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Adaptive User-Device Interface Generation for Websites

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Abstract - One of the hottest issues in web developer circles lately is accessibility of websites on various devices other than the standard desktop or laptop screens. With mobile devices, tablets, and similar gadgets becoming ubiquitous, it behoves organizational stakeholders to address the issues encompassing user interactions and acceptance of their websites on these latest diminutive gizmos and mobile devices with web-enabled screens.
Desktop, tablets, and mobile devices are fundamentally different and are used in very different ways. There is a difficulty of delivering web content on all these multiple devices.
This paper seeks to help find a solution to these challenges by using adaptive web design technique as a tool for adapting web sites to the preference of the user irrespective of their device.

Keywords - Adaptive Web Design, Responsive Reb Design, Progressive Enhancement, User Interface Generation.

I. INTRODUCTION

This explosive growth of the Internet in recent years has transformed it from a mere accessory to a necessary tool for a wide array of daily tasks both at work and in the home [8]. The productivity of Internet website users is fundamental to ensuring the constraints and deadlines for these tasks are satisfied. What determines this productivity is the ease with which users can find, understand and utilize the information contained in the site, a concept commonly referred to as website usability [11].
As the internet continues to develop exponentially, so also the devices used in accessing the internet are not left behind in this technological advancement. Nowadays, mobile devices such as smartphones, tabs, laptops which all have the capability to use the service of the internet as well as the desktops. There are also machines that are now been produced which require the service of the internet for their functionality. Interestingly, these devices are becoming so cheap that an average person can afford to have at least two of these devices. These would mean that at least 30% to 50% of your website's traffic now comes from mobile devices. It means that soon, desktop and laptop users will be in a minority on the web.
Web user interface should automatically change to adapt for resolution, image size and device abilities based on Responsive Web Design techniques. It should also allow users to access a single URL for an adaptable content, without taking the trouble of having to type different URLs depending on the device used, such as mobile, tablet, desktop, etc., [9]

In addition, an adaptive web interface can reduce search time, cognitive load, and motor movement and when the adaptation is successful, an adaptive interface can be faster, and is preferred over non-adaptive counterparts [6]
Finally, users who access websites through their mobile devices or other display screens really do not care what method was used to develop the website, just as long as they can effectively navigate the website on whatever device they are using. They are more particular about the satisfaction they get from the web sites they visit because that is what gives them a reason to return to the web site next time. For these reasons, adaptive web design (a concept of progressive enhancement that helps to adapt a web-site to suite the user's preference such as screen size, touch screen etc.) has been devised for web developers to meet the above mentioned challenges, so that numerous functionalities and environmental factors can be catered for in the most user friendly way, depending on the particular device being used to access websites.

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II. PROBLEM STATEMENT

As technology continues to advance and different kinds of hi-tech devices are being produced that can access the internet and our web site on the go, some of these devises make use of processor speeds higher than that of some of our computers, Samsung S4 and HTC One smartphones for example makes use of a 1.9GHz and 1.7GHz quad-core processing speed respectively. And we also have some old phones that probably do not use processors and can still access the internet.
Also, current Web document formats are not suitable for developing personalized, device independent Web applications.
The diversity of display capabilities of these hi-tech devices and mobile computing gadgets have caused a dramatic increase in the development effort of websites tailored to multi-platform access to cope with this challenge. Therefore, there is also a need for web developers to design and adapt web sites to the size of the device display.

III. OBJECTIVE OF THE STUDY

The research is aimed at using adaptive web design from the user's stance point to adapt a site to the user's preference so that the user can have the same experience of a website either on a smartphone, laptop or any type of user device.
The specific objectives are to

- provide a framework for the development of adaptive web design with the concept of progressive enhancement.
- demonstrate how the websites can be generated irrespective of the device and or the web browser used in accessing the website.

IV. WHAT IS ADAPTIVE WEB DESIGN (AWD)?

Adaptive web design, or content adaptation is a website structure in which different website code is tailored for different buckets of users. This can be done using a single URL (Dynamic Serving), or with mobile-specific URLs, such as m-dot or dot-mobi. In both cases server-side device detection is utilized allowing the web server to verify what should and what shouldn't be sent to the requesting device.
Adaptive web design (AWD), the term coined by Aaron Gustafson, describes content authored and layout designed for distribution across multiple channels, media, products and interfaces. This design is achieved through progressive enhancement, detecting the device, and static layouts.

The adaptive approach helps with:

Catering to the needs of different groups of users coming up with device-optimized website features, menus, images, texts, etc. Adjusting the website speed and page weight to suit users on varying connectivity and data plans

The major deliverables for an adaptive website are:

- Users are able to access the website with any browse-able device.
- Users can get the satisfaction irrespective of the web browser being used.
- The site is able to take into account the preference that best serves one device or the other.

A. What is progressive Enhancement (PE)?

PE can be described as a web design strategy that makes an effort to create websites that are accessible to all devices, using a layered approach with a set of core principals stressing accessibility of content and functionality. [14].

PE is the challenge response to a traditional web strategy known as "graceful degradation", meaning that the website is designed for a particular browser technology, and it would remain presentable or "degrade" even if older user agents were used. Graceful degradation also assumes that the users just need to "upgrade" their browsers or technology, putting the focus on the end user and not the website.

B. The layers of Progressive Enhancement

[2] wrote a notable article describing progressive enhancement model as a series of layers similar to a layer cake. In the Gustafson's model, the center is the content layer of rich semantic markup; the content layer is surrounded with the presentation layer, which is the CSS and styling; and the presentation layer is encased with the client-side scripting layer, otherwise known as JavaScript or jQuery.

The three layers or stratums of Progressive Enhancement:

- Content layer = rich semantic HTML markup
- Presentation layer = CSS and styling
- Client-side scripting layer = JavaScript or jQuery behaviors

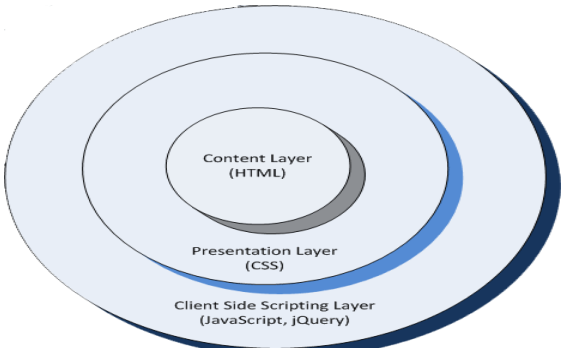

Fig 1. Gustafson's model/layers of progressive enhancement

V. REVIEW OF RELATED LITERATURE

[13] define adaptive websites as those that automatically improve their organization and presentation by learning from site visitors' access data.

Some studies recognized two areas in which adaptive websites modify themselves, the first being content and the second navigation [3][7]. In the case of content, the adaptation consists of recommendations to the user based on his or her preferences or actions, while with navigation the modifications primarily entail the creation of index pages showing the user those links most relevant to his or her interests [13].

Other studies [1], [4], [12] have investigated the adaptation of website structures, focusing principally on the creation of models and algorithms that allow sites to adapt automatically to various types of devices, including mobile ones.

[10] developed a culturally adaptive user interfaces called MOCCA. In her work she introduces 'cultural adaptivity'. The main idea behind it is to develop intelligent user interfaces, which can automatically adapt to the user's culture.
MOCCA that requires a cultural user model ontology, which includes various facets of users' cultural backgrounds. The facets were aligned with information on cultural differences in perception and user interface preferences, resulting in a comprehensive set of adaptation rules. MOCCA requires knowledge about culture, a user model which contains this information, a rule-base that formulates adaptations for an uncountable number of different cultures, and a flexible user interface, which is able to automatically trigger the modifications.
[15] proposed an interface generation model to provide customized user interface and interaction workflow. In their model, knowledge was involved to instruct the workflow of interaction. Templates were adopted to describe the user interface. Some significant points, such as user definition, data profile, user interaction workflow, interface description, were discussed in detail. A prototype system was implemented. Some demos were shown to verify the customized interface generation model. With this model, end-users can define the interfaces and interaction workflows of web services with rules and templates. Compared with the current interface generation in service composition, the proposed model is more flexible and more effective for end-users.
[9] proposed a novel framework providing a context adaptive user interface (UI} which automatically chooses appropriate Resources from a User Interface Page-Set consisting of multiple Resources. The proposed framework aimed to provide service directors who are not knowledgeable about UI development with opportunities for making context-aware UI, and to achieve high-quality user experience in complex services.

VI. OVERVIEW OF THE PROPOSED SYSTEM DESIGN COMPONENTS

A brief overview of the proposed system design components and an analysis of the development tools used in creating the application.

A. The Database

The database is a relational database, built and designed with MYSQL query statements under the WAMP server. A relational database is one in which the data and the relations between them are organized in tables. (A table is a collection of records and each record contains the same field).
The adaptive web-site database consists of one table where information about each device that access the website are stored.

B. Hyper Text Marked-up Language (HTML)

The html 5 was used in the structural design of the adaptive website. The evolution of HTML has also caused its vocabulary to expand steadily to offer more options for describing the content it encapsulates. The advent of HTML5 brought about new semantic options (such as header) and even augmented a few existing ones (such as the aforementioned <abbr> that took over for the ousted acronym). HTML is filled with attributes that help enrich the elements they adorn. It prescribes a number of "fixed use" ones, like alt and title, but it also offers a handful of attributes that can be used to build upon the language's native semantics in a less formal way with use of id and class. The classification and identification can help feed back into HTML, helping it become an even more expressive language.

C. Cascaded Style Sheet (CSS)

As with HTML, CSS is designed to be fault tolerant. Browsers ignore any syntax they don't understand and, by paying attention to how the language has evolved over time, we can easily embrace progressive enhancement by taking advantage of this ignorance to craft layers of design based on a given browser's capabilities. CSS is a series of human-readable rule sets, each composed of a selector and declaration block containing a set of property-value pairs (declarations) to be applied to any element matched by the selector. With the help of media queries which are powerful tools in CSS and allow you to really fine-tune your designs for specific devices. Using media queries can add a set of rules to a page based on the capabilities of the user agent.

D. JavaScript

This is the aspect that deals with the design of the behaviour of the web-site. The JavaScript helps with the interactions on the website, how the site behaves when an action is activated on the web-page. For example, on click event handlers takes charge of what happens to the element that is being clicked upon.

VII. DESIGN METHODOLOGY

In other to demonstrate the adaptive web design concept, a University website (Babcock University, Nigeria) was designed with adaptive properties with the use of the HTML 5, CSS, java script and a data base.
The design approach employed is the LSP (Logic Scoring of Preference) method proposed by [5]. This method help in assisting decision makers in the evaluation, comparison and selection of complex hardware and software systems. LSP start by assessing the number of individual performance variables, i.e. the number of test devices. These variables define the total number of ideal solution to be expected. As these test samples will provide varying results most of which might not perfectly

match the pre-set criteria, but LSP helps to take into account how well a candidate or sample match the different performance variables.
For each variable $_i$, a degree of suitability $E_i \in [0,1]$ is calculated. This score expresses the similarity between a candidate solution and performance variable $_i$, ranging from 0 to 100%. In order to attain these scores, LSP requires a predefined mapping function for each performance variable. Which can be obtained using either fussy logic or Boolean logic.
After obtaining the elementary degrees of satisfaction, all individual matching scores are to be combined into one objective overall suitability score. This aggregated score is used to determine the best-matching candidate. LSP supports the use of aggregation networks, expressing the mutual relationships between individual scores and how to calculate the overall score. The standard aggregation operators in LSP are based on the superposition of fundamental Generalized Conjunction Disjunction (GCD). These operators enable aggregations in terms of partial conjunction, full conjunction, partial disjunction, full disjunction, and neutrality in a single operator. Moreover, a GCD supports the specification of aggregations in terms of seventeen graded combinations of conjunction and disjunction.
A frequently used implementation for GCD are Weighted Power Means (WPM)

$$WPM(x1; x2; : : : ; xm; W1; W2; : : : ; Wm; r) = (W1xr1 + W2xr2 + : : : + Wmxr\ m)^{1/r}$$

The variables Wi in the above equation represent the relative weight for each elementary degree of suitability xi,

where $W1 + \ldots + Wm = 1$.

The exponent r is determined in function of the aggregation's desired degree of conjunction or disjunction. This approach allows an evaluator to precisely couple the mutual importance of individual suitability degrees.
The calculated aggregation network results in an objective overall suitability score

$$E = L(E1; : : : ; En)$$

Where the function L is a combination of one or more GCDs using the individual suitability degrees as input parameters.
After calculating E for each of the candidates, conclusions regarding the best-matching solution can be drawn. The LSP approach selects the candidate modification of the LSP method in order to support the adaptive composition of mobile web applications. In this particular case, the stacks of progressive enhancement layers are considered to be the candidate solutions. Each candidate must define the conditions in which it should be able to contribute to an application's optimization and to what extent these conditions are strictly required, or rather optional. As in the standard LSP approach, this degree of desirability is expressed in terms of a GCD.

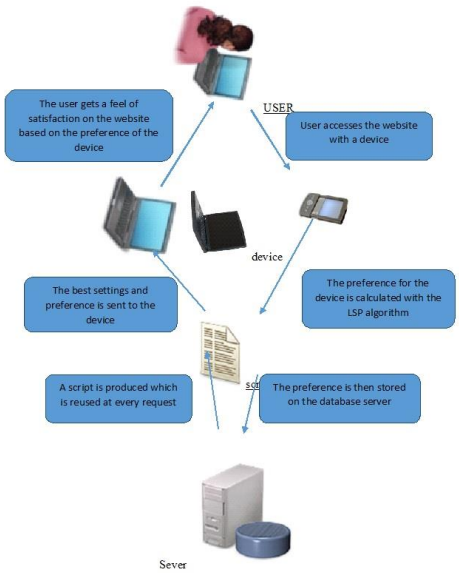

Fig 2.: Framework of the adaptive design running from the device to the server.

VIII. PROCESS IMPLEMENTATION

The above diagram (Fig 2} shows how the website performs the operation of adapting itself to the devices as indicated by the algorithm above, W represents the device used in accessing the websites. The preference of the device is then taken into consideration and the suitability factor x_i i.e. the settings suitable for that device is stored into the database so that when the same device is visiting the site again, the preference or settings is then applied to that device and if a new device comes visiting the site, process one is done all over.

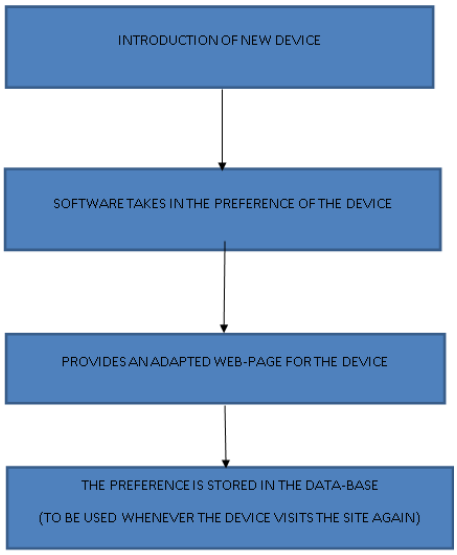

Fig 3. The schematic flow of the process on the adaptive design

IX. THE FRAMEWORK DESIGN PROCESS

As seen in the diagram, the content is the front-end, the interface with which the user interacts with the website. This is designed with the help of html 5, CSS, JavaScript. The structure is designed using html, the design interface, layout is done using Cascade style sheet, and the behaviour is designed with JavaScript.

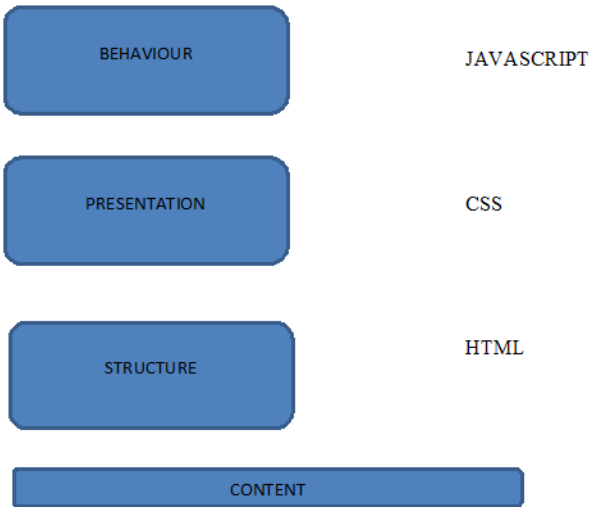

Fig 4.: The design process of the adaptive website

X. TESTING OF THE PROPOSED FRAMEWORK ON DIFFERENT DEVICES

This section gives a comprehensive insight to how adaptability was implemented on a university website (Babcock University, Nigeria web-site), how the site behaves on different devices and browsers, and the testing process.

This is also the phase where all the requirement analysis and system design are put to test to ensure effective delivery of the system. It also contains screen-shots of how the behaviour of the web-site with the concept of adaptability.

Fig 5. A screen shot of the Babcock website on a 7 inch screen.

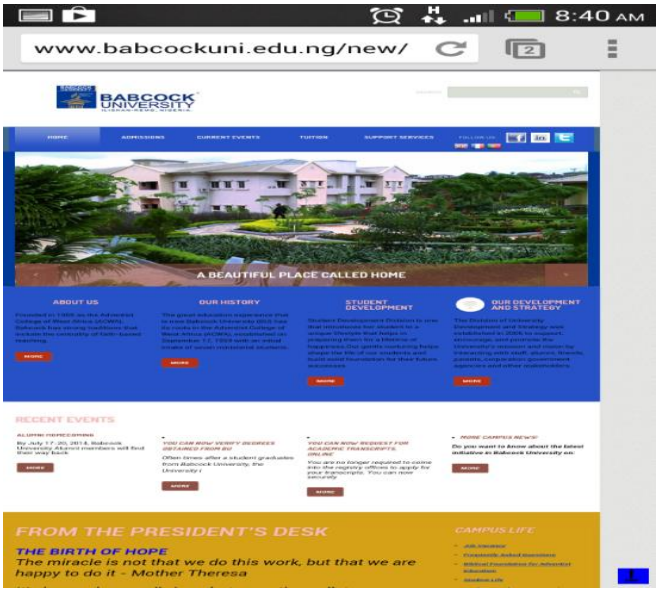

Fig 6. A screen shot of the Babcock Website on a 4.7-inch screen

The site was tested on devices of different screen sizes, fig 5 is a Samsung galaxy tab with 10-inch screen and Fig 6 is a HTC one xl with screen size of 4.7 inch. And from these images we can see that the necessary information is showing on both screen, there is almost no difference except for the image sizes that differs. With the adaptive design both users are able to get a fill of satisfaction on the website.

XI. CONCLUSION

This paper described adaptive web design as a concept that helps to adapt web sites to any device and or web browser thus making the site accessible to all kinds of users with a proof of concept to verify the proposed framework.

Most sites developed nowadays perform excellently with newer browsers and leaving out older browsers. And to solve this problem we proffer the use of adaptive web design.

In conclusion, adaptive web design is a concept of progressive enhancement that gives a form of satisfaction to all kinds of user that access web-sites. It possesses both backward compatibility and forward compatibility i.e. irrespective of the browser in use either the older browsers or the new sets of web browsers, the site is adapted to suite any preference. This will in-turn guarantees customers revisiting the site which is helpful to the business aspect of any establishment.

Therefore, with adaptive web design, users with older browser will not get frustrated while visiting the site. Also users will not be discriminated against because of the device with which they access web-sites.

XII. RECOMMENDATION FOR FUTURE WORK

This paper recommends that further work should consider more types of facts into our interface adaptation model. For example, invoking user's context and sensors from user devices can also be considered and used for generating suitable interfaces for different user devices.

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