Website Performance Measurements and Related Analysis

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Current digitally growing context embodies concepts which are new to the information society and rapidly gaining lots of attention not only in specific e-commerce or e-business areas but also in different other segments which weren't accommodated with digital demands. Terms like big data, fast and secure transactions, cloud and IoT are just a few items in the exponentially growing world of digital demands. Hence, a basic requirement related to prerequisites of the digital world is to have an e-business solution that can be easily monitored, which can be enhanced with the help of useful and relevant performance metrics. This situation imposes an adaptable structure which comes because of a comprehensive monitoring activity. In this context, through this paper, we are taking into consideration an in-depth analysis of a website structure, through which different e-business solutions can be evaluated.
Keywords: Monitoring, E-business, Cloud, E-commerce, IoT, Performance, Metrics

1 Introduction

Often, in monitoring issues, the quality of web pages is discussed. Aspects related to the quality of monitored web pages are also metrics that we can consider when creating a complex monitoring system. There are already free tools on the market through which we can measure the mentioned metrics, the basic aspects of which can be captured in the analysis of the web.dev portal. Thus, metrics related to: performance, accessibility, best practices and SEO can be extracted. In order to concretely highlight the mentioned aspects, I will consider the analysis carried out by the web.dev portal for a test web page created by me (comprising complex elements, both pluses and minuses from the point of view of quality and more.

Thus, the elements resulting from the web page quality analysis are:

1. Performance (by means of specific scores reflected in a lighthouse score, as a graphic representation)
2. Accessibility (conventions and legal frameworks for website/web application elements; best practices guide on web page development)
3. The best practices (regarding the method of contextualization and development of the web page, highlighting the graphic elements as well as the structure in its composition)
4. SEO (through which the degree of discovery and validity of the web page is highlighted, within a context given by a search engine; web ranking as well as optimization techniques).

There are multiple benefits for performing a complete, in-depth analysis on a website, hence some of the most important are referring to: traffic increase, data and transaction volume increase in the context of big data, marketing aspects that would add significant value to the e-commerce context to which it belongs, client retrieval and exposure to different business use cases, analyze competition's website to reflect on a better position on the market. Taking into consideration the multitude of benefits that arise from the complex website analysis, we can mention a few of the most important techniques that make part of this analytical framework. Hence, the following can be exposed for Customer Lead Website Analysis highlighting it's main components [1]:

1. Competitive Analysis (what other solutions visitors are looking at);
2. SEO Tools (what visitors are searching for);
3. Feedback/ VOC (what visitors expect, prefer related to a site);
4. Traditional Analytics (what other

solutions visitors are looking at);
5. Speed Tools (how fast the website loads);
6. Behavior Analytics (what visitors are doing on a website).

Along with the mentioned components, the following website analysis can be performed on a website:

1. Search Engine Optimization (SEO): On-Page SEO audit (review of website structure for technical issues that could affect search performance); SERP ranking analysis (this analysis shows you the page your website ranks for, the keywords you're targeting, and their position); Off-Page SEO audit (external factors website analysis); website speed (web page load time, as factor that affects web ranking).
2. CRO analysis: conversion rate optimization audit relies on a 360 analysis that eliminates conversion blockers and relies on two main aspects, traffic and messaging.
3. Usability analysis: the core of this analysis

relies on interface and how visitors respond to it, hence highlighting two main areas (website functionality and expert review – heuristic analysis).

Associated with the presented techniques, there are some dedicated tools that accomplish the functionalities, as follows:

1. Tools for Search Engine Optimization (Google Search Console; Screaming Frog; Ahrefs Site Audit Tool; Google Page Speed Insights; Pingdom Speed Test; GTmetrix; Bing Webmaster Tools; MozBar SEO toolbar; AnswerThePublic; Keyword Tool, etc.)
2. Tools for CRO Analysis (Figpii; Google Analytics; Fullstory; InstaPage; ConvertBox; OmniConvert; CrazyEgg; HotJar, etc.)
3. Tools for Usability Analysis (Userfeel; TryMyUI; Useberry; Userlytics; Optimal Workshop; UsabilityHub; User Testing; User Zoom, etc.)
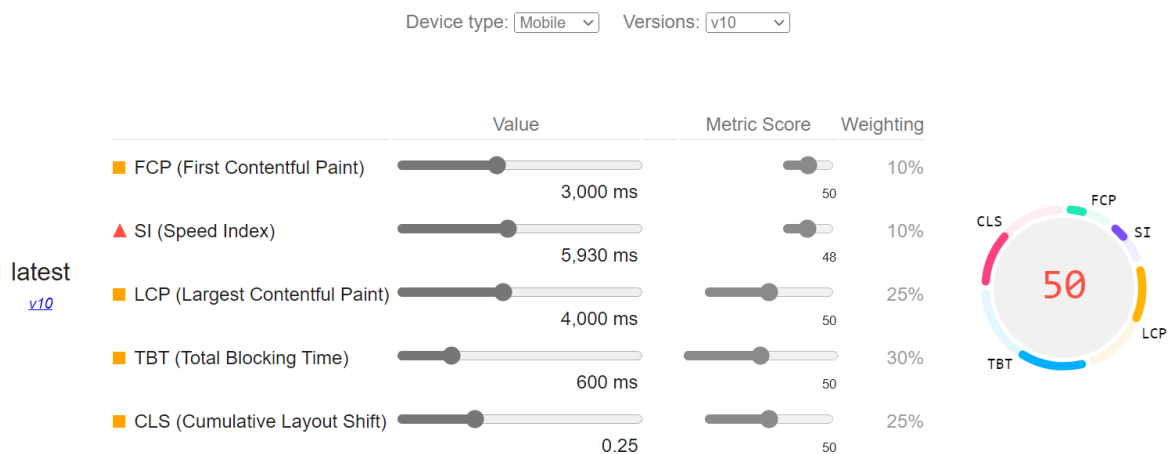

Fig. 1. Lighthouse Scoring Calculator – Default representation for Mobile device type
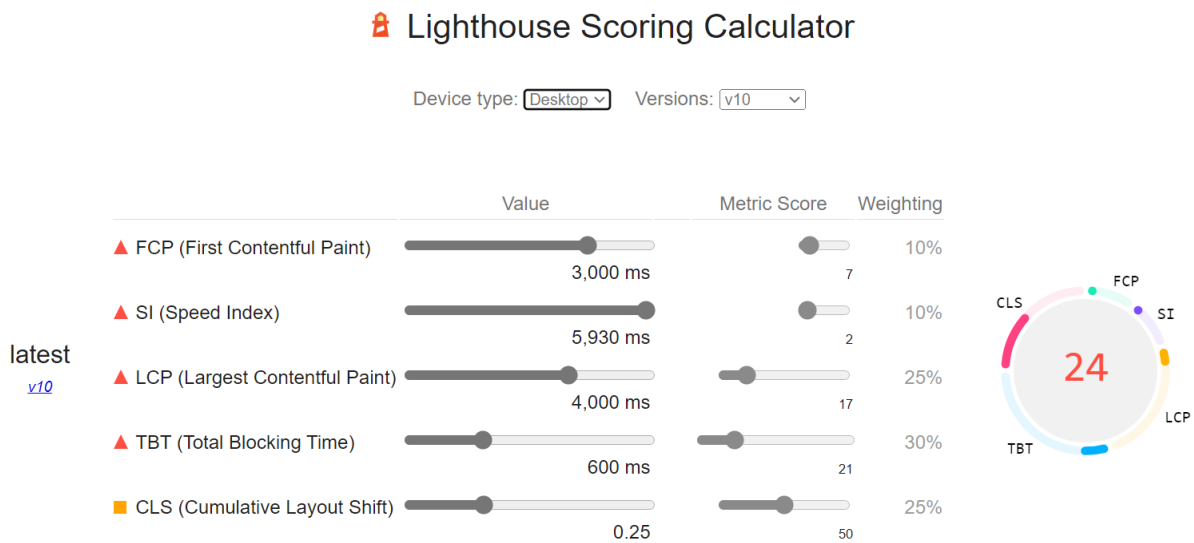
Fig. 2. Lighthouse Scoring Calculator – Default representation for Desktop device type

Through different conducted research activities, the first rendered image of a website is actually the impact element that makes the first impression of a user, hence along with this aspect comes the scoring calculator. A good example of scoring calculator is represented by Lighthouse Scoring Calculator, which describes relevant metrics associated to website interface, an element that will be highlighted in the analysis of a web page, in this paper [2]. It is important to highlight that presented tools could make e-business optimal in terms of usability and profitability, since e-business should mainly facilitate the execution of activities in a multitude of domains or areas, also supporting decision making [3].

In figure 1 and 2, the user has to possibility to select test metrics that could highlight website performance in terms of visualization layers. Also, as default, general context websites have presented indicators for mobile and desktop device types for version 10 of Lighthouse Scoring Calculator. Multiple versions can be selected for various tests (v10; v9, v8, v7, v6, v5).

2 Descriptive elements related to website metrics

It is important to highlight above presented aspects on a test webpage, hence I have chosen a simple page created specifically for experimental purpose. From website performance analysis point of view, the indicators resulted, for both mobile and desktop versions, are depicted in figures 3 and 4.
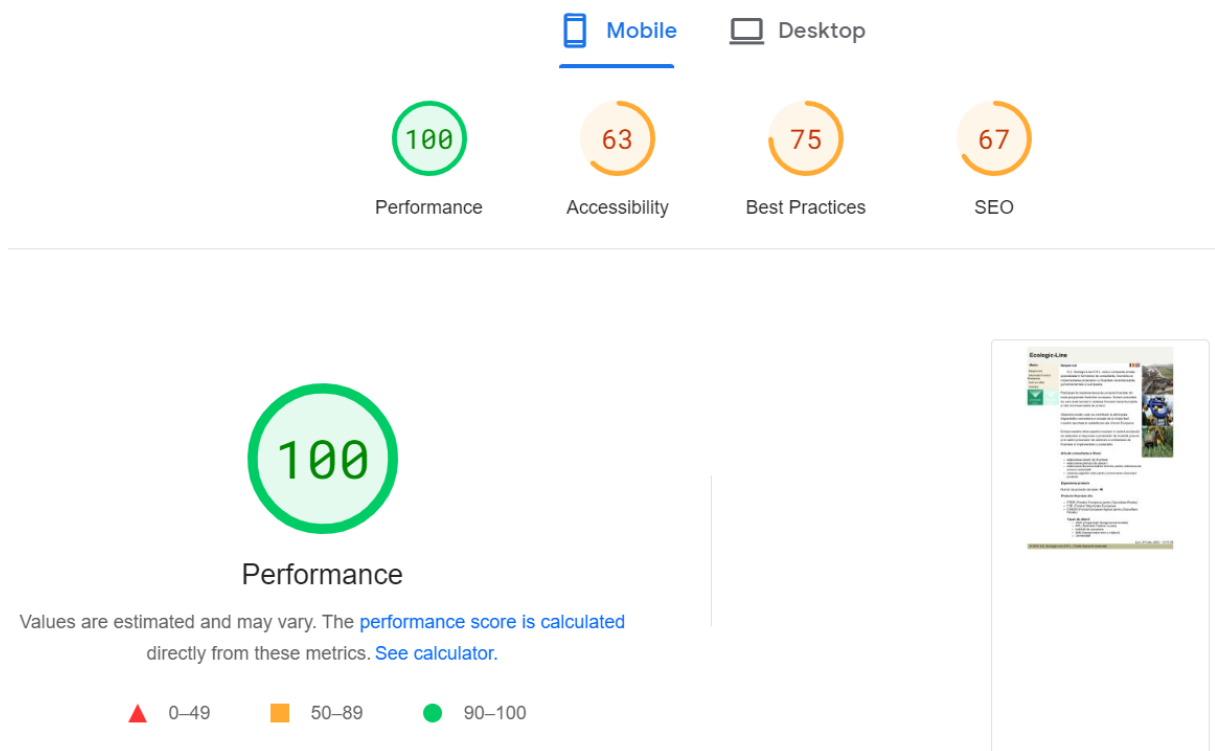
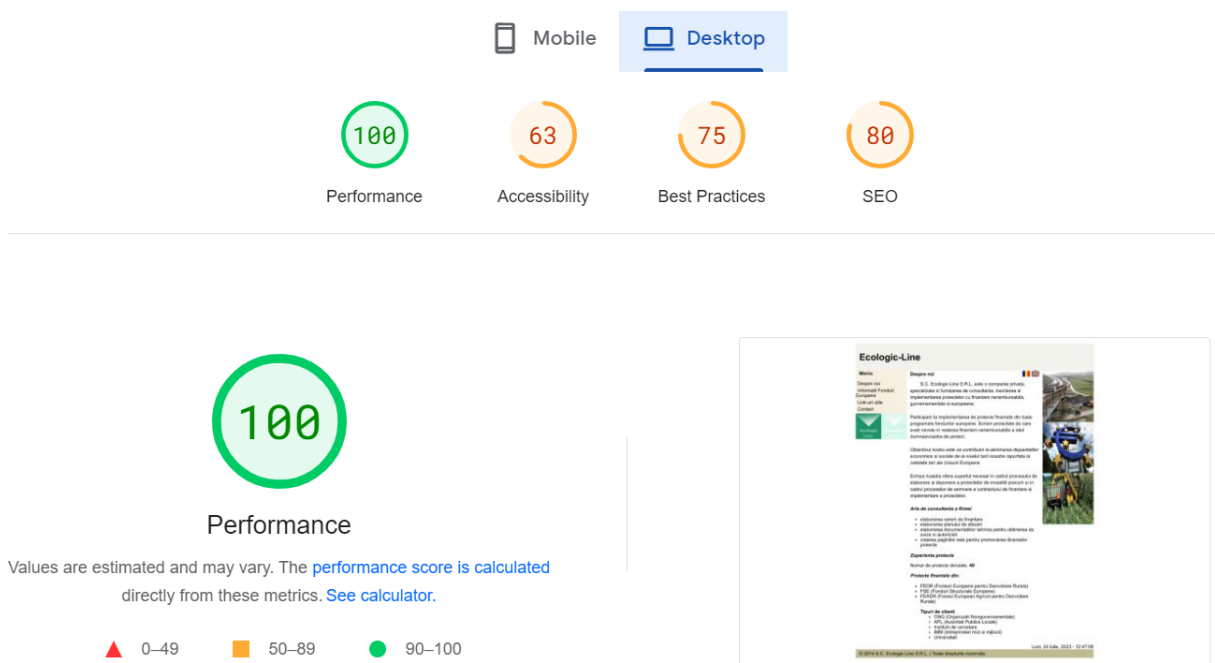**Fig. 3**. Website Performance Analysis – Mobile version

Fig. 4. Website Performance Analysis – Desktop version
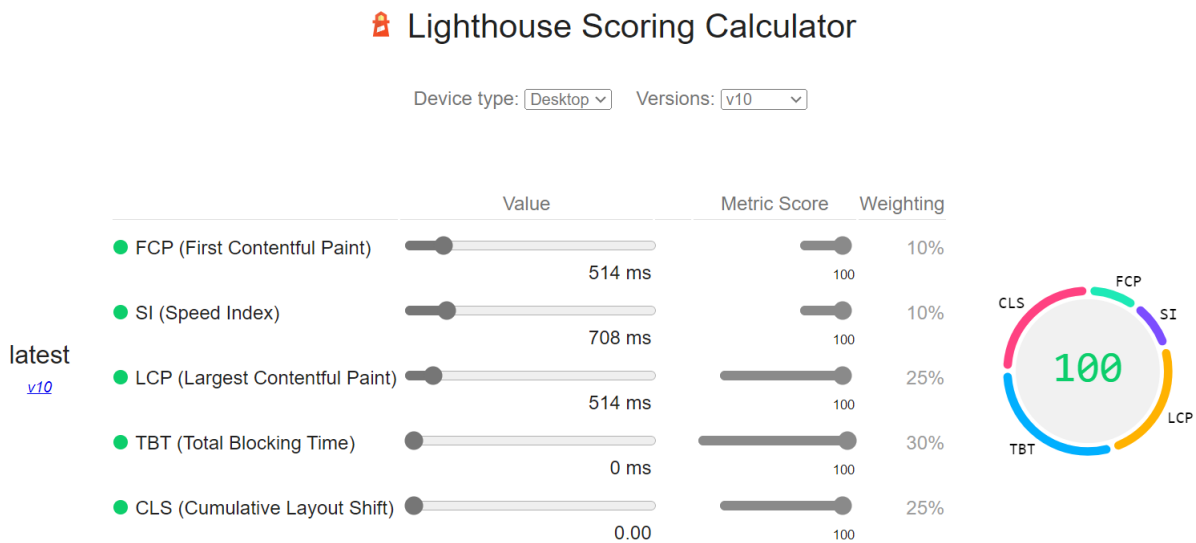
Fig. 5 - Calculating Test Page Metrics (Score Calculator)

Explanations of the obtained metrics, based on the score calculator, are:

1. FCP (First Contentful Paint) - When the browser renders the first bit of content in the DOM, providing the first feedback to the user that the page loads). The first timestamp for the contained painting is when the browser first rendered any text, image (including background images), non-white canvas, or SVG. In the present case, the value obtained is 10%.

2. SI (speed index). Speed Index is one of six metrics tracked in the Performance section of the Lighthouse report. Each value captures a specific aspect of page load speed. In the present case, the value obtained is 10%.

3. LCP (Largest Contentful Paint) - This is a Core Web Vitals metric and measures when the largest content element in the viewport becomes visible. It can be used to determine when the main content of the page has finished rendering on the screen. The most common causes of a poor LCP are: Slow server response times. In the present case, the value obtained is 25%.

4. TTI (Time to Interactive) - It is a non-standardized "progress" value of web performance, defined as the time when the last long task finished and was followed by 5 seconds of network and main thread inactivity. In the present case, the value obtained is 10%.

5. TBT (Total Blocking Time) - Is a Lighthouse performance metric introduced in 2020 that quantifies your page load response to user input. In the simplest terms, TBT measures the total amount of time your web page was blocked, preventing the user from interacting with your page. In the present case, the value obtained is 30%.

6. CLS (Cumulative Layout Shift) - It is a measure of the instability of a website. This measure determines whether a website behaves as the user expects it to behave. One of the most frustrating aspects of an unstable website is that the content of the page changes as the user views it. In the present case, the value obtained is 25%.

The values shown represent the optimal framework for 100% performance, and the calculated values of the metrics are associated with an analysis for display on a mobile device, considering versions 8 and 9.

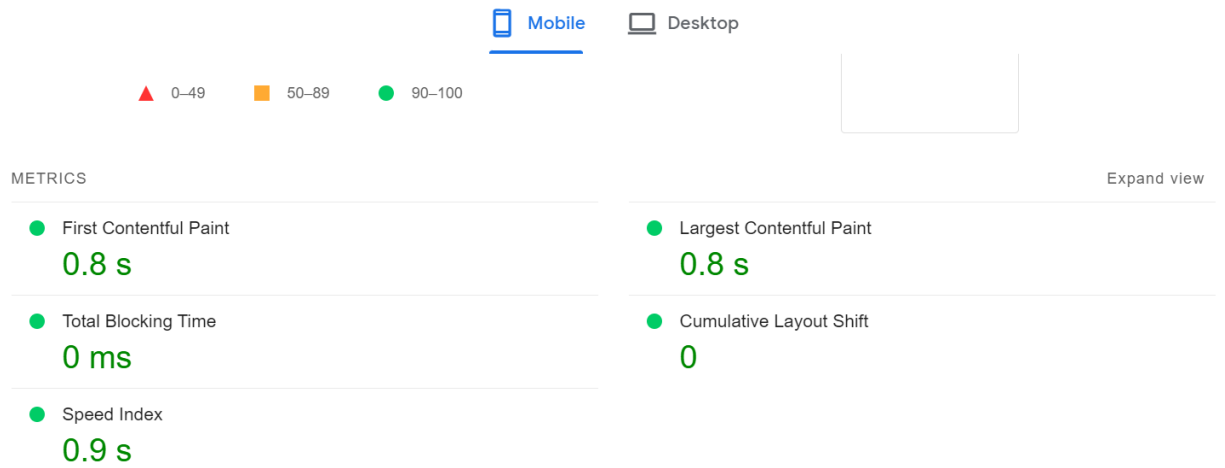A detailed analysis of metrics for the presented business use case can be found in figures 6 and 7.

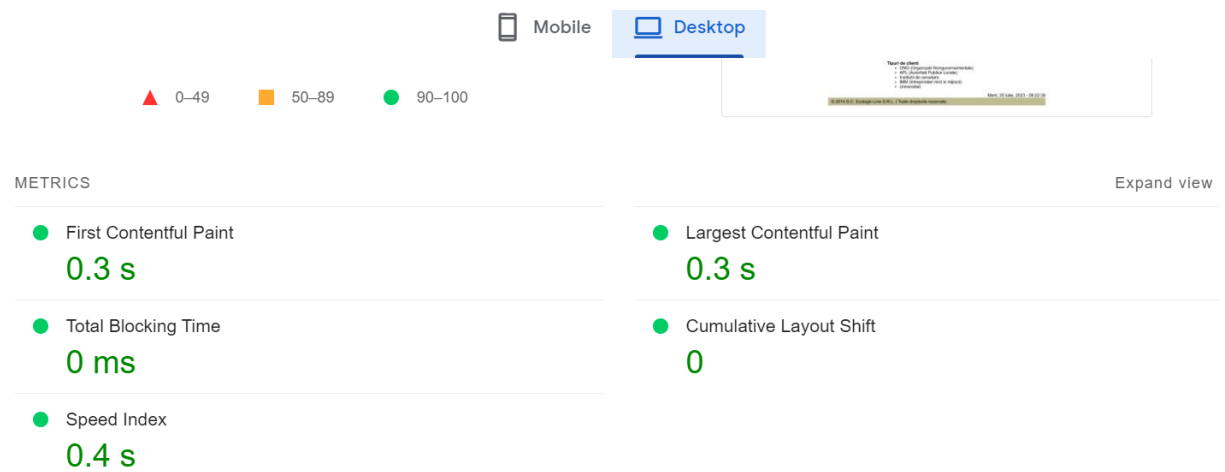**Fig. 6.** Detailed website metrics representation (mobile version)

Fig. 7. Detailed website metrics representation (Desktop version)

There is also an audit trace that can be explored using Page Speed portal (https://pagespeed.web.dev/), hence it is applicable in our case, as presented in figures 8 an 9.
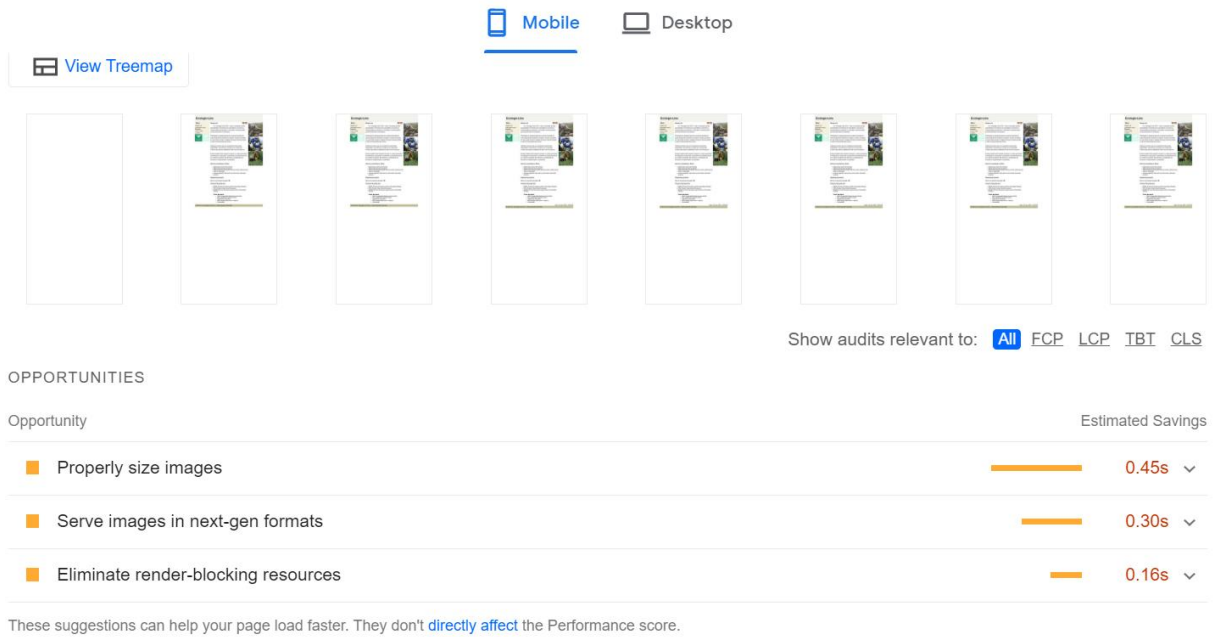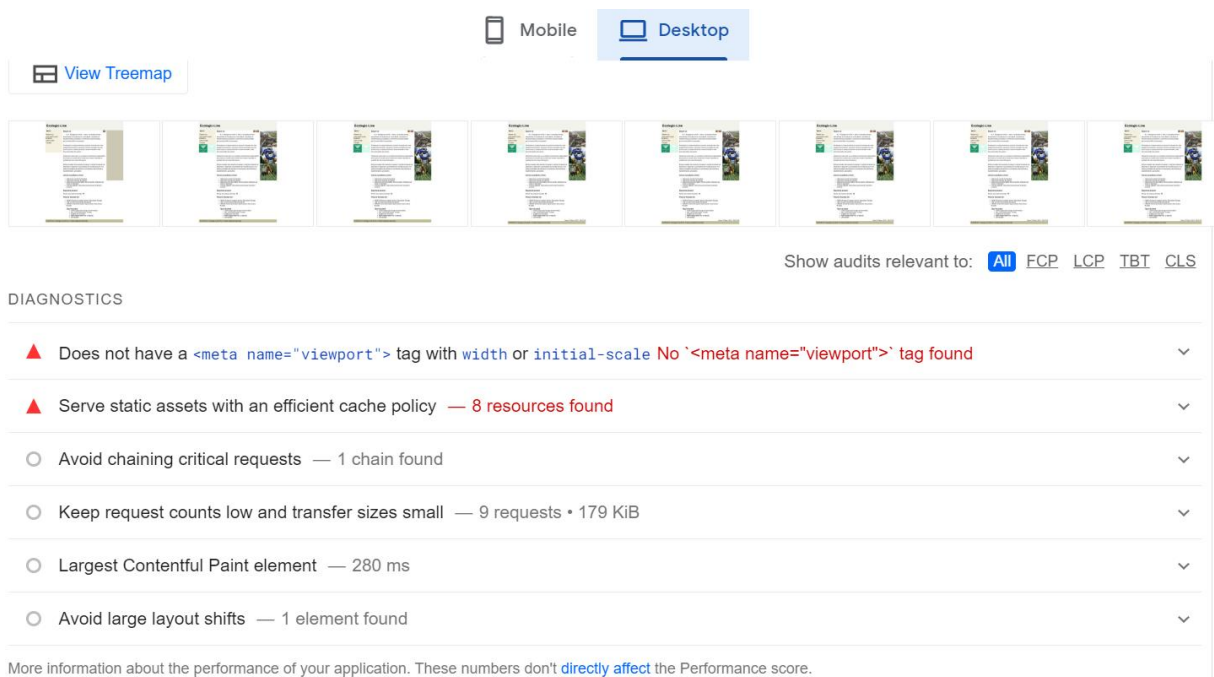
Fig. 8. Audit result for mobile version

Fig. 9. Audit result for Desktop version

3 Experimental method used for testing the model

For establishing a baseline of results on metrics, after a conducted audit, multiple aspects must be taken into consideration. Hence, some of the most important performance and process metrics, relevant for any business case, would take into consideration results from Page Speed, Gtmetrix and Pingdom. Taking as example the test page the I created, experimental method helped in highlighting some important indicators regarding Accessibility, Best Practices and SEO, as baseline for a simple website analysis. As a consequence of an in-depth analysis, the several details are available, as presented in figures 10 and 11.
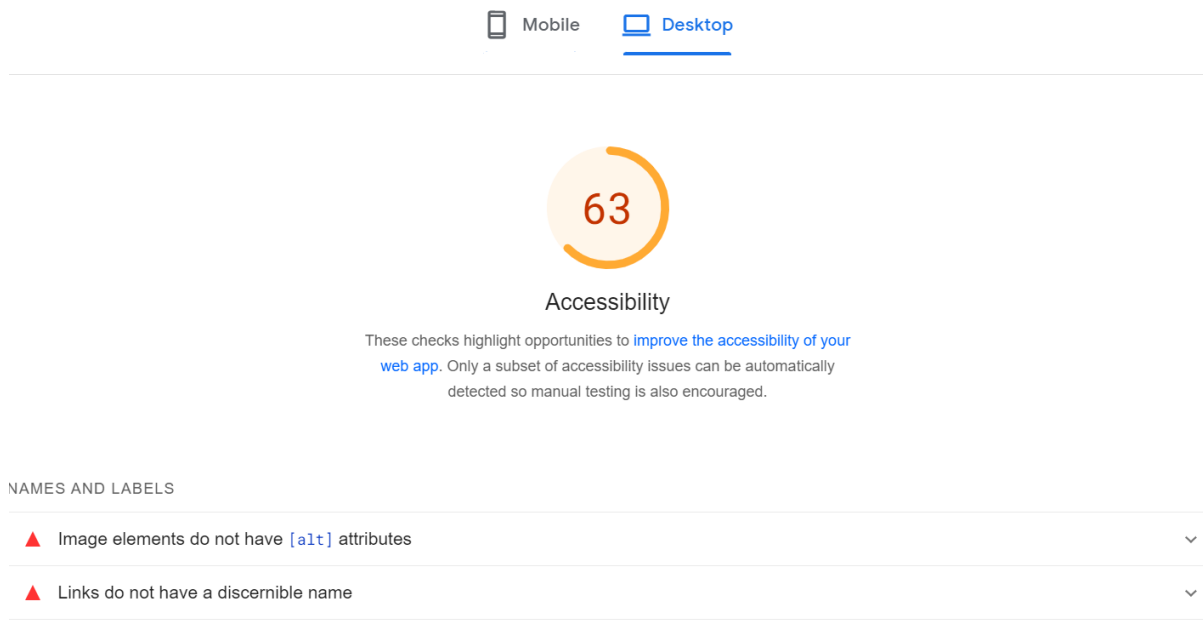
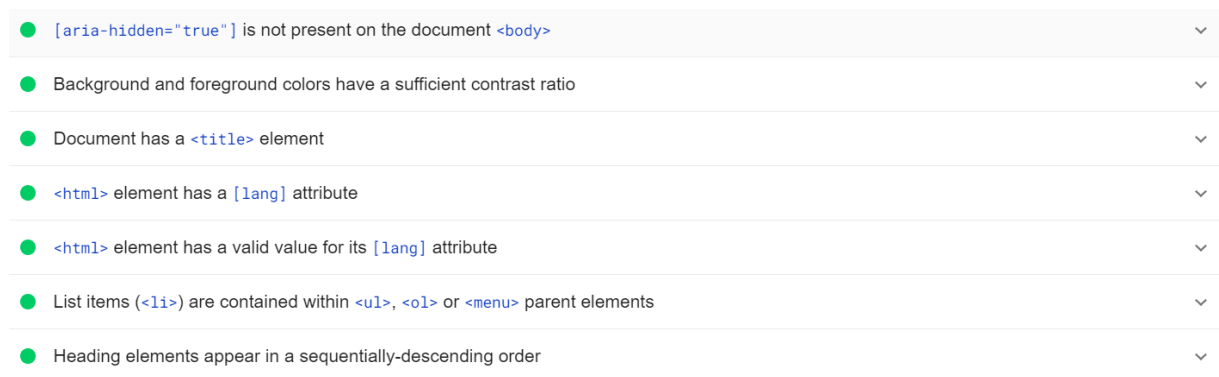**Fig. 10.** Accessibility highlighted aspects for Desktop version

Fig. 11. Positive highlighted audit results regarding Accessibility

From the situations presented in figures 12, 13 and 14, we can conclude that in most cases Desktop and Mobile audit results are approximately the same in terms of Accessibility and Best Practices, for simple web pages. For complex web pages, these aspects can differ based on the content enhancement methods, used technologies, add-in and plugins, as well as CSS used layouts. Although, these aspects can vary a lot, depending on the purpose and use case of the analyzed web page. It is important to highlight the fact that all presented aspects can contribute to a general monitoring system that has the purpose to create a baseline for enhancements in terms of performance, transactions and market context. Hence, any e-business solution should benefit from this kind of primary website analysis, while further enhanced methods of monitoring could leverage the existing metrics analysis to create a better context for more complex solutions. What we can conclude from this primary set of analysis is that monitoring metrics create the premise for further integrations and development of more complex and stable solutions for different business cases, adapted to the rapidly changing e-business world. Of course, for this kind of premise to have a valid support, necessary technologies must be included along with helpful tools that can make

integrations easier, from development and testing perspectives, and not only. Hence, a solid business and technical use case must be verified for its feasibility before the actual implementation to take place. In this picture, because of strong monitoring actions/ processes, it's important to include technological barriers, capabilities, scalability, and different aspects related to the real-world business use cases, since not everything is doable in terms of business solutions. In this context, AI/ ML techniques can have a solid contribution but it's important to know which are the most appropriate techniques and in what measure customers could benefit from them.
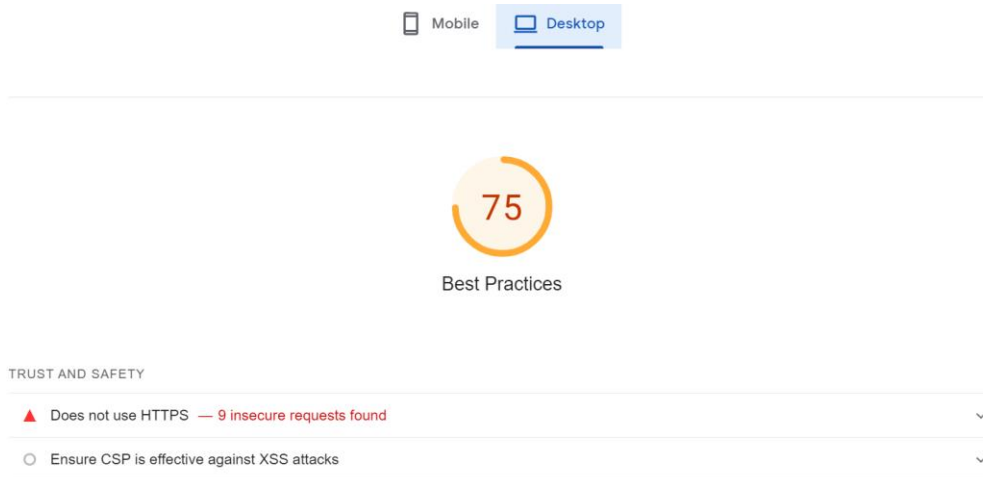

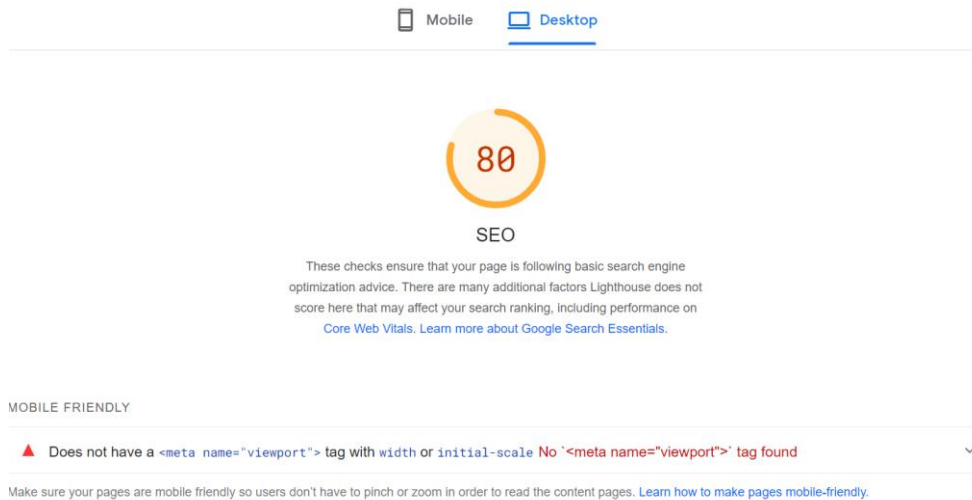**Fig. 12.** Best Practices highlighted aspects for Desktop version

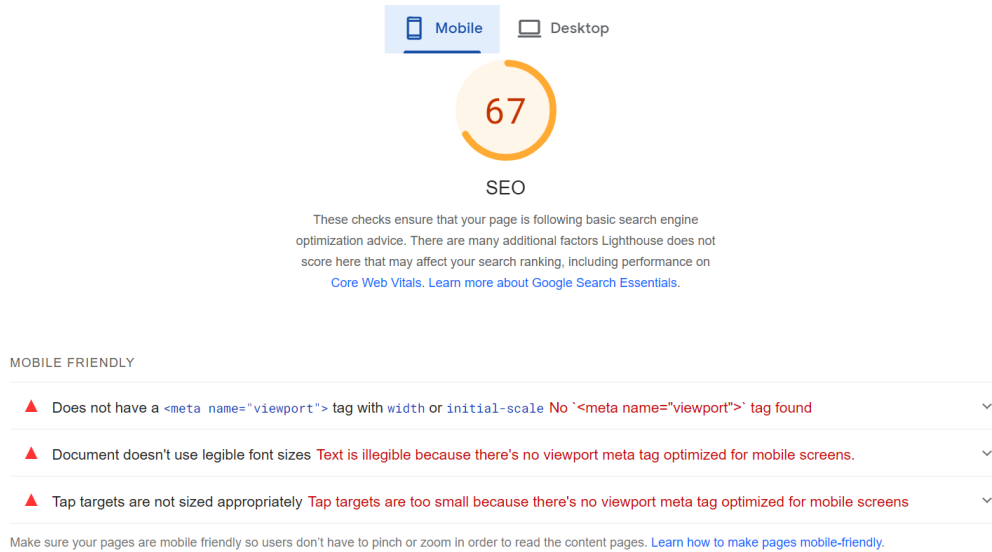**Fig. 13.** SEO highlighted aspects for Desktop version

Fig. 14. SEO highlighted aspects for Mobile version

Solid monitoring systems could enhance e-business solutions productivity, hence representing a good opportunity for ROI (Return of Investment) and further generating profits based on high customer demand. A website, whether it is simple or complex, that presents good metrics in terms of Accessibility, Best Practices and SEO, could determine high profitability rates and as a result, a good profit margin.

Of course, the presented aspects are referring to general details regarding metrics for a website, since it is also important to take into consideration the e-business and actual business contexts, market and social position, dependencies from third parties, regulations and security constraints as well as regional guidelines for creating a solid e-business solution.

When performing speed tests for a website it is important to take into consideration multiple monitoring solutions, such as Pingdom and Gtmetrix, that give relevant results in terms of performance and not only. Hence, figures 15 to 21 show details regarding relevant monitoring verifications performed for the created test site.
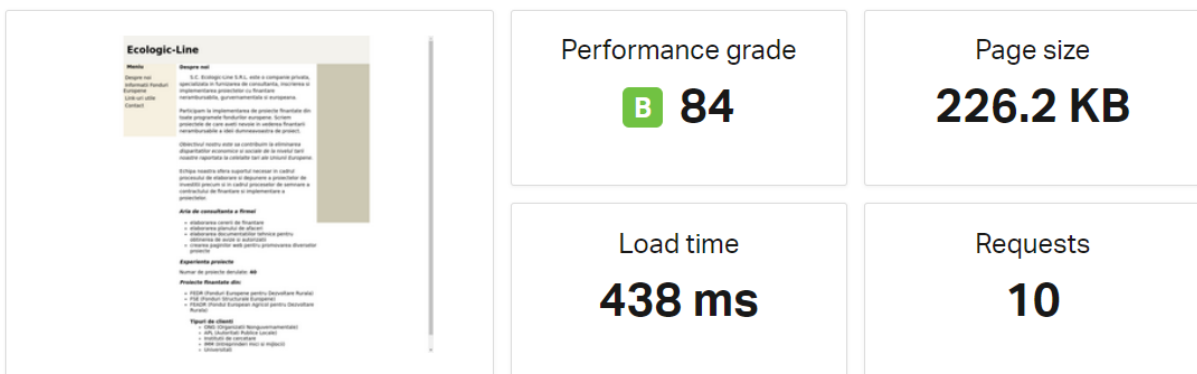

Fig. 15. Monitoring test details, performed by Pingdom portal

Improve page performance

GRADE	SUGGESTION	
F 12	Configure entity tags (ETags)	⌄
F 12	Add Expires headers	⌄
C 78	Compress components with gzip	⌄
A 100	Avoid empty src or href	⌄
A 100	Put JavaScript at bottom	⌄
A 100	Reduce the number of DOM elements	⌄
A 100	Make favicon small and cacheable	⌄

Response codes

RESPONSE CODE	RESPONSES
200 OK	10

Fig. 16. Audit results for test page, provided by Pingdom
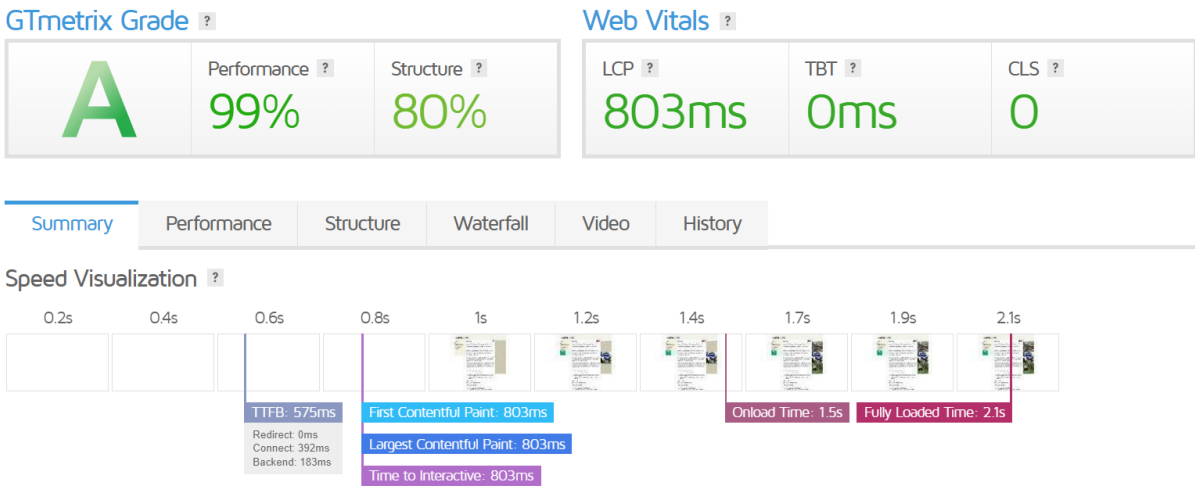

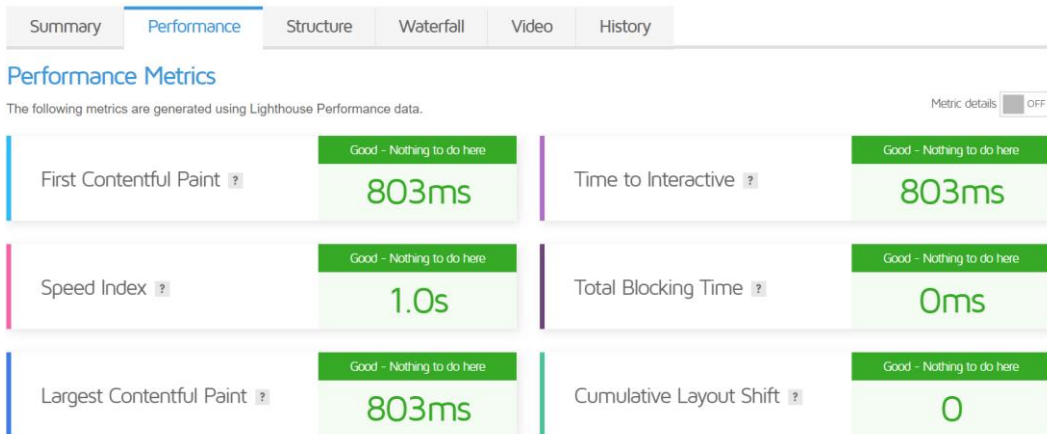**Fig. 17.** GTmetrix web analysis performed for test site

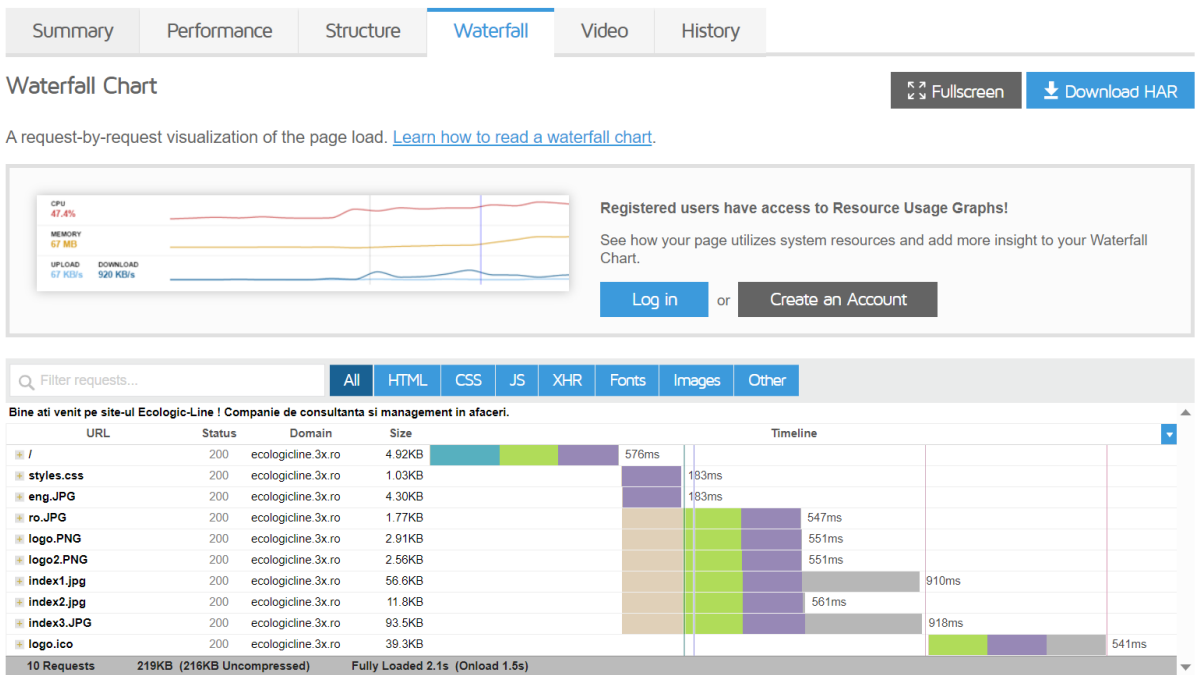**Fig. 18.** Performance metrics done by Gtmetrix for test site

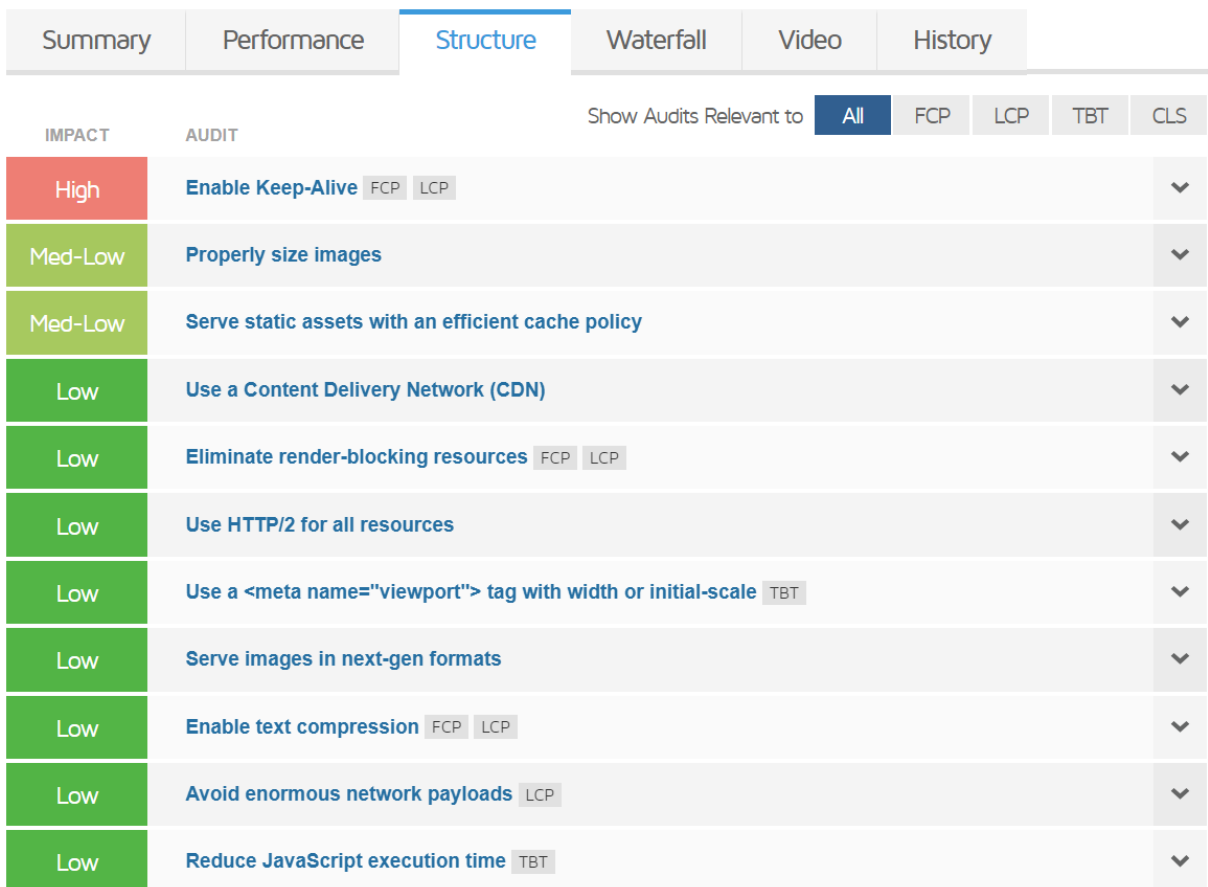**Fig. 19.** Waterfall analysis performed by GTmetrix for test site

Fig. 20. Structure analysis performed by GTmetrix for test site (part 1)

Fig. 21. Structure analysis performed by GTmetrix for a test site (part 2)

All above presented aspects highlight the necessity to add structural components like meta tag entities, adjust CSS layers and create a baseline for rapid search (SEO) along with security measures, especially on HTTP. Since provided test website doesn't have security protocol implemented (HTTPS – Secure Hyper Text Transfer Protocol) it could be threatened by BOTs, phishing and general hacking activities that could affect page structure and integrity, as well as transactions. A simple structured website, in the general e-business context, doesn't have complex transactional/ process back-end structures but it could be affected by significant image loss due to design layout degradation or unwanted content, hence affecting one of the primary purposes of an e-business solution, the marketing area. This aspect could produce demand decrease and consequently client loss.

When capturing measurement details for specific audit purposes it is important to take into consideration the relationship between the website as an entity and different involved parties, as in the context of a developed and rapidly growing digital world, most of e-business solutions depend on multiple third parties. From simple to complex, nowadays, almost each website incorporates elements from different parties with the help of plug-ins or API calls. This situation occurs mainly because, as in the real work, in the digital world, as well, it's difficult to be isolated, hence one e-business entity may need at least a few

providers of different services, web services, that have the purpose to enhance productivity and offer competitiveness on the market. Although, this competitiveness is split because of the multitude of relationships that develop between different entities, otherwise it's difficult to assure your position on the market.

Hence, monitoring aspects and especially audit reports regarding e-business websites or associated solutions, might have an important role in leveraging the relationships between entities, being in the interest of all involved parties, especially when we're talking about e-commerce platforms or e-market websites. Website performance, page loading speed, image rendering tests, color tests, HTTP analysis, graphical elements analysis, all these elements, as previously described in this paper, if enhanced in a proper way, could offer a significant added value, not only for the web solution that is analyzed, but also for the involved web service providers or parties, that have a major contribution in assuring that the main scope of the e-business is maintained. Hence, e-commerce platforms could benefit from the presented analysis, along with involved parties such as web service providers (ranking services, audit entities, marketing entities) or other parties such as: e-banking solutions, website complex functionalities providers, sponsors, etc. It is important to highlight that, in today's highly digitalized world, every element counts, and everything is accountable in terms of profitability when we're

discussing about e-business solutions and their involved functions, from simple to complex. Hence, one e-business entity may choose to cooperate with other entities to build an e-commerce platform, for example, but an efficient way to start this process is to involve as many functionalities as possible from the involved parties, and in this way, cooperation would mean profitability as well. In the opposite scenario, one entity may choose to start an e-commerce platform on its own, but this would mean a lot of work for development, resource allocation, complex project management and mainly a lot of funds for the activities. Although, in the previously presented scenario a degree of independence is offered, profit could appear in a later stage or even lack, due to the complexity of the project. Consequently, e-business agents or entities would preferably choose to cooperate with different parties that already offer complex solutions and services for complex and demanding business use cases, that would otherwise cost a lot of resources. Being integrated in a complex and rapidly changing digital world, means cooperation and teamwork in every possible detail, hence it doesn't represent a desire anymore but a must, to adapt to the prerequisites of a highly developed information society, as the world and the markets are getting more complex day by day.

The presented aspects are related to a complex set of e-business monitoring metrics and an in-depth investigation, like the details that have been shared previously in this paper, in the dedicated sections. Website performance measurements are representing a must as audits tend to increasingly develop, in a direct relationship with the complex demands of e-business solutions. It is important to mention that presented analysis can be applied to all sorts of e-business solutions, in terms of websites, from simple to complex, for the industrial area to different market segments, etc. Hence, what I have proposed here is a case study that takes into consideration a simple business use case, but with the possibility to extend the analysis to complex scenarios. The involved measurements and audit details will differ from one business case to another, but

the starting points, as essence, would remain the same, having the possibility to increase the analysis with more complex elements. The involved entities could be part of a cloud framework, as distributed systems along with high processing volume of data and big data analysis.

Based on website metrics we can correlate information, if the system is implemented in cloud, with cloud automation, which has the purpose to monitor the cloud system and its resources. Hence, we can involve in this framework the cloud monitoring concept which can significantly enhance already presented metrics and correlate them with VM specific metrics (instances created, resources under use, time for processing task [4].

4 Conclusions

For developing a stable e-business solution, mainly website based, monitoring metrics (accessibility, best practice and SEO) are necessary and they can further enhance the system for profitability and efficiency.

An extended website audit can offer relevant insights about the monitored entity but also about the related entities, in a transactional and process-based framework.

It is important to highlight that main audit elements described in this paper (accessibility, best practices and SEO) are at the core of every high-quality website, from simple to complex, from all market areas. Hence, for creating a solid business use case and a relevant e-business solution, a high-quality website can only be maintained if the described elements are constantly verified and enhanced.

Profitable websites take into consideration all areas of monitoring and measurements, while each detail from structure, process to graphical element is actually representing a key indicator to leverage the success of an e-business solution. Monitored websites, that bring profitability, are the actual adaptation of today's web technologies to the evolving information society and one of the examples is represented by Software as A Service (SaaS). SaaS is basically allowing the user to have access to specific software on a website/ platform, fact which reduces many costs from the

business owner (infrastructure, servers, storage devices, etc.) [5].

The inclusion of multiple monitoring and performance testing tools offer a more accurate image about the metrics that define a website, hence being necessary to consult multiple tools in order to get a more precise diagnose that could help in taking the appropriate decisions regarding enhancements, process guidelines, etc.

For simple websites it's necessary to highlight mainly accessibility, SEO, CSS layout elements analysis along with best practices, since there's no transactional framework involved, the structures being mainly used for marketing purposes. In case a complex website is involved in an audit analysis, apart from the already mentioned measurement categories, back-end measurements are very important, specifically regarding database processes, web services, API functionalities, complex accessibility elements, etc.

It is difficult to make a precise analysis about a website, whether it is simple or complex, since it mainly depends on the e-business context, the applied framework, used technologies, dependencies, security regulations, regional considerations, etc. Although, it is important to take every action possible in terms of testing and monitoring for a website platform to have high standards and be protected from cybernetic attacks, to assure it's credibility and integrity in front of the clients/ users.

Performance tests may differ using multiple tools, although website metrics are more relevant when taking data from multiple sources, hence an average of each indicator could correctly highlight or estimate an e-business solution position.

It's important to include into a website audit analysis as many records as possible, for a complete image of the e-business solution, integrating all possible dependencies. This kind of analysis could also be relevant for third parties, especially when metrics are collected from multiple relevant and credible sources. In the entire process is very important to consider latest security standards, especially when analyzing sensitive data, hence latest HTTPS and SSL protocols should be implemented into all e-business solutions. Also, it is important for the monitoring and testing tools to be, themselves, upgraded to latest security standards.

Webpage monitoring operations and audit test results should concentrate on output elements that are beneficial for the user/ client or consumer of the web functionality/ service, as organization's most significant objectives are to act as per the client's need and wants. The same phenomenon can be observed in the e-market sector/ area [6]. An imperative of enhanced website interfaces with large scale applicability in complex platforms is the introduction of IoT elements, solutions for interacting with distributed objects remotely. Hence, a premise for next generation systems is created, computational capabilities allowing to run the monitoring solution directly onto the objects, removing the idea of centralized monitoring. [7]

Nowadays, e-markets and associated monitoring metrics have evolved in such a manner that complex web-based solutions would require web services for specifically enhancing the electronic services frameworks that customers deliver. Web services are typically purchased from a Web Service Electronic Marketplace (WSEM) [8].

Described website metrics along with business intelligence and analytics could significantly improve the decision-making process, leveraging efficiency, thus creating the optimal framework for efficient operations, processes/ transactions etc. [9].

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