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HTML5 technologies for effective cross-platform Interactive/Smart TV Advertising.

Emmanouil Perakakis and Gheorghita Ghinea, *Member, IEEE*

Abstract— Developing an interactive TV Commercial (iTVC) for Internet connected TVs is complicated by the number of different platforms, each with its own Operating System and Application Programming Interface (API). To achieve cross-platform compatibility, we propose to use standard Web Technologies, instead of proprietary APIs for each device. With our approach only one iTVC was developed, which contained commonly used features of these kinds of advertisements, and used only Web Technologies (HTML5, CSS and JavaScript). The iTVC was first developed on a desktop personal computer and was tested on 3 different Smart TV platforms for feature compatibility. After achieving compatibility, a user study with 36 participants evaluated how platform related differences affect aspects of user experience (UX) and effectiveness of the interactive ad. The measured UX/effectiveness aspects and usability were consistent regardless of the iTVC performance on each device. These results show the potential of Web Technologies to deliver a uniform (and effective) interactive Ad across a range of heterogeneous devices.

Index Terms— Interactive TV Advertising, Smart TV Advertising, t-commerce, User Experience.

I. INTRODUCTION

Traditional television (TV) advertising consists of a short video clip (between 15 - 30 seconds). However, the increasing popularity and the interactive capabilities of internet connected TV (or smart TV) devices are attracting attention from advertisers that see potential beyond the traditional "30-second" TV spot [1]. These commercials combine enhanced "30 second" TV spots and microsites/applications (apps). These include interactivity and can even adapt to the viewing environment (e.g. using location information). Interactive TV advertising thus provides advertisers with new ways to pass their messages to potential clients including instant purchase (t-Commerce), on-demand product descriptions, newsletter subscriptions, social media interaction, longer presentations, and games.

Nevertheless, developing interactive TV commercials ('iTVCs') for connected TV can be complicated due to the number of available platforms. Connected TV platforms are being developed by service providers, traditional TV manufacturers, Internet service companies, computer manufacturers, personal computer (PC) software developers, TV channels, set-top box / Media Player manufacturers, and

even game console manufacturers.

In order to develop an iTVC, most of these platforms have proprietary APIs. However, there is movement toward the adoption of the standard web technologies of HTML, CSS and JavaScript for every connected TV device, either through their web browsers or their application development core [2]. By adopting these technologies in the TV arena, a universal method for developing apps and iTVCs seems feasible in the near future.

Because of the nature of Smart TVs, an HTML5 iTVC is not just a video broadcasted to the user's device but also depends on the client-side system for its correct rendition, similar to a web page viewed on different devices. Due to the many different platforms and capabilities of Smart TV hardware and software, it is virtually impossible to design for the exact same user experience on all Smart TVs. Thus, one concern is how users perceive these differences and if the differences can result in a decreased advertisement effectiveness.

This paper investigates whether such technologies can offer the required features needed for developing interactive ads compatible with most connected TV platforms. Advertising and marketing research usually use recall and preference measures to study the potential effectiveness of advertising [3][4][5][6]. Thus, we also investigate some aspects of the user experience on a cross-platform iTVC across different devices.

Our proposed solution uses web technologies including HTML5, CSS3 and JavaScript to create a single interactive ad to target different platforms running on the devices' web browsers. Our solution is cross-compatible, using a JavaScript detection of features and providing a "fallback strategy" for any missing features. Advantages of this solution are:

- Universal cross-platform compatibility with a single ad that will run on all platforms;
- Adaption for different input devices (remote controls) can be programmed;
- Features of current TV ad platforms can be reproduced with HTML5/CSS3/JS;
- Use of HTML5 with native video support, a vital feature for an iTVC [7];
- No need for platform-specific technical skills;
- Personalization of ads, localization, and mash-ups (e.g maps, social media) are supported.

II. UTILIZING WEB TECHNOLOGIES FOR iTVCs

HTML5 is not meant as a standalone technology and is still being developed [8]. Usually, when referring to HTML5, it automatically includes the combination of three main

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TABLE I
FEATURES OF HTML5, APPLICABLE TO INTERACTIVE TV ADS

Video	The <video> tag embeds a video onto the page. There are two different video formats supported with different browsers: (a) H.264 Baseline profile in an MP4 container and (b) VP8 in a WebM container, or Theora in an Ogg container. A workaround for cross-platform support is to include both video versions. There is a preload attribute for pre-loading videos.
Subtitles	Subtitles, for different languages, accessibility or for artistic enhancements (e.g. captions with only music as soundtrack) are supported using the WebM format and the <track> element. The track element supports specifying explicit external timed text tracks for media elements [8].
Audio	The <audio> tag is for playing audio. Synchronizing audio with graphics, video and interactions (e.g. push of a button) is supported with JavaScript Events or Timers for time-based sync
Canvas	The <canvas> tag is an area in the browser where the developer can draw graphics or produce animation using JavaScript with the provided API. This is useful for real-time graphics.
Interacti-on Design	JavaScript can offer interactivity features. JavaScript is extended with libraries, like jQuery
Text / Typogra-phy	Text includes new fonts, with @font-type tag of CSS3 and also with text effects, so common on TV such as shadows and borders (text-shadow), rotation (box-rotate) and even gradients and advanced masks (-gradient). Text can also be animated using JavaScript.
Graphics Effects (CSS3)	Effects of CSS3, such as shadows, rotation, gradients, and opacity can be very useful for the presentation of content. As opposed to using pre-rendered graphics, real-time options are available.

technologies: HTML5 for structure, CSS3 for presentation/style, and JavaScript for interactivity/animation.

Table I lists important features of HTML5 that can be utilized for interactive TV ads. Other features include many new semantic tags for more specific content structure, and local storage for storing values even when the browser is closed or refreshed.

JavaScript can detect compatible tags for the current browser and provide fallback strategies for when a feature is not available on the current device. For example, if the particular device lacks video support using the HTML5 <video> tag, an image could be displayed, or even a flash video, if the device supports it. Since JavaScript is supported on all devices, this technique will ensure that the iTVC will be viewable across all platforms. The client-side platform can be detected by using the standard navigator.userAgent property. Also the document.createElement functions can show the availability of features (e.g. HTML5 video or audio).

A. Platforms and Enabling Technologies

There are a number of different platforms for developing iTVCs using their dedicated tools. Some of these are

TABLE II
PLATFORMS FOR DEVELOPING INTERACTIVE TV ADS

Platform	Entry Point (Call to action)	Development Technology	Compatible TV Platforms
YuMe	Banner inside TV interface, Pre-Roll, During Loading	Flash / HTML5	LG SmartTV
Rovi	Banners, Menu placements	ROVI SDK/API	Samsung Smart HUB, DIRECTV, Sony PS3 and more
FreeWheel	Pre-roll	HTML5 / Flash	BrightClove (video website)
DirecTV	Video Banners, Menu placements, 30sec Spot	Undisclosed	DirecTV and compatible devices
adRise	Video, Banners, overlay, ticker	adRise SDK/HTML5	Roku, Google TV, Yahoo TV, Samsung Smart HUB, WD, Boxee, Android and more

DIRECTV [9], Rovi [10], YuMe [11], activevideo and adrise. Although these offer similar features, the methods to produce the iTVCs are quite different. Moreover, each is compatible with a limited number of platforms. Table II presents some of the available platforms with some of their key features.

Even on compatible TV devices, these platforms work only on particular areas. For example, pre-roll ads can work before playing a video or film through a service like BrightClove. This will not serve for ads for example, inside a TV App, or the TV web browser. Moreover, all of the above are closed platforms/services which only serve ads to compatible platforms.

A study of iTVCs produced with these platforms yielded features that most ads possess. The “always” column in Table III) guided our prototype system.

TABLE III
COMMONLY USED FEATURES OF DESTINATION (MICRO-SITES)

Feature	Always	Often	Sometimes
Intensively Graphically Branded.	X		
Graphics & Animation rich	X		
Music Soundtrack		X	
Audio Narration		X	
Sound Effects	X		
Interactive Menus	X		
Game / Contest			X
Signup Form (e.g. for a newsletter)			X
Textual Information about the product	X		
Extensive Information about products	X		
Utilizes Social buttons (Like box etc)		X	
Playable On-demand Videos		X	
T-Commerce (e.g. order online now)			X

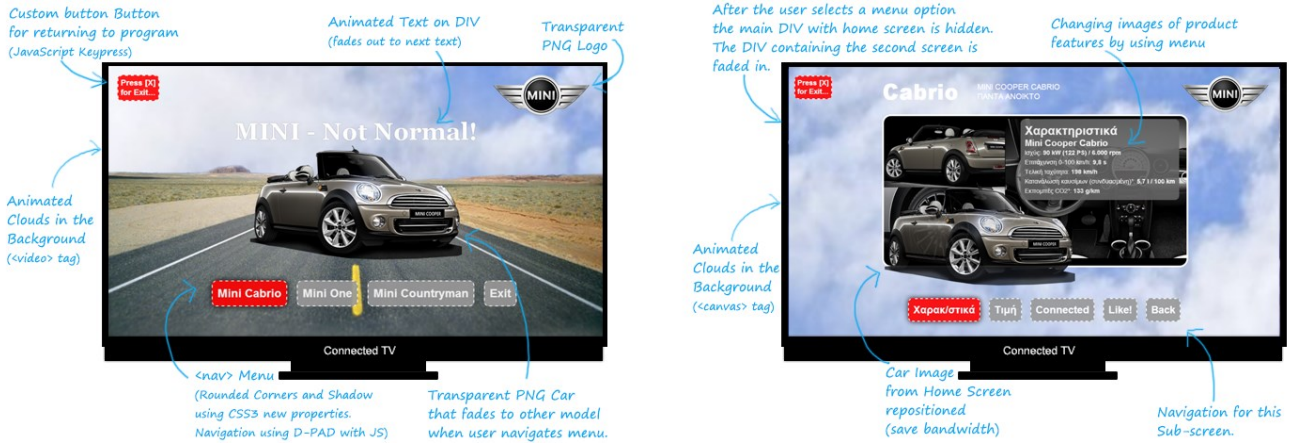


Fig. 1 Screenshots of the iTVC

III. PROTOTYPE iTVC

As a proof of concept and expanded from [12], an iTVC was developed, using only web technologies (Fig.1). The first part of the ad could be either a clickable banner or a “30-second spot”. Technically, the 30-second spot is a normal HTML5 page that has a full screen video in the background using the `<video>` tag, a music soundtrack and some car sound effects using the `<audio>` tag, and a sequence of text sentences in the foreground layered and faded-in and out on top of the video. The fade-in and fade-out effects are produced using the jQuery library which animates the CSS3 opacity property. The viewer watches part of the TV spot but s/he has the option to press a button on the remote control in order to continue to the second part. The button can be tracked using JavaScript onKeyPress events. If the user presses the predefined button it will redirect to the destination.

The destination is the main interactive part of the iTVC. It is composed of navigation menus and a number of screens for the main page and each menu choice. It is a single HTML5 page with a number of main DIV (division) layers that, depending on the user’s actions, are hidden or shown using JavaScript. Each of these main DIVs contains all elements of each screen. A standard menu is displayed on the main screen so the user can select a product for which he wishes to see more information.

The background for all screens is a video sequence of time-lapsed clouds in order to have a continuous sense of motion. This background video feature was not present in any of the commercial interactive ads examined. Since it is an HTML5 feature it is possible that it will not render on all connected TVs. A fallback strategy will show static clouds on unsupported devices. Alternatively, JavaScript can animate the background or Flash can be used. The menus can be navigated using the arrows on the remote control, where KeyPress events are traced with JavaScript and the current menu choice is highlighted by changing the CSS properties of box-shadow and background-color.

IV. DEVICE PLATFORM EVALUATION

Three connected TV devices are considered in this work (Table IV). Google TV is a set-top box, and represents the devices that add connected TV capabilities to any TV. It has

more powerful hardware, compared to the other two devices and runs a special version of Android [13]. The Samsung Smart TV is representative of a typical TV device with Smart-TV capabilities [14] being developed by most major TV manufacturers. The particular model is a mid-range one, which means that the hardware is relatively limited. The Nintendo Wii is a popular but dated game console. Due to hardware limitations and the limited capabilities of the web browser, this device represents the low-end for testing purposes [15] and would be useful for testing fallback strategies.

The system was developed on a desktop personal computer.

TABLE IV
WEB STANDARDS COMPATIBILITY OF THE 3 PLATFORMS

Device	GoogleTV (Sony nsz-gs7)	Samsung smartTV (2012)	Nintendo Wii
Performance	Middle-End	High-End	Low-End
Description	A set-top box with high-end hardware.	A TV with embedded Smart TV capabilities.	Popular but dated device, low specs.
OS	Android	Smart HUB	Linux (custom)
Browser	Chrome	Maple	Opera
HTML	FULL HTML5	FULL HTML5	Limited HTML5
CSS	CSS3	CSS2	CSS2
JS	YES	YES	YES
Remote Control	Remote with touchpad and Qwerty Kbrd	TV Remote	Wii Motion Controller

It was tested using the Google Chrome browser and then on each of the three devices. The final version was compatible with all three devices. Overall, the iTVC was able to run on all test devices with most visual features displayed correctly, providing responsiveness to user commands of less than 1 second for the GoogleTV/Samsung and a larger response delay of about 2-3 seconds for the Wii (Table V). These results compare favorably with the 0.1 to 1 second limit for keeping the user’s flow of thought uninterrupted, and, indeed, to the 10 seconds threshold to keep the user’s attention [16].

A. Technical observations

Table V summarizes the technical observations.

TABLE V
RESULTS OF AD PERFORMANCE ON DIFFERENT DEVICES

Device	GoogleTV (Sony nsz-gs7)	Samsung smartTV	Nintendo Wii
Resolution	1024 x 577	1280 x 609	800 x 472
CSS3 effects	Supported	Supported	Partially Supported (except Shadows)
Text animation	Supported	Supported	Supported
Video	Smooth (fps ≥ 30)	Smooth (fps ≥ 30)	Not Smooth (fps ≤ 20)
Audio	Supported	Supported	Supported but disjointed
Navigation Controls	D-PAD and Qwerty	D-PAD	Wii-remote
Interaction Responsiveness	Uninterrupted ≥ 0.5 sec & < 1 sec	Uninterrupted ≥ 0.1 sec & < 1 sec	Frequent Delays ≥ 1 sec & < 2 sec
Overall Performance	Smooth (but slow on scrolling BG)	Smooth	Disjointed
HTML5Score[18]	354/555	283/555	82/555

1) Google TV (on Sony NSZ-GS7 set-top box)

Google TV supported all visual features, at display rates of over 30 frames per second/fps, and was responsive to user commands within 1 second). This performance was expected as it is one of the newest devices, and is frequently upgraded. It uses a TV-optimized version of Google Chrome. Chrome as a browser offers compatibility with most HTML5 function and was able to display HTML5 video at a frame rate of greater than or equal to 30 fps, while the Sony hardware was adequate for displaying the iTVC without noticeable disruptions. One exception was the scrolling background which performed slower than with the other devices.

2) Samsung Smart TV (2012 model)

The custom Samsung TV browser offers compatibility with most major HTML5 capabilities (such as Video). The hardware performance of the device supported all visual features, displaying them at over 30 fps, and was responsive to users within a one second interval. It was able to present the iTVC without any noticeable visual or interaction disruptions. There was a need for some tweaking of the navigation elements, as the Enter key on the Samsung Remote D-Pad triggered the Click and Enter events simultaneously. This was addressed and did not cause any side-effects on other devices.

3) Nintendo Wii Internet Channel

Nintendo Wii uses a TV version of the Opera browser. The lack of video and audio support impacted the compatibility of the ad. A fallback strategy was included on the device for replacing the HTML5 video and audio tags with Adobe Flash FLV videos. In order to play the videos, a 5 year old version (3.17) of the JW-PLAYER [17] was used. Videos were converted to a lower resolution (640 x 320 pixels) and a frame rate of 15fps. This was obvious visually. The device supported canvas scrolling. For navigation, the D-pad on the Wii remote could not be used inside the ad as it does not produce any events visible to the browser. However, the standard functionality of the Wii-remote was compatible with the ad, and the click and hover events worked the same as with a

mouse. Overall the iTVC was workable but with noticeable limitations both visually and in terms of interaction responsiveness (delays greater than 1 second were experienced) when compared to the other two devices.

B. Discussion

The iTVC was optimized for compatibility with the three devices. Either primary or fallback solutions ran on the devices. The HTML5 syntax was very helpful in achieving compatibility. For example, the main navigation was initially implemented as a set of links on DIV tags, which did not work well on the devices that supported the D-pad navigation. Upon replacing the <div> element with the HTML5 <nav> element, D-PAD navigation worked across all tested devices. This demonstrates that the same feature-packed HTML5 ad can be compatible with different platforms, without the need to use propriety APIs.

V. USER EVALUATION METHODS

A. Participants

36 students and academic staff (13 male) from a higher education institution in Crete, Greece participated. Their ages ranged between 20 to 35 years. All were relatively unfamiliar with interactive Internet TV devices, although most had some IP-TV experience. All were experienced Internet/PC users.

B. Dependent measures

Subjective metrics were adapted from ad evaluation. System response metrics were also collected.

1. Usability: We used an adapted version of the System Usability Scale¹ [19].
2. Likeability: Whether the users liked the ad.
3. Recall: If the users remember important parts from the ad. In [20], we showed that Information Recall in multimedia clips can vary according to different Quality of Service parameters (such as frame rate). Accordingly, it was of interest to explore whether recall varies with the different platforms with different rendering capabilities.
4. Open-ended questions: User could state up to 3 things s/he liked about the ad and up to 3 things s/he did not like.

C. Procedure

The participant sat on a sofa and watched the iTVC on a 40 inch TV linked to the connected TV device being tested. The main control functions of the device were explained to the user and s/he was allowed 2 minutes to familiarize him/herself with them. The following directions were given:

"You will be watching a TV series on TV; at some point it will be interrupted by a TV Commercial. This is a normal TV commercial but you also have the option to enter an interactive part of it. Please enter the interactive Ad by pressing the [X] button on your remote when the instructor asks you."

The participant was asked to sit on the couch chair and watch the program (a short film) on the device. The film was then interrupted after 1½ minutes for a commercial break, at

¹ Available at <http://www.e-bilab.gr/wp-content/uploads/2014/10/ITVA-questionnaire.pdf>

which point the pre-interactive commercial (30-second spot) was displayed and the user was asked to press a button to enter the iTVC. Simple tasks were performed inside the ad:

“Take a look around and then find the price of the ‘Cabrio’ car. Then ‘Like’ it on Facebook and finally find out more about the ‘Mini Connected’ feature”. Upon completing these tasks, please exit the Ad to return to your TV program.”

After the user returned to the TV program, s/he continued to watch the program for 5 more minutes and the session ended. The participant completed a modified SUS questionnaire, a liking questionnaire and a recall questionnaire. Finally, each user answered 3 open-text questions.

D. Experimental Design and Data Analysis

12 participants were randomly assigned to each device. Data were analyzed with the Statistical Package for the Social Sciences (SPSS). An Analysis of Variance (ANOVA) was applied to analyze the participants’ responses.

VI. RESULTS

A significance level of $\alpha = 0.05$ was adopted for the study. Results are summarized in Table VI.

TABLE VI
USER TESTING RESULTS WITH THE 3 DEVICES (MEANS AND STD DEV)

Device	SUS Score	Like iTVC	Like the Look of iTVC	Found iTVC Informative	Correct Recall (Out of 5)
Google TV	75.62	4.50 (0.90)	4.50 (0.90)	4.17 (0.94)	3.58 (1.08)
Sam-sung	83.75	4.58 (0.52)	4.50 (0.91)	4.58 (0.52)	2.75 (1.05)
Wii	76.87	4.25 (0.75)	4.00 (0.85)	4.42 (0.52)	3.08 (0.79)

A. System Usability Scale Score

The System Usability Scale scores across the three devices were not significantly different even though the Samsung TV handles the scrolling HTML5 background at a little higher frame rate and the response times for user commands were a little shorter. All devices scored above 68 which is considered a threshold for good usability on the SUS test [19].

B. Likeability

For the three likeability questions (liking the ad (in general), liked the visual aspects of the ad, and finding it informative), there were no significant differences between the devices. The conclusion was that the users liked the iTVC regardless of the device.

C. Recall

There were no significant differences for the devices with respect to recall.

D. Open-Ended Questions

Three users reported that they were annoyed by the performance (speed) of the ad on the Samsung device while only one reported the same thing on the (slower) Wii device. Also, there were two complaints about a video that was played inside the ad (Mini Connected) but only for the Wii device, which was not surprising, as it had loading issues. In general, most users liked the visuals, the music and the interactivity of the ad. Three did not like them on the Wii device, probably due to the low video quality and lower screen resolution. Overall, there were no major complaints for any device, but most were for the Nintendo Wii, as expected.

VII. DISCUSSION

As more advanced hardware is available at lower prices, and Smart TV capabilities are integrated into an increasing number of devices, iTVCs are set to play a major role in the advertising industry. Here through developing and evaluating a prototype, we addressed whether an HTML5 iTVC can (i) run effectively on different connected TV platforms and (ii) offer a consistent user experience across these platforms. The results showed that, for the system in question, both of the above premises were true. All tested hardware systems, although very different, managed to run the iTVC effectively, without the need to use any device-specific APIs. However, users seemed to clearly like the iTVC and found it easy to use on all platforms, regardless of differences in the performance characteristics of the different input devices.

TABLE VII
DEVICE-SPECIFIC APIS COMPARED TO WEB STANDARDS FOR DEVELOPING INTERACTIVE TV COMMERCIALS

	Device-specific APIs	Web Standards
Coding Language	Developers have to learn the language for each different platform. Sometimes this can be Javascript but with different API to be learned for each platform.	HTML5, CSS and JS are very popular and most developers have already experience on these languages, enabling them to develop these TV Ads immediately.
Development Environment	Some platforms need for the developers to learn and use a specific IDE while others make possible the use of a standard web editor or event text editor.	The developer can use its preferable text or web editor environment. So again, no learning curve here.
Deployment	Every platform has its own process for packaging and deploying the iTVC, usually through an Ad-Service.	Can run through the Web Browser of any device. In some cases it could also be deployed using platform-specific packaging.
Features	Can utilize Video, Audio, Controllers, animation etc. using the device API. Also, this guarantees that all device-specific features can be utilized (e.g. a special controller)	Can utilize Video, Audio, Controllers, animation etc. using HTML5, CSS3 and JS. Using these, the iTVC will have all the standard interactive features. However, in some cases a specific device feature may not be accessible.
Performance	Performance using the device APIs is expected to be the maximum possible.	The performance will probably not be the maximum that can be achieved using the APIs, as there will possible not be more middleware between the iTVC and the device hardware.
Compatibility	The iTVC has to be explicitly re-developed for each device/platform. Each version can only run on a single platform.	The same iTVC can run across every TV platform with a web browsers. In most cases, it will also run well on new and untested devices, since all new devices now support web standards.
User Experience	It could easily be assumed that User Experience on the API-developed Ads would be better. This however, was not tested on this paper.	However, cross-platform User Evaluation of the same Web Standard iTVC showed very little to none perceived differences by the users, regardless the performance differences.

The example prototype was a simple iTVC, encompassing the most common features that these ads share. There were no significant differences across the three diverse platforms with respect to usability, likeability and memorability/user recall. This highlights a relatively seamless cross-platform user experience although it is not clear whether this was due to the novelty factor of the application tested. Table VII shows a comparison of using Device-specific APIs compared to Web Standards, with conclusions drawn from this research. Web Standards thus seem the way forward towards cross-platform interactive TV.

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