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WEB CATEGORIZATION AND END USER SURVEY ADDRESSING MOBILE WEB

WEB KATEGORIZACIJA I KORISNIČKA STUDIJA O POKRETNOM WEB-u

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Abstract: It is hard to imagine everyday life in recent times without access to a wide spectrum of various services and applications delivered via the Web, especially in the mobile environment. Additionally, it is important today to satisfy end user needs, i.e., improve their Quality of Experience (QoE), taking into account that many factors, characteristic for different categories of Web, influence user's mobile Web QoE. Therefore, this paper provides the categorization of the Web and focuses on the identification of the most and least influential factors in general according to examined user opinions in the context of browsing Web sites via mobile devices, and all for the successful management of QoE in mobile Web context.

Keywords: categorization, experience, factor, influence, mobile, quality, QoE, user, Web

Sažetak: Teško je zamisliti svakodnevni život bez pristupa širokom spektru različitih usluga i aplikacija kojima se pristupa preko Web-a, naročito u pokretnom okruženju u zadnje vrijeme. Dodatno, danas je veoma važno zadovoljiti potrebe krajnjeg koriniska, tj. poboljšati njegovu iskustvenu kvalitetu (eng. Quality of Experience, QoE), uzimajuću u obzir da mnogo faktora, karakterističnih za različite Web kategorije, utiču na Web iskustvenu kvalitetu pokretnog korisnika. Ovaj rad, predstavlja podjelu Web-a u nekoliko kategorija, te se fokusira na identifikaciju najuticajnijih faktora prema ispitivanju korisnika u kontekstu pretrage Web stranica putem pokretnih uređaja, a sve radi uspješnog upravljanja iskustvenom kvalitetom u kontekstu pokretnog Web-a.

Ključne riječi: faktor, iskustveno, kategorizacija, korisnik, kvaliteta, pokretni, QoE, uticaj, Web

INTRODUCTION

The Web has become the most significant technology of the 21st century [1]. In its rapid rise, it has caused many welcome disruptions. For instance, it has made people change how they gather information, do their work, buy goods and services, connect with friends and family, spend their leisure time, and even find their partner, lost friends as well as acquaintances. It has also forced businesses to rethink and change how they conduct business, connect with their customers and suppliers, innovate, and collaborate. Furthermore, the Web has changed even the face of politics and governance.

Therefore, it is hard to imagine everyday life without access to a wide spectrum of various services and applications delivered via the Web. Web content is available across a wide range of platforms and networks, with responsive Web design and adaptive media becoming the de facto standard approaches. Moreover, the proliferation of mobile devices such as smartphones and tablets, and emerging devices such as smart watches or smart wristbands, together with the advances in their capacity, functionality, and design, have changed the usage of these devices beyond making calls or sending and reading text messages, to usage scenarios such as reading e-mail, browsing news sites, social networks, online shopping, etc. Such trends are further pushed by rapid developments in the field of wireless mobile communications, resulting in increased user requirements and expectations in terms of accessing a wide variety of Web services, i.e., anywhere, anytime, and via multiple devices [2]-[6].

However, the evolution in Internet, wireless mobile communications, and mobile devices, as well as their increased usage, has also posed new challenges regarding the maintenance and improvement of applications and services' performance in the mobile context. Hitherto,

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performance in telecommunications and for computer networks has been typically addressed in terms of Quality of Service (QoS), i.e., technology-oriented approaches. However, intense research in the field of Quality of Experience (QoE) has shown that traditional QoS mechanisms are not sufficient and they may need to be complemented with more user-centric approaches in order to truly meet end user requirements and expectations [7]-[11]. That is the consequence of today's trends and the fact that people are quality meters, and their expectations, perceptions, and needs with respect to a particular product, service, or application carry a greater value [9]. Therefore, in order to satisfy end users, prevent their churn, and attract new customers or incline them to adopt new complex services and support further technology development, it is not enough just to provide higher communication capabilities, but to understand those mobile end user needs and expectations and offer them maximized quality perception of a service while at the same time minimizing the costs.

There have been numerous attempts to define QoE in both literature and standards. Recent definition given by [12] describes QoE as "the degree of delight or annoyance of the user of an application or service. It results from the fulfilment of his or her expectations with respect to the utility and/or enjoyment of the application or service in the light of the user's personality and current state. In the context of communication services, QoE is influenced by service, content, device, application, and context of use". While the concept of QoE has been widely applied in the domain of multimedia communication systems (e.g., in the context of audio and video applications), its application to the domain of Web is rather young, especially when it comes to the mobile context. In the context of QoE, the main difference between multimedia communication systems and Web is the interactivity of Web, i.e., task and related user behaviour, due to the fact that the Web does not function only on a request-response basis, but more commonly as a session of such requests and responses [13]. Therefore, Web QoE has been defined as the "Quality of Experience of interactive services that are based on HTTP protocol and accessed via a browser" [14].

Based on previously mentioned, the research community will consequently focus on improving mobile Web user experience (UX) and QoE [15], i.e., special attention will be given to exploring the factors that influence user's experience and its quality, understanding how they mutually correlate, and investigating their optimization. According to this, a wide research field in managing the mobile Web UX and QoE, i.e., UX and QoE of interactive services based on the HyperText Transfer Protocol (HTTP) and accessed via a browser on a mobile device, is opening and this paper aims to contribute to it.

In accordance with the intended contribution, we considered that is necessary to give a brief overview on Web and mobile Web evolution in Section 1 together with its categorization in Section 2 and 3, since when addressing UX and QoE in both desktop and mobile Web context, it is crucial to take into account the fact that Web may be categorized on various basis, and that different categories have their own sets of characteristics that may influence the end user's QoE in different ways. Besides, browsed Web sites are increasingly becoming more complex in terms of utilized technologies, design requirements, interactivity, etc., which is extending the list of factors that affect user satisfaction [16]. However, for the sake of quantitatively identifying the most and least influential factors that affect QoE according to users' opinion in mobile context, we have conducted an end user survey by way of an online questionnaire. The subject survey, which is targeted at investigating user satisfaction, opinions, habits, and expectations related with Web browsing via mobile devices, and its results are given in Section 4, while Section 5 concludes this paper.

1. WEB EVOLUTION

The initial idea of the Web arose in the early 1980s, but it was a long journey until it started the revolution in information distribution in the early 1990s. Since its inception over 20 years ago, when the scientists at Conseil Europeen pour la Recherche Nucleaire (CERN) created the World Wide Web (WWW) for exchanging and sharing information [17], the Web has evolved steadily and significantly and still continues to evolve along multiple directions. The nature and structure of the Web, as well as the way we use it, have been continuously changing. Therefore, after going through the initial, so called Web 0.5 stage [18], [19], and Web 1.0 and Web 1.5 phases, that were all about connecting information, the Web continued to evolve into media for connecting people.

A new stage in Web evolution, which constitutes a shift away from a one-way medium towards a read-write concept of the Web, is referred to as Web 2.0, or also called wisdom, participative, read/write, social, as well as people-centric Web [1]. The new usage and technology paradigm, that is often described as dynamic, interactive, user-oriented, content-sharing, social networking, etc., has been recognized by O'Reilly, and described as the following "Web 2.0 is the business revolution in the computer industry caused by the move to the Internet as platform, and an attempt to understand the rules for success on that new platform. Chief among those rules is this: Build applications that harness network effects to get better the more people use them." [20].

Effectively, Web 2.0 represents an umbrella term for the collection of an important set of technologies, business strategies, and social trends [21], [22]. More specifically, Web 2.0 encompasses several new Web technologies such as blog, wiki, mashup, social networks, RDF

Site Summary (RSS), tagging, and folksonomy, which are based on technologies supporting dynamic micropages that harness collective intelligence. Asynchronous JavaScript and XML (AJAX), a Web development approach comprising technologies such as Extensible HyperText Markup Language (XHTML) or HyperText Markup Language (HTML), Cascading Style Sheets (CSS), JavaScript and Extensible Markup Language (XML), are among the most common tools used for the development of most interactive Web sites by retrieving small amounts of data from a Web server and displaying it in the Web application without reloading the whole page.

At the same time, Web 2.0 offers several key features such as: facilitating flexible Web design, creative reuse, and easier updates; providing rich, responsive and adaptive user interface which allows users to view Web applications on different devices and various screen sizes; supporting collaboration and assisting in gathering collective intelligence; facilitating collaborative content creation and modification by users; establishing social networks of people having common interests; enabling a creation of new attractive applications by reusing, combining, and/or merging different applications on the Web or by combining data and information from different sources [1]. In other words, Web 2.0 makes the most of intrinsic advantages of the Internet as a platform.

Web 2.0 has today become a mainstream technology, and it is often used as a buzzword for everything that becomes "popular" on the Web. Motivated by some highly successful social and business applications based on Web 2.0, such as Facebook, LinkedIn, SecondLife, Flickr, or YouTube, Web 2.0 technologies and concepts are now widely used in several different domains [1]. Within the past five years, Web 2.0 has changed the face of society and business significantly and has forged into enterprises in ways that were previously unimaginable.

Going beyond the current Web 2.0 paradigm, but still remaining in the "all about the user" era, the evolution sails into another intermediate phase - Web 2.5 [1]. Evolved Web 2.0 will be characterized by the increased user demands for mobility, i.e., having access to any Web service, anywhere and anytime, over any mobile device and network technology. In other words, users of Web 2.5 will be "always-on", carrying along their mobile devices connected to the Internet. Actually, it may be concluded to a significant extent that this mobile Web era has already begun due to the fact that mobile wireless communications have experienced phenomenal growth and more people are increasingly using their mobile devices for conducting their various affairs on the Web. Therefore, when looking to summarize certain user expectations, one can identify users as increasingly expecting Web content to be mobility-aware, device-oriented, user-, link-, or time-sensitive, cross-site, dynamic, content-moving, etc.

A future step in the Web evolution, Web 3.0 (also referred to as the semantic Web) [23], [24], has been envisioned as a path that will be about integrating data, knowledge, and applications on the Web and putting them to work in ways that make the Web more meaningful and about making the Web a collaborative platform. Although one does not know when the world will break into this stage, it must be realized that we will experience a lot of changes before it emerges [1], [19], [25]. Further on, despite the fact that it has still been considered an "underground idea" in progress, the idea that the Web will evolve into a ubiquitous Web has been expressed [21]. Namely, in an expected Web 4.0 stage, sophisticated artificial intelligence technologies will come into play, while the line between human beings and devices will blur and may even disappear [26], [27].

The main goal of the Web evolution, or as it is often called the Web X.0/Web X.Y movement, is to utilize the Web's potential in a more interactive, adaptive and collaborative way. An additional aim is to facilitate the collaboration and leveraging of the collective intelligence of peers, as well as of collective information available on the Web by reasonable use of old and new Web technologies in new ways. However, using numbers to represent the evolution of the Web does not mean that Web 1.0 is superseded or replaced by Web 2.0, or Web 2.0 by Web 3.0 and so on, as it is the case with software updates or revisions. In this context, each stage has its own characteristic objectives, addresses different problems and gives different features. Thus, all versions of the browsed Web content will continue to coexist, supporting and forming the foundation of the others. In that spirit, one may not call the evolution of the Web really the evolution, but rather objective based classification [1], [16].

2. CATEGORIZATION OF WEB

It is quite challenging to classify various types of Web sites, contents, and applications since there are various aspects on which basis the classification could be performed and consequently a great number of categories. Additionally, Web can be classified into several categories at the same time due to its characteristics. However, some of the aspects for differentiation are: objective, functionality, usage context, complexity, user task, front-end presentation, interaction level, interface sensitivity, content, QoS requirements, etc.

Section 1 has already provided a classification of Web based on the **objective**. Thus, we can differentiate between Web sites, contents, and applications aiming at: (i) connecting information, i.e., information-centric Web 1.0; (ii) connecting people, i.e., people-centric Web 2.0; (iii) connecting data, knowledge, and applications on the Web, i.e., machine-centric Web 3.0; and (iv) connecting the power of human and machine intelligence on the ubiquitous Web, i.e., agent-centric Web 4.0. As stated previ-

ously, the Web 2.0 era has introduced several new types of Web which differ in the **functionalities** they offer. Thus [16]:

- *Blog* is a hybrid between a diary and journalism online, characterized by chronological ordering of information displayed in the reverse order [28]. Blogs may be categorized into several types that differ in the type of content, the way it is delivered or written: personal blogs, microblogging, corporate and organizational blogs, by genre (e.g., politics, health, travel, fashion, etc.), by media type (e.g., video blog - vlog, photo blog, etc.), by device (e.g., mobile device - moblog).
- *Wiki* is a Web site which allows its users to add, modify or delete its content via a Web browser usually using simplified markup language or rich-text editor [29].
- *Mashup* is a Web application that uses and combines data, presentation or functionality from two or more sources, i.e., Web sites or Web applications to create new service on the Web. There are many types of mashups such as business, consumer, and data mashups [30].
- *Social network* is a virtual place where people create their own space on which they write blogs, post pictures, videos, or music, share ideas, and link to other locations they find interesting, and open up this space for access by their friends and their friends' friends. It is very powerful and popular medium for human communication and interaction [1].
- *RSS* is a family of Web feed formats used to publish frequently updated works such as blogs, news, audio, or video in a standardized format [1].

Depending on its **complexity and development history**, Web may be classified into the following nine categories [1], [31]:

- document centric (e.g., static homepage, Web radio, company Web site),
- interactive (e.g., virtual exhibition, news site, travel planning),
- transactional (e.g., online banking, shopping, booking system),
- workflow based (e.g., e-government, business-to-business solutions),
- portal oriented (e.g., community portal, online shopping mall, business portal, search engines),
- collaborative (e.g., chat room, e-learning platform),
- social (e.g., blogs, collaborative filtering, virtual shared workspace),
- ubiquitous (e.g., customized services, location-aware services, multi platform delivery),
- semantic (e.g., knowledge management, syndication, recommender system).

Further on, Web may be categorized based on **usage context**. Therefore, one may differentiate among Web sites, contents, and applications for communication (e.g., Gmail, Hotmail, Facebook, etc.), searching (e.g., Google), content aggregation (e.g., Google Reader), office tools (e.g., Google Docs), multimedia and communities (e.g., YouTube, Flickr, Myspace, etc.), publishing and encyclopaedias (e.g., Wikipedia), and analysis and statistics (e.g., Creative commons, Mayflower, etc.) [32].

On the other hand, stimulated by the work of Choi, Lee and Moon in [33], in the scope of this paper we have categorized Web depending on **task that a user performs** while accessing it. Therefore, one may differentiate among:

- *Entertainment Web* is a Web site, content, or application which is used when users have no intentional task, i.e., for entertainment, spending their free time, or pastime, etc (e.g., TV program, music, video, humour, cartoons, etc.).
- *Communication Web application* is a Web site, content, or application used for performing tasks, such as daily correspondence, e-mail, light conversation, photo or video sharing, social networking, collaboration, etc.
- *News* is a Web site, content, or application visited when user performs a task of obtaining new information that cover topics of the day, such as politics, economics, gossip, etc.
- *Professional information related Web application* is a Web site, content, or application that users use when they have a professionally-related task, i.e., obtain information for papers, research, reports, homework, etc.
- *Community Web* application is a Web site, content, or application that is used during the task of obtaining information related to a specific topic that users are interested in.
- *Transaction Web* application is a Web site, content, or application that is used when performing a transaction-related task, whether that is online banking, online shopping, etc.

A categorization proposed in the scope of this paper in terms of the current Web sites, contents, or applications depending on additional aspects besides the ones previously considered is depicted in Figure 1 [16]. In the front-end context, Web may be differentiated according to the way it is presented, the level of interaction it allows, and sensitivity of the interface. Therefore, depending on the **presentation style**, there exist three categories of Web: (i) one that uses static pages, i.e., HTML-based Web pages that do not change and are only rarely altered to reflect new information or news about the site; (ii) one that uses dynamic pages, referring to the Web pages that can dynamically change their content based on the selection of

a menu item or tab, and where all information is stored in the page (i.e., only parts are shown) or the whole page is (re)loaded on demand; and (iii) one that uses dynamic micropages, i.e., the Web pages that (almost continuously) reload information based on a triggering event (e.g., time or the user) from the server and in contrast to dynamic pages reload or exchange only parts of the whole page (e.g., by using AJAX, JSON, or Flex HTTPService).

When the **level of interaction** is considered, the Web may offer: (i) no interaction, which implies that the application does not support any interaction besides providing content and metadata, commenting or searching; (ii) form-based interaction, meaning that the interaction in the shape of forms that provide contact deposit and data shipping is allowed; and (iii) desktop-alike interaction, i.e., Rich Internet Applications (RIA), where (almost) all the functionality of the local desktop applications is provided.

According to the **interface sensitivity**, a Web may be: (i) insensitive, which means that the interface is fixed and does not change in any case; (ii) user-sensitive, meaning that the interface is automatically or manually adapted to the preferences of the user or a group of users, i.e., personalized and adaptive; (iii) device-sensitive, indicating that the interface adapts to the device (e.g., smartphone, tablet, etc.) that is used for viewing the service and content; (iv) location-sensitive, referring on the interface that is sensitive to location in the physical world (e.g., using Global Positioning System (GPS)); (v) content-sensitive, implying that the interface adapts to the content it presents (e.g., by getting darker if a dark movie is shown); and (vi) time-sensitive, which means that the interface is sensitive to the time when the application is used. Similar distinction of Web may be performed in the context of sensitivity of the offered service [19].

In the **content** context, Web may be categorized into the following three classes, depending on the type of content they contain:

- plain text and image Web applications,
- animated Web (e.g., animated Graphic Interchange Format (GIF), Flash, etc. without other media), and
- multimedia Web (containing video, audio, animated slides, etc.).

Shifting to more technical QoS terms, one can differentiate Web depending on the **QoS requirements**. Firstly, Web can be divided into two categories according to the Web traffic communication model: synchronous and asynchronous. Additionally, there are several time related QoS metrics, such as delay and response time that may be used as a classification factor. Namely, loading time and responsiveness of the Web are influenced by these factors, but some are more, while some are less sensitive. Bandwidth consumption of the Web as a QoS metric as well can be used for distinguishing between applications that have high and low bandwidth requirements.
As previously stated, Web applications can at the same time fit across several categories. For example, the British Broadcasting Corporation (BBC) site is both an information- and people-centric application; interactive according to the complexity, but in terms of front-end interaction, it is an application that offers no interaction (in terms of content editing); users visit it for reading news, i.e., multimedia content, etc. Additionally, YouTube is an application also belonging to both the Web 1.0 and Web 2.0 era, has high bandwidth requirements, uses dynamic pages for front-end presentation, offers a device-sensitive interface, can be used for multimedia and communities, etc. Over the course of time, the task of classifying Web applications will become even more difficult due to the fact that many Web applications are becoming multi-objective, focusing on multiple tasks, becoming increasingly complex, etc.

3. MOBILE WEB

As stated previously, recently we have seen the field of mobile technology grow exponentially, leading to the increased importance of delivering content and services to users who want to be "always-on" using their mobile devices. Depending on several aspects such as needs, target users, and their experience, cost, etc., there are three options in delivering content and services to mobile users: as native, mobile Web, or hybrid. Native applications are specific for a given mobile device (e.g., smartphone, tablet, etc.). They are developed using tools and languages that the respective mobile device platform supports, purchased through online stores or marketplaces, and installed directly onto the mobile device (Table I) [34]. On the other hand, mobile Web applications refer to standard Web applications. They are developed by using technologies such as HTML, JavaScript and CSS, but specialized for mobile devices and accessed through the mobile device's Web browser. The third option, hybrid applications, are developed as a combination of the previous two [35].

Table II gives a comparison of the three options according to a number of features. The advantages of native applications in comparison to mobile Web applications as well as hybrid ones are: easy and consistent full access to a mobile device's hardware, security mechanisms, and consequent dominance in the context of aesthetics, application loading time, usability and provision of high user experience. The disadvantages, on the other hand, are long and costly development and ongoing maintenance of the applications, as well as inconsistency in used process and time to get to the market, low development costs, applicability on multiple platforms, as well as simplified access to an always updated version of the application. Oppositely, the main disadvantages that characterize this option are partial access to the mobile device's hardware and low user experience [36], [37].

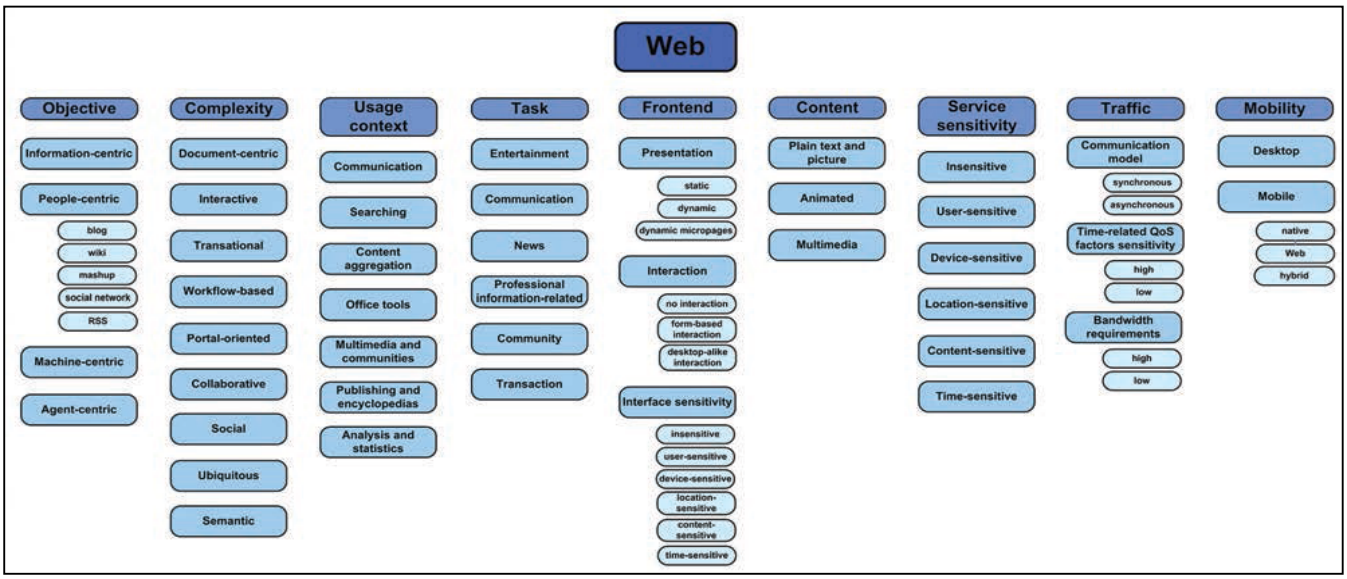

Figure 1: Web categorization based on various features

Table I: Native applications development and purchase environment

Platform	Android	Apple	Windows	BlackBerry
Tool	Android SDK	Xcode	Visual Studio, Windows Phone Dev Tools	BB Java Eclipse Plug-In
Language	Java (C, C++)	Objective C, C, C++	C#, VB.NET	Java
Application store	Android Market	Apple iTunes	Windows Phone Market	BlackBerry App World

Table II: Comparison of native, mobile Web, and hybrid applications (based on [35] and [37])

Feature	Native	Mobile Web	Hybrid
Required skills	Objective C, Java, C, C ++, C#, VB.NET	HTML5, CSS3, JavaScript	HTML5, CSS3, JavaScript, Mobile development framework
Development speed	Slow	Fast	Moderate
Development cost	High	Low	Moderate
Application maintenance	Difficult	Low	Moderate
Applicability on multiple platforms	No	Yes	Yes
Distribution	Application store	Internet	Application store
Time to reach the market	Long	Short	Moderate
Manual updates	Yes	No	No
Monetization	Mobile specific platforms, charging a download price, application store payment process	Site advertisement, subscription fees	Mobile specific platforms, site advertisement, subscription fees
Capabilities (device access)	Full access (camera, microphone, GPS, gyroscope, accelerometer, file upload, etc.)	Partial access (GPS, gyroscope, accelerometer, file upload)	Full access (camera, microphone, GPS, gyroscope, accelerometer, file upload, etc.)
Offline access	Yes	Yes (HTML5)	Yes
User experience	High	Moderate	High
Aesthetics quality	High	Moderate	Moderate
Loading time	Fast	Slow	Moderate
Usability	High	Moderate	Moderate

The most important feature in the context of this paper is the user experience, i.e., QoE in a broader sense. As stated, this is the area where currently native applications precede mobile Web applications [38], [39], since they tend to have a smoother look and feel, and due to the fact that they are leveraging the elements of their native operating system, a feeling of being more integrated into the mobile device is produced. Additionally, native applications seem faster, since they come with lots of pre-loaded elements and only need to fetch user data from the Web rather than the entire application. Therefore, when it comes to application aesthetics, application loading time, usability

and the overall QoE, it is currently difficult for mobile Web applications to trump native ones. However, it is only a matter of time before the mobile Web applications are able to compete with the capabilities of the native ones. Further on, battery life and mobile wireless connections which are currently affecting mobile Web application performance, among other factors, will improve in the future and eventually cease to have a strong impact on mobile Web application QoE.

4. END USER SURVEY ADDRESSING MOBILE WEB

According to [16], [40], mobile Web applications will eventually crush native ones, since it is likely that developers and users will be driven away by the policies of the native application stakeholders (big Internet players such as Microsoft, Apple, etc.) aimed at gaining profit and turn to the alternatives. Even if the future of mobile applications is not the Web, together with the downloadable native applications, it certainly is. Therefore, we have conducted the end user survey study aiming at the identification of the most and least affecting influence factors (IFs) that affect QoE according to user opinion. It has been stated in [12] that QoE IF may be defined as “any characteristic of a user, system, service, application, or context whose actual state or setting may have influence on the Quality of Experience for the user”. Also, IFs may be categorized into three categories: system, human, and context IFs [12].

The subject study questionnaire covers ratings of the impacts of a wide spectrum of considered factors (application, resource, context, and user factors, i.e., belonging to all three abovementioned groups), selected based on the overview of the existing literature [2]-[5], [12], [41]-[43]. Also, the study tends to verify relevant qualitative conclusions and quantitatively express the extent to which the subject factors affect QoE in a given context. Additionally, the survey contains sets of questions that aim to identify user habits and opinions in the context of browsing the Web via mobile devices, but they are neglected in this paper.

The online survey in Bosnian has been prepared and distributed using the Google Docs service (https://docs.google.com). The questionnaire containing 50 questions was completed by 218 users in a 10-day period. The users have been selected randomly in order to achieve representatives of the sample.

Collected demographic data related to the age, gender, educational level, origin country, and city of the participant describes the group that approached the questioning:

- the average age of 218 participants was found to be 24.43,
- 158 of them fit into the category of age 16 to 29; 52 fit into the category of age 30 to 44; and 8 fit into the category of age above 45,
- 60% of participants were male, while 40% were female,
- 47% of participants reported as having a faculty degree, 36% reported as being students, 8% as having a Master of Science degree, 6% as having finished high school, and 3% as holding a PhD,
- 96.78% of participants are from Bosnia and Herzegovina (74.77%) and Croatia (22.01%).

The influence of each factor has been rated on a 5-point scale where 1 means "does not affect", 2 "weakly affects", 3 "moderately affects", 4 "affects", and 5 "strongly affects". In order to identify the most and the least important IFs according to users, statistical analysis of obtained results has been conducted by using percentages and descriptive statistics, i.e., measures of central tendency and variability (Table III).

In order to determine which factors have the strongest effect on user satisfaction in the context of mobile Web browsing (based on participant opinions), the ones with means higher than 3.6 and coefficient of variance under 33% have been considered. Namely, a mean of 3.6 means that 4s and 5s are the most frequent rates of participants in terms of the impact of the factor, while the second condition means that the average distance from the mean of all rates for each factor is less than 33%, i.e., the values do not vary more than 33%. According to this, the first eleven influence factors from Table III have been found to be the most influential: **Web site loading time, service price, up-to-date information, procedure for accessing desired Web site (number of taps), screen size, screen resolution, processor speed, interesting information, battery consumption, screen brightness, and movement**, going from more to less influential.

Further on, in order to supplement the results, the frequencies of each rate, i.e., the mode, have been considered as well. Namely, the factors that 67% of questioned users have rated with 4s and 5s have been considered as most influential. According to participants’ ratings, those factors are: **Web site loading time, service price, procedure for accessing desired Web site (number of taps), screen size, up-to-date information**, and **battery consumption**, as well going from more to less effective.

Listed IFs are mostly already recognized in the literature for the importance of their influence on user experience and QoE in Web and mobile Web context [2]-[5], [41]-[43]. Only aesthetics related factors, which are to a large extent addressed in the literature, have oppositely not been marked as highly influential.

However, what differentiates this paper in comparison to the literature is that here we have provided a list of IFs

Table III: Descriptive statistics for collected ratings (User opinions on how a given factor affects their satisfaction on a scale of 1-5 (1 – does not affect; 2- weakly affects, 3 – moderately affects, 4- affects, 5 – strongly affects)) and frequency of scores 1-5 for each influence factor

No.	Influence factor	Mean	Median	Variance	Standard deviation	Coefficient of variation (%)	Freq. of 1	Freq. of 2	Freq. of 3	Freq. of 4	Freq. of 5	%
1.	Web site loading time	4.252	5	1.019	1.009	23.73	7	8	24	63	116	82.11
2.	Service price	4.229	5	1.154	1.074	25.40	7	13	25	51	122	79.35
3.	Up-to-date information	4.027	4	1.160	1.077	26.74	9	9	38	76	86	74.31
4.	Procedure for accessing desired Web site (number of taps)	4.013	4	1.110	1.053	26.25	6	13	40	79	80	72.93
5.	Screen size	3.981	4	1.041	1.020	25.62	5	15	39	83	76	72.93
6.	Screen resolution	3.963	4	1.012	1.006	25.38	6	14	46	77	75	69.72
7.	Processor speed	3.922	4	1.058	1.028	26.23	13	14	48	70	78	67.88
8.	Interesting information	3.807	4	1.317	1.147	30.14	13	24	43	63	75	63.30
9.	Battery consumption	3.747	4	1.461	1.208	32.25	9	21	59	80	49	59.17
10.	Screen brightness	3.651	4	1.122	1.059	29.01	14	19	58	66	61	58.25
11.	Movement	3.646	4	1.353	1.163	31.90	19	20	54	68	57	57.33
12.	Web browser	3.573	4	1.388	1.178	32.97	19	20	54	68	57	57.33
13.	Spelling accuracy of the information	3.568	4	1.481	1.217	34.10	13	29	52	68	56	56.88
14.	Web site object visual organization	3.541	4	1.060	1.029	29.08	16	22	60	77	43	55.04
15.	Keyboard type	3.504	4	1.449	1.203	34.35	21	15	63	75	44	54.58
16.	Web site object display size	3.500	4	1.292	1.136	32.48	17	25	61	61	54	52.75
17.	Prior experience	3.486	4	1.375	1.172	33.63	9	20	74	74	41	52.75
18.	Weather	3.376	4	1.526	1.235	36.59	18	40	48	66	46	51.37
19.	Web site object loading order	3.206	3	1.353	1.163	36.28	21	34	74	57	32	40.82
20.	Colour of background and text	3.160	3	1.444	1.201	38.02	25	33	76	50	34	38.53
21.	Location	3.013	3	1.525	1.234	40.97	37	37	76	52	26	35.77
22.	Lightning of the environment	2.779	3	1.637	1.279	46.03	61	36	46	50	25	34.40
23.	Visual difficulties	2.733	3	1.910	1.382	50.55	61	38	46	47	26	33.48
24.	Hand injury	2.720	3	1.916	1.384	50.89	43	53	56	41	25	30.27
25.	Emotional state	2.573	2	1.803	1.342	52.18	61	61	54	24	28	23.85
26.	Noise in the environment	2.559	3	1.639	1.280	50.02	60	47	60	31	20	23.39
27.	Time of the day	2.504	3	1.523	1.234	49.27	63	44	63	36	13	22.47

that were ordered by user perception of the strength of their impact on user satisfaction. This may serve as a useful input, in terms of what to focus on and what to enhance, for stakeholders dealing with Web and mobile Web environment (network providers, service providers, Web designers, information providers, device manufacturers, etc.) when trying to improve their performance. Most of these IFs fall into category of system IFs, thereby confirming existing literature's qualitative conclusions that the most influential factors in terms of QoE in this context comes from this class. However, having service price and up-to-date information on a second and third place in the list, together with movement and interesting information in top 10 of identified IFs, launches context IFs, as a group, shoulder to shoulder with system IFs, and should additionally motivate research community and stakeholders to investigate these factors and enhance their positive and suppress the negative effects. This is especially important in context of aforementioned Web categorization, given that each of categories have their own, mostly context, characteristics that influence the perception and QoE for a specific Web category, and consequently may improve it by proper management.

In addition, in the subject questionnaire, we gave the opportunity to participants to give their opinion on the most influential factor and to suggest additional factors that may affect their satisfaction with the service. Gathered answers indicate that the list of examined factors is comprehensive and that factors identified as the most influential by the statistical analysis have been identified as most influential by the participants as well.

In the same way, we have determined that the least influential IFs are the ones that can be classified in human IF group: time of the day, noise in the environment, emotional state, hand injuries, and visual difficulties, going from less to more influential. This justifies the lack of research which addresses this category of IFs (in comparison to system and context IFs) in context of user experience and QoE.

5. CONCLUSION

To summarize, when addressing UX and QoE in both desktop and mobile Web context, it is crucial to take into account the fact that Web may be categorized on various basis, and that different categories have their own sets of characteristics that may influence the end user's QoE in different ways. Therefore, this paper provides the categorization of the Web that will be, in future work, further complemented with the identification of the most influential and characteristic parameters and factors in terms of UX and QoE for each of the categories.

As a pre step towards that goal, focusing on the mobile environment, due to the galloping towards fully-mobile technology and the trend of mobile traffic increase, we have identified the most and least influential IFs in general according to examined user opinions in the context of browsing Web sites via mobile devices. This is the first time that the list of IFs ordered by the impact strength on QoE has been provided. The list emphasizes the dominance of system IFs, but launches context IFs on the same level, while confirming the relapsing significance of human IFs. The identification of key IFs for each mobile Web category, planned in future work, is important due to the multidimensional nature of QoE [3], [16] and crucial for truly meeting end user requirements and expectation, i.e., the successful management of QoE in mobile Web context including all its constituents: modelling, monitoring, and optimization.

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