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Enrichment of Interactive Digital TV using Second Screen

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ABSTRACT
In this paper, the new paradigm of the second screen in interactive digital television (iDTV) is discussed and analyzed through a systematic literature review. An architecture is proposed for the use of mobile devices as a second screen, so interactivity sent via broadcast can be also used in mobile devices, in a contextualized and synchronized fashion. A prototype was implemented in two modules: the first one to primary screen (TV) with the remote control and the other for second screen in order to compare their use.

General Terms
Digital TV, Ubiquitous Systems, Digital Convergence, Mobile Devices, Systematic Review

Keywords
Interactivity, Second Screen, Dual Device, Middleware Ginga, SBTVD, DTV, iDTV, DVB-MHP, Smartphone, Tablet, Android, Remote Control, Home Network

1. INTRODUCTION
The introduction of Interactive Digital TV (iDTV) creates a new paradigm on how we watch television, it starts to function as a bidirectional communication channel, where television can send information to the viewer and vice versa. The main new feature of digital TV is interactivity, allowing applications like t-commerce, t-learning, games and additional information about a program, sent through broadcasting. However, the remote control was developed in a scenario where the television worked as a unidirectional communication device, where the viewer would only consume the information sent.

The iDTV is related to computer technologies and internet and will offer a user experience quite different than the traditional user experience model for televisions [14]. Therefore, this brings a new question about the remote control: "Would it be the most appropriate device to interact with the television?" This is a work in progress that aims to analyze the use of mobile devices as a mean of interaction with television and its interactive applications.

The remote control used in analogue TV still prevails [23], but its model may not be enough for users who have constant and dynamic interaction with iDTV. The popularization of these interactive services directly depends on the physical artifacts available for interaction [23]. The remote control has been adapted to be used in the context of iDTV and several buttons were added, making it difficult to use and to recognize, especially for the elderly and children [18]. The interactive applications are limited for simultaneous multiusers, due to only one user having the control of the content presented at a time [5]. The interactive application that overlaps the television programming can be intrusive and invasive for collective use.

New researches have emerged proposing improvements to interaction using alternatives devices, such as joysticks, touchpads, pointing devices or mobile devices [7]. Since digital TV started offering interactive services, mobile devices began to gain space in this digital convergence. Watching television in conjunction with the use of a second screen has become increasingly popular because these devices are more accessible and disseminated [6][17][1]. This motivation arises from the increasing digital convergence and the need to always provide innovative services for home users [21]. A research from The Nielsen Company and Yahoo! Inc [27] shows that 42% of tablet owners and 40% of smartphone owners use their devices while watching TV. Although these interactions are common, these devices are not integrated with each other [10].

The second screen approach enables an intuitive interaction between TV and any other mobile device (smartphone, tablet, laptop, PDA – Personal Digital Assistant). This model offers an opportunity to transfer the application to the second device, making the user experience more pleasant and personalized. The main program is shown on the television (primary screen) and the interactive content in a second screen, synchronized and contextualized [12]. This approach aims to overcome the current limitation of input devices and enrich the user experience.

The remaining of the paper is organized as follows. In Section 2, a systematic review of the literature is presented, including articles about iDTV interaction with mobile devices. In Section 3, the proposed architecture is presented. In Section 4, a prototype implementation is discussed, using as a case study a nutritional evaluation system, followed by the conclusion in Section 5.

2. REVIEW OF LITERATURE
To perform a balanced and objective overview of related work, a systematic review of literature (SRL) was made. A SRL is a way of identifying all relevant research available according to a research question [3], using a well-defined methodology [16]. All researches with the objective to improve interaction with iDTV using mobile devices were considered relevant work. The research question that guides the systematic review consists of:

Which solutions are being proposed to improve the interaction with TV using mobile devices?

The keywords used for the search in this systematic review were as follows: *television OR TV OR DTV OR ITV OR iDTV OR TVD OR TVDi) AND (tablet OR smartphone OR "cell phone" OR "remote control" OR "mobile device" OR "second screen" OR "secondary screen" OR "smart home" OR "mobile handset" OR "input device" OR multidevice OR "multiple device" OR android OR ios OR "windows phone" OR "mobile interaction" OR "dual device" OR "handheld device" OR "digital convergence" OR "cross-platform"*. Data collection was conducted during October 2012 and the sources were scientific databases in computer science. Thirteen researches were selected ([2] [4] [8] [11] [13] [15] [19] [20] [21] [22] [25] [26] [28]), and were divided in two main categories: focused on remote controller and focused on second screen, described in details in the following section.

2.1 Remote Control

The researches that aim to improve the remote control have as main motivation the improvement of the navigation in Electronic Program Guide (EPG), the using of remote control with eyes-free and the sending of messages to TV programs. The smartphone was the most used as prototype, followed by laptops, pockets PC and PDAs. All the prototypes where implemented in Java. Set-Top Boxes (STB) [15][25], computers as Media Center [20] and TVs with operating systems (Android and Linux) [19][28] were used as the main servers to receive and execute messages sent from mobile devices. Some prototypes of remote controls are shown in Figure 1, the prototype (A) refers to [19], developed to send messages to a TV program, (B) refers to [25] and implements an EPG and (C) refers to [28], that is similar to a traditional remote control and have the interactive buttons.

In paper [28], an average time of TV discovery and sending commands to TV were calculated. A smartphone with Android 2.3.5 resulted in a better response time to send commands to TV (24ms) and iOS to TV discovery (1123ms). The measured results were satisfying because the infrared remote control response usually takes 100ms of response time. [25] is about an exploratory study aiming to investigations participants. The evaluation showed that the prototype was easy to use, and that participants were responded positively about the multiuser approach.

Table 1, at the end of the document, compares these prototypes. The main focus, besides the switch channel function was the EPG visualization function. Wi-Fi technology is the most used technology for communication exchange, mostly because home networks are fairly widespread, especially in North America and Europe.

2.2 Second Screen

The main consumption for interactivity in second screen, according to [22] is related to the entertainment and content being broadcasted. Motivational factors were identified as: saving time, performing routine tasks more efficiently, feeling close to family and friends and entertaining oneself anytime, anywhere. The proposal is to use the second screen as an EPG, remote control, and as an access sync and asynchronous content. The architecture is defined using four main elements: the broadcast station that will deliver audiovisual and interactive content; the STB/TV that will render the content and execute the interactivity, and also delivery this interactive content to mobile devices; the mobile device that will receive the interactive content and optionally, via internet, use the return channel; and an application server responsible for managing the return channel.

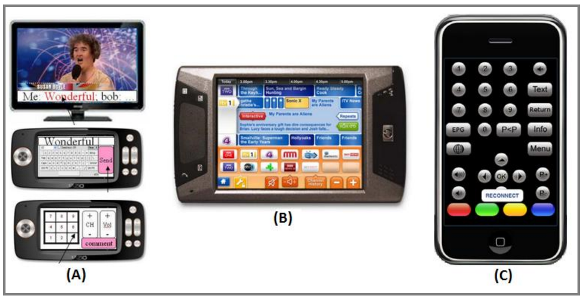

Figure 1: Some prototypes using mobile devices as remote controls

Paper [4] studies four scenarios to use a second screen: control, enrich, transfer and share. The control scenario is about navigation, content selection, preview, EPG, etc. Transfer is about continuous presenting, that means using the device as primary screen when the user moves from one room to another, for example. Share is related to social networking, making comments and sharing fragments of television content in the web.

Article [11] develops a multiplatform system for informal language learning. The project called *Television and Mobile phone Assisted Language Learning Environment* (TAMALLE) facilitates language learning using interactive digital television and mobile devices. As shown in Figure 2, a synchronous service provides related content to television and mobile device. The architecture of TAMALLE´s project suggests two solutions: the first is to develop a learning management system in an external server that provides content for both platforms. The second solution is to encode the content and interactive television program together and send it via broadcasting. In this second solution, the learning content could be recovered via DVB-MHP and through a content sharing API, and send this to mobile devices.

Figure 1: TAMALLE Project interface. Simultaneous content on the TV and mobile device.

The framework called *Multi-user Variable Remote Control iTV Service* (MVC-iTV) [26] aims to solve the control problem with multiuser. The servers in the architecture are responsible for controlling and coordinating data between TV and mobile devices. This architecture allows more than one server if many TVs are available in the home network. Data exchange happens through the wireless network, using XML documents. A prototype was implemented using the Microsoft ASP technology for developing a server. Both the TV's and devices' interface was developed using Adobe Flash.

Motivated by the lack of standard delivery of interactive content on mobile devices using the DVB-MHP in [8], a standard called Interactive Mobile Service is proposed to improve the user experience with interactive services. The standard uses the SVG (Scalable Vector Graphics), where graphical interfaces are easily scaled without loss of quality for any screen size. Interactive services are viewed on mobile devices in a Web browser developed in J2ME (Java 2 Mobile Edition). Another distinguishing feature to the project is the authoring tool that allows interactivity designing compatible with the proposed standard.

2.2.1 Recognition of devices on the network

One of the challenges about the use of second screen is the intuitive connection with the STB or TV in the home network. This subsection presents some papers showing solutions for this challenge.

Paper [13] aims to enable multiuser access and customization of interactive content on mobile devices using the UPnP framework. This framework doesn't require user configuration and automatically recognizes devices on the network. It has the following information flow: the mobile device detects iDTV services via UPnP framework, receiving the synchronization information and a list of events that are happening at that moment from STB. The applications are hosted on a server (internet or STB). With a local server in STB, no internet connection is needed to access the information.

Also concerned about providing an intuitive way to connect devices, paper [2] improved the UPnP framework. When the user connects to the network, all devices yet connected respond with an XML standard based on UPnP but with an extra tag that contains a link to a representative image of the device. All images were previously hosted in a local database. After that, the user can point the device's camera along with the accelerometer, and then a vision computer module is activated and, in real-time, processes the image and compares it to the database, and recognizes the electronic device.

The platform developed in paper [21] aims to develop a smart home with tasks like control gates, cameras, temperature sensors, printing documents linked to a TV using the middleware Ginga – from the Brazilian DTV standard. Besides the Ginga, the platform uses OSGi (Open Services Gateway Initiative) framework components. Figure 3 shows a device sending messages to the TV screen.

Figure 2: Platform built using components of the Ginga middleware and the OSGi framework

Given the systematic review, we conclude that mobile devices serve as a way to enrich the TV content used as second screen. The approach of turning a mobile device only as a remote control has helped in understanding the features and needs of users, but does not represent the best use of interactive applications. Showing the interactivity, or part of it, on the second screen can be a big difference, because studies show that reading on the TV screen can be complicated, the remote control use is not collective and the interface of applications can be intrusive on the TV screen. The main requirements of the second screen usages were multiple user support, the intuitive recognition of these devices on the home network, easy access to sync information and information share in social media.

3. PROPOSED ARCHITECTURE

The interaction involving television content and second screen already occurs, for example, when using the internet. Users can search for information or post on blogs and social networks about what's currently happening on TV at that moment. It also occurs using phone lines, through voice calls or SMS messages. However, there isn't a unified communication between mobile devices and iDTV. The current scenario of interactivity access and use of second screen is shown in Figure 4, TV and mobile devices are not integrated with each other.

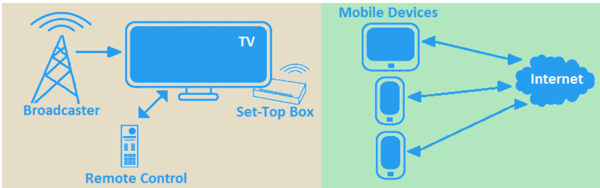

Figure 3: Current scenario for iDTV and mobile devices

In this context, the motivational factors to propose this architecture are a non-intrusive interface for iDTV, synchronized second screen application and support for multiusers. The architecture takes advantage of the data sent via broadcast and then the STB transfer the data to mobile devices through wireless network, without requiring external access, such as Internet. The internet can be used optionally to share context data. Figure 5 shows the proposed architecture.

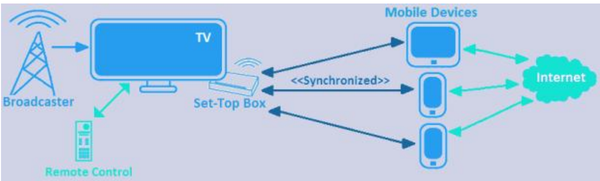

Figure 4: Architecture overview. STB and mobile devices are synchronized. The remote control and internet are optional

Each TV/STB present in a room is responsible for managing the mobile devices, independently. Each TV is a server responsible to receive message from devices, manage connections and send the interactive content. This model allows more than one television in the same Wi-Fi network without problems deciding which TV is being used at the time. As shown in Figure 5, the internet can be used optionally as return channel and to share broadcast data. For example, share a quiz result, allowing a social interaction between interactive data and social networks.

The interactive content sent by the STB to mobile devices can contain an expiration date. The expiration date is used for interactive applications that need to be synchronized with television programming. Interactive applications that do not have this validation date or timestamp are stored in mobile devices and can be viewed later and used with or without the presence of a TV/STB

As a motivational scenario, an application about a questionnaire or assessment can be made, synchronized with the TV program, where each device can respond and view the result, or show all the results on the TV screen. It's possible to share their results on social networks, if internet use is available. This scenario used for prototyping is shown below.

4. PROTOTYPING

The implementation was based in the already existing proposal of a nutritional guidance and monitoring system named Horus [24]. The chosen module for prototyping has a nutritional evaluation that's based on data given by the user, such as weekly physical activities, family obesity, blood pressure, as well as weight, height, age, etc. The evaluation is processed through a Bayesian Network that presents evaluation results as: under-weight, normal weight, overweight, and obese.

The interactive app for iDTV was migrated from an already existing web system with a form-based interface, as shown in Figure 6. On the web, all the data entry points are presented at once, some fields being selection boxes, other value entry boxes. The migration to iDTV occurred in two steps: the creation of an interactive app using the traditional remote control and the second-screen app.

Figure 5: Horus system interface on the web

The interface was adapted for television language, through an intuitive, minimalist approach, using whenever possible images as opposed to text and short text with readable font sizes. The questionnaire was divided in four parts to better use the TV screen, as showed in Figure 7. App navigation with the remote control uses directional arrows and the colored interactive buttons. The interactive application has the following flow of information: An icon in the upper right corner of the screen warns that interactivity is available. The viewer presses a button that triggers interactivity. The viewer answers approximately ten questions and the result is displayed on the TV screen.

The iDTV app was developed in Brazilian Digital TV standard, SBTVD-T, using the Ginga middleware. The implementation was made using NCL and Lua languages. Ginga-NCL module has a VMWare linux virtual machine called *Ginga-NCL Virtual Set-Top Box* containing a Ginga-NCL C++ v. 0.12.2, allowing tests using the computer to simulate the DTV. The application was first performed on the virtual machine running on a computer Dual Core 2.1 GHz, 1GB of RAM, NVIDIA 8400M GT with 256MG of dedicated memory.

The system was also executed in a real environment using a Gradient LCD TV 37 inch without embedded digital converter. The digital converter used to test was a Proview XPS-1000 STB with traditional remote control (both TV and STB can be seen in Figure 7, Proview STB is on the right side). Some negative factors were observed: The performance was worse in the STB than the virtual machine and there was an effect similar to Flicker Effect. Feedbacks from the remote actions were not immediate as the computer keyboard. To allow more than one user in the questionnaire, it was necessary to use the app sequentially, after one viewer completed the questionnaire, the second could start it, using the same remote control.

Figure 6: Adaptation of Horus system for TVDi using the main screen with remote control

The second stage of system migration was the development of the application for the second screen. The interfaces were adapted, so that the TV screen only displayed the connected users, and the nutritional evaluation is displayed on the mobile devices, as shown in Figure 8.

The flow of information was altered in the following fashion: an icon in the upper right corner of the screen indicates available interactivity. Activating interactivity, the viewer is notified of the mobile device connectivity possibility and prompted in regard to how many users. While the Set-Top Box waits connections from all mobile devices, the users can open the app on their device, type their name and press "connect". As soon as all devices are connected, interactivity commences. The viewer answers the questions and the system processes the results using the Bayesian Network, the user can view the results in the mobile devices or send it to the TV screen.

The architecture is a server-client model, where the STB assumes the server role, implemented in NCL and Lua, and the clients are the mobile devices, implemented in Android, using socket to communicate. The tests were conducted using a Samsung Smart TV along with a EITV STB with STi 7105 processor (450 MHz), 256 Mbytes of RAM and 128 Mbytes of Flash memory. The socket communication occurred through the Wi-Fi network with a specific communication protocol. Using the device's cameras it was possible to connect to the TV using QRCode, which contains information about connectivity and TV's IP. After the connections were stabilized, the STB sent content via XML documents for mobile devices.

Figure 7: Primary screen (*top*) showing instructions and who's connected and second screen application (*bottom*) in many devices

This is a working in progress and other tests will be performed to judge its effectiveness and efficiency. A survey with end users will be conducted as a future test study to compare the use of the two implementations: app with remote control and second screen, to collect feedbacks.

5. DISCUSSION

The proposed architecture has shown four main functionalities, which are:

1. Second screen content received via broadcasting by the STB and sent to mobile devices;
2. Synchronous and asynchronous interactive content
3. Use of multiple TVs in the same Wi-Fi network. Each mobile device connects to the TV/STB via QRCode, which contains the server IP.
4. Support for multiusers to interact with the television, during the execution of interactivity. Each mobile device is a different application but all devices can be connected with the main application on TV, part of the content can be seen in the devices and another part can be seen on the TV, as shown in prototype: results from every device can be shown on TV screen.
5. Social content: share data in social networks, such as the result of nutritional assessment performed in the prototype.

In Table 2, related works selected in the systematic review are compared with the present work, related to the following features: sync content, asynchronous content, multiuser interaction, multiple TVs and social content.

6. CONCLUSION

This article had the goal of reviewing the literature regarding the use of mobile devices as interactive devices for the iDTV, as a second screen or remote control. This paper also proposes an architecture for the use of mobile devices and iDTV that enables the data coming from broadcast to be reused on mobile devices without the need for internet access. Two prototypes have been implemented: an interactive app for utilization with the remote control and a modified version for second screen using mobile devices.

The second screen has as its main functions to enrich interactivity, to allow multi-users, to serve as remote control and to share data regarding watched scheduling. The use of mobile devices for interacting with iDTV has been welcomed and several solutions like communication standards and multi-platform content development frameworks are proposed in the literature, advancing new frontiers and enriching iDTV content.

7. REFERENCES

[1] Basapur, S.; Harboe, G.; Mandalia, H.; Novak, A.; Voung, V.; Metcalf, E.C.. "Field trial of a dual device user experience for iTV." *In Proceddings of the 9th international interactive conference on Interactive television (EuroITV '11). ACM, New York, NY, USA*, 2011: p. 127-136..

[2] Belimpasakis, P.; Walsh, E R. "A combined mixed reality and networked home approach to improving user interaction with consumer electronics." *Consumer Electronics, IEEE Transactions on , vol.57, no.1*, Feb. de 2011: p.139-144.

[3] Brereton, P.; Kitchenham, B.A.; Budgen, D.; Turner, M.; Khalil, M. "Lessons from applying the systematic literature review process within the software engineering domain." *Journal of Systems and Software*, 2007: 571-583.

[4] Esar, P.; Bulterman, D.C.; Jansen, A.J. "Leveraging user impact: an architecture for secondary screens usage in interactive television." *Multimedia Systems, Volume 15, Issue 3*, July de 2009: p. 127-142.

[5] Cesar, P., Chorianopoulos, K.; Jensen, J. "Social Television and User Interaction." *Comput. Entertain*, Mai de 2008.

[6] Cesar, P.; Knoche, H.; Bulterman, D.C.A.. "From One to Many Boxes: Mobile Devices as Primary and Secondary Screens." *In: Mobile TV: Customizing Content and Experience, Human-Computer Interaction Series 2010*, 2010: p. 327-348.

[7] Choi, S.; Han, J.; Lee, G.; Lee, N.; Lee, W. "RemoteTouch: touch-screen-like interaction in the tv viewing environment." *Proceedings of the 2011 annual conference on Human factors in computing systems (CHI '11)*, 2011: 393-402.

[8] Cody, R.L.; Cosmas, J.; Tsekleves, E.. "Open-standards rich media mobile platform & rapid service creation tool." *Global Mobile Congress 2009*, 12-14 de Oct. de 2009: p. 1-6.

[9] Cruickshank, L.; Tsekleves, E.; Whitham, R.; Hill., A. "Making Interactive TV Easier to Use: Interface Design

for a Second Screen Approach." *The Design Journal*, 2007

[10] Edwards, W.K.; Grinter, R.E.. "At Home with Ubiquitous Computing: Seven Challenges." *In Proceedings of the 3rd international conference on Ubiquitous Computing (UbiComp '01), Gregory D. Abowd, Barry Brumitt, and Steven A. Shafer (Eds.). Springer-Verlag, London, UK, UK*, 2001: p. 256-272

[11] Fallahkhair, S.; Pemberton, L.; Griffiths, R. "Development of a cross-platform ubiquitous language learning service via mobile phone and interactive television." *Journal of Computer Assisted Learning, vol. 23. Issue 4*, 2007: p. 312-325.

[12] Fleury, A.; Pedersen, J.S.; Baunstrup, M.; Larsen, L.B. "Interactive TV: Interaction and Control in Second-Screen Tv Consumption." *In: Adjunct proceedings of the 10th European interactive Tv conference (EuroTV)*, 2012: o. 104-107.

[13] Hölbling, G., Rabl, T.; Coquil, D.; Kosch, E.H. "Intertainment - Interactive TV Services on Mobile Devices." *IEEE Multimedia, vol.15, no.2*, 2008: p. 72-76.

[14] Ingmarsson, M.; Dinka, D; Zhai, S. "TNT: a numeric keypad based text input method." *Proceedings of the SIGCHI conference on Human factors in computing systems (CHI '04)*, 2004: 639-646.

[15] Jana, R., Yih-Farn C.; Gibbon, D.C.; Huang, Y.; Jora, S.; Murray, J.; Wei, B.. "Clicker – An IPTV Remote Control in Your Cell Phone." *Multimedia and Expo, 2007 IEEE International Conference on*, 2-5 de July de 2007: 1055-1058.

[16] Kitchenham, A.B. "Procedures for Performing Systematic Reviews." Technical Report TR/SE-0401, Keele University, NICTA, 2004.

[17] Lee, M.S.; Kim, S.J.; Kim, M.J.; Seong, C.K.. "Remote collaboration screen control using mobile multi-touch interface." *ICT Convergence (ICTC), 2012 International Conference on*, Oct. de 2012: p. 272-273.

[18] LI, L., Yi, R. "MEMS-based digital TV interaction innovation research." *Computer-Aided Industrial Design & Conceptual Design (CAIDCD), 2010 IEEE 11th International Conference on*, 17-19 de Nov. de 2010: 665-667.

[19] Lin, C.; Hung, Y.; Chen, H.; Chu, S.. "Content-aware Smart Remote Control for Android-based TV." *Consumer Electronics (ICCE), 2012*

[20] Lo, S.; Lin, C.; Chen, M.. "Controlling digital TV set-top box with mobile devices via an IP network." *Consumer Electronics, IEEE Transactions on* 52, n. 3 (Aug 2006): 935-942

[21] Lucena, V.F.; Chaves Filho, V; Viana, N.S.; Maia, O.B.. "A home automation proposal built on the Ginga digital TV middleware and the OSGi framework." *Consumer Electronics, IEEE Transactions on , vol.55, no.3*, Aug. de 2009: p.1254-1262.

[22] Ma, M.; Wilkes-Gibbs, D.; Kaplan, A.. "IDTV broadcast applications for a handheld device." *Communications, 2004 IEEE International Conference on , vol.1*, Jun. de 2004: p. 85- 89.

[23] Miranda, L.; Hayashi, E.; Baranauskas, M.. "Identifying Interaction Barriers in the Use of Remote Controls." *Web Congress Latin American (LA-WEB '09)*, Nov. de 2009: 97-104.

[24] Stumm, J. "Sistema Inteligente de Monitoração Alimentar via Web Baseado em Lógica Fuzzy." In: Dissertação, for Master-Degree in Computer Science, Univerisidade Federal de Santa Catarina - UFSC, Florianópolis, Brazil. Dez. de 2005.

[25] Tsekleves, E.; Cruickshank, L.; Hill, A.; Kondo, K.; Whitham, R. "Interacting with Digital Media at Home via a Second Screen." *Multimedia Workshops, 2007. ISMW '07.* Ninth IEEE International Symposium on, 2007. 201-206.

[26] Wang, S. C.; Chung, T. C.; Yan, K.Q. "A new territory of multi-user variable remote control for interactive TV." *Multimedia Tools Appl. 51, 3*, Feb. de 2011: p. 1013-1034.

[27] Yahoo! Inc and The Nielsen Company. *Mobile Shopping Framework: The Role of Mobile Devices in the Shopping Process.* Jan. de 2011. http://advertising.yahoo.com/article/the-role-of-mobile-devices-in-shopping-process.html (acesso em 20 de Dec. de 2012).

[28] Zivkov, D., Majstorovic, B.; Andjelic, T.; Davidovic, M.; Simic, D. "Smart-Phone Application as TV Remote Controller." *Consumer Electronics (ICCE), 2012 IEEE International Conference on*, 13-16 de jan de 2012: 431-432.

Table 1: Characteristics of the remote control prototypes analyzed

Ref.	**Implementation**	**Wireless**	**Touch-screen**	**Sincronized interactivity**	**Main Functions**	**TV Focus**
15	Java	Wi-Fi	No	No	switch channels, EPG, preview clips	IPTV
20	Java	Wi-Fi	No	Yes	switch channels, PVR	DVB
19	Java	Wi-Fi	Yes	No	switch channels, send messages	Android-TV
25	Java	Bluetooth	Yes	No	switch channels, volume adjustment, EPG	[*not informed*]
28	Java e Objetive-c	Wi-Fi	Yes	No	switch channels, access interactive buttons	Linux based TV

Table 2: Functionalities present in each second screen proposal

Ref.	Synchronous content	Asynchronous content	Multiple TVs	Multiuser interaction	Social content
2	-	-	Yes	-	-
4	Yes	-	-	-	Yes
8	Yes	-	-	-	-
11	Yes	Yes	-	-	-
13	Yes	Yes	-	-	-
21	-	-	Yes	-	-
22	Yes	Yes	-	-	-
26	Yes	-	Yes	Yes	-
Proposal	Yes	Yes	Yes	Yes	Yes