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Mechanisms for interoperable content production among Web, Digital TV and Mobiles

Mecanismos para a produção de conteúdo interoperável entre web, TV digital e dispositivos de telefonia móvel

Abstract: This paper presents a standardization proposal for unified development of interoperable applications among Digital TV, Web and Mobiles. The main objective is to avoid redundancy in the content production, focusing on the adaptation among the different platforms instead of exclusive creation and maintenance for each one. Many recommendations based on worldwide standards are presented, seeking to minimize the ruptures on the current processes of learning objects creation. To validate the proposal, two interoperable applications were developed, one involving just texts and menus, and the other much more complex, involving a complete educational course. Both applications validated the presented proposal successfully.
Keywords: Interoperability. Digital TV. Mobile devices. Web. Education.

Resumo:Este trabalho apresenta uma proposta de padronização para o desenvolvimento unificado de aplicações interoperáveis entre web, TV digital e celular. O principal objetivo é evitar a redundância na produção de conteúdo, focalizando a adaptação entre as diferentes plataformas, em lugar da criação e manutenção exclusiva para cada um. São apresentadas recomendações com base em padrões internacionais, buscando-se minimizar as rupturas nos processos atuais de criação de objetos de aprendizagem. Para validar a proposta, duas aplicações interoperáveis foram desenvolvidas: uma, envolvendo apenas textos e menus; a outra, muito mais complexa, envolvendo um curso de ensino completo. Ambas as aplicações validaram a proposta apresentada com sucesso.
Palavras-chave: Interoperabilidade, Web, TV digital, dispositivos de telefonia móvel, Educação.

Alexandro Bordignon
Universidade Federal do Rio Grande do Sul

Adriano Simioni
Universidade Federal do Rio Grande do Sul

Fernando Varella
Universidade Federal do Rio Grande do Sul

Julio Toss
Universidade Federal do Rio Grande do Sul

Maria Lúcia Kroeff Barbosa
Universidade Federal do Rio Grande do Sul

Valter Roesler
Universidade Federal do Rio Grande do Sul

1 Introduction

The world, more and more interconnected, provides the population access to digital services through several mechanisms, like Web, Digital TV and mobile devices. This way, independently where the user is, there is the possibility of accessing the digital technology. The percentage of users of each of these technologies in Brazil is approximately: mobile phones 76%; TV 98%; home internet 17%[1].

1 TELECO. *Knowledge in Telecommunications*. 2008. Available at: <http://www.teleco.com.br/en/en_ncel.asp> Accessed: jan. 2009. NIC.BR – Network Information Center. *TIC Home 2007*. 2008. Available at: <http://www.nic.br/imprensa/coletivas/2008/tic-domicilios2007.pdf> Accessed: jan. 2009.

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A natural result of this convergence is the need of standardization for content development among these technologies, because making content with the same objective, but in a specific way for each platform, raises unnecessarily the cost of production and maintenance. Therefore, the objective of this paper is to present a new proposal seeking the interoperability among Web, Digital TV and mobile devices, in a way that minimize the effort of making interoperable content.

This paper defines interoperability as the capacity of reuse a language, standard or protocol, independent of the device, in a way that the same content can be used in different environments.

The contribution of this paper is threefold:

a) optimization on producing and maintaining content, because it proposes unique formats;
b) redundancy elimination; c) reduction of needed storage space.

An example of a natural application of this paper is in the education area, where the teacher, with the necessary technical support, generates the content of a single course only once, using the interoperable formats recommended by this paper, obtaining access to a vast quantity of users, because the course works in all the three platforms. The maintenance and update of the course is also performed only once, minimizing efforts.

In terms of standardization, the authors worked with the ISDB-Tb (International System for Digital Broadcasting – Terrestrial – brazilian flavor) for Digital TV. In the area of mobile devices, the mobile phone platform was used, due to its large use compared to the remainder of mobile equipments. Considering the personal computers, no restriction was applied, because its processing power and flexibility are much higher than the other devices. Nevertheless, the obtained results can be easily carried to other existing standards.

The remainder of this paper is organized as follows: section 2 presents related works. On section 3, the authors' recommendations for interoperability among the available media standards are described. Section 4 shows two interoperable applications developed to validate the system. Section 5 brings the final remarks.

2 Related Work

The concern about making a common platform which allows information access through several equipments is not a recent objective. Among the W3C efforts, today the most respected organization in terms of Web standardization, there is the goal "Web Interoperability", which publishes open standards for compatibility on the Web access through all devices[2]. The initiative of W3C Mobile Web has as a goal to make the Web access, from any kind of equipment, so simple, easy and convenient as accessing through a desktop[3]. This way, mobile phones, smart phones, personal digital assistants, interactive TV sets, voice response systems, kiosks, and even some household appliances can access the Internet[4].

To achieve the objective of a single Web, the specifications for the Web formats and protocols need to be compatible among themselves and allow that all equipments and software used to access the Web work together[5].

This paper follows the protocol recommendations issued by W3C for Web and Mobiles, but it goes further, also analyzing the Digital TV environment and proposing interoperable media formats.

The focus of several research papers today is related to the interoperability between mobiles and digital TV. It's the case of Paulson's[6] paper, which makes an analysis of possibilities of band and types of existing standards to watch TV on mobiles. Cagenius[7] proposes an approach in which the user transfers the visualization from the Digital TV to the mobile phone, also being able to interact by the mobile device.

2 W3C. **About the World Wide Web Consortium**. 2008. Available at: <http://www.w3.org/Consortium/about-w3c.html> Accessed: dec. 2008.

3 *Ibid*.

4 *Ibid*.

5 *Ibid*.

6 PAULSON, L.D. TV comes to the mobile phone. In: **Computer**, Baton Rouge, LA, v. 39, n. 4, p. 13-16, apr. 2006.

7 CAGENIUS, T. *et. al*. Evolving the TV experience: Anytime, anywhere, any device. *Ericsson Review*, Stockholm, v. 83, n. 3, p. 107-111, 2006.

The paper of Liang[8] presents the standardization for future scenarios involving the standard DVB-S, integrating Digital TV, mobile devices and broadband connection internet. The paper approaches some network needs, like the use of QoS and the standardization of return channels via satellite.

The related papers above work with the possibility of the user being able to watch TV on the mobile device, and not on the content generation standardization, seeking for interoperability and resources optimization, as proposed in this paper.

No other paper in the same research line of this was found.

3 Recommendations for interoperable content

This section begins with some interface recommendations on each environment and presents the recommendations from the authors for the several levels of standardization needed for the interoperability among the three platforms.

3.1 User Interface

Interfaces for Web, Mobile devices and Digital TV have different usability recommendations, which reflect on the interface construction. While on the Web and mobile phone, light background colors and dark font colors are suggested, on the Digital TV the opposite is recommended (dark background color and light font color). Relating to the font standard itself, each mobile browser has its own font definition where, for example, independently of the font specified on the HTML, the Opera Mini browser[9] render the text to the same font. Another example is the Nokia Web Browser, that uses the Nokia Sans font[10]. For Digital TV, Gill Sans, Tiresias and Frutiger are recommended, because they are not seriffed fonts and, therefore, more readable[11]. On the Web, many fonts can be used. In relation to the font size, on the mobile phone 12 pixels are recommended due to the screen size. For the Web, however, no recommendations like these were found.

On Digital TV, in which there are the main reading issues, due to the screen resolution and also to the distance between the televiewer and the TV, the following list of use recommendations is suggested[12]:

1. Body text should not generally be smaller than 24 point
2. No text should ever be smaller than 18 point in any circumstances
3. Light text on a dark background is slightly easier to read on screen
4. Text on screen needs looser leading (greater line spacing) than in print
5. When technically possible, tracking should be increased by up to 30%
6. A full screen of text should contain a rough maximum of 90 words
7. Text should be broken into small chunks that can be read almost instantly

3.2 Text Content

Among the text contents, the proposal of this paper is the use of the language XHTML[13], along with style sheets and script languages, as following detailed:

• Extensible Markup Language (XHTML): It's a markup language that has the same elements and attributes of HTML 4, but follows the rules of XML (Extensible Markup Language) syntax. Besides not consuming a lot of space, the XHTML is standardized for the Web, Digital TV and Mobile Devices. On

8 LIANG, X. *et. al*. Fusion of digital television, broadband Internet and mobile communications - Part II: Future service scenarios. **Wiley International Journal of Satellite Communications and Networking**, Hoboken, NJ, v. 25, n. 4, p. 409-440, jun. 2007.

9 OPERA SOFTWARE. **Opera Mini 4.2**. 2009. Available at: <http://www.opera.com/mini/> Accessed: jan. 2009.

10 NOKIA. **Nokia Web Browser Design Guide**. Version 1.0. 2007. Available at: <http://www.forum.nokia.com/info/sw.nokia.com/id/7845f71c-0-c0c-400f-8c66-69b13eafa2cb/Nokia_Web_Browser_Design_Guide.html> Accessed: jan. 2009.

11 BBC. **Designing for interactive television**. 2005. Available at: <www.bbc.co.uk/guidelines/futuremedia/desed/itv/itv_design_v1_2006.pdf> Accessed: dec. 2008.

12 BBC, 2005, *op. cit*.

13 XHTML™ 1.0 The Extensible HyperText Markup Language. Available at: <http://www.w3.org/TR/xhtml1/> Accessed: jan. 2009.

Digital TV, the XHTML is also recommended for interoperability with the main Digital TV existing systems in the world[14] [9]. Besides, with Web Browsers in set-top boxes, the developed learning objects will be able to be accessed by them without further modifications.

• Cascading Style Sheets (CSS): The use of CSS3[15] style sheets is strongly recommended to solve the problem of interface customization on each environment, according to the item 3.1. This way, the application server returns a different style file depending on the device that is requesting the web page.

The Web Designer defines a styles file for each device only once and reuses it on every additional page. The identification of the kind of device that is requesting the pages is solved using different URLs for each device or through specific request parameters.

• Script Languages: The XHTML and CSS represent static contents, limiting the possibility of user data validation, dynamic logic creation, math and procedures on the receiver's side. To overcome the markup languages limitations, script languages are used. The ECMAScript standard was generated through the harmonization of technologies, mainly the JavaScript (Netscape) and the Jscript (Microsoft). The ECMAScript raises the functionalities of XHTML on the Web, mobile phones and Digital TV, but with different versions: on the Web, the most common standard is the ECMA-262[16], while mobile phones and Digital TV support subsets of this standard. On mobile phones, the ECMAScript – Mobile Profile (ESMP) was created to give a better support to both communications on low bandwidth and customers with little resource. On this environment, it's suggested the use of ESMP along with the XHTML profile for mobile phones, known as XHTML-MP[17]. On Digital TV, it is optional in the set-top boxes, but when present, the subset of ECMA 262 supports basic services of the main existing Digital TV standards in the world[18].

3.3 Images

In relation to the images, for Digital TV the formats PNG, JPEG and H.264/MPEG-4 AVC "I-Picture" are mandatory in all receivers. The MNG format is mandatory in full-seg devices (set-top boxes and integrated televisions) and optional in one-seg ones (handhelds). The formats GIF, MPEG-2 "I-Frame" and MPEG-4 "I-VOP" are optional ABNT [19].

On mobile devices, the formats GIF, JPEG and PNG are supported by the majority of the current mobile devices, as it can be seen on the mobile phones configuration on their manufacturer websites[20]. Also, the use of GIF 89a and JPEG formats on mobile Web contents is a W3C recommendation[21].

14 ABNT. *ABNT NBR 15606-2.* Digital terrestrial television: Data coding and transmission specification for digital broadcasting. Part 2: Ginga-NCL for fixed and mobile receivers. 2008b. Available at: <http://www.abnt.org.br/tvdigital/norma_eua/ABNTNBR15606-2_2007Vc_2008Ing.pdf. Accessed: jan. 2009.

15 Web Site: <http://www.ietf.org/rfc/rfc2318.txt>

16 STANDARD ECMA-262: ECMAScript Language Specification. 5th ed. 2009. Available at: <http://www.ecma-international.org/publications/standards/Ecma-262.htm> Accessed: jan. 2009.

17 OMA. *ECMAScript Mobile Profile:* A Wireless Mark-up Scripting Language. 2006. Available at: <http://www.openmobilealliance.org/technical/release_program/docs/Browsing/V2_2-20061020-A/OMA-WAP-ESMP-V1_0-20061020-A.pdf> Accessed: dec. 2008.

18 ABNT. *ABNT NBR 15604*: 2007. Digital terrestrial television: Receivers. 2008a. Available at: <http://www.abnt.org.br/tvdigital/norma_eua/ABNTNBR15604_2007Ing_2008.pdf> Accessed: jan. 2009.

19 OMA, 2006, *op. cit.*

20 LG ELECTRONICS. *LG Mobile Developer Network*. 2008. Available at: <http://developer.lgmobile.com/lge.mdn.pho.RetrievePhoneList.laf> Accessed: dec. 2008.
MOTOROLA. *MOTODEV*: Documentation & Tools. 2008. Available at: <https://developer.motorola.com/docstools/specsheets/> Accessed: dec. 2008.
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SAMSUNG. *Samsung Mobile:* Device Specifications. 2006. Available at: <http://developers.samsungmobile.com> Accessed: dec. 2008.
SONY ERICSSON MOBILE COMUNICATIONS. *Phone Specifications*. 2008. Available at: <https://developer.sonyericsson.com/site/global/docstools/phonespecs/p_phonespecs.jsp> Accessed: dec. 2008.

21 W3C. *Mobile Web Best Practices 1.0*: Basic Guidelines. W3C Recommendation. 2008. Available at: <http://www.w3.org/TR/mobile-bp/> Accessed: dec. 2008

Based on this, for image interoperability the use of JPEG format is recommended, because it is standard on the three environments. The format PNG can also be used. Although not standardized on mobile devices, it's widely supported on existing devices in the market and it's standardized for TV and Web.

3.4 Video

The video compression standard defined for the ISDB-Tb system was the H.264/AVC[22], being recently standardized also in ATSC[23], due to its compression superiority.

On mobile devices, the 3GP format with H.263 compression is the most used and, therefore, recommended by this paper authors. 3GP is the file format defined by 3GPP[24] for use on 3G mobile phones (but also used on some 2G and 4G phones)[25]. The video standard MPEG-4 Visual (.MP4) is an optional video codec on several recent multimedia standards. However, it's widely supported on the most recent Nokia devices on the market, along with the H.263[26].

On the validation made on this paper, the videos were stored in H.264 and 3GP, since there is not a common video format for all the three platforms. So, to run the application on Digital TV and Web, it was used H.264, and to run on a mobile phone, it was used the 3GP format with H.263 compression. For the necessary conversions, the software SUPER (Simplified Universal Player Encoder & Renderer)[27] was used.

3.5 Audio

In relation to the audio, the standard ISDB-Tb define as mandatory the format MPEG-4 Audio AAC-LC, and as optional the formats MPEG-2 Audio AAC LC/BC, PCM (AIFF-C), MPEG-1 audio layer 3 (MP3)[28]. For mobile devices, several audio codecs are frequently used, like AMR-NB, AMR-WB, RealAudio Voice, RealAudio 7, RealAudio 8 and RealAudio 10, MP3, AAC (MPEG-4 Advanced Audio Coding), AAC+ and eAAC+.

Because it's standard on all the three environments, the authors recommend the use of the AAC audio format.

4 Implementations to Validate the Proposal

For the development of an interoperable content, based on each environment available technologies, two implementations were made.

On the first one, a learning object called "Outras Infâncias" ("Other Childhoods")[29] was chosen. It was chosen because it's simple, so it's a good case study for the first implementation, besides being pedagogically validated.

Figure 1 illustrates the website currently published on the Web, on the module "Desafios" ("Challenges"), page "Infâncias" ("Childhoods").

Following the recommendations mentioned on section 3, the format XHTML was used for text content, the CSS to adapt the exhibition and JPEG for the images.

The XHTML files remained the same on the three platforms. However, on the Digital TV there was the need of a NCL (Nested Context Language)[30] file to be created, because it is the base to mount the declarative applications on the brazilian system and it works as a connection language[31], indicating which pages will be shown.

According to what was illustrated previously, each page of the learning object "Other Childhoods" has a great amount of text, exceeding what can be shown on each TV screen or on the mobile phone. Therefore, each page of "Other Childhoods" was segmented, and for

22 ABNT, 2008a, *op. cit*.

23 ATSC – Advanced Television Systems Committee. 2009. Available at: <http://www.atsc.org/> Accessed: dec. 2008.

24 3GPP – THE 3RD GENERATION PARTNERSHIP PROJECT. 2009. Available at: <http://www.3gpp.org> Accessed: dec.2009.

25 3GPP – THE 3RD GENERATION PARTNERSHIP PROJECT. *TS 26.244*: 3GPP file format (3GP). 2007. Available at: <http://www.3gpp.org/ftp/Specs/html-info/26-series.htm> Accessed: dec. 2008.

26 NOKIA, 2008a, *op. cit*.

27 eRightSoft. *SUPER* – Simplified Universal Player Encoder & Renderer. 2008. Available at: <http://www.erightsoft.com/SUPER.html> Accessed: dec. 2008.

28 ABNT, 2008a, *op. cit*.

29 NUTED. *Other Childhoods.* 2007. Available at: <http://homer.nuted.edu.ufrgs.br/ei2007/infancias/index.html> Accessed: dec. 2008.

30 NCL – Nested Context Language. 2006. Available at: <http://www.ncl.org.br/> Accessed: dec. 2008

31 ABNT, 2008b.

each new page, a new image was associated, to keep the website pedagogic model.

Figure 1 – Learning object "Other Childhoods" on its original format

The object "menu", that uses Java Script, also needed to be reformulated to guarantee, besides the functionality on the three environments, the same standard of usability and interface. This reformulation used a button, in which the user shows or hides the menu, improving the screen usage, besides the browsing buttons to access pages of a same content group. The result generated new XHTML pages, according to Figure 2, which depicts implementation photos for Web, Digital TV and mobile phones, respectively.

In relation to the validation environment on the client side of this paper's proposal, for the simulation on Digital TV it was used the Ginga Virtual Set-top Box (version 0.9.28)[32].

For mobile devices, it was used the Web Browser of the platform S60 3rd Edition emulator, Feature Pack 2 (also known as S60 version 3.2), distributed by Nokia[33], because it allows the visualization of HTML, WML (Wireless Markup Language) and XHTML-MP (Mobile Profile) pages. In this paper, the mobile phone Motorola v196 was also used. On the Web, Mozilla Firefox[34], version 3.0.5 was used, because it is free software and known for its implemented functionalities according to the W3C recommendations.

On the server's side, the pages were generated by a Web server, using the technology of Servlets and Java Server Pages (JSP). Each device accesses the LO by a different URL, making possible for the server to adapt the used style sheet.

For Digital TV, an intermediate application was developed to request the pages on a presentation format for the Digital TV, to store them in a local directory to further broadcast transmission.

With the success of the first development, the authors proceeded to a more complex validation, involving the creation of an educational interoperable course named "Viva Saudável" ("Live Healthy"), whose objective is to increase the population awareness of the importance of a healthy alimentation and physical exercises. The motivation came out of several factors, among them, the growing index of obesity in Brazil. The target audience comprehends students between the 7th grade of primary education and 1st year of secondary education in Brazil.

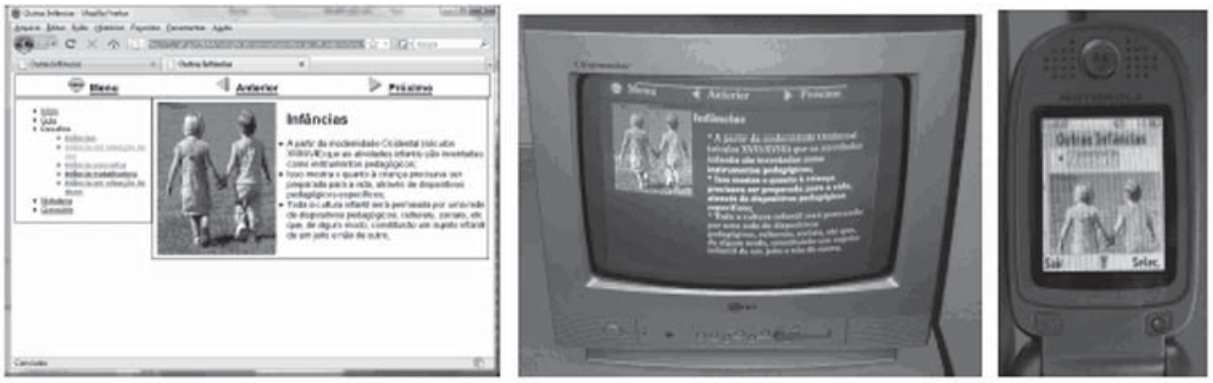

Figure 2 – Reformulated learning object for Web (left), Digital TV (middle) and mobile phone (right).

32 GINGA Middleware. In: BRASIL. Portal do Software Público Brasileiro. Brasília, 2008. Available at: <http://www.softwarepublico.gov.br/ver-comunidade?community_id=1101545> Accessed: mar. 2009.

33 FORUM.Nokia.com. *Tools, Docs & Code*: Tools. 2009. Available at: <http://www.forum.nokia.com/Resources_and_Information/Tools/> Accessed: dec.2008.

34 MOZILLA Firefox 3.5. 2009. Available at: <http://www.mozilla.com/firefox/> Accessed: dec. 2008.

The course is divided in four modules: 1. Introduction and Initial Motivation; 2. Alimentation; 3. Physical Activity; 4. Final remarks. Each module is made of several activities and learning objects (LO).

Concerning interoperability, the recommended and described standards on the beginning of the paper were used. For video, the H.264/AVC was used and, for mobiles, it was converted to H.263 encapsulated in 3GP. The audio was AAC-LC.

For text, XHTML and CSS were used. The images were converted to JPEG with two different resolutions, one for Web and Digital TV, and another for mobiles.

Figure 3 shows photos of two Learning Objects in Digital TV, whose interface is very similar to the Web interface. On the first image, one course agent named "Vivita" is supporting the learning, using text, audio and video. The second image is showing the student some test possibilities: IMC (Index of Physical Mass) calculation, EAT-26 (Test of Alimentation Behavior) and a questionnaire about the acquired knowledge.

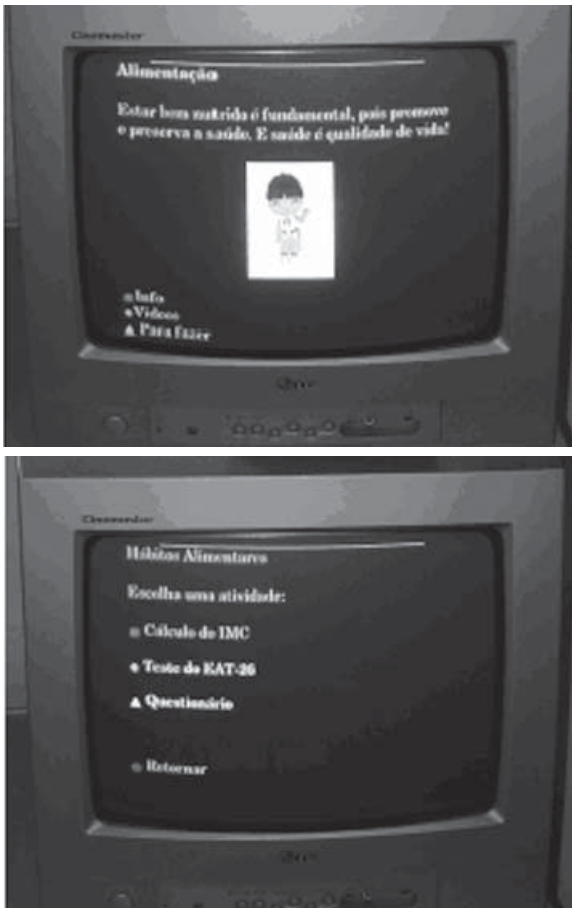

Figure 3 – Example of two learning objects of an educational course on Digital TV.

Figure 4 shows two LO with mobile phone interface. The first one shows text, audio and video of the agent "Vivita" already with interaction options. The second hows the mobile interface for the same screen seen in Figure 3 (IMC calculation, EAT-26 and questionnaire).

Figure 4 – Example of two leaning objects of an educational course on mobile phone.

This course is still in development and it will be used as a base to measure both the motivation and learning on each platform.

5 Final Remarks

This paper presented a standardization proposal to obtain interoperability among Digital TV, Web and Mobiles. A study of mandatory standards on each platform was made and a recommendation was generated, seeking to unify at most the media formats.

It was identified that the platforms with most limitations were Digital TV and Mobiles and a bigger emphasis was given to them. It was concluded that a computer on the Web can adapt itself to any standard without problems; the only need is the commitment of the content producers with interoperable formats.

To validate the performed recommendations, the group developed two interoperable applications. The first one consisted only of text and menus.

Nevertheless, several lessons were assimilated, involving not only the technical issues, but also the matter of interface and usability for each platform. The second application was more complex, comprehending a complete course and demanding the use of all recommended elements, as images, text, audio and video. Both applications validated successfully the interoperable formats

suggested in this paper, sharing the same content for the three platforms, adapting automatically.

From the base presented on this paper, many research possibilities were opened, like the pedagogic validation on different platforms, the specification of support tools to the interoperable content generation, the validation of intelligent learning agents, and so on.

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Alexandro Bordignon
Universidade Federal do Rio Grande do Sul, Brazil, abordignon@inf.ufrgs.br
Adriano Simioni
Universidade Federal do Rio Grande do Sul, Brazil, asimioni@inf.ufrgs.br
Fernando Varella
Universidade Federal do Rio Grande do Sul, Brazil, favarella@inf.ufrgs.br
Julio Toss
Universidade Federal do Rio Grande do Sul, Brazil, jtoss@inf.ufrgs.br
Maria Lúcia Kroeff Barbosa
Universidade Federal do Rio Grande do Sul, Brazil, malukroeff@yahoo.com.br
Valter Roesler
Universidade Federal do Rio Grande do Sul, Brazil, roesler@inf.ufrgs.br