AccessWeb Barometer

A Web Accessibility Evaluation and Analysis Platform

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Abstract—**The constant evolution of all Web related technologies, and the considerable adoption of these technologies in our society's everyday life, has brought to the discussion table the ability of these Web technologies and Web contents to become accessible to all, including those with some sort of disability. During the past years, a research project has been executed in order to, not only give the Web accessibility topic more visibility within our society, but also to achieve indicators on the levels of accessibility presented by privately held company websites. Considering the growing need to rapidly achieve Web accessibility indicators, whose complexity has significantly increased, the research team inherent to the referred project developed a software platform, entitled "AccessWeb Barometer", that has the ability to perform Web accessibility evaluations to multiple websites in simultaneous. It also has the ability to analyze and publish the results inherent to those evaluations, and to allow its users to create their own analysis and dashboards. In this paper, we present the AccessWeb Barometer software platform architecture, its overall characterization and validation, and also the possibilities of what a platform like this can bring to Web content developers and to organizations worldwide.**

Keywords- Web Accessibility; AccessWeb Barometer; Evaluation Platform; Analysis Service; Diagnostic Service.

I. INTRODUCTION

The topic of Web accessibility has been of major relevance for the global community, and particularly for those who have some sort of impairment or disability. When analyzing the majority of existent websites one can recognize that their compliance levels with current Web accessibility standards is incredibly low [1-3]. The referred topic can be simultaneously seen as an ethical and social problem, but also as an economically relevant issue. By merging these facts with current economic and financial difficulties assumed by almost all organizations, one can pinpoint the importance of a project that focus on, not only identifying websites accessibility issues, but also on providing information on how to solve those same issues.

We present a three layer architecture proposal for a software platform whose goal is to be able to simultaneously evaluate several websites against international Web accessibility, usability and compliance standards, and simultaneously create analytic dashboards that will be made available to all Internet users through a set of collaborative Web platforms.

The present paper is divided into five sections, starting with an introduction section where a very brief approach to the paper's main topic is made. A second section presents the readers with a detailed perspective on the theoretical background inherent to both the relevance of Web accessibility topic and Web accessibility evaluation tools and systems already present in the literature. In third section, a comprehensive description and characterization of the proposed software platform design is made. A fourth section was developed in order to address the validation tests performed in order to ensure reliability to the proposed software solution. The paper finalizes with a fifth section containing some conclusions on the performed work, and on the expected future work.

II. WEB ACCESSIBILITY BACKGROUND CHARACTERIZATION

A. Conceptual Framework

The internet offers a variety of information that, by nature, is constantly changing and evolving, both in size and in complexity, thus becoming an indispensable tool for individuals and organizations in everyday life [4].

Though the Internet is to be used by all, there is a niche of individuals whose physical and/or mental characteristics increases the level of difficulty associated with the referred interaction. Despite their limitations, these individuals should be allowed access to the Web and all its resources in the same manner as a normal user [2]. With this concern in mind, Babu and Sekharaiah [1] argue all Web resources need to incorporate accessibility characteristics that allow disabled users to use them by themselves or by using assistive technologies to do so.

Gonçalves, et al. [5] presented the term "accessibility" as the ability that allows people with some sort of disability or incapability to interact with any product, resource, service or activity in the same manner as an individual without any impairment would. Complementarily, Henry [6] argues that "Web accessibility" is the term used to characterize the ability possessed by Web interfaces that allows them to be perceived, understood, navigable and easy to interact with. Recently, several authors [3, 7, 8] also complemented this initial definition by assuming that it represents Internet usage by

everyone, regardless of their physical, perceptive, cultural or social capacities or skills.

According to Gilbertson and Machin [9], there are two parallel approaches one can make to study and work the Web accessibility topic: 1) a more functional approach that focuses on the user's limitations and on the possible solutions (within the available technology) for those limitations; and 2) a more technical approach that focuses on Web technologies and how they can be used, modified or created to diminish or eliminate the obstacles opposing the users to fully benefit from the potential associated with the Web.

B. Legal and Regulatory Concerns

In the last two decades, the Web accessibility topic has been on the agenda of several national and international regulatory entities, which allows to highlight the importance of the topic [2].

In recent years, several organizations have been working on the Web accessibility topic. The most prominent one is the World Wide Web Consortium (W3C), mainly due to its Web Accessibility Initiative (WAI) and its Web Content Accessibility Guidelines (now in a second and more updated version) [10]. These guidelines are a set of detailed descriptions to accessibility issues associated with the development of Web applications and content that everyone can use [11]. The current version of the referred guidelines were defined according to several layers of conceptualization, including: principles, general strategies, testable success criteria, a collection of techniques to promote the Web accessibility topic, and a set of complex documentation on all the possible accessibility faults and errors [12].

In parallel with W3C, the International Organization for Standardization (ISO) has been aiming their activities on improving the knowledge inherent to the Web accessibility topic, and to establish a set of standards that should bring the much needed normalization to the area. The most public results of ISOs work have been the ISO TS-16071, ISO 9241-111 and ISO 9241-171 standards that aimed on, not only implementing a set of rules that should be fulfilled, but also helping both the public and organizations to create accessible Web platforms, websites and Web content [13-16].

Despite the existence of several international standards and regulations focused on the Web accessibility topic that were adopted by the majority of the countries, some of them decided to create their own regulations and enforce them at their own will. An example of this creation is the Web accessibility regulation by the United States of America, entitled "Section 508", which highlights the existing right for all data or information be made available by any ICT related systems or any Web platform, to be accessible to all citizens, including those with some sort of disability or incapability [17, 18].

Even though there are several legal and/or regulatory requirements, W3Cs WCAG 2.0 is the most relevant Web accessibility standard. This is the one that most countries and organizations have adopted as the basis for developing accessible Web content.

C. Recent Perspectives

According to Burger [19], global tendencies towards increasing Web accessibility levels have significantly improved. Several major software houses and Web consulting agencies are now incorporating accessibility concerns in all their products and contents. The referred author also highlighted that several researchers are also focusing their research activities into, not only developing the technologies in order for them to become more accessible, but also into creating and improving the existing Web development platforms and technologies. This helps developers create accessible Web content and also to promote the Web accessibility topic in both the scientific community and to the general population.

In 2012, Rocha, et al. [20] performed a research project that was aimed at understanding the social and economic reality of individuals that presented some sort of disability or incapability. With this study, these authors were able to conclude that the great majority of the analyzed individuals are unemployed or don't have a factual economic activity, but receive monetary governmental complements and subventions in order to survive. By acknowledging this fact, one can perceive that organizations who do not implement accessible websites are directly neglecting a market share that, due to their impairments, are prone to adopt and use such websites.

Braga, et al. [21] performed a research project in which the authors intended to evaluate the accessibility levels of Bank of Brazil's online banking system. The research was done by using a manual evaluation process that allowed them to better identify the barriers and struggles posed to the referred system users. Assuming that the proposed evaluation methodology was correctly defined, after performing the evaluation activities, the authors were able to acknowledge that some changes were needed and had to be implemented in order for their methodology to be totally usable and reliable. Nevertheless, through the execution of this project, a set of important accessibility faults and issues was identified and transmitted to the bank's IT department in order for them to incorporate the necessary changes.

As stated by Oh and Chen [22], Web accessibility represents an increasingly important variable within the organization's corporate and social responsibility scope. An organization collaborator can perform a decisive part in enforcing both the need to create accessible Web content and presenting an accessible website. With this concern in mind, Santarosa, et al. [23] proposed an accessible e-learning platform that complied with W3C WCAG 2.0, aiming on allowing for universities to offer their students a change, in concerns to the access of information on their courses or classes. In their work, the authors also present strategies to train teachers and educators in order for them to be able to create accessible learning content.

Evaluating websites against Web accessibility standards is not an easy task; the present time surrounds itself with a significant margin for individual or manufacturer interpretation [24]. As reasoned by W3C, when assessing websites accessibility levels one should use a mixed approach

and combine both automatic and manual testing in order to guarantee a significant level of reliability [25].

There are several tools to perform Web accessibility assessments in an automated or semi-automated manner, but these tools lack the necessary combination of both a machine perspective and a human comprehension, thus tending to not responding to both the users and the Web content development firms needs [7, 26-28].

III. ACCESSWEB BAROMETER – A WEB ACCESSIBILITY EVALUATION AND ANALYSIS SOFTWARE PLATFORM

With the AccessWeb Barometer software platform, the research team envisioned to simultaneously create a diagnostic tool that delivered accurate and easy to analyze results, and to raise awareness on the accessibility and usability practices inherent to the design of corporate websites. Execution of website accessibility diagnostics on a large-scale represents a very considerable challenge since the known test instruments are manual or semi-automated, and require the allocation of an unsustainable amount of human resources in order to ensure an acceptable execution time [29].

From the experience collected from previous research and development projects, the research team was able to perceive that each website evaluation takes an average of 6 hours to be evaluated by the software tools. After that, another 40 minutes of specialized work, performed by an expert, in order for the evaluation results to be analyzed. With this in mind, the proposed system allows the execution of a great number of simultaneous evaluations in a smaller period of time. Above all, it increases the degree of confidence in the results, by eliminating the error inherent to human intervention in the analysis of the evaluation data.

Besides the diagnostic and analytics layers of the proposed software platform, another very important part is the Website component because it represents the platform's public interface where users can become more aware of the Web accessibility topic, and interact with the various outputs and results from all the performed Web accessibility evaluations. With this component users can, in a collaborative manner, acquire several new information and resources on the Web accessibility topic. Users can also perform synchronous and asynchronous discussions with other users and with the platform administrators or moderators.

A. Proposed System

The proposed architecture for the evaluation and analysis platform is composed of three different layers (Figure 1), with two of them representing the back end (responsible for the diagnosis and analysis - Diagnostic Layer; Analytics Layer) and the other one representing the Website Layer and serving as an accessible front end.

A three tier system was defined and implemented in order to address a fault very much present in the everyday life of those who are responsible for developing Web content and platforms, and to those who are facing the need to have accessible websites in order to benefit from its content. By allowing for a full automatic mechanism that only needs a list

of websites to start evaluating them and to publish their results in a modern and dynamic manner that simply allows users to create their own results analysis and achieve more personal acknowledgements.
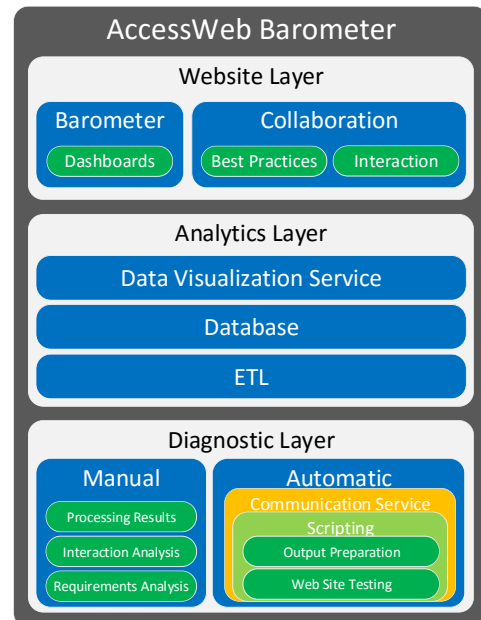

Figure 1. AccessWeb Barometer Software Platform Architecture.

At each layer, there are a set of well-defined tasks that need to be performed and that are responsible for delivering input to the components of the upper layer.

In the following sections, we describe in detail the intrinsic function of each component that integrates the AccessWeb Barometer platform architecture.

B. Diagnostic Layer

In the proposed architecture, the diagnostic layer represents all the components responsible for the accessibility evaluations that is to be performed during the execution of the project inherent to the AccessWeb platform. All Web accessibility evaluations will be supported by W3C WCAG 2.0 and will follow the indications from W3C and use both automatic and manual evaluation mechanisms and techniques [12]. The automated tools are usually fast, but are not able to identify all existent accessibility, usability and compliance issues. Thus, there is a need to complement these automatic assessments with manual reviews. This helps to ensure issues such as language clarity and navigation ease.

The proposed platform incorporates both the use of automated evaluation tools and manual reviews with real users in real environments. This aims on achieving a unified model for analyzing and reaching conclusions on the real limitations that a given website might pose to its users.

1) Manual Evaluation

In the first architectural layer, the Diagnostic Layer, we will focus on the assessment of websites by inspecting their

compliance with international guidelines, which are presented to a specialist, and an evaluator. They verify if the system complies with each guideline and registers all failures observed. During the manual evaluation stages the research team will include in the evaluation activities real users and evaluators. The main objective of presenting new and more hands-on results can complement the ones achieved during the parallel automatic evaluation procedure. Therefore, the evaluators will use a manual direct review approach to proceed with the inspection of compliance with Web accessibility and usability guidelines. On the other hand, real users will also be included in the evaluation procedures and through direct interaction, will explore and assess the tested websites interfaces [30-32].

In this context, we will use the barrier's walkthrough method and set-up the following stages of assessment [33]: 1) Identification of scenarios involving two types of users (with visual and motor disability); 2) Definition of accessibility evaluation objectives; 3) Execution of scenarios identified; 4) Analysis of the results; and 5) Presentation of a list of problems with severity level for each of the problems identified by the evaluator.

The assessment of accessibility is not complete without an additional usability evaluation; therefore, we will follow the criteria for measuring usability established by the ISO 9241 standard: 1) Analysis of the characteristics required of the product in a specific context of use; 2) Analysis of the interaction process between the user and the product / system / design; and 3) Analysis of efficiency (agility in enabling work), effectiveness (guarantee that the planned results are obtained) and satisfaction, resulting from the use of the product [34].

Within this scope, in order to achieve the above criteria, we will apply the following usability evaluation techniques: usability testing, cognitive walkthrough, questionnaires and interviews.

2) Automatic Evaluation

There is a wide variety of software and online services that help determine if a given website complies with the existent Web accessibility and guidelines, and also with other technology standards. The AccessWeb Barometer platform was not envisioned to be just another assessment platform, but instead, it aims on providing a public barometer that reveals an extensive set of indicators, in a graphical manner, that encourage discussion on the degree of preparation presented by websites, and on the possible interest to society of having accessible and usable websites and Web content.

Despite the existence of several Web accessibility and usability evaluation software tools, to our knowledge there are no solutions for performing multiple and simultaneous websites evaluations. In the proposed platform, the automatic diagnostic component consists of multiple virtual machines, mounted according to the size of the pool of websites that are going to be evaluated, giving the platform a very interesting scalability level. The limits inherent to this approach lie on the physical resources presented by the virtualization servers and on the available Internet access bandwidth.

The Communication Service subcomponent running on each virtual machine has the role of orchestrating and commanding all of the evaluation process of a given website. Its first task is to validate the existence of records on the queue containing the websites to be evaluated. This action is done through proper database queries, which return specific websites attributes (such as name and url), that are needed to perform the referred evaluation and make sure that only those who haven't been evaluated yet are queued. Each website evaluation is launched at the same pace that the virtual machine becomes available. This ensures that a given website is only evaluated once and by a single machine. At the same time the process starts, an update to the website database record is made, in order to "mark it" as already in evaluation. By being aligned with these procedures, the Communication Service subcomponent passes the website url parameter to the scripting application, named "AutoIt 2015", which is responsible for coordinating the execution of the software that will be used to conduct the evaluations.

AutoIt scripting tool runs on each virtual machine, serving to automate the graphical interface of Windows operating system, (i.e., assumes the user's role and performs all the steps that need to be performed for the site to be properly analyzed and evaluated). The proposed website evaluation software platform also incorporates Power Mapper's "SortSite V5.0" whose aim is to perform website evaluations against international Web related standards, such as Section 508, WCAG 2.0 and usability.gov guidelines.

After SortSite finishes the evaluation of a given website, the scripting tool stores the generated reports, passing the workflow again for the Communication Service subcomponent, which will move the evaluation reports to a shared folder ("dump" folder) on the platform server machine (virtual machine responsible for Extract, Transform and Load (ETL) and Data Analysis/Visualization). This process ends with an update to the database, thus ensuring that the website record will be marked as already evaluated and starting a new website evaluation cycle.

The data treatment inherent to the generated reports is performed by the Analytics Layer components described in the following section.

C. Analytics Layer

The intermediate layer, entitled Analytics Layer, of the proposed software platform architecture, runs on the server side. It is responsible for the analysis and process of data collected by the lower layer, and aims to prepare it to be presented in the next layer. In practical terms, the components inherent to this intermediate layer is responsible for the Information and Knowledge needed to feed the dashboards that are going to be displayed to the public through the Website Layer.

The first task of this layer workflow is performed by the ETL component, which is of vital importance since it involves moving data from their original sources into the BI system. The ETL component is used to construct and populate the central data repository of the BI architecture, but it is also for identifying relevant data sources in order to build a stable data

model (which uniforms, through metadata, all kinds of data), and organize data according to business policies and data storage [35]. In the proposed architecture, the ETL extracts the evaluation report files, stored in the dump folder, and treats and stores the inherent data into new database records. When this process is finished, the component will move the reports files to a "log folder", ensuring a copy of the evaluation results and a possible future data recovery.

Given the need to store and access data by almost all of the proposed architecture components, a database component was incorporated in order to serve as a central data repository structure, according to a traditional transactional approach.

For the set of data analysis related tasks, some Self-Service Business Intelligence (SSBI) techniques and technologies were used. The main goal of the SSBI is to assist managers in making decisions based on highly complex data analysis and involving less IT know-how's. This allows for the common user to add new perspectives to the predefined analysis and produce their own queries and reports. This increase of autonomy allows productivity gains for both regular users and IT departments that don't need to allocate their elements to provide analytical technical support [36].

Having detected the need for a solution that allowed for the representation of complex data in a graphic form, the research team decided to incorporate a Data Visualization (DV) approach, which by definition allows for the visual representation of data and enhances the value of the available information, allowing for an easy identification of trends, exceptions and deviations that are normally hidden in massive amounts of data stored in data sources [37, 38]. This feature of the proposed platform is highly critical because it uses creativity, design concepts, colors, shapes and sizes, to create visual contents that represent the knowledge inherent to a large amount of data [39]. To support this activity, several DV techniques and technologies were used, such as analytical models and statistical functions, whose results are presented visually through interactive dashboards composed of tables, charts, graphs, diagrams, histograms and maps [40].

In the analytics layer, in order to perform the data analysis and visualization, a decision was made to use the Microsoft's BI stack ("Microsoft Power BI"), which responds to all requirements specified for this software platform and for the graphical representation of data.

D. Website Layer

Website Layer corresponds to the front end of the platform, (i.e., serves to interact with all the users). Although the architecture in this layer is composed by two components, the "Barometer" and the "Collaboration" component, a special attention is given to the Barometer component as it is the one that is directly related to the evaluation system results. As a consequence, the Collaboration component enjoys a certain degree of independence by enabling users' access to additional resources, such as, documentation on best practices in the areas of accessibility, discussion forums and blogs, which have no direct relation with the evaluation system.

Barometer component serves to share all the knowledge extracted from the multiple evaluations carried out to different

organization websites through visually rich dashboards; for example, providing a varied combination of graphics, manipulated by a wide range of filters, according to the users' preferences. These indicators range from the analysis of various sectors of activity, analysis of the most common mistakes, and the geographical distribution faulty websites.
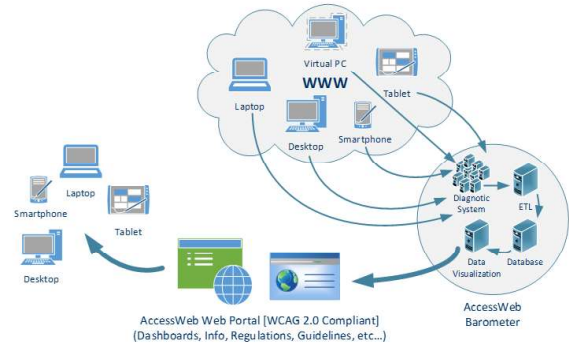

Figure 2. AccessWeb Barometer software platform workflow.

As shown in Figure 2, AccessWeb Barometer software platform acknowledges and also incorporates the prominent role of studying and analyzing the accessibility, usability and compatibility of websites when accessed through the various types of existing devices. All the front-office related components are defined to not only have an attractive and updated design, but also to be responsive (adaptable to both desktop and mobile environments), be compliant with WCAG 2.0 guidelines and compliant with international usability guidelines.

IV. PROPOSED PLATFORM VALIDATION

Given the complexity associated with the proposed solution, the research team decided that an initial validation stage was needed in order to ensure that, not only all the platform outputs were adequate and correct, but also to acknowledge that an increase of efficiency and performance of the Web accessibility evaluation process was verified.

In order to perform the referred initial validation, and following previous works [5], 1000 Portuguese privately held companies with the biggest business volume were chosen to be used as the evaluation target group. In Figure 3, it is possible to perceive that from the 1000 initial companies, only 862 were evaluated, mainly because the remaining were without a website or had one that was in maintenance or was incompatible with PowerMapper Sortsite tool.

After performing the analysis of the target group and achieving the list of the 862 companies whose websites were to be evaluated, the research team registered that same set of websites in the Analytics Layer "Database" component and started the websites evaluation procedure against WCAG 2.0.
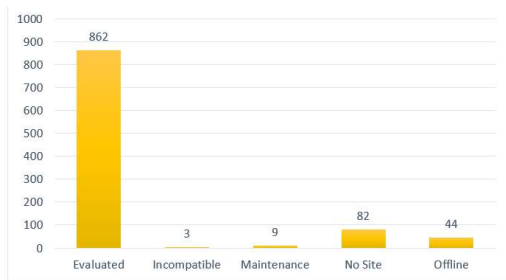
Figure 3. AccessWeb platform initial validation target group analysis.

When all evaluation results were registered in the Analytics Layer by the Diagnostic Layer we were able to achieve all the visual dashboards needed to acknowledge the accessibility levels and compliance presented by the evaluated websites.
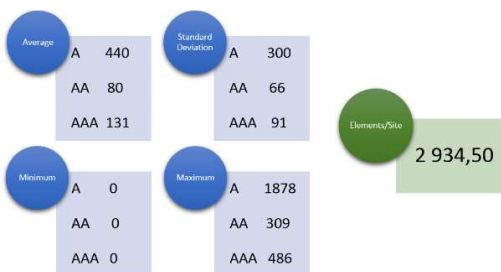

Figure 4. Statistical analysis of the Web accessibility evaluation results.

From the analysis of Figure 4, one can perceive that, despite the average number of evaluated elements from each website is significant (≈ 2900), the average number of detected accessibility errors is still very considerable of what might represent, in line with previous studies [2, 5, 41]. Those levels of compliance with WCAG 2.0 are still very low and those with some sort of disability cannot access the majority of the target group websites without encountering several difficulties or impossible to transpose barriers.

By examining the achieved results, one can acknowledge that the proposed platform is capable of delivering valid and accurate results that allow for a simple and direct understanding on the Web accessibility status of a given website or sets of websites.
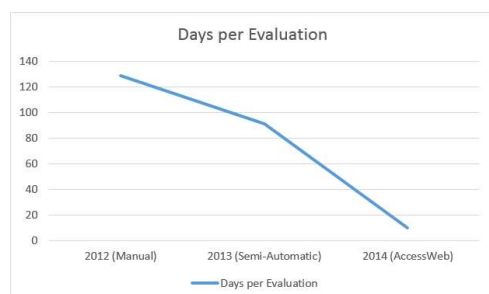

Figure 5. Comparison between the duration of previous Web accessibility evaluations and the one perfomed with AccessWeb platform.

Another critical issue for the research team was the performance presented by the proposed platform. In Figure 5, one can observe a direct comparison between the performance from previous evaluations that the research team performed to the same target group, and the performance presented by this new Web accessibility evaluation performance. From this observation, one can easily highlight the significant improvement of the time necessary for undergoing an evaluation to a set of 1000 companies.
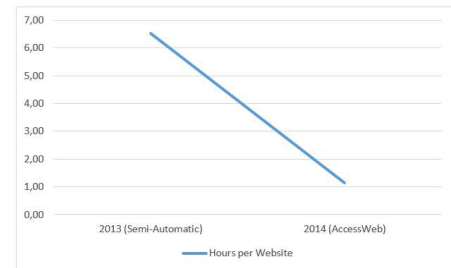

Figure 6. Comparison between the average number of hours necessary for evaluating a website against WCAG 2.0 when using a semi-automatic approach and when using the AccesWeb platform.

By analyzing Figure 6, it is possible to recognize that the use of the AccessWeb platform brings a very interesting improvement to the overall Web accessibility evaluation. Given that, it can reduce in a considerable manner the number of hours necessary to fully evaluate a website, to validate and store the achieved results, and to reach visual dashboards that allow for a direct visualization of the referred website accessibility status.

V. CONCLUSION

An accessible website should allow all users, regardless of their physical or mental situation or impairments, to understand, navigate and interact with the published content. When analyzing the current perception on the Web accessibility concept, one can easily perceives that it is no longer just a technical issue, but also an ethical and social issue, a market (economic) issue, and a SEO issue.

According to W3C one of the most common reasons to the lower levels of accessibility presented by websites is the lack of knowledge which organization managers, Web software developers and Web content creators have; on topics such as Web accessibility standards, assistive technologies and development tools. Drawing on this assumption, the research team inherent to the present project projected a software platform, entitled "AccessWeb Barometer", for performing multiple accessibility evaluations to sets of websites (mainly belonging to private organizations), giving public access to the results of those evaluations and with this, increasing the global awareness on the Web accessibility topic, and on the importance that it has on the lives of those with some sort of disability or incapability.

With this paper we propose an architecture proposal for the referred software platform that is composed by three main layers, a diagnostic layer (constituted by several components

directly responsible for the accessibility evaluations to the chosen websites), an analytics layer whose components have a direct intervention in the extraction of the data inherent to the evaluation processes, in the storing of that same data and in the creation of sets of analyzed and treated information that will be serving as the basis for the public dashboards that are to be available to users through the website layer. This third layer will not only be constituted by the graphic elements that will show the evaluations results to the users, but also by a set of collaborative tools and technologies that should be used to increase the public awareness on the Web accessibility topic.

Currently, all architecture components have been developed and an initial Web accessibility evaluation to a set of 1000 Portuguese company websites was performed, allowing not only to validate that the proposed platform is accurately evaluating the chosen websites, but also to verify that output results are valid and in line with other similar Web accessibility scientific works.

From the referred platform validation, the research team could also identify that the proposed platform ensures a very significant improvement in the overall Web accessibility evaluations field, not only by decreasing the amount of time necessary to perform bulk Web accessibility evaluations, but also by reducing the average time necessary to evaluate a single website.

By incorporating all the considerations achieved from the actions mentioned above, the research team is already planning a future Web accessibility evaluation that focus its attention on websites belonging to both large European companies and SMEs.

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