the 3-tier Architecture present in DNN.

4.4 Design and Development

This section aims to present the final aspect of the solution for each defined BOA object (User, LO, Group and VC). Each dashboard is different because of the defined metrics but it is very similar design-wise in order to maintain consistency throughout the platform, this way as time goes by and users interact more with the platform, it is easy to find the needed information in each dashboard. All dashboards are structured this way:

1. Indicators Tab - contains all counters for most relevant metrics - for an overall view of the object's actions;

2. Reputation Tab - contains a Navigation Chart that allows time filtering (with a minimum of five days) in order to have a more granular view;

3. Activities Tab - contains two types of charts: first a Pie Chart that shows the total and percentage of activities, then a navigation chart that shows the activities through time with filtering option, either through time or chart category (activity).

There is also an additional Dashboard that belongs to the user, but only if that user is Admin of the platform. Besides maintaining structure consistency for user familiarization with the platform and the dashboards, a color schema was defined for each existing action.

All dashboards also contain the export option, in order to generate a PDF report containing all visualization elements that are important for analysis.

4.4.1 User page

The User Visualization Dashboard Page aims to present most relevant information on the user's activity throughout its registered time in BOA.

There are two types of users: common users, that perform actions in the BOA platform such as searching, creating LOs, groups or other actions already described in section 3.2 and administrator users that, besides performing the same actions as a common user, also has the responsibility of monitoring the BOA platform and its objects. As such, for the same information visualization page, these two types of users must be taken into account. For that reason these two types of users have a common design of information presentation, but the Admin user also has an additional tab - the Admin Tab.

The information presented in this page refers to the users activities, that is actions performed by the users upon LOs, Groups and VCs. These activities are presented in Figures 4.4, 4.5, 4.6.

The admin tab contains information on general BOA metrics, such as the Top Users, Groups and VCs, ie which have the highest reputation scores.

4.4.2 Group page

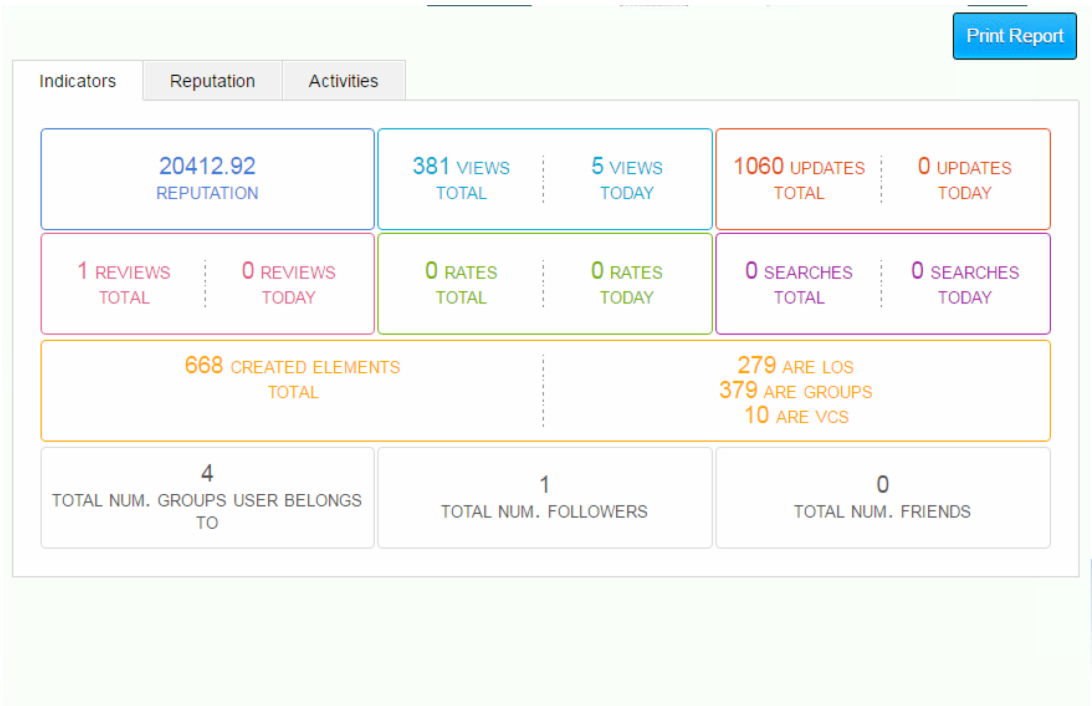
The Group Visualization Dashboard Page presents most relevant information on a certain Group, such as its number of aggregated Users, LOs and VCs. Such information is not only available for the administrators of the group but also for anyone who would like to join it. Figures 4.7 and 4.8 present the Group's Visualization Dashboards.

4.4.3 LO page

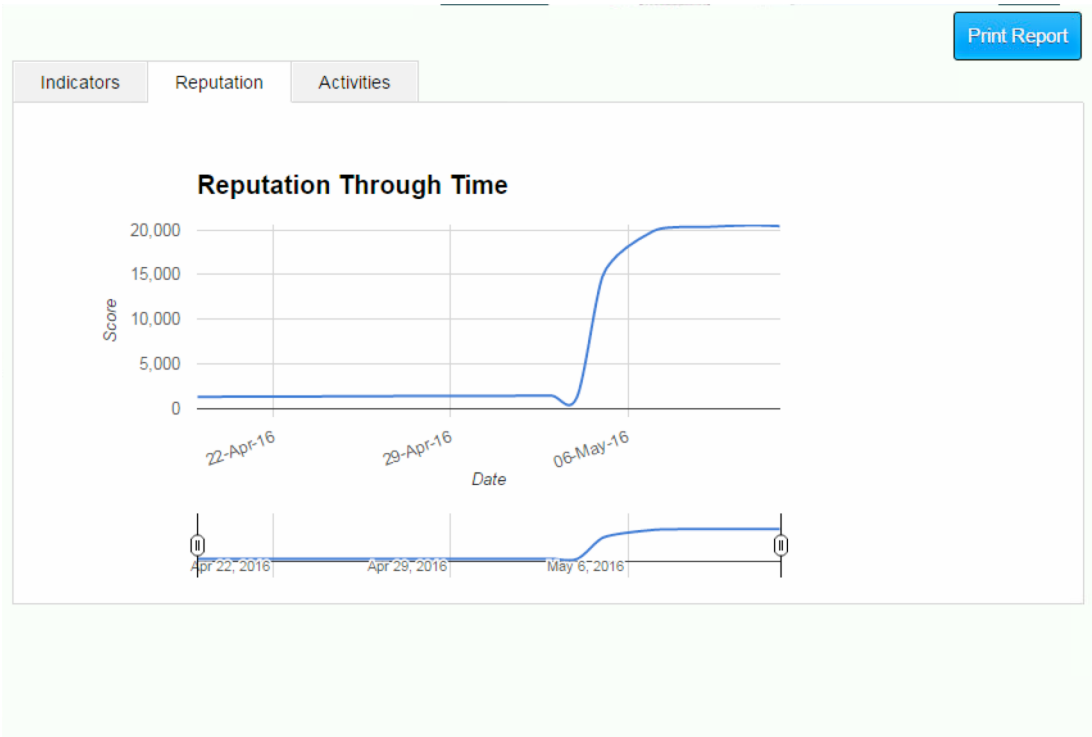
The LO Dashboard Page presents LOs most relevant actions made upon it, such as its searchability, updates, views, reviews and rates. It also shows its reputation and the number of elements it belongs to. Figures 4.9 and 4.10 present the various tabs that incorporate the LO Visualization Dashboard.

4.4.4 VC Page

Much like the LO page the VC Dashboard Page shows information on the selected VC, presenting the actions made upon this social object. This information can be seen in Figures 4.11 and 4.12.

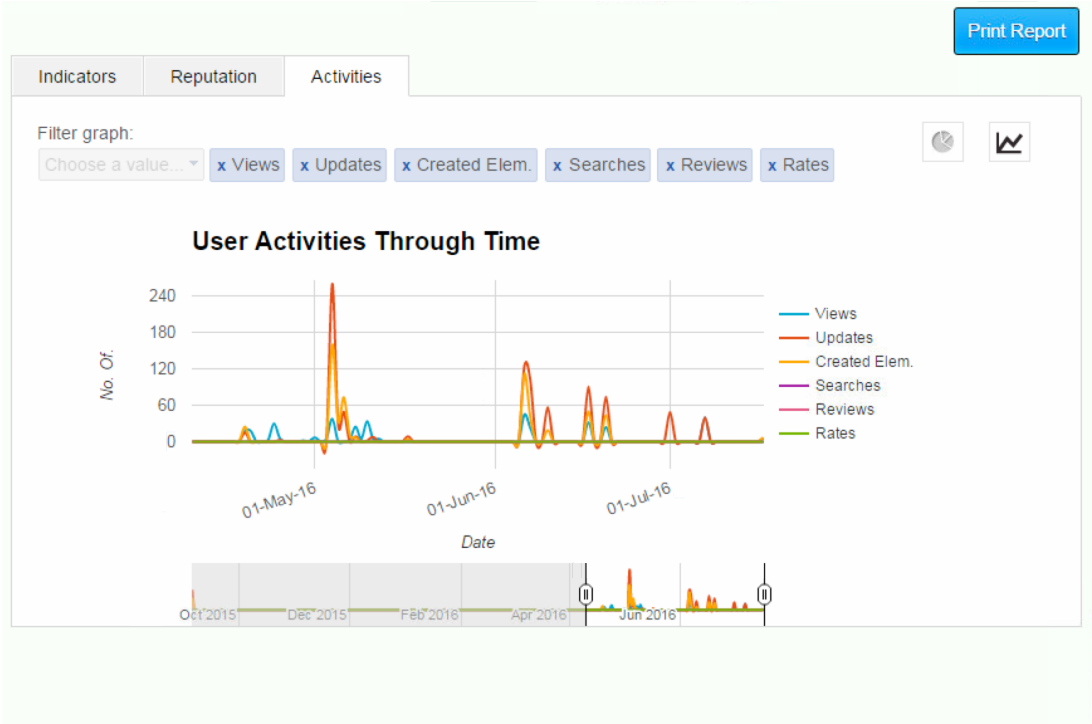


(a)

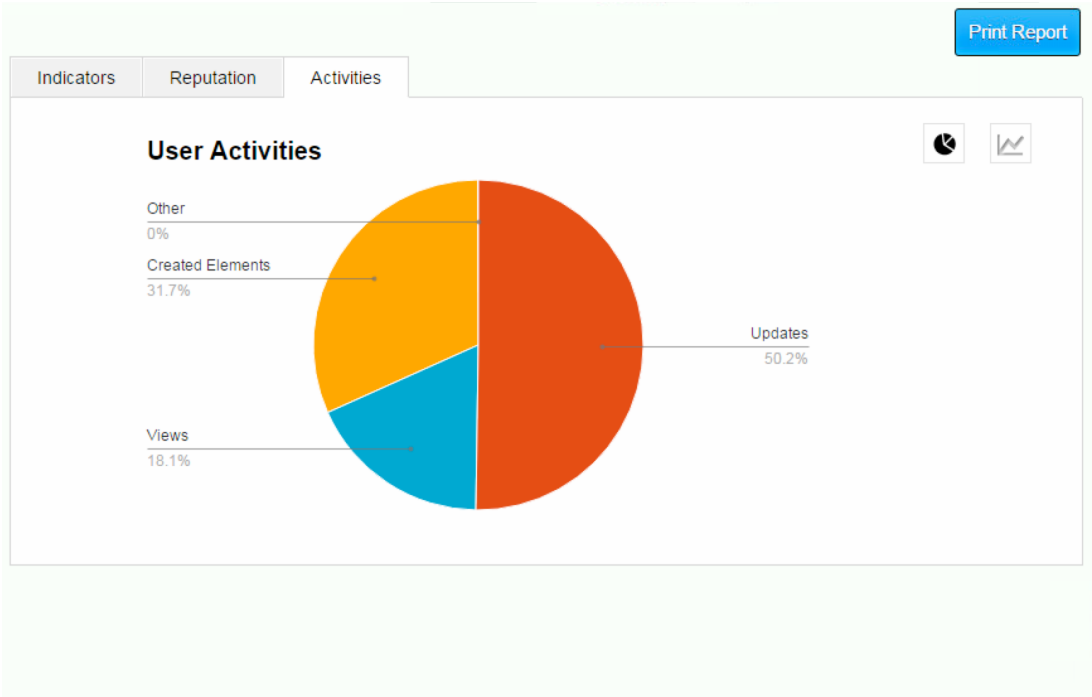


(b)

Figure 4.4: User Dashboard Page



(a)



(b)

Figure 4.5: User Dashboard Page

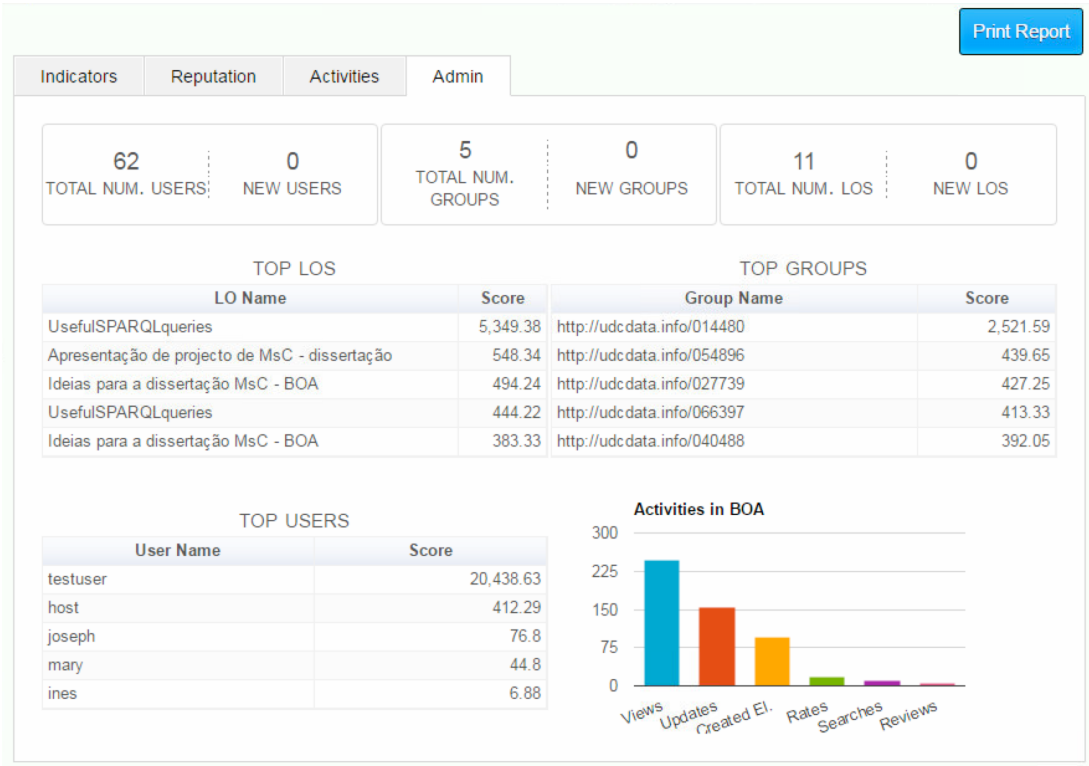
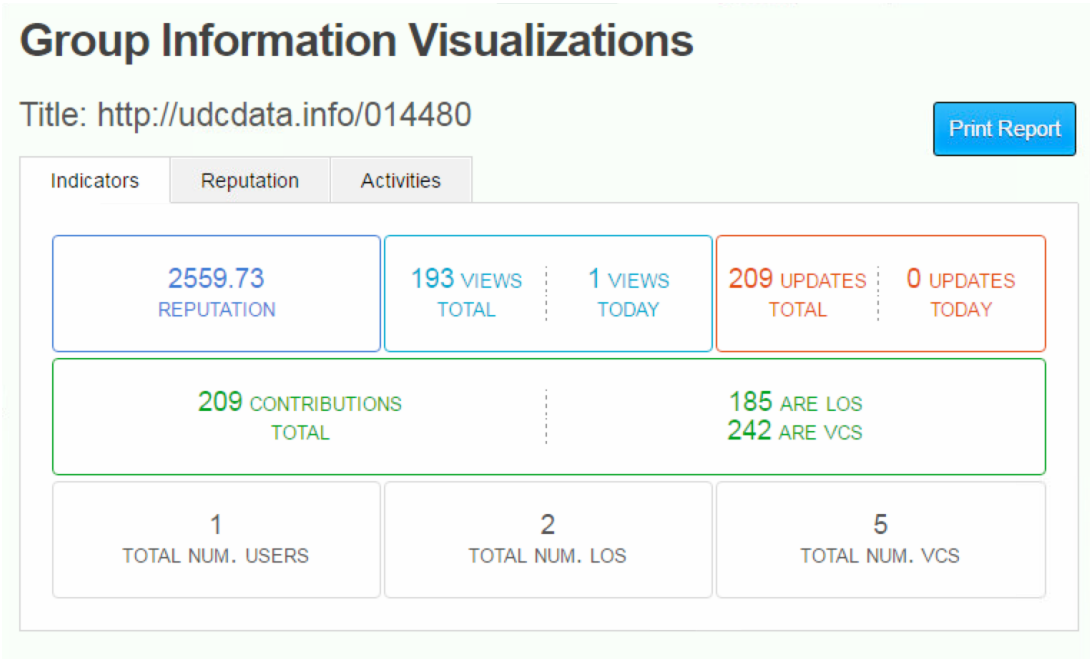
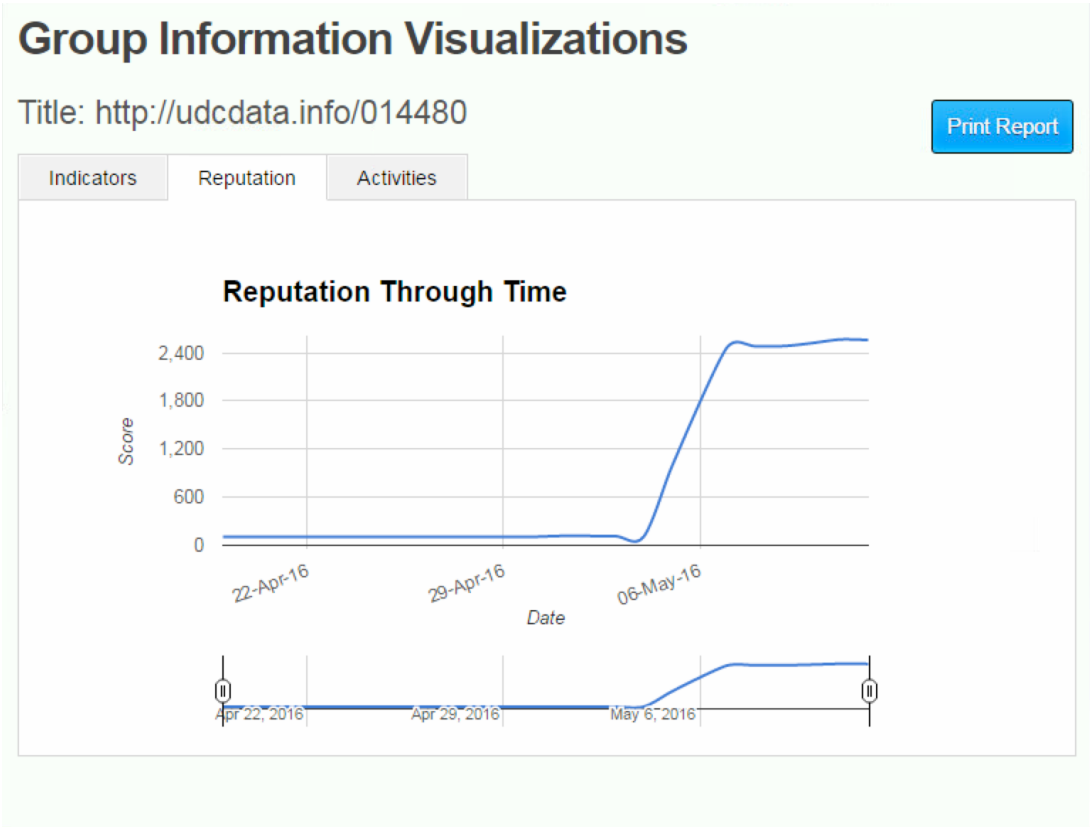


Figure 4.6: User Dashboard Page - Admin

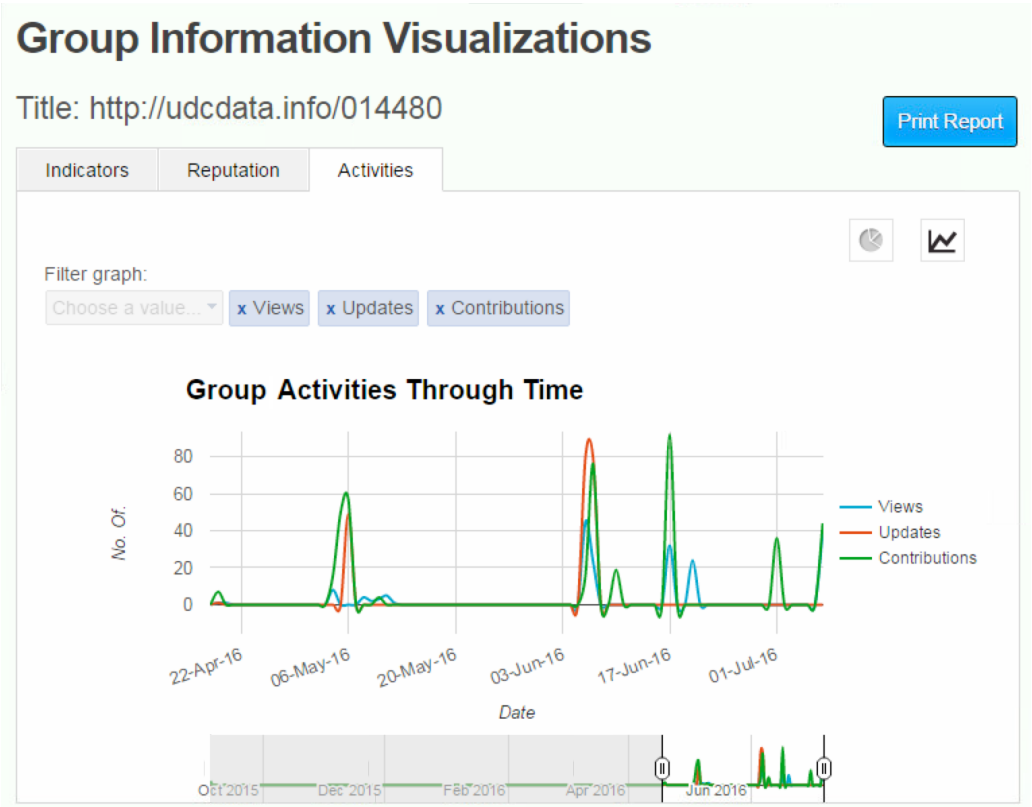


(a)

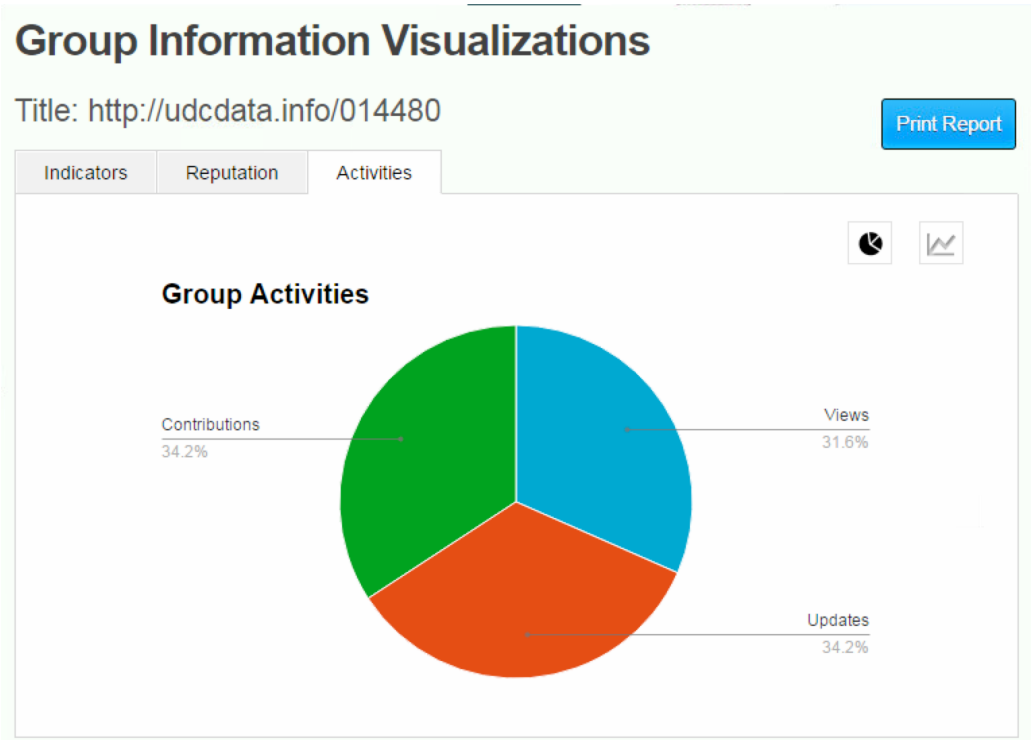


(b)

Figure 4.7: Group Dashboard Page

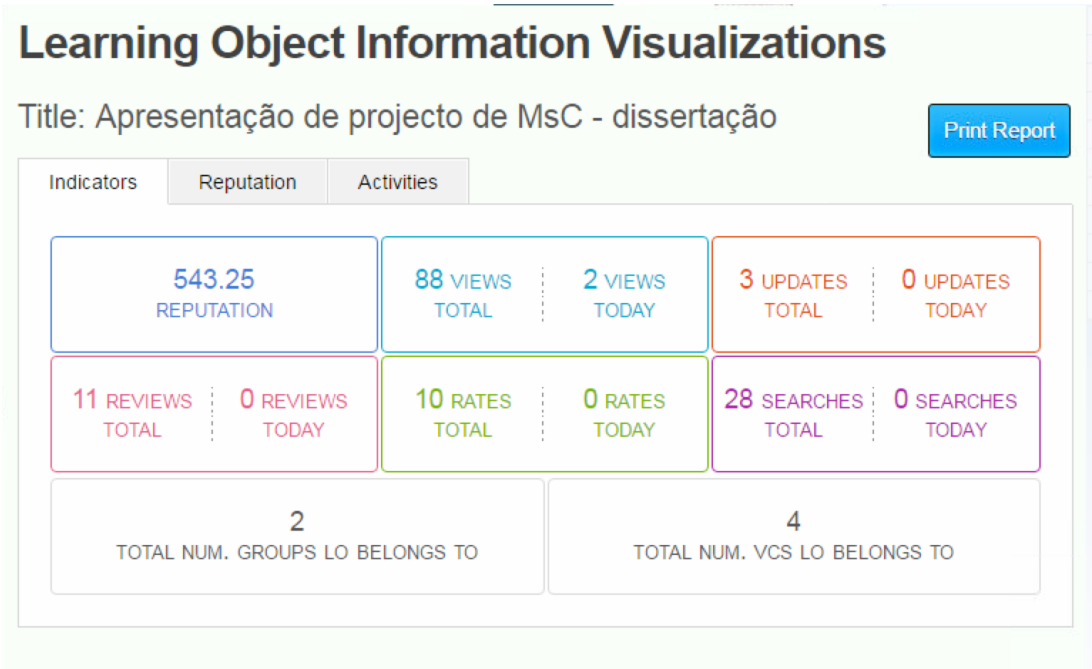


(a)



(b)

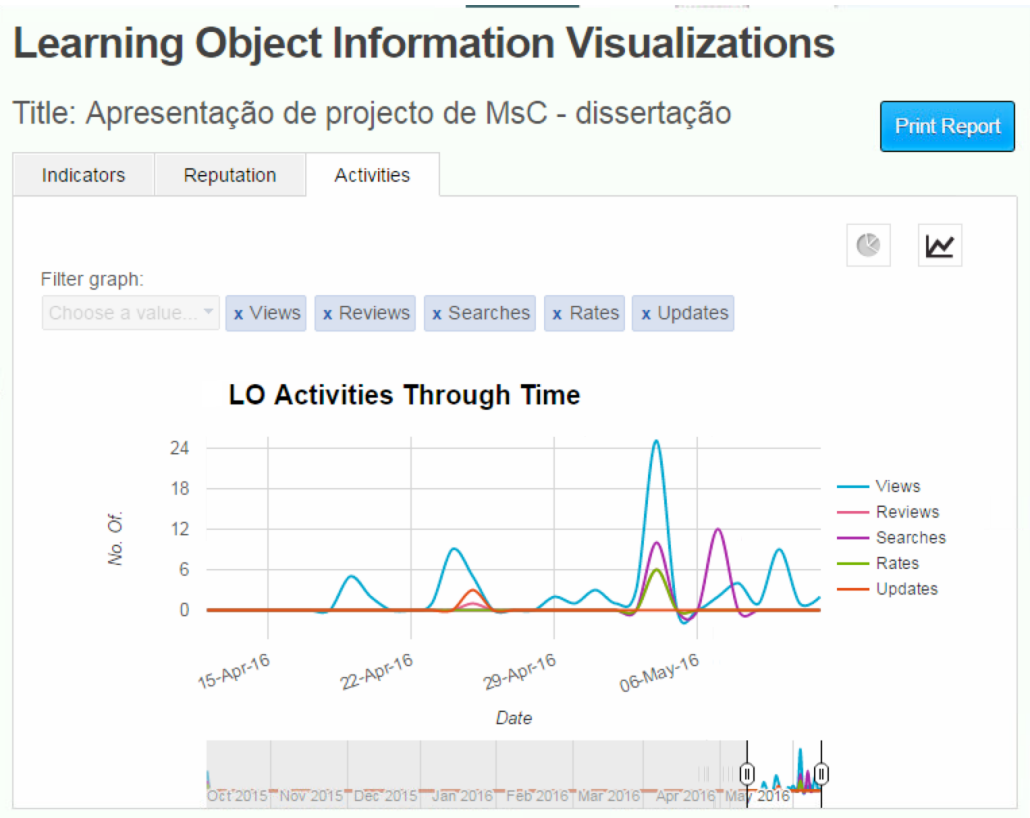
Figure 4.8: Group Dashboard Page



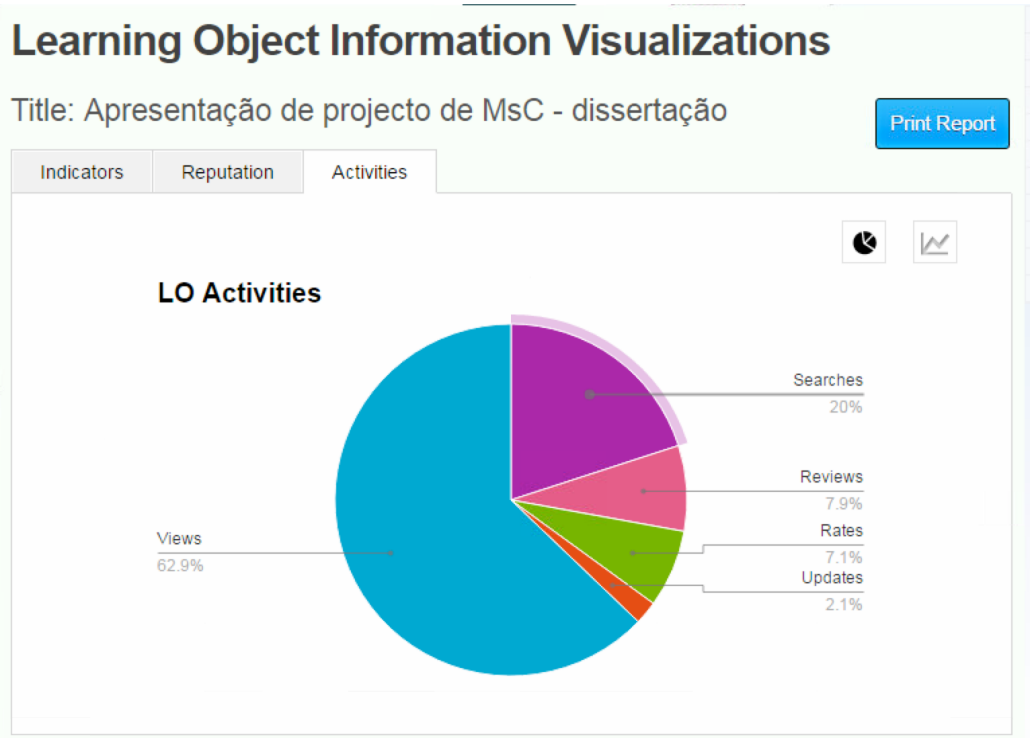
(a)

(b)

Figure 4.9: LO Dashboard Page

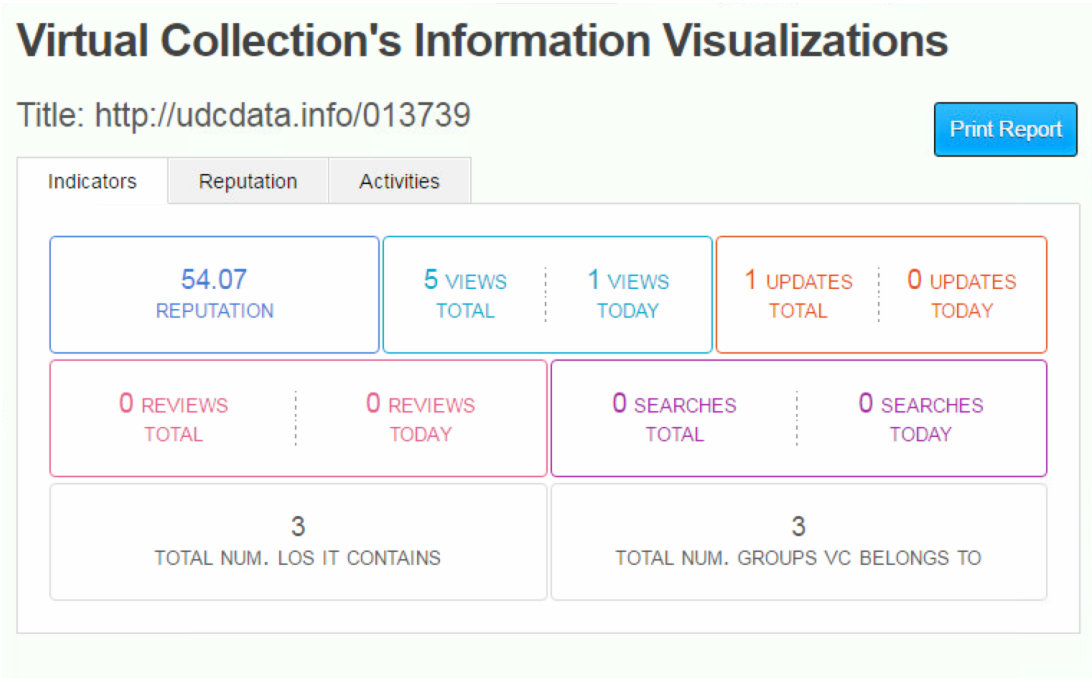


(a)

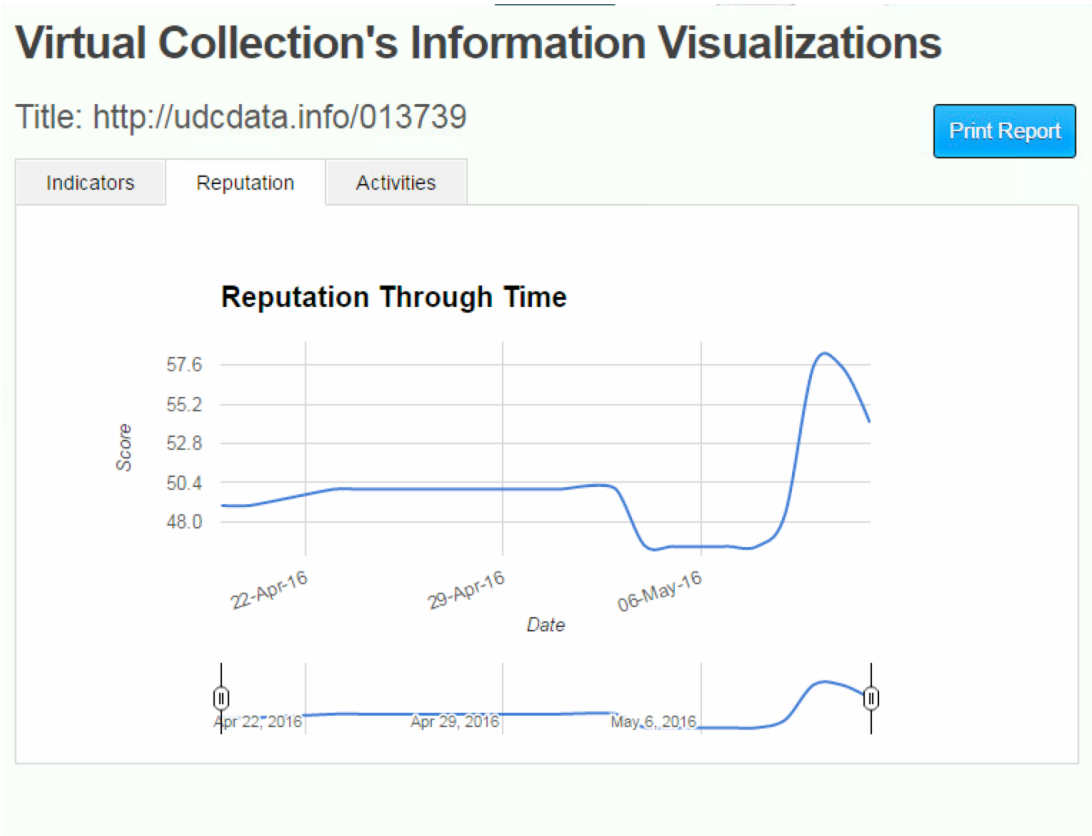


(b)

Figure 4.10: LO Dashboard Page

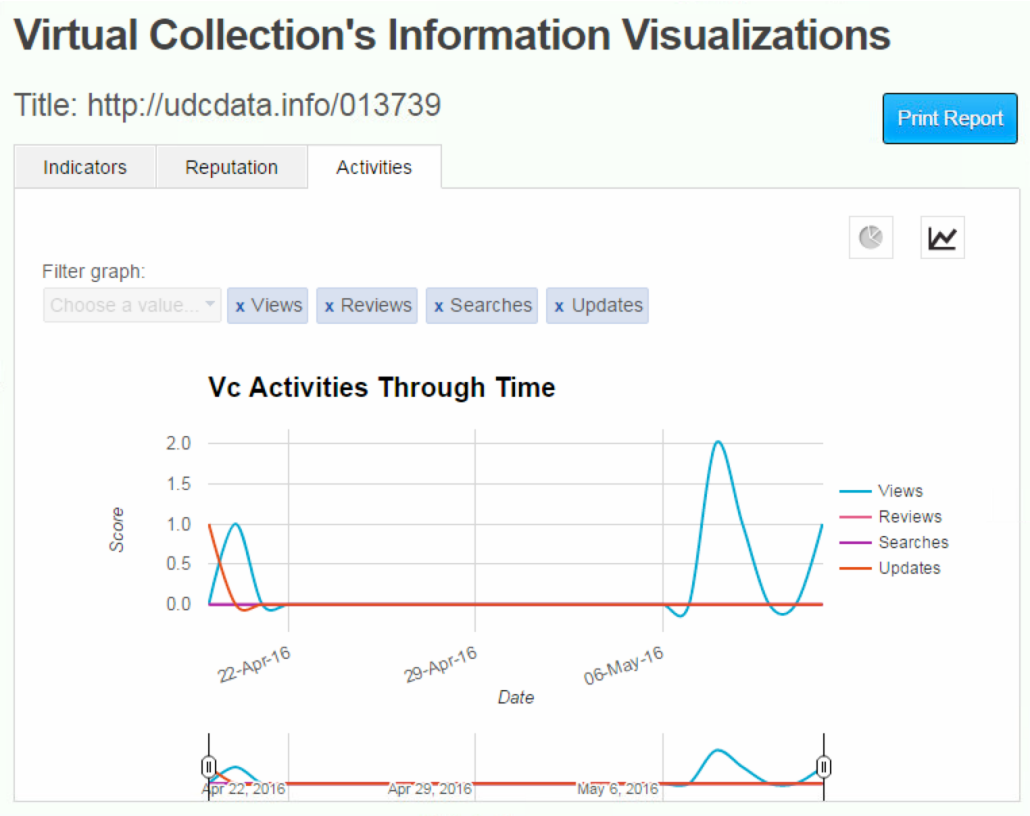


(a)

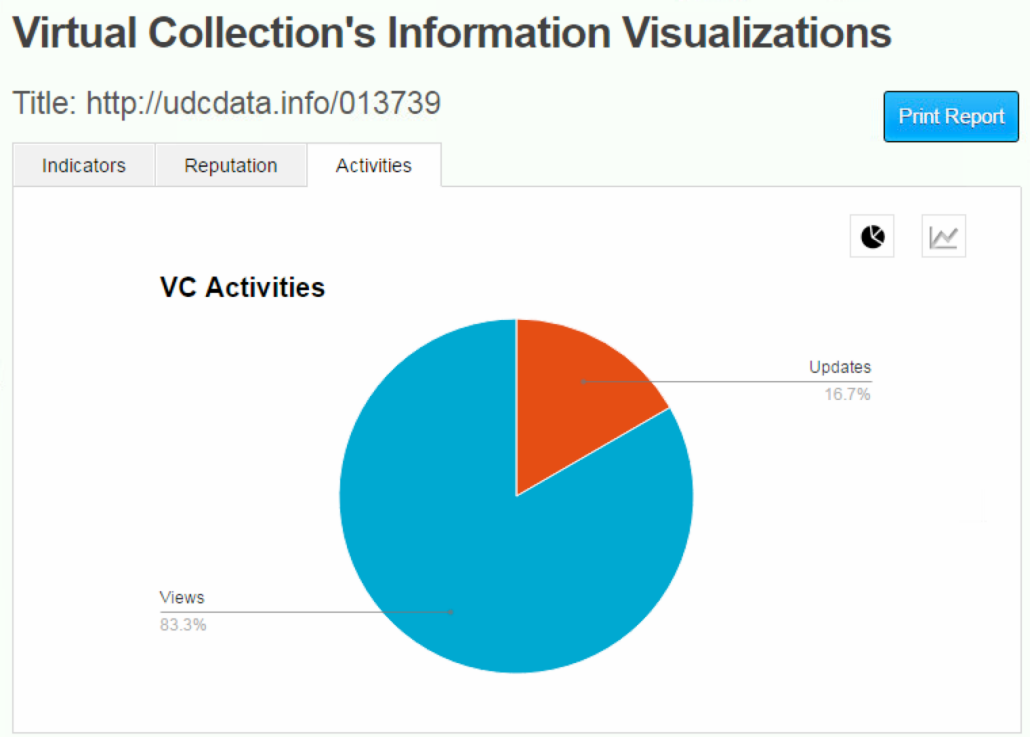


(b)

Figure 4.11: VC Dashboard Page



(a)



(b)

Figure 4.12: VC Dashboard Page

5

Tests and Evaluation

Contents

This chapter intends to present the evaluation methods performed to infer if the implemented solution behaves as expected.

5.1 Performance

This chapter presents the testing mechanisms used to validate the implemented solution against possible real situations. Because visualization tools are difficult to test, in the case of BOA performance and scalability testing is quite useful. As such, the solution was tested in those terms. The testing methodology was to create a number of scenarios to test the application that most assimilate to a real case scenario, being the best case scenario a very active platform. As the actions' data is stored in SQL Server databases, a SQL script was created for this purpose.

As it is not easy to test charts or visualizations, the intention of this test is to verify how well the charts behave when populated with increasing amounts of data, ie actions made upon the social objects.

The application was tested against four possible scenarios and the average page load time was measured in each of the dashboard and scenario:

Scenario 1: 1000 actions for each social object;

Scenario 2: 10000 actions for each social object;

Scenario 3: 100000 actions for each social object;

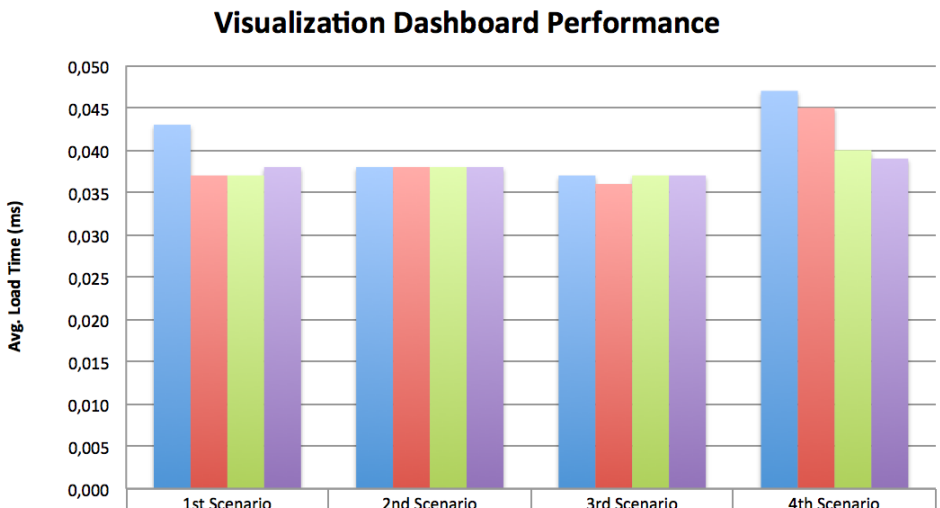
Scenario 4: 1000000 actions for each social object.

The results in Figure 5.1 show that for increasing data there is little difference in chart rendering and information visualization, even though in the 4th scenario there is a time increment in load time it still maintains a reasonably low average loading time for each Visualization Dashboard Page. This means that the dashboards are prepared for incremental data increase, which is most likely to happen through time.

5.2 Usability

Besides scalability testing, usability tests were performed in a group of 10 inexperienced users. The users were given a brief explanation on the platform and the goal of this thesis and were then allowed to explore the dashboards for a certain amount of time, while at the same time giving feedback on their overall experience. At teh end of the test, they had to answer 4 simple questions:

1. How did you feel about the data disposition?
2. How difficult was it to understand the information throughout the dashboards?
3. Evaluate the usefulness of these dashboards in a platform such as BOA.



	1st Scenario	2nd Scenario	3rd Scenario	4th Scenario
LO Page	0,043	0,038	0,037	0,047
VC Page	0,037	0,038	0,036	0,045
Group Page	0,037	0,038	0,037	0,040
User Page	0,038	0,038	0,037	0,039

Figure 5.1: Dashboard Performance Comparison

4. Overall, rate your experience using these dashboards.

Question 1 had two possible answers: Confusing or clear and concise. All users responded that the information was presented in a clear way, allowing them to analyse and understand quickly the presented data.

Question 2 had five possible answers that rated the level of difficulty understanding the data, these levels went from 1 (Very Easy) and 5 (Very Difficult). Even though the answers are sparse, none of the users evaluated it as very difficult to understand and more than 50% thought the data was quite simple to understand throughout the dashboards, as can be verified in Figure 5.2.

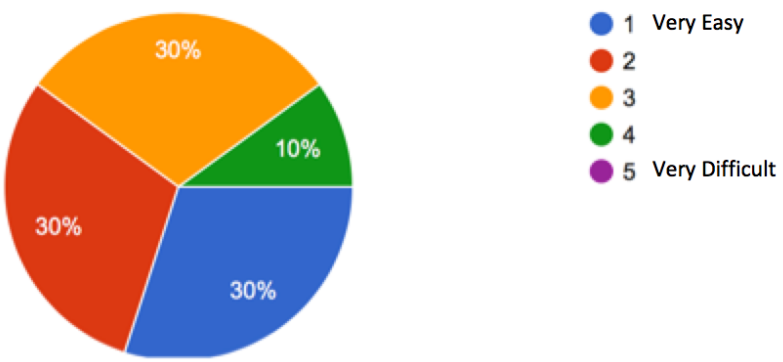


Figure 5.2: Usability Test - Q2 results

Question 3 also contained 5 possible answers that varied from 1 (Very Useful) to 5 (Useless) in order to understand the users' view on the usefulness of such mechanism and data presentation. In a way, all users thought it was useful to have a centralized view of their actions in the platform, as can be viewed in Figure 5.3.

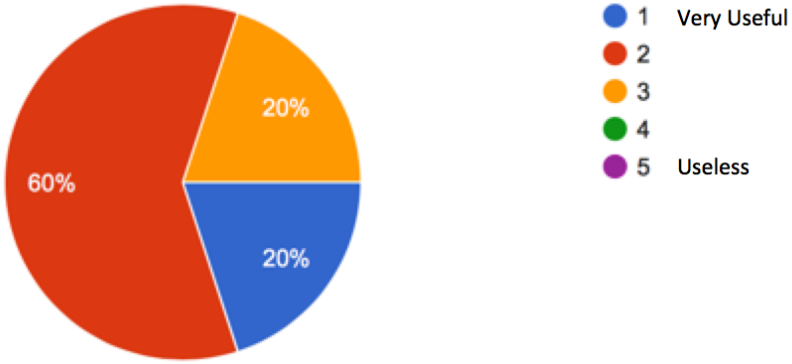


Figure 5.3: Usability Test - Q3 results

The final question - Q4 - aimed to get an overall rating of the users' experience using the dashboards. The available answers were 1 (Excellent), 2 (Very Good), 3 (Good), 4 (Bad), 5 (Very Bad). More than 50% rated their experience between Good and Excelent - Figure 5.4.

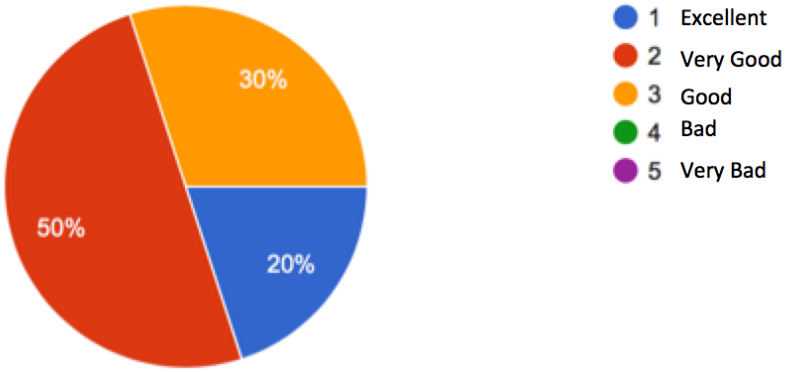


Figure 5.4: Usability Test - Q4 results

Even though these results are quite satisfying, more tests are necessary for these dashboards to improve, not only increase the number of users but also choose more experienced ones, users that better know the BOA platform.

6

Conclusion

Contents

This chapter presents most relevant conclusions on this work, more specifically its main contributions, limitations and future work.

Building an effective dashboard is not just assembling some metrics together and creating a graphical view with it. It takes a certain process, contextualization of the project understanding target audience, the choice of metrics, choice of charts and tables that best convey the previously chosen metrics.

That is what this thesis addressed. First contextualize on what dashboards are as well as their purposes and what aspects are important to build an efficient one. Essentially dashboards are useful tools for data visualization if they are simple and concise in the way they present information.

Also analyze platforms that measure and retrieve analytical social data such as Facebook, Slideshare, LinkedIn, ResearchGate, Picasa and Flickr in order to create a reference model for the BOA platform. After this, the choice of dashboard technology implementing tool taking into account that it must be integrated with the current BOA architecture.

It is also proposed a dashboard prototype for each BOA social object with a number of customized operations.

6.1 Contributions

This solution improves the current BOA platform not only because the solution lacked a specific area that aggregated BOA's social objects data for consultation and also because this way users are now more informed on their actions in the platform. By being more informed on their data and providing clean ways to show information users are stimulated to become high reputation users or to achieve other goals. It is important for a collaborative platform such as BOA to always find ways to stimulate users to use it and collaborate with it and with eachother.

6.2 Limitations

Currently the system has been developed and tested uniquely in a development environment. Even though it has been through stress and load tests for both the database and HTML requests, there is no absolute guarantee that it will fully work in a real life scenario.
In terms of visualizations more questionnaires and usability tests are required, specially with intensive and proficient users of the platform to inquire user satisfaction regarding the visualizations provided and the effect they have had in their activities. More complex visualizations can be developed in order to increase users productivity in the platform.

6.3 Future Work

For future work and since platforms such as BOA should be in constant renovation in search for ways to motivate users to either participate in the platform and collaborate with eachother. Duval et. al [30] suggest a system of badges in order to reward the user for its contributions to the platform. Such mechanism would also be valuable to improve and motivate users in the increased participation with the system and collaboration with other users thus stimulating users engagement.

Other, more complex visualizations can be developed such as Radial Charts or Bubble Charts in order to connect the data throughout the platform even more. As there are Export functions available (that only export PDF) it makes sense to also allow the user to export their data to Excel.

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