Socio-Technical Barriers Induced by the Design of Emerging Technologies

A Perspective Situated in iDTV Applications

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Abstract. Emerging technologies may impose barriers on groups of people or even the whole society. These barriers are of a socio-technical nature and impact the acceptance, adoption and use of technology. In this paper we investigate Interactive Digital TV (iDTV) as an example of such emerging technology. We identify and discuss socio-technical barriers that arise in the domain of iDTV. As our method, we present, analyze and discuss a study of iDTV application design situated in the real context of a Brazilian broadcasting company. News and documents from the Brazilian Digital TV Forum portal were used to understand external forces that act on Digital TV and the society. Our findings indicate that iDTV acceptance is negatively influenced by project decisions that do not consider socio-technical constraints, and also the beneficial of the "Socially Aware Computing" perspective to propose design solutions that make sense for stakeholders, including end users.

Keywords: Interactive Digital TV · Human-Computer Interaction · Socially Aware Computing · Organizational Semiotics · Participatory Design

1 Introduction

When trying to access or use emerging technologies, people often face socio-technical barriers that range from affordability to social and technical acceptance and that include cultural and (socio-) cognitive aspects such as values and motivation. As Bannon [4] argues, "the sophisticated and complex technologies available to us" can "confuse us—or even worse, disable us". These barriers have their roots in the outset of ideation and design. Few theoretical and methodological references are available to inform design and evaluation of emerging technologies in the scenario of a society mediated by information and communication technologies [10].

These barriers tend to increase when the design decisions to solutions are motivated mainly by the interests of governments, industry and service providers in detriment of potential benefits or drawbacks for direct and indirect users [6]. In situations where the introduction of a new technology is imposed by norms and laws, the population may

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not be prepared to receive such technologies, especially those most in need, such as the elderly, disabled, and people in unfavorable socio-economic situations [13].

In this paper, we discuss such barriers and show how they appear in a real design context, how they are identified, influence design decisions, and how designers might deal with them to minimize their impact. The background scenario of our study is interactive Digital TV (iDTV) in the Brazilian context. Digital TV is an emerging technology in Brazil and many other countries [14], and the Brazilian government considers it a promising medium for the dissemination of information and for fostering social and digital inclusion by reducing barriers that prevent the participatory and universal access of Brazilian citizens to knowledge [5].

Our study is situated in the real context of EPTV [17] – a Brazilian broadcasting company with an audience reach of more than ten million people. The study resulted in a prototype for an iDTV application that aims at encouraging and motivating viewers to interact with the TV. The main goal of the discussion presented in this paper was to understand the challenges that arise during the design of an emerging technology in a situated perspective. To understand challenges that are external to the company we used documents and news available in the Brazilian Digital TV System Forum website [14], an entity that brings together the main stakeholders concerned with Digital TV in Brazil.

The paper is organized as follows: Sect. 2 introduces the background scenario of our study, including the socially aware approach proposed to design an iDTV application in the situated context of a TV show. Section 3 describes the study for identifying barriers to be addressed during the design of an iDTV application. Section 4 presents the barriers found in the study. Section 5 shows the design solution proposed by the EPTV team to address the barriers found; it also presents and discusses the main findings from the study, Sect. 6 presents our final considerations and directions for further research.

2 Background

Digital TV was launched in Brazil in 2007. The city of São Paulo was the first city to receive the digital technology, which gradually extended to other cities and metropolitan areas. However, in most Brazilian cities digital transmission is still being offered by a few broadcasters, depending on the population density, market prospects and feasibility inherent to local broadcasters [14].

The implementation of Digital TV in Brazil was conducted in collaboration with the SBTVD Forum. The SBTVD Forum's important mission is to support and stimulate the standardization and quality assurance of the transmission and reception of digital signal (e.g., audio, video and protocols) and data (e.g., iDTV applications). Moreover, it promotes and coordinates technical meetings among receiver and transmission industry, broadcasters, software companies, and also representatives of the research entities, education and federal government that develop activities in Terrestrial Digital TV (e.g., technical, marketing, and promotional issues). The Forum is also responsible for an information portal with news and documents, and it is the main communication channel with the population [14].

EPTV (Portuguese acronym for "Pioneer Broadcasting Television Stations") is affiliate of a large Brazilian broadcaster that is member of SBTVD Forum. Currently, EPTV reaches part of national population that includes 300 cities with more than 10 million people. EPTV provides for this region both regional programming (e.g., journalism, documentaries, programs, and regional advertisers) produced by itself and national programming (e.g., soap operas and national journalism) produced by its parent broadcaster [17]. For instance, EPTV produces the "Terra da Gente" (TdG, "Our Land", in English) program, which is focused on ecotourism, regional cuisine and sport fishing [16].

Since 2007 EPTV has been producing digital programs with high quality of video and audio. In 2008, EPTV began broadcasting its programming in the digital format to some regions, which was gradually extended to all its regions. EPTV wants to add interactive content associated with its various programs in order to increase the viewer interests, and the first EPTV program to receive interactivity will be the TdG program. Interactivity aims to add useful content to complement the program's content, without competing for the audience's attention [17].

Aiming at promoting interactivity with TV as something that makes sense to all stakeholders, and for addressing the complex challenges involved in design of iDTV applications, we adopted a theoretical-methodological background that favors the identification and understanding of the different forces that govern iDTV development at different abstraction levels. Following we present the adopted referential.

2.1 Socially Aware Computing (SAC)

"Socially Aware Computing" (SAC) [2, 3] is a design approach that seeks to understand the complex relationship of signs that govern an organization in its complex social context in order to design a technical system that fits this organization. Therefore, Baranauskas [2] argues that the design of a system involves a cyclical, interactive and iterative movement that begins with understanding the society in which the organization operates, and then goes through the informal and formal layers of this organization towards reaching a technical solution.

SAC is grounded in Organizational Semiotics (OS) [12] as the main theoretical framework articulated with techniques from Participatory Design (PD) [15]. On one hand, while OS provides artifacts that can look systemically for socio-technical layers of an organization, on the other hand, PD allows different stakeholders to discuss their concerns about the system in a participatory way. To understand the organization situational context and the role of a technical system on it, the SAC proposes workshops that bring together the main stakeholders, an heterogeneous group of people who influence and are influenced by the system to be developed, not only the end user [3]. In this sense, it is essential start with stakeholders from technical (iDTV examples: engineers and technicians), formal (e.g., producers, journalists and designers) and informal layers (e.g., audience). Figure 1 shows the semiotic onion and how SAC design approach acts on it.

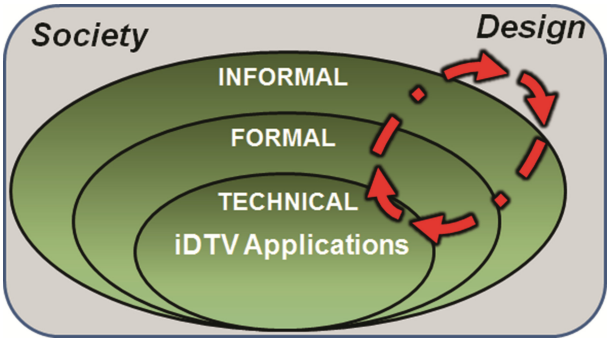

Fig. 1. SAC design approach

3 Practical Study

In order to identify barriers faced during the design of iDTV applications, we mainly used two sources of knowledge:

1. EPTV workshops: 4 workshops conducted inside EPTV in order to design an iDTV application for TdG TV program.
2. SBTVD News: Documents and news produced by the SBTVD Forum [14].

Inside EPTV, we conducted four participatory workshops grounded on SAC approach [2, 3]. The workshops encompassed different design stages spanning problem clarification, solution prospection, requirements identification, content and prototyping ideas, the creation of the user interface for the prototype, and prototype evaluations (see Fig. 2). Ten workshop participants were directly involved in the problem domain, including different profiles such as designers, engineers, researchers, TV program director and interns. The interested reader may consult [7–9] for detailed results and discussions related to these activities.

Complementing the knowledge from EPTV workshops, we reviewed news and documents shared in SBTVD Forum website since 2008. In total, we analyzed around 700 news distributed over the 8 years. Some news are related to the locations where the TV companies began operating in digital signal; and other news are about the status, updates and decisions about Digital TV in Brazil and Latin America. The Forum website has also the presidential decrees and technical standards (ABNT) on Digital TV. Documents are open to public access, and were also used to identify barriers for iDTV applications design.

These two knowledge sources (SBTVD Forum and EPTV workshops) feature information with different nature. On the one hand, the knowledge from the EPTV workshops focuses on the barriers that a TV company may face on situational context that involve from technical to social layers, including society. On the other hand, the knowledge gained from the SBTVD Forum [14] website applies to technical and formal contexts of the focal problem (iDTV application design); it considers all the necessary infra-

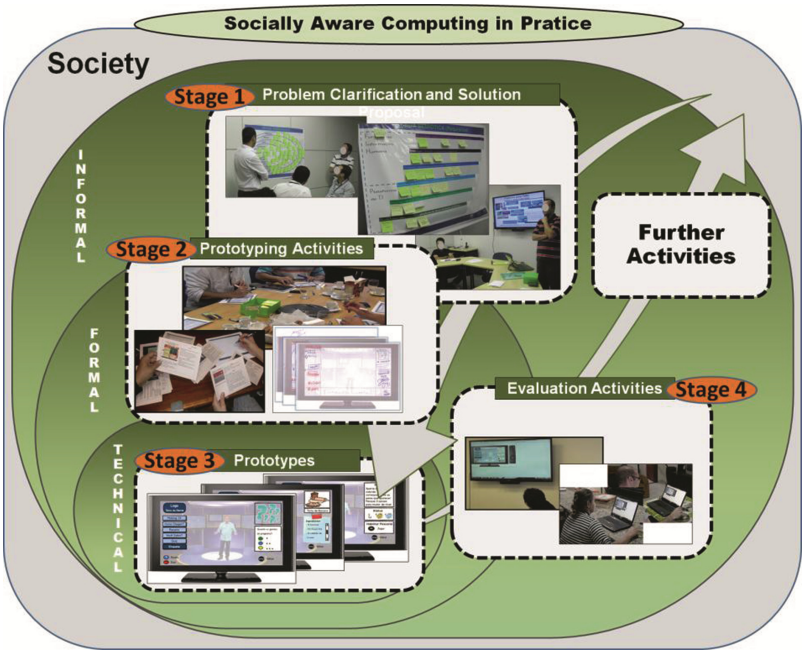

Fig. 2. The design process as an instance of socially aware computing

structure for production and transmission of Digital TV in Brazil, including iDTV applications. For example, this infrastructure defines transmission constraints (e.g., types of modulation), and the basic requirements (minimum and maximum features) receivers must attend to receive the digital signal. This infrastructure also encompasses the entire definition of protocols, languages and hardware configurations for the transmission and reception of iDTV applications.

In the next section, we describe some of the barriers faced for designing iDTV applications encountered during both EPTV workshops and analysis of new and documents produced and posted in the SBTVD's Forum portal.

4 Preliminary Findings and Discussion

This section presents and discusses barriers found in both contexts (SBTVD Forum and EPTV workshops). Barriers marked with the letter "E" (**E**xternal) came from the knowledge from SBTVD Forum, while barriers marked with the letter "S" (**S**ituational) were identified in the context of EPTV and came from the situational context.

Geographical Barriers (E): On December 2014, the SBTVD Forum reported that "the Japanese-Brazilian digital TV system reaches more than 89 million Brazilians in 425 municipalities, including all the country's capitals, according to the Ministry of Communications" [14]. Brazil is the 5th largest country in terms of territory and population (around 200 million people); 89 million people represent around 44 % of the population

receiving the digital signal. This shows that 64 % of the population does not receive the digital signal yet; this represents a barrier once people that do not receive the digital signal will not be able to interact with iDTV applications.

Economic Barriers (E + S): Economic barriers prevent the viewer to receive the digital signal and access television applications. According to news published in September 2014: "Public broadcasters receive government support, but private companies, which are the vast majority, need resources to make the investment." In addition, "the high tax burden was also cited as an obstacle" and "30 % of the final value of the product is the result of taxes. A reduction of the tax burden could speed the deployment of transmission equipment in the cities" [14]. In summary, this kind of news shows that although 44 % of the population are reached by the digital signal, only part of TV companies are transmitting digital signal to certain places.

For the Reception Industry there are economic challenges in order to develop high quality receivers with a competitive cost. These receivers must be economically viable for viewers but also have to be compatible with the Brazilian standard for Digital TV (ABNT). In this regard, the industry has to customize production costs and also the chipsets that compose the receivers.

For TV companies, new technologies also involve financial resources for development and for maintenance. The workshop participants commented that "it is not difficult to find qualified professionals to develop iDTV applications, but to find resources to hire employees to perform services that are outside the scope of TV company production chain." In this sense, investing in new technology should involve the prospect of financial and knowledge return to the TV company.

Viewers also have to deal with economic challenges. In 2007, São Paulo was the pilot city to receive digital signal. However, as reported in news published in September 2014: "1/3 of the São Paulo population still use tube televisions" in the analog version [14]. News published in February 2015 report that the Federal Government created an assistance program to distribute "digital signal receivers to families enrolled in the assistance program". There are government and industry forces to these receivers "mandatory incorporate the interactive capacity" within their features [14].

Socio-Political and Socio-Cultural Barriers (E + S): Digital TV was influenced by political strategies and presidential decrees that established the SBTVD. Among other things, the SBTVD was created to "promote social inclusion, cultural diversity of the country" and to "stimulate the research and development, and encourage the expansion of Brazilian technologies and national industry related to information and communication technology" [5]. Another objective, as reported in SBTVD Forum news published in December 2014, is related to release of bandwidth used by analog TV signal so that it would be possible to create the "infrastructure to support the sign for the fourth-generation Internet (4G)" [14]. Thus, the iDTV in Brazil is an initiative of both government and industry, not necessarily a necessity claimed by society. Thus, these barriers are limiting, although not preventing the design of iDTV applications.

In addition, the Brazil is a country with high level of socio-cultural inequalities. The high diversity of users (regarding age, skills, gender, intentions, literacy, special needs) may influence directly on the design of iDTV applications. In the EPTV workshops, the

participants have argued that "considering the diversity of the target audience is an issue that would hardly be treated". These barriers improve the challenges to designing iDTV solutions.

Technical Barriers (E + S): Infrastructure to digital TV should be flexible so that different manufacturers (receivers and transmitters), TV companies and viewers could use the digital TV according to their needs. This technical diversity ensures that manufacturers produce receivers and transmitters of different types and a "set of essential features required by devices" [1]. A technical barrier faced during design came from iDTV receivers' companies: to gain economic advantage, they produce devices with limited processing and memory capacity. For the workshop participants "receivers from some brands not are in accordance with Brazilian Digital TV standard". Thus, "iDTV applications may run incorrectly or even block the receiver". For Kunert [11] other technical challenge is related to the absence of input resources (keyboard and mouse). In this sense, the application should have few resources and functionalities that would enable users to interact with it in a pleasant way.

Kunert [11] also argues that every emergent technology suffers from a lack of references, processes and artifacts for supporting their design. For workshops' participants, designing iDTV applications is a novelty activity, and a design process to guide them is essential to develop the first iDTV applications for TdG TV program.

The interactive channel, which is the communication channel between viewers and broadcasters via the Internet, is not a reality for part of national population yet. This problem comes from geographic and economic barriers and is directly reflected in the technical solutions to be implemented for the design of iDTV applications. For example, if the TV company wants to create a poll in order to identify the satisfaction of viewers regarding a particular program, the interactive channel will be necessary. On the one hand, while some workshop participants were against the use of the interactive channel, on the other hand, other participants pointed out the usefulness and benefits of functionalities that might be obtained with the interactive channel.

Use Barriers (E + S): Workshop participants argued that "an iDTV application for the TdG program must use features that the TV offers and should not need any additional resource from viewers". This barrier is directly related to economic barriers and diversity of users that may affect users with different economic profiles.

An additional use barrier is the diversity of devices surrounding the TV, and competing for the users' attention. Currently, as devices are even more present in our everyday lives it is difficult to build attractive solutions that are restricted to a single device. Thus, analyzing the potentialities and resources from these technologies and bringing these resources and knowledge can be a differential to design solutions that have a good acceptance by their target audience.

Kunert [11] also mentions the lack of habit to interact with television content and the usual presence of other viewers in the same physical space as habits of use from analogical TV that impact negatively on iDTV usage.

Organizational Barriers (S): Workshop participants reported that "any iDTV television created by the parent company or subsidiaries must follow a set of premises that

work as a pattern to be followed by the companies. These premises define constraints on the layout type to be used by the iDTV application. Moreover, the participants defined a premise that the application should complement the program content". This barrier partially limits the design options for an iDTV application. In this case, the participants should propose creative solutions that attract the audience and do not disperse the attention of conventional viewers.

Figure 3 shows the identified barriers according to the layers of the Semiotic Onion it operates. For instance, while use and geographic barriers are located in the Semiotic Onion's outside layer, technical and organizational barriers are closer to the Semiotic Onion's core layer.

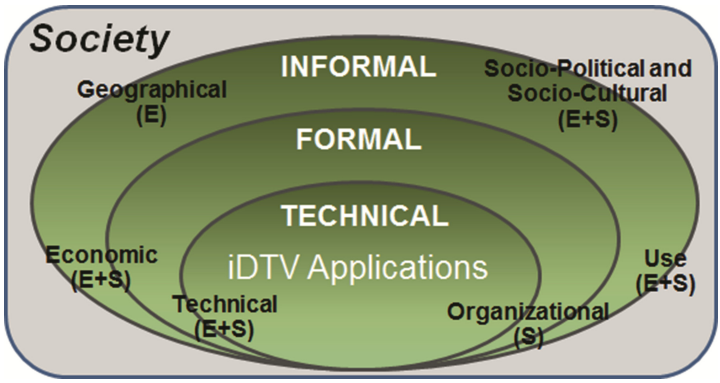

Fig. 3. Barriers mapped to the layers of the Semiotic Onion

5 Designing Solutions to Address the Barriers

In this section we present the solutions proposed by participants from EPTV workshops to lower the barriers pointed out in the previous section. Figure 4 shows some elements of a prototype of the first designed application. The design of the prototype was informed by participatory workshops with the EPTV team. In the remainder of this section, we use this prototype to illustrate design solutions that have been proposed by the participants in order to address the identified barriers.

Geographical Barriers (E): To face geographical barriers, TV companies should have access to the infrastructure of digital technology. Thus, new production and transmission equipment must be purchased to replace analog technology. Currently, EPTV reaches the full coverage area with a digital signal. Therefore, the design of an iDTV application for the TdG program would not suffer from this kind of geographic barriers.

Economic Barriers (E + S): EPTV is a pioneer in the production and transmission of the digital TV signal. Thus, the economic constraints come from the receiver industry and viewers. Accordingly, some viewers still use analog technology or use digital receivers that do not support the interactive channel. Thus, only some viewers are able

Fig. 4. Prototype screenshot

to receive iDTV applications. In this sense, the TdG application being developed must accommodate both users that want and can interact with iDTV applications and those who cannot or do not want to interact with such applications. Receivers without interactivity automatically discard data regarding applications and no action needs to be performed. For viewers who have receivers with interactivity, workshop participants opted for a discrete initial icon (see detail D in Fig. 4) that shows the iDTV application is loaded into the receiver. In this case, a user action is required (e.g., press a remote control key) for the application to open on television. Thus, users who do not want to interact will not feel uncomfortable with an iDTV application opening without their consent.

Regarding financial resources for the development and maintenance of the iDTV application, the workshop participants stressed the importance of easy maintenance. Thus, the application must be maintained by the engineering or production team without the need to hire new employees.

Technical Barriers (E + S): The strategy adopted by the participants in order to deal with limited processing and memory capacity during the application design was to propose a simple application with clean layout and few images (see details A and B in Fig. 4), compatible with the hardware performance. This application is also easy to broadcast as it is small and will not require a large bandwidth. Furthermore, the iDTV application must be able to automatically customize functionalities as Pool or Quiz after identifying the existence or absence of the interactive channel. These functionalities should be present or absent from the application interface depending on the existence of the interactive channel.

To deal with the receptors that are not in accordance with the Brazilian Digital TV standard, the workshop participants suggested that applications must strictly follow the standard. Final application must also be tested in receptor of several brands before being transmitted with the TdG TV program.

Socio-Political and Socio-Cultural Barriers (E + S): A social-cultural barrier is related to diversity (cognitive, educational, physical, socio-economic, cultural) of Brazilian viewers. In this case, the participants chose to work with few menu options (to reduce cognitive load – see detail A in Fig. 4) and attractive features (for people with high technology affinity – see details B and C in Fig. 4) to attract and motivate different profiles of viewers. For instance, detail C in Fig. 4 shows a Fishing Game: a ludic game to maintain attention from viewers while they watch the TdG TV program. In this case, fishes will appear on the screen and the viewers must select a different remote control key to fish them.

Use Barriers (E + S): Workshop participants established that "the remote control should be the main interaction device." Although the remote control presents several problems regarding the lack of inputs and the difficulty of interaction, it comes with the TV and everyone has access to it. In relation to concurrence with other devices, the iDTV application must have mechanisms and features to attract viewers to interact and/or attract the audience to the TV program. For instance, participants select contents (e.g., making of – see detail B in Fig. 4) and functionalities (e.g., fishing game – see detail C in Fig. 4) that are essential for the TdG program.

Organizational Barriers (S): The participants decided to follow the constraints determined by the parent company. For example, the layout on the screen corners is a suggestion from the parent company so that the application does not disturb users who want to see the television content while another user is interacting with the iDTV application. IDTV application content that complements the TV show with information was another suggestion followed by the participants.

5.1 Discussion

Identifying barriers in the design of iDTV applications is fundamental to propose design solutions compatible with the technology constraints and also with the interests of the organization. In this study, we pointed out barriers of different nature and situated in different levels (from technical to informal level) those were considered and influenced the design of an iDTV application for the TdG program.

When these barriers are neglected, and when no design solutions are proposed to minimize them, the end users may suffer the consequences. Minimizing these barriers is a challenge for most designers of such applications. In this sense, design approaches, such as SAC, can make the difference as there are dynamics that allow looking at the problem from different perspectives and levels of abstraction. In this sense, to propose solutions that made sense to all participants of EPTV workshops it was necessary to involve different stakeholders in discussions. For example, the interactive channel, which allows for direct communication between the TV company and viewers, is not present in every viewer's house. Thus, technical participants were against the use of the interactive channel, while other participants, who enjoy new features, argued by the use of the interactive channel functionalities to attract the target audience. A customizable interface was the solution that pleased the two participant groups.

The use of the SAC approach in a situated context seemed efficient and effective regarding the identification of barriers and proposal of solutions to overcome them. Some of these barriers (e.g., lack of human resources to create and maintain iDTV applications) would only be identified in the real context of an organization.

6 Conclusion

In this paper we discussed the importance of identifying and considering different barriers that may exist in the design of emerging technologies. We situated our discussions in the practical context of a Brazilian broadcast TV organization, where an iDTV application was designed for one of its TV shows. The results presented and discussed in this paper include the identification and situated discussion of the internal and external barriers related to iDTV applications design. We organized these barriers according to the different layers of information systems (informal, formal, technical). We furthermore showed that the barriers influence the design of iDTV applications and indicated how they might be considered during the design process.

Results showed that interaction design in this situated context does not involve only the relationship between humans and computers, but also social, technological, political, cultural, and motivational issues. Ignoring these issues during software design might result in solutions that do not make sense to stakeholders and end users. Discussions also pointed out the effective contribution of SAC to understand this scenario (audience, interests and barriers) in techno-social dimensions. In addition, we argue that industry, government and investors impose iDTV technology and its ecosystem, and decide on solutions for their own benefit, neglecting the interests of the most important stakeholder group: the end users' who buy and use iDTV products. In this sense, adopting the SAC perspective showed to be potentially beneficial to end users.

As further work, we intend to test the design solution with end users, and to verify the application acceptance with the TdG TV program's audience.

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