Conceptual Model of an Application for Automated Generation of Webpage Mobile Versions

Todor Rachovski [1], Stanka Hadzhikoleva [1], Emil Hadzhikolev [1]

[1] *Plovdiv University Paisii Hilendarski, Faculty of Mathematics and Informatics,*
236 Bulgaria Bul., Plovdiv, Bulgaria

Abstract: **Accessing webpages through various types of mobile devices with different screen sizes and using different browsers has put new demands on web developers. The main challenge is the development of websites with responsive design that is adaptable depending on the mobile device used. The article presents a conceptual model of an app for automated generation of mobile pages. It has five-layer architecture: database, database management layer, business logic layer, web services layer and a presentation layer. The database stores all the data needed to run the application. The database management layer uses an ORM model to convert relational data into an object-oriented format and control the access to them. The business logic layer contains components that perform the actual work on building a mobile version of the page, including parsing, building a hierarchical model of the page and a number of transformations. The web services layer provides external applications with access to lower-level functionalities, and the presentation layer is responsible for choosing and using the appropriate CSS. A web application that uses the proposed model was developed and experiments were conducted.**

Keywords: **Responsive Design, Automated Generation of Mobile Pages, Mobile Website.**

1. Introduction

In recent years, there has been a steady tendency to increase access to websites through mobile devices with the purpose of viewing information, shopping, learning and other business activities. This places high requirements on web developers. Their efforts have shifted from creating an artistic design that appeals to consumers to a relatively simple design that looks good on a variety of mobile devices. The change was dictated by search engines that gave priority to "content over packaging". In summary, we can distinguish three strategies for mobile web design: ***responsive web design***, an approach that adapts page layout based on the screen size; ***adaptive web design***, a strategy that optimizes the webpage according to the capabilities of the device; and ***separate site*** in which two sites are built, one for desktops and one for mobile [2].

The term ***Responsive Web Design*** was created by Ethan Marcotte. It means design of a website that, without changing the code, is visualized equally well on different devices with different resolutions - mobile phones, tablets, personal computers and laptops (https://ethanmarcotte.com).

The following understanding is also common - it is a design that provides optimal web page visualization and easy interaction with it, suitable for various mobile devices, with different screen resolutions - laptops, tablets, smartphones, etc. The purpose of this adapting is to minimize the need for resizing and scrolling the screen [21].

Responsive web design uses three primary techniques: ***CSS3 media queries*** (allows for delivery of tailored styles to suit the browser environment), ***Fluid-grid layouts*** (enables the underlying page grid to scale nicely, using relative proportions rather than fixed pixel dimensions), and ***Fluid images and other media*** (enables images and video to scale effectively within the grid) [14] and [9].

There are many benefits to using a responsive design. From a business perspective, a better consumer experience often results in higher profits. A number of search engines, including Google, consider responsive design as a part of the algorithm for site ranking in keyword search results. Something more - Google ranked mobile optimized sites higher when searching on a mobile device [5]. The company offers a web analytics tool that verifies whether the web page has responsive design, highlights design weaknesses and identifies resources with information

DOI: 10.18421/TEM64-30
https://dx.doi.org/10.18421/TEM64-30

Corresponding author: Stanka Hadzhikoleva, *Plovdiv University Paisii Hilendarski, Faculty of Mathematics and Informatics,Plovdiv, Bulgaria*
Email: stankah@gmail.com

Received: 19 September 2017
Accepted: 08 November 2017
Published: 27 November 2017

about optimization (search.google.com/test/mobile-friendly).

The design of a huge part of the websites developed before the "mobile era" has not been updated for various reasons – lack of financial resources, insufficient awareness of the advantages of creating a mobile version, low priority in using the Internet as a channel for communication and marketing, etc. Some of these websites have high value for their users but cannot be conveniently viewed through mobile devices. This puts the task of developing web tools to convert webpages into a mobile-friendly format. This includes a variety of transformations - the dimensions of webpage elements must be presented in percentages, not in pixels; images must be sized against the display; the web page design must be formatted according to a specific style developed for the specific type of mobile device; mobile versions of pages should be made "lighter" by removing different items as mobile browsers do not support some technologies (such as Flash, Java and other plugins), they do not have much memory, etc. [1], [4] and [11]. Additional efforts should be made to ensure faster loading of the mobile applications [10].

The limitations and difficulties in using responsive web design are related to various aspects. There is no universal screen resolution that suits all mobile devices [19]. This implies different approaches to adapting the content of webpages for visualization on different mobile devices. Following the trends in development of semantic web, the HTML 5 standard supports a number of specialized semantic elements. They allow the analysis of a web page structure and content. Such are the elements section, nav, article, aside, hgroup, and others [3].

The article presents a conceptual model of an application for converting an ordinary webpage to a mobile one. It has a multilayered architecture that allows flexible expansions and independent changes in functionalities, as well as their use by external applications.

2. Tools for building responsive design websites

Modern trends in mobile application development outline a variety of requirements: the option to distribute the apps through multiple channels using different operating systems, application scalability based on cloud services, focus on security, and more. [7]. The basic requirement, however, is related to the use of responsive design.

There are a number of ***software tools that automatically create a mobile version*** of a site. Generally, it takes uploading modules that convert and store the generated mobile version of the site onto the server where the site is hosted. This implies administrative access to the website server. Such applications are bMobilized (www.bmobilized.com), Mobify (www.mobify.com), Duda Mobile (www.duda.co), goMobi (www.gomobi.info) and more. This type of applications build automatically a mobile version of an ordinary web page through several steps: menu recognition; automatic choice of appropriate mobile view; creating mobile styles; adding plugins. At a later stage, the user can independently, through visual tools, indicate multiple additional settings: specify the menu blocks and the main content; choose a different mobile view; set styles; add different buttons to the site, implemented as plugins – telephone, email, location map, contacts, links to social networks and sharing links, animated images (click to call, click to e-mail, click to map, contact bar, social bar, share bar, carousel) and many more.

When independently developing a new mobile version, one can use different ***frameworks that offer responsive design***. Some of them are free and easy to use. One way to create a responsive design is through the use of responsive CSS, such as W3.CSS. W3.CSS facilitates the development of websites that look good on screens of any size - desktops, laptops, tablets or phones [20]. Bootstrap is a popular framework. It uses HTML, CSS and jQuery to create responsive web pages (www.getbootstrap.com). Other well-known HTML 5 mobile frameworks are: jQTouch (http://jqtjs.com), jQuery Mobile (http://jquerymobile.com), Wink (http://winktoolkit.org), Titanium (http://www.appcelerator.com), PhoneGap (http://phonegap.com), DHTMLX Touch (https://dhtmlx.com/touch/) etc. [18].

Developers can also use ***libraries for automated creation of a mobile version of a site***. This is, for example, PHPMobilizer. To use it, one must install the classes on one’s own server, in a subdomain of the existing website [13]. W3C DAP is a device API. It is a client - side API, written in JavaScript, that enables the development of web applications that interact with device hardware, sensors, services and applications such as the camera, microphone, proximity sensors, native address books, calendars and other (https://www.w3.org/2009/dap/). The use of ***responsive design patterns*** gives reusable ideas and solutions [8] and [12]. [6] describes an automated processor for web content to mobile-optimized content transformation. The technology is patented and aims to provide a solution for automatical transformation of a desktop website into mobile-optimized content. Input may be provided by a user who interacts with the system by simply entering a website address, or may be provided in an automated way using a software programming interface method.

3. Basic requirements and functionalities

In the context of the ever-changing requirements and standards for websites, imposed by both users and search engines, we have set the following ***basic requirements to the technology being created***:

- ***To support responsive design*** for different types of mobile devices with different screen resolutions and for different browsers;
- ***To allow the addition of styles for new mobile devices, incl. ones with non-standard sizes and resolutions***;
- ***To have an intuitive user interface***;
- ***To store the built mobile versions of webpages*** so that when a web page is reopened, instead of re-converting it, the ready mobile version would be loaded (in case the content of the web page has not been changed);
- ***To collect information about errors in the conversion process*** with the purpose of eliminating them in the future development of the technology;
- ***To be open for future expansions and changes***, its components should be reusable, replaceable and/or usable by other applications, etc.

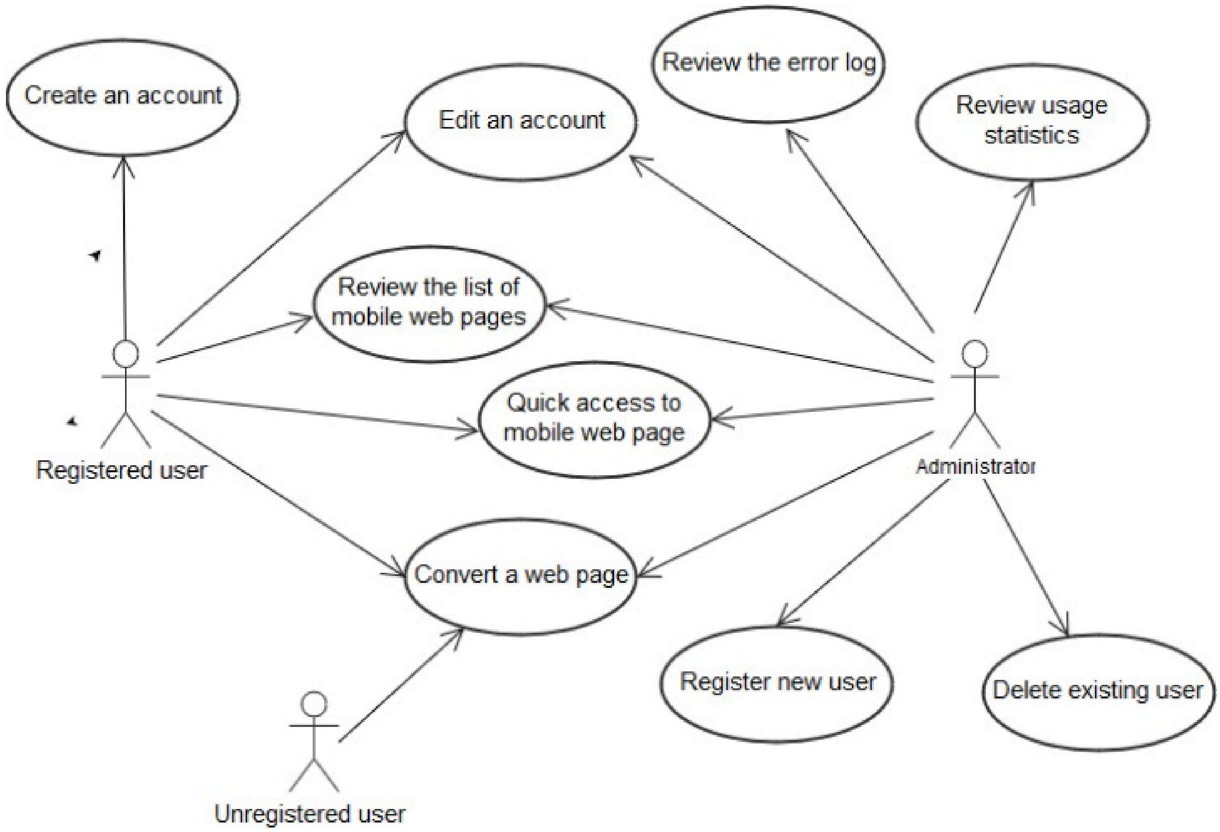


Fig. 1. *Main use cases*

The main types of the application users are: administrator, registered user and unregistered user. The ***unregistered user*** is authorized to enter webpages URLs and view the visualizations generated for a mobile device. In addition, ***registered users*** can view the mobile pages generated by them. When a new webpage is requested, first a check is done to verify whether the page has a mobile version in the database, and if it does, and its content is unchanged, the saved mobile version is loaded. The ***administrator*** has full rights to manage the application. He can review the error log and usage statistics, register new users and remove existing ones. The main use cases are illustrated with the UML diagram in Fig. 1

4. Application Model

The architecture we offer is multilayered and includes: Database, Database management layer, Business logic layer, Web services layer and Presentation layer.

1. The ***Database*** stores all data for app users, generated mobile pages, error log, and some statistics. To ensure greater flexibility and scalability and to enable data recording without a predefined scheme, it is appropriate to use non-relational databases (NoSQL).

2. ***The database management layer*** is based on the concept of ORM technology (Object-relational mapping) for data conversion using object-oriented

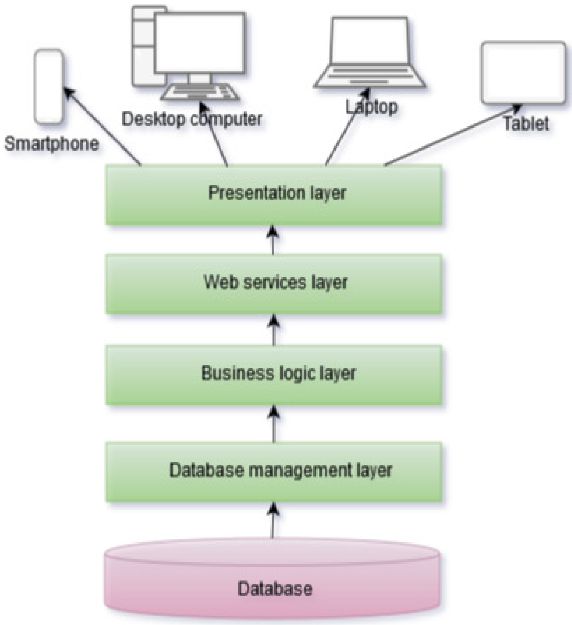
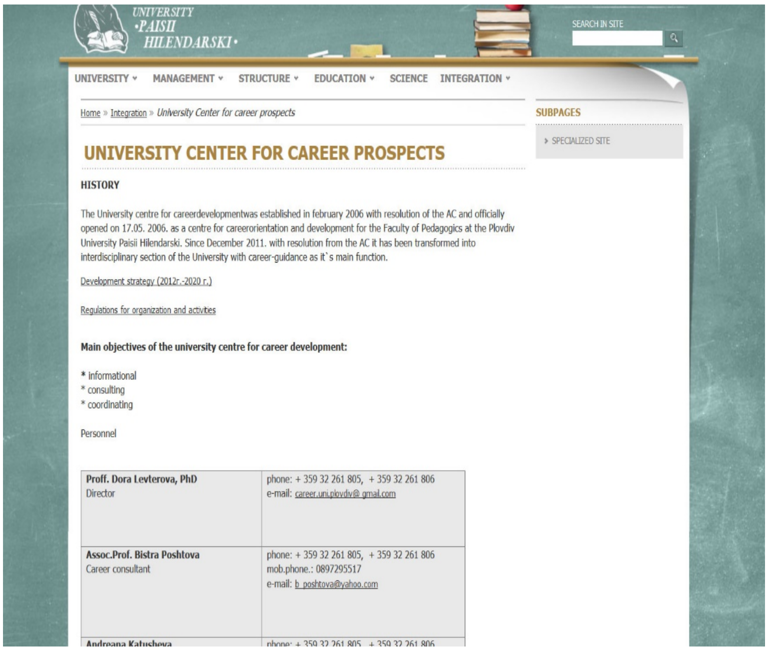


Fig. 2. Application model



Home » Integration » University Center for career prospects

UNIVERSITY CENTER FOR CAREER PROSPECTS

HISTORY

The University centre for careerdevelopmentwas established in february 2006 with resolution of the AC and officially opened on 17.05. 2006. as a centre for careerorientation and development for the Faculty of Pedagogics at the Plovdiv University Paisii Hilendarski. Since December 2011. with resolution from the AC it has been transformed into interdisciplinary section of the University with career-guidance as it`s main function.

Development strategy (2012r.-2020 r.)

Regulations for organization and activities

Main objectives of the university centre for career development:

* informational
* consulting
* coordinating

Personnel

Proff. Dora Levterova, PhD Director	phone: + 359 32 261 805, + 359 32 261 806 e-mail: career.uni.plovdiv@ gmail.com
Assoc.Prof. Bistra Poshtova Career consultant	phone: + 359 32 261 805, + 359 32 261 806 mob.phone.: 0897295517 e-mail: b_poshtova@yahoo.com
Andreana Katusheva	phone: + 359 32 261 805, + 359 32 261 806

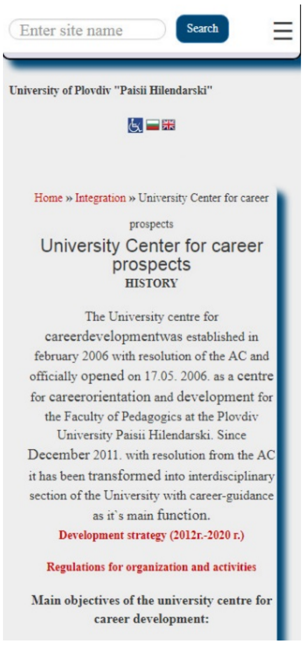
Fig. 3. Web page

programming languages. It contains information about accessing the application to the database, presentations of database information in the form of classes and objects, etc. The layer creates a "virtual" object database that can be easily manipulated by means of a particular programming language without the need for additional processing.

3. The ***business logic layer*** contains the components that perform the actual work on building the mobile page. The main component of this is the HTML parser which performs the analysis of the original web page, creates a tree-structure object model, optimizes the webpage objects and builds an intermediate, non-stylized version of the web page.

4. The ***web services layer*** receives the processed information from the business logic layer, converts it into JSON format, and transmits it to the presentation layer for further processing. This layer defines interfaces to access to web services and hides the details of the business process to build the JSON file. It enables third-party access to JSON files, respectively for applying styles developed by other providers.

5. The ***presentation layer*** is responsible for choosing and using the CSS style appropriate for the mobile page being built, depending on the mobile device used.



University of Plovdiv "Paisii Hilendarski"

Home » Integration » University Center for career prospects

University Center for career prospects

HISTORY

The University centre for careerdevelopmentwas established in february 2006 with resolution of the AC and officially opened on 17.05. 2006. as a centre for careerorientation and development for the Faculty of Pedagogics at the Plovdiv University Paisii Hilendarski. Since December 2011. with resolution from the AC it has been transformed into interdisciplinary section of the University with career-guidance as it`s main function.

Development strategy (2012r.-2020 r.)

Regulations for organization and activities

Main objectives of the university centre for career development:

Fig. 4. Web page mobile version

The advantage of using this architecture is that it maintains a high level of abstraction, it is open, easily expandable and flexible.

The created algorithm for converting an ordinary webpage into a mobile one includes the following basic steps:

1. Reading the web page - the user enters a web page URL, the application validates the address and retrieves the web page.

2. Parsing the web page where the analysis and processing of information is performed using an HTML parser and a hierarchical object model of the web page elements is built.

3. Generating a model suitable for styling. At this point, all elements of the hierarchical object model are subjected to further processing. Objects are recognized and recorded in a correlation table containing information about the main structural components (page title, language, meta data, links, main content, etc.). A web page presentation suitable for visualization through different styles is generated in JSON format.

4. Visualization. A style that conforms to the mobile device parameters is applied to the webpage and it is visualized in the client's browser.

5. Experiments

A prototype was created to test the proposed model [15]. The application uses the MongoDB NoSQL database. Database processing and management is done through the ORM platform Microsoft Entity Framework 6. The web services layer uses an established REST technology - Microsoft WCF (Windows Communication Foundation). The presentation layer is implemented using Microsoft ASP .NET MVC 6 (for webpage development with an MVC design template) and AngularJS 1.3 (JavaScript frame with MVVM design template).

Fig. 3. and Fig. 4. show screenshots from a conducted experiment. Fig. 3. shows a view of a web page from the Plovdiv University website, and Fig. 4. presents the mobile version automatically generated by the app.

Building a responsive design of a website is not a panacea. There are many large sites that support complex functionalities and contain large amounts of information. Making a responsive design for such sites is not always possible. In cases like these "light" mobile versions that contain only the basic information are created. Similar experiments were carried out at the Plovdiv University: building a mobile university system [16] and mobile management and administration of e-learning in Moodle [17].

6. Conclusion

Adapting the “pre-mobile-era” websites to modern requirements for responsive design is one of the major challenges for web developers. In general, the task can be solved in two ways - complete rewriting of the web site to build a responsive design or creating a new mobile version of the site. A compromise for users of such sites is the use of applications – shells that automatically generate a mobile version of the web page appropriate for viewing on the particular device used.

The article presents a multilayered conceptual application model of an application for automated generation of mobile pages. It parses a web page, creates a hierarchical object model of the page and presents it in JSON format. JSON files are accessible through web services and can be used for third-party formatting by applying CSS styles. It uses an ORM technology to provide flexible presentation of database data in object format and easy manipulation. The model presented was tested by building a prototype.

The proposed technology is suitable for building a plug-in that integrates into browsers of mobile devices. This can automatically launch the process of building and visualizing a mobile version of a web page and „hiding“ the details about the application's work from the user.

Acknowledgements

The work is partly funded by SP17-FMI-005 and MU17-FMI-007 projects at the Research Fund of the Plovdiv University "P. Hilendarski".

References

[1]. Borowska, P. & Laurinavicius, T. (2014). *Mobile Design Book*. Amazon Digital Services LLC.

[2]. Cazañas, A. & Parra, E. (2016). *Strategies for Mobile Web Design*, International Conference on Information Systems and Computer Science 2016, Nov 24-26, 2016, Quito, Ecuador.

[3]. Frain, B. (2015). *Responsive Web Design with HTML5 and CSS3*. Packt Publishing. ISBN: 1784398934.

[4]. Giurgiu, L., & Gligorea, I. (2017, June). Responsive Web Design Techniques. In *International conference KNOWLEDGE-BASED ORGANIZATION* (Vol. 23, No. 3, pp. 37-42). De Gruyter Open.

[5]. Webmaster Central Blog. (2013). *Changes in rankings of smartphone search results*. Retrived from: https://webmasters.googleblog.com/2013/06/changes-in-rankings-of-smartphone_11.html , (accessed 07 August 2017).

[6]. Hashmi, A. (2014). *Automated Processor For Web Content To Mobile-Optimized Content Transformation*, Patent Application Publication, Pub. No.: US 20140089786 A1, Pub. Date: Mar. 27, 2014.

[7]. Kasakliev, N. (2015). *Contemporary trends in development of mobile applications*, *Computer Science and Communications Journal*, *2*(4), 96-105.

[8]. Marcotte, E. (2015). *Responsive Design: Patterns and Principles*, A Book Apart Publ., 2015, ISBN: 978-1-937557-33-1.

[9]. Marcotte, E. (2011). *Responsive Web Design*, A Book Apart Publ., 2011, ISBN: 978-0984442577.

[10]. Matsudaira, K. (2013). Making the mobile web faster. *Communications of the ACM*, *56*(3), 56-61.

[11]. McWherter, J. & Gowell, S. (2012). *Professional Mobile Application Development*. Wrox Publ. ISBN: 1118203909.

[12]. Neil, T. (2014). *Mobile Design Pattern Gallery: UI Patterns for Smartphone Apps*, O'Reilly Media Publ., 2014, ISBN: 978-1449363635.

[13]. PHP Mobilizer. (2017). Retrived from: https://code.google.com/archive/p/phpmobilizer/downloads , (accessed 8 August 2017).

[14]. Power, M. (2012). *Delivering Web to Mobile*, JISC Observatory Techwatch Report, version 1.0, May 2012.

[15]. Rachovski, T., Hadzhikolev, E. & Hadzhikoleva, St. (2017). *Software application for generating mobile versions of webpages*, Scientific Session "Days of Science 2017" of the Union of Scientists - Plovdiv, Plovdiv, 2-3 November 2017 (in print).

[16]. Rachovski, T., Kovatchev, B. & Totkov, G. (2012). *Towards a Mobile University System*, Scientific Works of USB-Plovdiv, Series B, Natural Sciences and Humanities, Plovdiv, 25-26 October 2012.

[17]. Rachovski, T., Totkov, G. & Enkov, Sv. (2011). *Mobile management and administration of e-learning in Moodle*. IV National Scientific Conference 2011, Science and Higher Education Federation at Plovdiv HEI, USB-Plovdiv, p. 117-121, ISSN: 978-954-9449-44-0.

[18]. Smutný, P. (2012, May). Mobile development tools and cross-platform solutions. In *Carpathian Control Conference (ICCC), 2012 13th International* (pp. 653-656). IEEE.

[19]. Subić, N., Krunić, T., & Gemović, B. (2014). Responsive web design-Are we ready for the new age. *Online Journal of Applied Knowledge Management*, *2*(1 s 95).

[20]. W3.CSS. (2017). *W3.CSS Tutorial.* Retrived from: https://www.w3schools.com/w3css/ , (accessed 05 August 2017).

[21]. Wikipedia. (2017). *Responsive web design*. Retrived from: https://en.wikipedia.org/wiki/Responsive_web_design (accessed 05 August 2017).