Smart TV – Smartphone Cooperation Model on Digital Signage Environments: An Implementation Approach

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***Abstract*—Modern pervasive digital signage environments demand capabilities beyond the interaction schemes, frequently implemented throughout personal area network technologies or touchscreen features. Smart TV emerges as an interesting alternative model for public displays and Smartphone cooperation, in order to implement a multi-screen approach that complements the task of ads recommendation algorithms for a group of people watching the screen. This paper introduces an implementation approach for a Smart TV – Smartphone cooperation model in digital signage environments using a multi-screen paradigm.**

Keywords - Pervasive advertising; digital signage; Smart TV; cooperation model.

I. Introduction

Advertising has played an important role in the commerce from its origins; as part of the promotion, one of the marketing areas, the advertising is defined as "any paid form of non-personal presentation and promotion of ideas, goods or services by an identified sponsor" [1]. Recently, a new paradigm known as pervasive advertising, which refers to the use of pervasive computing technologies for advertising purposes [1], has arisen as a promising bet for modern advertisers and consumers. Although most of pervasive advertising approaches has been addressed to mobile devices (Smartphones or tablets), even the public spaces are very interesting for the industry, taking into account that the 75% of the purchase decisions are taken at the purchase places or near of them [2]; this field, known as Digital Signage, it is related to digital content display using public screens [3].

Traditionally, the public screens have been static and non-personalized devices, but modern approaches have enabled the public displays inclusion on pervasive environments. Specifically, the Smart TV model emerged in 2010 throughout the initiative of big vendors such as Samsung, LG, Sony and Intel to build televisions and set-top boxes with more processing power and a better Internet integration [4]. The results for this emergent model are not only limited to free internet access and customization capabilities throughout applications download, but also a valuable capability for connecting and sharing content via standards like Universal Plug and Play (UPnP) or Digital Living Network Alliance (DLNA) [5] with other devices like Smartphones or tablets; this feature is extremely interesting for advertising environments. Although several researches have developed interaction schemes between public displays and mobile devices using personal area network technologies like Bluetooth or Near Field Communication (NFC), even the research for Smart TV model incorporation is incipient. On the other hand, pervasive digital signage environments face other challenges related to customized ads for a group of people watching the screen; traditionally, this issue has been addressed from Recommender System (RS) perspective, which applies search and information filtering techniques to provide users with personalized suggestions about a set of items in a particular domain [6]. However, the perceived serendipity and accuracy about ads recommendations may be not only a matter of the RS algorithm itself, but also a better display strategy issue. Most of public displays interaction initiatives do not consider multi-screen approaches were the content is distributed between the screens in a complementary way; a screen content replication has been used instead.

This paper proposes an implementation approach for a Smart TV – Smartphone cooperation model in digital signage environments using a multi-screen paradigm supported on a flexible protocol. Section 2 summarizes some related work. Section 3 presents a reference architecture for the proposed cooperation model and summarizes some aspects related to the protocol design. Section 4 describes some experimentation results from the user perceived satisfaction perspective. Finally, Section 5 provides some conclusions and future work.

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II. STATE OF ART

The research about pervasive advertising involves several interesting topics related to the most important challenges in its implementation. Although several research works have focused on mobile environments where mobile devices are the main tool for advertising purposes, the modern digital signage environments demand the study of new interaction schemes between Smartphones and public displays. Next, some relevant works related to the context of this article will be presented.

At first, some interesting experiences about interactive public displays have been developed around the world. For example, the University of Oulu, in Finland, installed thirteen interactive LCD-screens in several public places across the city, which have been updated and studied since 2009 [7]. The users could interact with the screens by using the touchscreen or their mobile devices. In a similar way, the University of Lancaster, England, installed interactive displays in the small village of Wray [8]. The displays allowed people to upload photos about the village's history and later some capabilities for advertisements uploading about village's services and products were added. Meanwhile, the University of Stuttgart in Germany developed an interesting study about the factors for a successful public digital display environment for advertising purposes [7]. However, these experiments neither consider the use of Smart TV as Interactive Public Display nor interaction schemes throughout Smartphones that enable multi-screen features.

On the other hand, several approaches have been studied for years about content adaptation and collaboration schemes. For example, [9] analyses the interaction between Smartphones and public displays throughout gestures that are used during a screen replication and [10] introduces a touch screen interaction supported on NFC capabilities, but a collaborative interaction between devices is not considered in both approaches. Otherwise, [11] outlines an overview of some functions for a Smart TV – Smartphone interaction, but a reference implementation is not provided. Other researches consider some collaboration models for including zoom functions for the main screen content on the mobile devices [12][13] and some of them consider some phone sensor functionalities [14][15]. Nonetheless, the pervasive advertising in public spaces faces other challenges related to personalized recommendations when a group of people is watching the main screen. Traditionally, this issue has been addressed from the Recommender Systems perspective. Regarding to group recommendations several approaches have been developed: Jameson [16] analyses the issues related to groups recommendations and Masthoff [17] discuss some strategies known as aggregation techniques, which try to aggregate (averaging) individual preferences models in order to create a group model to deliver the recommendations. Other systems related to this approach, like Polylens [18], a particular MovieLens system version, recommends movies based on an algorithm that combines recommendation lists for individual users and sort them in decreasing order. Other similar approaches may be found in [19][20]. Carolis [21] developed a proposal for a pervasive advertising environment using an aggregation approach for recommending ads to the people working at a gym. The ads were displayed on public screens an also on mobile devices but basically they were replied and there was no an interaction mechanism between them. The context of this paper analyzes the personalized ads recommendations provision in public spaces throughout a Smart TV – Smartphone cooperation approach that complements the RS perspective, in order to improve the users perceived satisfaction using interaction and multi-screen display approaches that favors the RS algorithms results assimilation.

III. COOPERATION MODEL REFERENCE ARCHITECTURE

According to the state of art, traditionally the digital signage spaces use public displays with static information following a broadcast approach or some interaction approaches using mobile devices, but they do not use a multi-screen paradigm, so the smartphone or tablet screen capabilities are somewhat wasted. The cooperation model architecture proposes a Smart TV – Smartphone cooperation scheme in which the Smart TV behaves as a public screen displaying recommendations adapted for the group of users that are in front of the TV as long as the Smartphone screen is used to display ads according to the preferences of each user individually. The purpose of this scheme is to take advantage of the full capabilities of each device, using a multi-screen cooperation paradigm, so the TV information is not replied to the Smartphone screen; instead, a complementary information about ads is always displayed on the mobile device, offering more details about a specific offer in the TV screen or giving a more personalized set of items according to the individual profile of the user. Figure 1 shows the reference architecture proposed for Smart TV-Smartphone cooperation model.

A Recommender System (RS) is used for ads suggestion on both Smart TV and mobile device screen. The RS applies search and information filtering techniques to provide users with personalized suggestions about a set of items in a particular domain, in this case advertising. Specifically, a User x User collaborative filtering approach [6] was used for customizing ads on Smartphones and aggregation techniques were used to deliver the recommendations on the Smart TV; in simple terms, the aggregation techniques try to average individual preferences models in order to create a group model [17] as it was previously defined. Although the RS techniques description is out of the scope of this paper, from the RS perspective, the expected results are extremely interesting because this display scheme favors the precision for the ads in the Smartphone. Also, a larger extent of serendipity may be perceived for the recommendations on the TV screen, because the RS uses aggregation techniques for trying to satisfy the preferences of a group of users. So, the recommendations may not be enough accurate for each user, but they may result on novel ads instead, something valuable for pervasive advertising environments with persuasion purposes.

A reference implementation for this model was developed using the Apache Mahout framework [22] for the RS and Samsung Smart TV SDK [23]; mobile application was implemented over the Android platform as long as a simple Representational State Transfer (REST) Application Programming Interface (API) was developed to handle the communication between RS and applications of Smart TV and Smartphone. The communication between the Smartphones and the Smart TV for interaction purposes was enabled throughout the UPnP protocol [24].

According to previous description, a loosely HTTP-based protocol was designed to support multiple user interactions. Standard Simple Service Discovery Protocol (SSDP) [25] messages were used to discover Smart TV Devices in order to be compliant with Samsung Smart TV SDK and Convergence Framework restrictions. A full protocol messages description may be complex for the scope of this paper, so a special emphasis will be done about the discovery, authentication and pairing mechanisms, which are essential processes to start a two-way interaction between the Smart TV and Smartphones under a multi-screen paradigm.

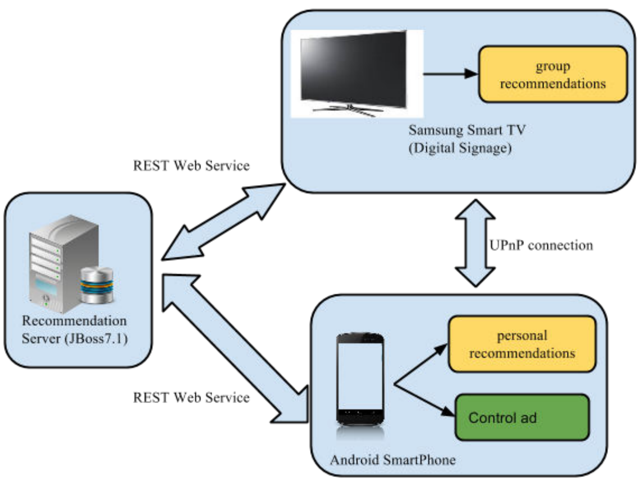


Figure 1. Smart TV – Smartphone cooperation model.

A. Discovery

Throughout this process, the Smartphone application looks for available Smart TV devices. SSDP messages defined by the UPnP standard must be used according to Samsung Smart TV Convergence Framework. A list of discovered devices is shown to user at the end of process. The complete messages flow is shown in Figure 2.

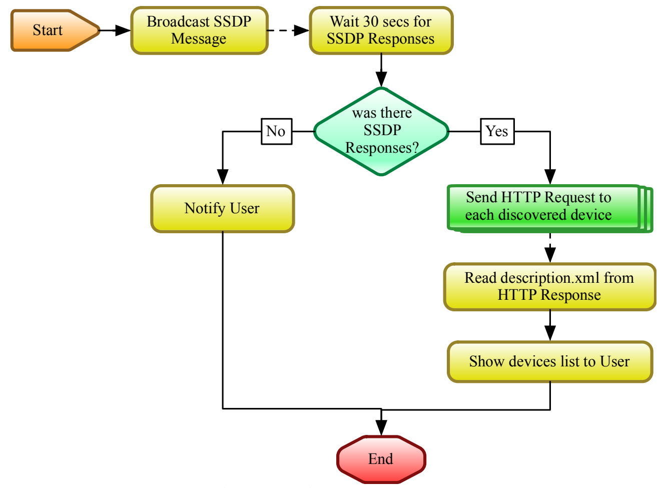
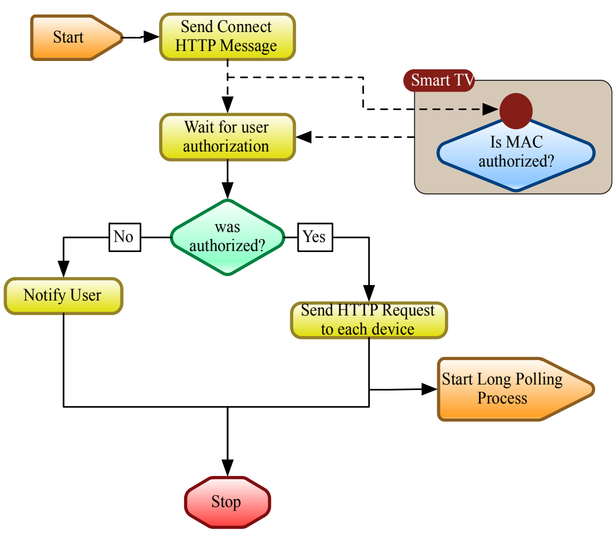


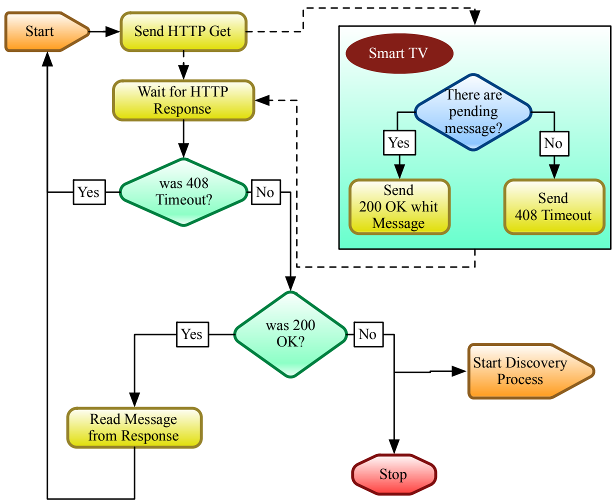
Figure 2. Discovery process.

B. Authentication and pairing

In this process, the Smartphone application requests a connection with the Smart TV. In order to be compliant with Samsung Smart TV Convergence Framework, the Smart TV device authenticates the mobile device using the MAC address (Figure 3.a). Once authorized, Smart TV and Smartphone start a long polling process to keep the connection alive (Figure 3.b).



(a)



(b)

Figure 3. Authentication and pairing.

C. *Login*

A login process is required to identify the user in front of the Smart TV screen, so the ads may be customized for the group and individual profiles by the RS accordingly. A "login with Facebook" approach was used to make the process easier and transparent for the users. Once the user login has been completed successfully, the system assigns a color id to each connected smartphone in order to identify all users interaction with the ads on the screen (Figure 4).

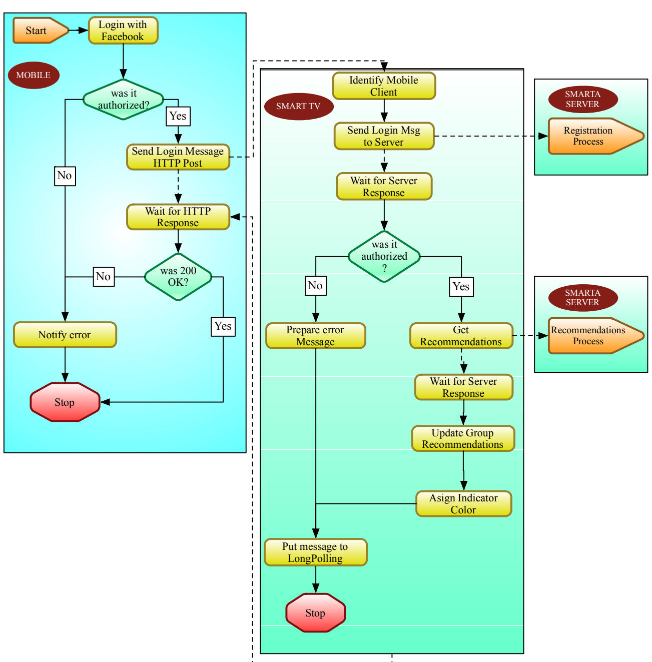


Figure 4. Login.

The other protocol messages were designed as a template for the business logic messages required for a particular advertising application. The messages transport user actions information such as ads retrieval, ads rating or ads publishing to screen, by encoding this content using Java Script Object Notation (JSON). Table I shows a detailed package example for posting ads from the Smartphone to the Smart TV.

IV. EXPERIMENTATION

A small prototype for experimentation purposes was developed and tested in an academic environment. The prototype basis was to implement an electronic alternative to a traditional static ads board, where users post ads using paper posters; these boards are frequently found in small shops or academic campus. The alternative implementation replaces the old board by a new cooperative Smart TV – Smartphone model, where both devices screens are offering ads to users under different but complementary approaches: ads recommendations for group profiles on TV screen and ads recommendations for individual profiles on the Smartphones screens. Moreover, interaction capabilities between both devices were provided to change the static behavior of the traditional board.

In summary, the prototype application included the following functionalities: ads recommendations for a group of users watching the TV screen; ads recommendations according to individual preferences on the Smartphone screen; basic interaction between Smartphone application and Smart TV to go over the ads on TV screen from the mobile application and detail the information for a particular ad in TV screen on the Smartphone screen; post ads to system from the mobile application, mark ads as favorites and rate ads (Figure 5). Alternatively, the interaction protocol detects the users activity, so a list of top ads is displayed on Smart TV when no interaction is detected.

TABLE I. AD POST MESSAGE.

<table>
<tr><td colspan="3">Ad post message request</td></tr>
<tr><td>Source – destination</td><td colspan="2">Smartphone - Smart TV</td></tr>
<tr><td>Type</td><td colspan="2">HTTP POST</td></tr>
<tr><td>Path</td><td colspan="2">http://TV_IPADDR/ws/app/SMARTA/connect</td></tr>
<tr><td rowspan="2">Path parameters</td><td colspan="2">TV_IPADDR: Smart TV IP address</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td rowspan="8">HTTP Headers</td><td>SLDeviceID</td><td>Random sequence of 10 alphabetic characters</td></tr>
<tr><td>ProductID</td><td>SMARTDev</td></tr>
<tr><td>VendorID</td><td>VendorMe</td></tr>
<tr><td>msgNumber</td><td>Auto incremental sequence number for the message</td></tr>
<tr><td>Content-Type</td><td>application/json</td></tr>
<tr><td>Connection</td><td>Keep-Alive</td></tr>
<tr><td>Accept</td><td>*/*</td></tr>
<tr><td>Accept-Encoding</td><td>gzip, deflate, sdch</td></tr>
</table>

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	Accept-Language	es,en-US;q=0.8,en;q=0.6
	Transfer-Encoding	chunked
	Content-Length	Number of sent bytes in JSON format
Content	{ "type":"post", "title":"post title", "content":"post content", "img_url":"http://someurl.com" }	

Ad post message reply		
Reply codes	200	Accepted connection
	403	Not authorized to receive messages.
	404	Unknown APP_ID.
Reply content	{ "type":"post", "posted":"true/false" }	

At a first stage of the experiment, a group of 26 students from the Tourism program of University of Cauca, posted items and rated almost all of them using an alternative system, even without interacting with the Smart TV and Smartphone cooperation framework. The objective of this first phase was to build a low sparse and editable dataset to make offline tests about the performance of some RS algorithms, previously to online tests. In a second phase, a group of about 50 students posted and rated items in a 1 to 5 scale, using the Smart TV - Smartphone cooperation structure. During this phase, groups of four people were configured randomly to interact with the Smart TV using an Android Smartphone during about five minutes. During this time, users watched the ads recommendations on both screens and used the prototype functions described previously; the number of people per group was a restriction imposed by the UPnP protocol handling of Samsung SDK, but it was considered enough by experimentation purposes. Figure 6 shows some latency results for Smartphones – Smart TV connections and Figure 7 shows the estimated latency for getting ads detailed information in the Smartphone from server, once the user has chosen and ad from Smart TV screen. The tests were performed using a WiFi connection, a Samsung Smart TV 6 Series and Samsung Galaxy and LG Nexus phones with Android 4.2 or above.

At the end of the session, each student filled out a survey form where they were asked explicitly about the perceived satisfaction regarding to the ads delivered on both Smart TV and Smartphone screen. The following analysis will be focused on these results, taking the three aggregation techniques defined by Masthoff (Table II) and tested during the experiment as a starting point; the purpose is try to infer which technique supposes a better connection between the proposed Smart TV – Smartphone cooperation model and the Recommendation System.

Figure 5. Smart TV - Smartphone prototype.

The survey results showed good levels of perceived satisfaction about the ads accuracy using this cooperation scheme between TV and Smartphone screens. However, a deeper analysis was performed for the perceived satisfaction from a group profile perspective, a challenging issue for this kind of digital signage environments. Table III shows the results for the perceived satisfaction for the three techniques.

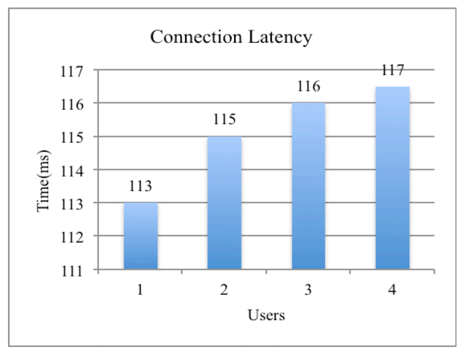

Figure 6. Connection latency.

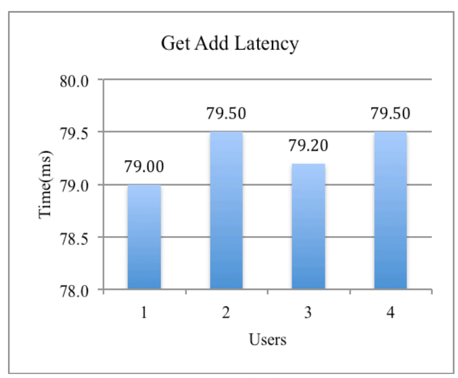

Figure 7. Getting ads latency.

TABLE II. SATISFACTION PERCEPTION.

Test No.	Aggregation technique	Description
1	Additive	Ratings are added; the larger the sum the earlier the alternative is recommended
2	Less Misery	Make a list of ratings with the minimum of the individual ratings; items are recommended based on the rating on that list, the higher the sooner. The idea is that a group is as happy as its least happy member
3	Most pleasure	Make a list of ratings with the maximum of the individual ratings; items are recommended based on the rating on that list, the higher the sooner.

The mean value suggests that less misery technique offers a best-perceived satisfaction value for users; however, it is important to find out if this difference is meaningful. Each technique was tested for a different group of users, so it is required to compare the mean difference in two independent samples. The goal is to define if the satisfaction expressed by users using a less misery technique is significantly higher than Additive or Most pleasure techniques respectively; this analysis was performed using the Two sample t technique, which is frequently used to compare whether the average difference between two groups is really significant [26]. According to this, a null hypothesis should be considered to carry out the test; in this case there are two null hypotheses: the first one proposes that the satisfaction perceived when additive technique is used, is the same when a less misery technique is used; in the same way, the second one involves less misery and most pleasure techniques. In both cases there is an alternative hypothesis, which proposes that less misery strategy offers the best-perceived satisfaction value.

TABLE III. SATISFACTION PERCEPTION.

Aggregation technique	Sample size	Mean	Standard deviation
Additive	16	uA = 3,375	0,957
Less misery	18	uLM = 4,056	0,725
Most pleasure	14	uMP = 3,5	0,941

Table IV shows the analysis results for both hypotheses using a significance level (p) of 5%; a p-value lower than 0.05 is a statistical evidence that approves the alternative hypothesis over the null hypothesis.

TABLE IV. 2 SAMPLE T RESULTS FOR PERCEIVED SATISFACTION.

Test	Null hypothesis	Alternative hypothesis	p-value
1	uLM = uA	uLM > uA	0,014
2	uLM = uMP	uLM > uMP	0,040

For both tests, p-values were less than 0.05; it means there is a meaningful difference about the perceived satisfaction by the users using less misery in contrast with additive or most pleasure techniques. These results suggest that perceived satisfaction about ads recommendations for the group improves when less misery is provided to the least satisfied of its members. In this sense, the contribution of the Smart TV – Smartphone cooperation model is very relevant, because even the least satisfied member of the group has the alternative to find more customized ads recommendations on his Smartphone screen, which seems to increase the perceived satisfaction.

V. CONCLUSION AND FUTURE WORK

This paper proposes a Smart TV – Smartphone cooperation model for digital signage environments using a multi-screen and interactive approach for ads recommendations display. The design of a loosely coupled and simple protocol based on HTTP using a RESTful style and UPnP packets, provides a scalable and compatible framework for the cooperation model implementation.

On the other hand, although the recommendations to groups have been a challenging issue on digital signage environments, it has been addressed frequently from RS algorithms perspective, but the Smart TV – Smartphone cooperation model offers an alternative to complement the RS algorithms task from an information display approach. The experimentation suggests that less misery aggregation technique offers the best results in this kind of digital signage environments regarding to perceived satisfaction by users, taking into account that even the least satisfied user has the chance to improve the perceived accuracy of group recommendations displayed on TV, using his Smartphone screen.

Future work is related to the cooperation model evolution towards a more distributed middleware that overcome some restrictions related to the number of supported users and some intermittent behavior during pairing and connection mechanisms observed during the experimentation with Samsung Smart TV Convergence Framework.

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