User Interface adaptation for multi-device Web-based media applications

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***Abstract*— The quest to transform the television viewing experience into a digital video service is happening on second screens. Multi-device experiences become more intuitive and easier to use federating cooperative devices. They also bring new creative opportunities to schedule and distribute interactive content synchronised with the TV programme through any connected screen. The rise of HTML5 to develop responsive applications across multiple devices adds a significant amount of improvement enabling universal delivery. The key challenge to harness the power of navigation engaged with the story on the TV is the responsive design of a unique application spanning all the available screens. This paper presents user tests in order to explore the relevant parameters to create responsive User Interfaces for Web-based multi-device applications driven by media content.**

***Index Terms*— 1. Multimedia systems and services**: 1.4 VoD, interactivity, datacasting, 1.8 Future services of Broadcasting; **2. Multimedia devices**: 2.4 Mobile, portable and handheld devices, 2.6 New human-device interaction.

I. INTRODUCTION

COMPANION experiences engage consumers in relevant contents on second devices -smartphone, tablet or laptop- while watching something in the first screen -usually a TV-. The industry is adopting second screen viewing services to capture audiences and deploy new monetisation models.

Web-based applications enables universal delivery via HTML5 to reach those users who do not want to download an application. This trend is also driving the evolution of HTML5, making a wider range of devices capable of running applications that gain features previously available only through native SDKs [1].

Once the self-capacity and interoperability are being addressed by HTML5, the key challenge for next generation applications is to provide users coherent multi-device experiences with simple and intuitive interfaces that ease the navigation through the information provided with a right timing. This is a natural step in the adaption of the market and society to the growing behaviour of users accessing services from several devices simultaneously [2], aiming to have a single experience through multiple devices at the same time.

Despite the clear opportunities to catalyse new business models, the lack of standards hinders the creation of seamlessly connected, intuitively converged and conveniently continuous experiences across a heterogeneous ecosystem of devices. The priority for future research is shifting towards fully manageable, context-sensitive and controllable or self-regulating multi-device applications.

To overcome all the intrinsic features needed on a distributed web application, a complete capabilities stack is needed. It should comprise: a discovery service layer to federate other experience participants; a cross-platform user authentication layer for security; a communication layer to consolidate a synchronised multi-device context by means of autonomous information exchange and event triggering; and a cross-device application adaptation to distribute the experience across all the devices and suit the different visual components to each specific device conditions. The work presented in this paper is part of the research activities that are being performed in the MediaScape European project[1] that addresses the aforementioned challenges. In this case, this paper focuses on the User Interface adaptation challenge for media applications across multiple devices.

To really boost the interface creation and maintenance of multi-device Web-applications, it is mandatory a universal mechanism that, based on Web standards, considers common possible situations that fire a set of orchestrated adaptation actions. Thus, it eases design and reusability while provides a default behaviour valid for a wide range of applications and contexts.

To this end, it is necessary to evolve application design from developing a different applications for concrete target devices and application roles, adding to each one ad-hoc mechanisms to control one by one their functionality and interfaces according to application-specific events for inter-device communication, to a single application where developers describe once the complete functionality map around regular attributes on a standard basis that govern the interface and the behaviour of the application for a multi-device environment.

The seamless translation of a single application into a multi-device execution while still providing a well fitted portion of the application on each device, is the multi-device adaptation

[1] http://mediascapeproject.eu

challenge.

This paper present user tests performed over 47 end users to analyse the impact of different parameters on how to arrange the User Interface for simultaneous Web-based multi-device media applications. These conclusions will help multi-device application developers to design multi-device media application providing a responsive User Interface on each device depending on the parts of the application that is presenting regarding the multi-device dimension context.

II. State of the Art

This section will provide a state-of-the-art of the existing technologies and frameworks to create responsive and device-adapted Web applications.

All these languages, recommendations and frameworks are very useful for smooth local adaptation but need to be extended towards the multi-device dimension. They are all designed to adapt an application to a device aiming the adaptation depending on the device features. However, they do not consider that an application can be running in one or more devices simultaneously, including only part of the application.

III. Multi-device Model

Our research aims to explore which parameters have a relevant impact on the arrangement of the components to be shown on each device in a simultaneous multi-device application.

We will have a media Web application implemented with different logic parts developed with Web Components, and on top of this, we assume there will be an adaptation engine, out of the scope of this paper, taking the decisions of which components present on each device. For instance, if a user is consuming a media application through different devices at the same time (e.g. a TV and a smartphone), the adaptation engine will device which components to show on the TV and which ones on the smartphone. But once the adaptation engine decide the components to be shown on each device, a responsive User Interface should be created, able to adapt to the context changes (new devices connected or disconnected by the user). This paper aims to explore how to create a responsive User Interface depending the user context and which parameters are relevant for this task.

Our hypothesis underlines these four parameters to affect to the User Interface:

- **The device**: As happens in a single-device application, the target device is very relevant to build a responsive Web application. In the same way, the devices involved in a multi-device application are expected also to be relevant.
- **The number of Web Components**: The quantity of pieces of information to be shown in that device can affect on how to present the content.
- **The nature of the application**: This parameter could be important to decide the arrangement of the User Interface. For instance, if there is a main video and related information on the device, or if the video is being displayed on another device and that device is being used only for extra information.
- **Other devices being used at the same time**: We want to know if having a second device being used simultaneously has an impact on how the user wants to arrange the components in the first screen.

IV. User Tests

We performed tests with 47 end users on a laboratory simulating a home environment. The tests combined different situations over the parameters aforementioned. We reduced the parameters to the following possibilities:

- **The device**: 3 different devices. A Motorola Moto G Smartphone in portrait mode, A Nexus 10 tablet in landscape mode, and a Samsung UE40C8000 TV.
- **The number of Web Components**: Showing 3 or 6 components at the same time.
- **The nature of the application**: Two different scenarios. At least one of the components is a video, or there is not a video in the components.
- **Other devices being used at the same time**: Two possible situations. This is the only device being used or there is another device as a second screen.

We created testing images simulating a broadcasted live F1 race scenario following the Extra Media scenario[2] with all the possible combinations of the first three parameters, and the figures below present some examples of these combinations:

Id	The device	The number of Web Components	The nature of the application	Other devices being used at the same time
1	TV	3	At least one video	No
2	TV	6	At least one video	No
3	TV	3	No videos	No
4	TV	6	No videos	No
5	Tablet	3	At least one video	No
6	Tablet	6	At least one video	No
7	Tablet	3	No videos	No
8	Tablet	6	No videos	No
9	Smartphone	3	At least one video	No
10	Smartphone	6	At least one video	No
11	Smartphone	3	No videos	No
12	Smartphone	6	No videos	No

Apart from these 12 context situations, we created 4 more to evaluate the "Other devices being used at the same time" parameter. We defined as a second screen a TV showing two fixed components and present different contexts in a tablet, making the user think about how to present the content in the tablet, while they are also watching related content in the TV. As an outcome we have 4 new combinations:

Id	The device	The number of Web Components	The nature of the application	Other devices being used at the same time

[2] http://mediascapeproject.eu/files/D2.1.pdf

13	Tablet	3	At least one video	Yes. A TV.
14	Tablet	6	At least one video	Yes. A TV.
15	Tablet	3	No videos	Yes. A TV.
16	Tablet	6	No videos	Yes. A TV.

For each one of the 16 combinatorial contexts, we created always four different user interface arrangement patterns:

- **Grid Layout**: Based on the CSS Grid Layout Module Level 1[3] (see example in Figure 1).
- **Picture-in-picture Layout (PiP)** (see example in Figure 2).
- **Menu Layout** (see example in Figure 3).
- **Horizontal Layout** (see example in Figure 4).

Figure 1: A grid template layout example on a tablet in the context with ID number 6

Figure 2: A grid template layout example on a tablet in the context with ID number 6

Figure 3: A menu template layout example on a TV in the context with ID number 2

Figure 4: A horizontal template layout example on a smartphone in the context with ID number 9

The tests have been done with 47 users, one by one, being always an expert presenting each one of the 16 context situations. The expert gave them a very brief description of the context of the testing and ask them to choose always the layout they would prefer on that moment to see the F1 race. All the tests have been carried out in the Digital Home Lab of Vicomtech-IK4, where there is a similar environment on what we can find on a living room. From the 47 users, 40 of them where researches in Vicomtech-IK4, with expertise on different fields and not related with the MediaScape project, and 7 of them where administrative staff people. It took around 15 minutes to perform the test with each user, so around 12 hours in total, divided in three different days. Figure 5 presents pictures took during the tests.

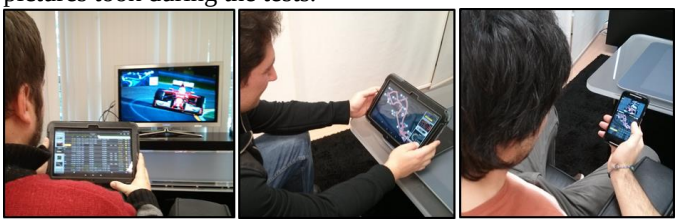

Figure 5: Images from user tests. In the left a user in front of the context situation with ID number 16 with the menu layout on the tablet. In the middle a user with the context situation with ID number 16 with the PiP layout in the tablet and in the right a user in the context situation with ID number 9 with the horizontal layout on the smartphone.

V. Results of the User Tests

This section will present the results obtained in the previously described user tests.

VI. Conclusions

This section will present the conclusions.

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[3] http://dev.w3.org/csswg/css-grid/