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The Evolution of TV Systems, Content, and Users Toward Interactivity

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Abstract

Interactive TV research spans across a rather diverse body of scientific subfields. Research articles have appeared in several venues, such as multimedia, HCI, CSCW, UIST, user modeling, media and communication sciences. In this study, we explore the state-of-the-art and consider two basic issues: What is interactive TV research? Can it help us reinvent the practices of authoring, delivering, and watching TV? For this purpose, we have reviewed the research literature, as well as the industrial developments and identified three concepts that provide a high-level taxonomy of interactive TV research: (1) content editing, (2) content sharing, and (3) content control. We propose this simple taxonomy (edit–share–control) as an evolutionary step over the established hierarchical produce–deliver–consume paradigm. Moreover, we demonstrate how each disciplinary effort has contributed to and why the full potential of interactive TV has not yet been fulfilled. Finally,

we describe how interdisciplinary approaches could provide solutions to some notable contemporary research issues.

> *'Interactive Television is an oxymoron. On the other hand, television provides the most common ground in our culture for ordinary conversation, which is arguably the most enjoyable interaction a person has. We should try to leverage the power of television while creating some channel back from the audience to provide content, control or just a little conversation.'*[*]

[*] Although we have tried to summarize previous research as much as possible, we still find that the quote by Dan O'Sullivan (Interactive Telecommunication program, New York University, Tisch School of the Arts) has been the most comprehensive definition of interactive television, so far. Retrieved from: http://itp.nyu.edu/~dbo3/proj/#tele (July 2008).

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1

What is Interactive Television

The user activities that surround television creation, distribution, and viewing have been interactive long before the digitization of television systems. For example, viewers compete mentally against quiz show participants. Moreover, viewers react emotionally to TV content, they record and share TV content with friends and discuss about shows either in real-time, or afterward. Currently, the digitization of TV systems and TV content has only increased the opportunities for interactivity. A major question that should be answered before we describe the details of this research area is: "what is interactive TV (iTV)?" Despite the widespread use in industry and academia, the term "iTV" is still quite ambiguous.

For a long time, the answer to the question "what is iTV" has been dependable on the discipline or the industry concerned, which might have been one source of ambiguity when the respective disciplines had to coordinate:

(1) i**TV as infrastructure:** A telecom engineer assumes digital broadcast, return channel, or broadband Internet infrastructure (e.g., IPTV);

(2) i**TV as user terminal:** A multimedia designer refers to interactive graphics and dynamic editing on the user terminal;
(3) i**TV as media format:** A media manager describes new content formats such as betting, interactive storytelling, and play-along quiz games; and
(4) i**TV as social actor:** A sociologist's definition focuses on the interaction between people about TV shows.

While none of the above definitions seems to agree with each other, each one stands for an approach followed by iTV researchers so far. In particular, each one makes some assumption about one or more of the following elements: (1) infrastructure, (2) user terminal, (3) content, and (4) social behavior, respectively. Therefore, in order to setup a unifying definition of iTV we need to abstract from the particularities of disciplinary approaches and their implicit assumptions. We have found that there are at least two high-level approaches for defining iTV. The first one considers iTV as an artifact or experience. The second approach considers iTV as an area of academic study.

In terms of user experience, we consider interactive TV (iTV) to hold the following properties: (1) mash-ups of fixed (pre-edited) video-clips, which have linear narrative (2) low-to-mild levels of user input, and (3) dynamic graphics that are employed mostly for video-overlays. Nevertheless, the borderline between other media formats (e.g., videogames) and iTV is sometimes vague. For example, there are song-contest videogames that follow the format of the respective TV-shows. At the same time, there are iTV formats that have been modeled after adventure videogames. For the sake of consistency within this study, we do not treat borderline applications, but we provide a few references to developments from the industry and mainly focus on the academic treatments of iTV.

In terms of academic discipline, iTV research studies the interaction among users and video-clip-based content, which is presented on networked multimedia computers. Therefore, iTV research builds and extends upon established disciplines such as Human–Computer

Interaction, Multimedia, and Communication Science. Again, there might be borderline cases, in which research methods in iTV have been transferred from other disciplines. Nevertheless, iTV research focuses on those interdisciplinary cases that have guided researchers to leverage existing disciplinary methods, in order to address the development and use of iTV systems.

The goal of this work is to provide a common framework for future iTV research by surveying the most relevant publications and the most innovative industry developments. In order to abstract from the different disciplines and views, we structure the framework on three basic television concepts that we believe capture the basics of all previous approaches: (1) content editing, (2) content sharing, and (3) content control. In the following section, we provide further details regarding the scope and assumptions that we made in the course of this work.

1.1 Framework and Delimitation of Scope

This section provides a detailed description and rationale of the framework we utilize to position the different initiatives around iTV research. It delimits the scope of the study and highlights key assumptions.

Firstly, the intention of this study is not to enumerate the most significant technological achievements in terms of television delivery. Although several iTV developments (e.g., Web-based TV, IPTV, and broadcast TV) have followed parallel or even competing paths, we prefer to elaborate on the common themes from the viewpoint of the human, as a creator, distributor, and viewer of content. For example, broadcast developments have been in competition with video streaming approaches, and the TV as device has been in conflict with the PC. Nevertheless, the convergence of network and rendering platforms has made such distinctions somewhat superficial. Even though there are still significant differences between the networking and rendering platforms, those differences regard mostly to the context and the preferences of the user, rather than to the capabilities of the technology.

As introduced by Pine and Gilmore [143] in The Experience Economy, we are living a shift from a service economy to an experience economy. In other words, if the first technological challenge was to

provide efficient delivery mechanism, now the challenge is to provide enhanced experiences [13]. While during the 1990s iTV research concentrated in the provision of digital television and on how efficiently broadcast digitalized television, the challenge now is to provide interactive television experiences as represented by the efforts of personalization, social television, interactive narratives, and ambient technology.

With the goal of being as inclusive as possible, this work takes a pragmatic view and considers research coming from the industry and the academia. Notably, many significant iTV developments have been realized by industrial players (content producers, network operators, and device manufacturers), who have very different strategies and interests.[1,2] For this reason, in addition to academic literature we have also examined iTV developments published in the popular press. Nevertheless, it is outside the scope of the present work to provide an overview of all commercial trials and products, which are described elsewhere [89, 88, 141].[3,4,5]

The goal of this study is to provide a comprehensive overview of iTV research around a unifying concept: television as a set of activities that include content edition, content sharing, and content control. In the rest of this article we organize previous research and development efforts along the three major categories, which have an immediate impact on the way people interact and participate in the TV lifecycle.

Content editing, apart from professional content edition, considers the casual viewer as an active node in the content creation value chain. Contemporary viewers have the expectation of producing digital content by employing easy-to-use applications. Although the current shift has important implications in the television value chain, we do

[1] Frank Rose, The Televisionspace Race, Wired 6.04, 1998 http://www.wired.com/wired/archive/6.04/mstv.html

[2] Frank Rose, TV or not TV, Wired Issue 8.03, 2000, http://www.wired.com/wired/archive/8.03/bskyb.html

[3] Sean Dodson, A short history of interactive TV, guardian.co.uk, Thursday 5 April 2001, http://www.guardian.co.uk/technology/2001/apr/05/onlinesupplement5

[4] Robert X. Cringely, Digital TV: A Cringely Crash Course, PBS, http://www.pbs.org/opb/crashcourse/

[5] Tracy Swedlow, Interactive Enhanced Television: A Historical and Critical Perspective, http://www.itvt.com/etvwhitepaper.html

not expect that professional content production will disappear in the future. Indeed, high-quality production values and massively attended events function as a reference point and as social glue for society [100]. At the same time, the popularity of services like YouTube and MySpace demonstrates that there is an increasing demand for user-generated content. In conclusion, there is a need to accommodate both approaches by providing lightweight authoring tools for end-users.

Content sharing corresponds to a meta-content activity, "have you seen that goal?" or "you should definitely watch this clip!" When a viewer calls a friend to chat about a current program, he is following a communication process. This process can be synchronous (while viewing) or asynchronous (after viewing). Research on communication process includes, among others, providing chat-enabled television channels, real-time voice communication, or synchronous avatars that indicate the current status of a viewer.

Content control corresponds to the selection process, "what to watch?" and to the consumption process "Where to watch it?" For example, after scanning the program guide, when the viewer changes to another channel he is controlling the television content. Research on content control can be divided into a number of subtopics such as the input devices to be utilized, automation and personalization, and the available rendering devices.

1.2 Methodological Considerations

Researchers have employed several methodologies in the study of TV viewing and they have established a rich body of knowledge, which has been expanded by the design, development, and study of novel iTV content and applications. In the following, we highlight relevant methods from selected research in the iTV field.

Although researchers have identified the differences between the TV, the personal computer and the Web,[6,7] the majority of the research and many commercial products have been created in the face of usability

[6] Jakob Nielsen, WebTV Usability Review, February 1997: http://www.useit.com/alertbox/9702a.html

[7] Jakob Nielsen, TV Meets the web, February 1997: http://www.useit.com/alertbox/9702b.html

Fig. 1.1 In addition to the contrast between lean-back versus lean-forward user posture, the TV environment considers a shared dispaly and social activities in a relaxed domestic setting.

measured as efficiency. Several aspects of video search and navigation could be modeled after the traditional HCI tasks and goals. For example, the usability of the Electronic Program Guide (EPG) is very similar to the usability of productivity software, because it involves more information processing than enjoyment of iTV content. Still, there are some aspects of the EPG design and many other types of iTV applications that would benefit by a consideration of the affective dimension [45, 46]. The focus on the affective dimension of iTV applications was motivated by the realization that users' subjective satisfaction is at odds with the established notion of efficiency.

A usability test of a video skipping user interface (UI) revealed that user satisfaction was higher for the UI that required more time, more clicks, and had the highest error rate. In other words, the most usable UI was not the most favored one [58]. This result is opposite to the assumptions of the efficient usability paradigm, which conceives the efficient as more usable and thus preferable. One could not blame the designers of those efficient UIs (the widely acclaimed TiVo and ReplayTV), which have been designed according to the established UI principles (e.g., "provide shortcuts"). Nevertheless, the satisfaction questionnaires exposed that users preferred the most relaxing UI over the most efficient one [58]. Therefore, UI in ITV applications should be tested in the face of affective goals, in addition to the traditional efficient usability conceptualizations. In other words, upcoming user experience evaluation methodologies should be applied in the iTV domain.

In addition to the evaluation conceptualization, there are methodological differences with regard to the techniques and processes employed during the development of new iTV products and services. Monk [123] argued that there is a need to adapt the traditional UI design and evaluation methods to the home environment (Figure 1.1). Since iTV applications serve entertainment goals and domestic leisure activities for a diverse user population [101], there is a need to re-examine the traditional usability engineering concepts and evaluation methods, under the light of existing results from the field of media studies. Indeed, the intersection between the human-computer interaction (HCI) and the mass communication disciplines has been highlighted as a significant area for further research [112].

Chorianopoulos and Spinellis [47] have integrated the research from affective HCI with media studies, in order to devise a conceptualization for UI evaluation that facilitates the universal access to iTV applications. Mass communication has explored the effects of broadcast electronic media messages to the TV audience. It has developed several important concepts, such as the "uses and gratifications" theory [159], which describes the motivations for watching TV. The uses and gratifications theory does not assume an attentive user like the traditional usability engineering methods do, but measures explicitly a continuum of viewer involvement with a TV program [142]. Moreover, the "selective exposure" paradigm [190] regards the viewer as an active receiver of the media messages, who changes TV channels and actively selects TV content to be exposed to. The selective exposure concept contrasts with the traditional usability conception of a specific task to be performed by a user.

An important element in the process of usability evaluation is the notion of the user task. A user task consists of a finite number of steps and it has an exact ending. Accordingly, a usability evaluation session includes a few tasks that should be performed by a user. Tasks might not be suitable in the context of many iTV applications. Indeed, Maguire [113] raised the research question of whether tasks should be fixed, or users should be allowed to use the service as freely as they wish. It has been argued that the users should be allowed to use the service for a predefined, but flexible duration of time (e.g., 15–30 minutes),

without any particular task to complete [47]. Because viewers select TV channels and watch TV programs in order to regulate their mood, the evaluation of an iTV UI should facilitate free exploration and enjoyment of the iTV application. The emphasis on an affective methodology for iTV applications does not entail a complete abandonment of the efficient usability paradigm. For example, an iTV news application used in the morning before leaving home for work should afford efficient information retrieval and navigation. The same application, used in the evening after returning home from a long day at work, should be more automated and encourage relaxed use.

Shrimpton-Smith et al. [168] provide an empirical comparative evaluation study of two versions of the traditional think-aloud method. In particular, they suggest that since TV is a social medium it must be tested in a social context as well. For this purpose, they employed real life couples in think-aloud usability testing. The same usability test was also performed with single users. It was found that couples detected more usability issues than single test users. Furthermore, the test session was considered to require less effort in the couple condition. Besides collocated groups, there is also a need for evaluation methods in the context of distance communication among multiple TV viewers. Duchenaut et al. [59] performed an elaborate analysis of the voice communication between two remote groups of TV viewers. The evaluation was based on video-taping and detailed transcripts (both spoken and non-verbal) of the interpersonal communication, within the same room and between the two remote rooms.

In continuation to the past qualitative analysis of traditional TV audience [110], ethnographic studies in the living room are popular evaluation methods [130]. More recently, Obrist et al. [132] performed an extensive ethnographic study of interactive TV use. They employed diaries and cultural probes, and evaluated a broad range of iTV applications. They found that the preferences of different user groups (e.g., couples, singles, flatsharing, and seniors) could only be fulfilled with an equally diverse set of iTV applications, and they put special emphasis on social communication. Elderly users have been involved in the design of navigation interfaces [155]. In complement to qualitative studies, Sperring and Stradvall [174] employed multiple usability and media

evaluation methods including eye-tracking, questionnaires, and physiological measurements. They report that the viewers' behavior during the show and involvement in the game varied depending on whether they participated together with friends or alone.

While usability tests are suitable during the development process, ethnographic methods are more useful for requirements collection and for investigating the long-term effects of iTV applications. Bernhaupt et al. [22] developed two variations of cultural probes by introducing creative cultural probing cards and extending it toward playful cultural probing. Creative cultural probing material is based on the idea that creative stimuli will motivate participants in their self-observation to provide more insightful information on daily routines and technology usage. For the playful probing approach, traditional games are adopted for the research needs to enhance participants' involvement. For example, they extended "card games" by including research-related question cards. These questions were answered by participants while playing the game. Furthermore, they experimented with modeling clay as a means for answering design oriented questions. Overall, they found that the playful approach motivates participants to reflect on the research topic more thoroughly.

In summary, the contemporary usability techniques are necessary for the evaluation of iTV applications, but it seems that they are not sufficient. In particular, the TV audience has been accustomed to expect much more than ease of use. In particular, the TV audience receives information and expects to be entertained, in a lay-back posture and through an emotionally loaded visual language. In this way, having satisfied the basic usability requirement, everybody should be receiving a reasonable level of entertainment.

1.3 Timelines and Basic Concepts

After many decades of development, iTV has remained one of the most elusive consumer technologies [99]. Several reasons have been cited, such as pervasiveness of basic TV infrastructure (Figure 1.2),

[8] The sources for all timelines are wikipedia, http://www.fcc.gov, http://www.digitaltelevision.gov.uk

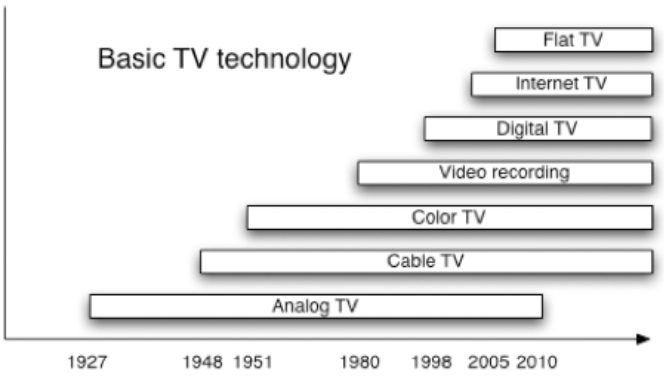

Fig. 1.2 Summary of basic technical advancements.[8]

unrealistic expectations, slow evolution of iTV technologies, and conflicting viewpoints of the stakeholders.[9,10,11]

There are several ways to look into the development of TV technology, applications, content, and social practices over time. In this section, we discuss multimedia content flow in TV and we study historical development for each building block of the TV value chain. In the timelines, we have selected the most significant technological advancements in terms of the impact they had in the way users (producers, distributors, and viewers) employed TV. It is worth noting that the proposed framework to study iTV research (edit–share–control) stands as an evolutionary step over the traditional model of authoring–delivery–consumption.

The flow of multimedia content is started when the media is captured. The raw material might be captured using digital means or can be, later, converted into digital format. Then, the content is encoded and might be authored by aggregating various media elements into one presentation, by determining the layout characteristics of each media element, and by introducing handlers for user interaction. Finally, the

[9] Kevin Kelly, Becoming Screen Literate, NY Times, November 23, 2008, http://www.nytimes.com/2008/11/23/magazine/23wwln-future-t.html

[10] Bill Rosenblatt, 500 channels and nothing's on, http://www.cnn.com/TECH/computing/9812/04/500channels.idg/index.html

[11] Bill McConnell, The Shape of Things To Come, Broadcasting & Cable, 1/5/2004, http://www.broadcastingcable.com/article/CA372624.html

Fig. 1.3 Simplified view of the hierarchical content flow.

content is delivered to the end-user's device for consumption. Figure 1.3 shows a simplified version of the established content flow [31]. The hierarchical content flow is useful in order to define a benchmark against which we are going to measure the progress toward alternative or complementary paradigms, such as the participatory model edit–share–control (ESC), which we propose in this article.

Based on the hierarchical flow of multimedia content, we can distinguish major research topics: content production and authoring, content delivery, and content consumption.

Regarding content authoring, television content has been traditionally produced in expensive studio settings using digital means. As a matter of fact, previous research has emphasized large video libraries and professional settings with desktop computers [184], instead of living room arrangements. Major research in this area included the provision of efficient video encoding mechanisms for effective video stream rendering and retrieval. The most popular solutions include MPEG-2[12] and MPEG-4[13] video formats. Even though encoded video is an efficient manner for rendering, it provides very limited interactive capabilities. Contemporary technical developments (Figure 1.4) have introduced lightweight content authoring tools for viewers as well [96].

Apart from video encoding, higher level or integration tools allow the composition of multimedia presentations by integrating and synchronizing different media elements. Some examples include Synchronized Multimedia Integration Language (SMIL) [33], Flash,[14] MHEG [57], and MPEG-4 [140]. Integration tools permit to generate multimedia presentations by defining the spatial and temporal relationships of the media elements. In addition, interactivity can be achieved

[12] http://www.chiariglione.org/mpeg/standards/mpeg-2/mpeg-2.htm
[13] http://www.chiariglione.org/mpeg/standards/mpeg-4/mpeg-4.htm
[14] http://www.adobe.com/products/flash/

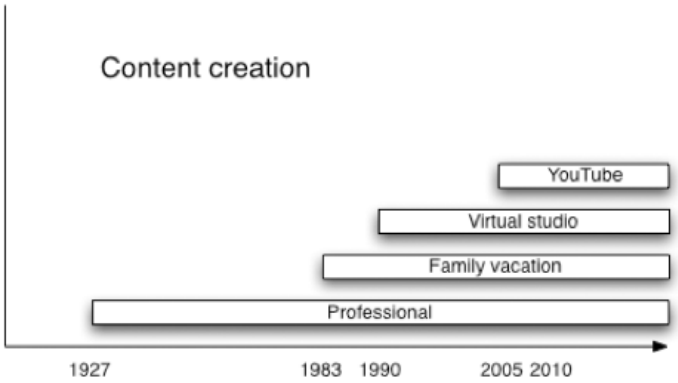

Fig. 1.4 The home-made family video is anything but new, but the popularity of YouTube has been the tipping point for a democratization of the multimedia authoring and editing processes.

by the inclusion of internal and external links. These solutions have been mainly investigated by the research community, but have not been widely deployed by the industry. Instead, in the later 1990s and the beginning of the 2000s the industry concentrated on standardizing an open middleware for iTV set-top boxes, which led to a set of Java-based standards such as Multimedia Home Platform (MHP) [124, 42] in Europe, OpenCable Platform (OCAP) [124] and Advanced Common Application Platform (ACAP) [42] in the USA, Broadcast Markup Language (BML) [42] in Japan, and Ginga [171, 172] in Brazil. Unfortunately, their acceptance and popularity have never met the initial expectations.

Regarding content delivery (Figure 1.5), the first most important challenge for the broadcast community was to actually distribute television content in an efficient manner, so research focused on the transmission mechanisms. This body of research was influenced by the unexpected success of the DVD technology and reused a number of underlying concepts (e.g., using MPEG-2 streams to deliver the content). This wave of research concluded with the deployment of digital television systems [121, 69, 150, 157, 161, 151] and three major regional standards were defined. Advanced Television Systems Committee (ATSC) in North America, Integrated Services Digital Broadcasting (ISDB) in Japan, and Digital Video Broadcasting (DVB)

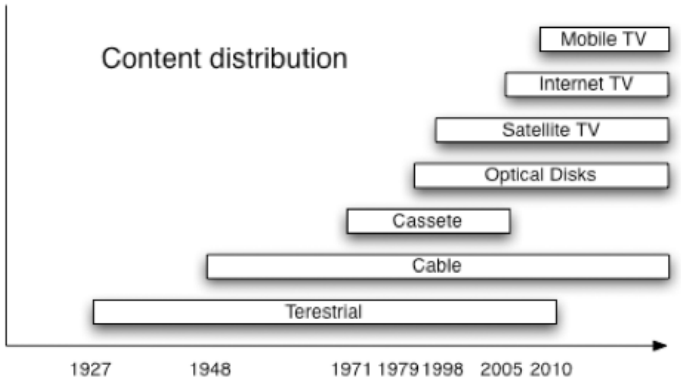

Fig. 1.5 Although the distribution of content has been an hierarchical one-way process, the development of broadband Internet and mobile infrastructures has released content from monolithic distribution mechanisms.

in Europe, [42]. The Japanese solution has been selected in other countries such as Brazil [171]. In addition to broadcast to home, interesting advances have occurred for the delivery of mobile television. Mobile transmission of television content can now be achieved using a number of standards like DVB-H,[15] Digital Multimedia Broadcasting (DMB),[16] and Mobile Broadcast Services Enabler Suite (BCAST).[17]

The previous paragraphs quickly summarize the story behind broadcast television and its content flow. Since this study is not restricted to broadcast transmission, the following paragraphs will discuss about Web-based TV and IPTV solutions.

Web-based TV (or Internet TV) and online video sharing have become a primary activity in the World Wide Web. Some relevant examples include services like YouTube, Yahoo! video, and MySpace. The common characteristics of these systems are that they provide easy-to-use interfaces for uploading, searching, viewing, rating, and most notably for sharing videos. They are intended for personal computer usage and mostly focus on user-generated material. At the same time, a number of Web-based TV solutions are targeted for consuming

[15] http://www.dvb-h.org/
[16] http://eng.t-dmb.org/
[17] http://www.openmobilealliance.org/Technical/release_program/bcast_v1_0.aspx

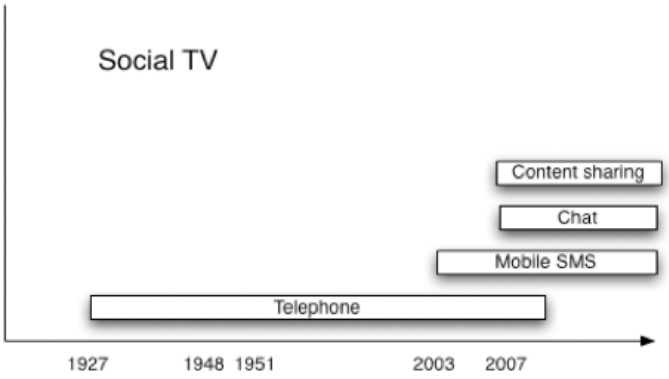

Fig. 1.6 Content sharing and social communication about TV content have taken place over out-of-band channels (e.g., telephone, mobile SMS) but contemporary services have introduced integrated services (e.g., Joost).

professionally produced videos. Some examples include Joost and Lycos Cinema.

Finally, IPTV systems [4, 9, 43] reuse the Internet infrastructure for delivering television content. Over the past years, IPTV systems have been steadily evolving and now they have become a key technology for future television. In many cases, IPTV systems are as well upgrading their infrastructure in order to provide social communications (Figure 1.6). We refer to these solutions as social interactive television. For example, CollaboraTV [127], from AT&T, permits to record the viewer's comments while watching a television program. Then, such comments are replayed when a friend is watching the video using avatars to identify who has said what. At the same time, synchronous communication features have been introduced by Motorola's SocialTV [82, 119] and Alcatel's AmigoTV [50].

The development story of closed captioning might provide further ground for understanding the shortcomings as well as the potential of iTV. In the beginning, closed captioning was conceived as a service for people with hearing disabilities (Figure 1.7). It was implemented by exploiting an invisible part of the television signal, known as the Vertical Blanking Interval (VBI). Closed captioning was initially available to viewers through special caption decoder boxes that were attachable to televisions. Lately, closed caption technology has been used for

Fig. 1.7 TV has been an inclusive technology from very early. Closed captioning was conceived as a way to communicate voice to hard-of-hearing-people.

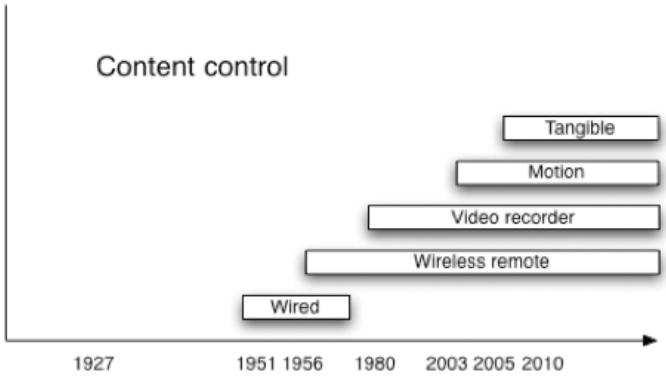

Fig. 1.8 The wireless remote control has been a pervasive input device in user terminal configurations, but novel paradigms have emerged.

a number of different services including BT's talk TV video editing tool [24]. There are a number of lessons to be learned by the story of closed captioning: (1) the VBI technology has been later on exploited to introduce the TeleText service, very popular in Europe, as a first solution toward accessing the Web from the television set (popular services sometimes are not the one the designers had in mind); and (2) the integration of novel technologies into TV sets is necessary for wide adoption by viewers and broadcasters (Figures 1.8 and 1.9).

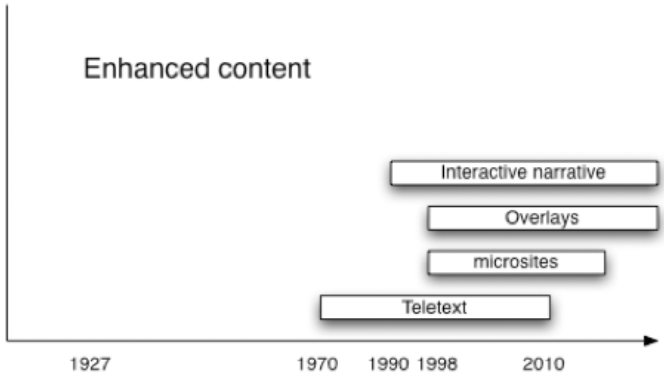

Fig. 1.9 Starting with Teletext systems the audiovisual experience in TV has been extended with additional material, which is rendered at the viewer's terminal.

Although there are many technological, creative, and behavioral changes in the way TV is authored, distributed, and consumed, we do not expect that the established paradigm (author–deliver–watch) will be replaced by the emerging paradigm (edit–share–control). Indeed, television is an information and entertainment medium that has occupied the largest share of domestic leisure time [189] and has become a rather pervasive activity. Therefore, we expect that the emerging paradigm will either build upon or complement existing practices.

Table 1.1 summarizes the traditional view on content flow and compares it with the current view on how television content will be produced, delivered, and consumed. The proposed developments are not meant to replace the traditional practices, rather to complement and enhance them. Our assumption is that traditional television watching will be enhanced with current trends on Web-based television systems, it will incorporate user-generated content and will allow for social communication between viewers. In summary, this work argues that television consumption is composed of three basic components: content control, content sharing, and content editing. Hence, we argue that research topics aimed to improve any of these categories will make a difference in the interactive television landscape.[18,19]

[18] http://www.fcc.gov/
[19] http://www.digitaltelevision.gov.uk/

Table 1.1 Comparison between the traditional view on the content flow and the emerging paradigm.

Topic	Subtopic	Established paradigm	Emerging paradigm
Editing content	Metatada	Professionally produced	User-generated
		Professional metadata	User tags (folksnomy)
	Middleware	Proprietary frameworks	Web-based frameworks
			IPTV solutions
	Mash-ups	Studio enhancements	User enhancements
Sharing content	Topology	Terrestrial, cable, and satellite transmission	Mobile distribution of content
		Static user terminals	User Broadcast of content
		Broadcaster or client-server architecture	P2P technologies
	Content rights management	Closed system	Content sharing between users
Controlling content	Content selection	Recommender systems	Contextual-based searches
	Content navigation	EPG-like functionality	
		VCR-like functionality	Group-based searchers
			Semantic navigation of content

1.4 Reaching Its Full Potential

The story of television, as the story of many other technologies, is a constant trial of new ideas and innovations. This section discusses a number of promising technologies and system that did not achieve their full potential. Such exercise will help us to understand how to better provide services and technologies in the future. The first generation of iTV applications has been influenced by the traditional computer paradigms such as the desktop and hypertext. Application developers put most of the efforts on issues that were familiar to them, sometimes forgetting the unique characteristics of the television experience. For example, iTV applications are deployed in a domestic environment and users have entertainment goals when compared to desktop applications, which are deployed in a work environment for productivity goals (Figure 1.10). Other issues that have been sometime forgotten include: (1) television watching is a social and shared experience, (2) contextual information is essential for content rendering and selection, and (3) nowadays in a house there are more rendering components than the television set and more interactive devices than the remote control.

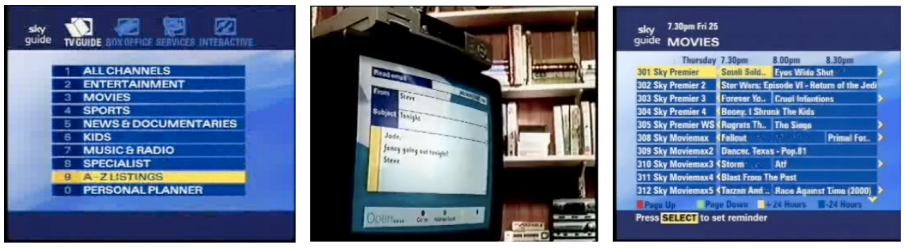

Fig. 1.10 Many interactive TV applications have been designed with the "look and feel" of personal computer applications.

Table 1.2 Topics that have not fulfilled expectations and reason why they did not.

Topic	Major reasons
Video on demand	High demands on the network. After ten years, desktop-based Video on Demand is becoming a reality.
Return channel	There has not been a wide deployment of solutions. Nowadays, the use of SMS messages is the most popular return channel.
Interactive content	Interactivity as video overlays might be disruptive to the entertainment experience due to the intrusiveness of the content
Usability (based on productivity)	Consistency and task efficiency might not be adequate for pleasurable interactive television experiences
Electronic Program guide	Lack of contextual searching (television as a planned activity, different layout, and options depending on the people in the room or the time of the day)
User modeling and personalization	Limited research on group modeling and social communication support (apart from collaborative filters)

Table 1.2 summarizes the topics that we consider did not meet the high expectations generated, when proposed. We must admit, nevertheless, that they provided valuable results. The following sections will inspect each of the topics in detail.

1.4.1 Multimedia Technology and System Architectures

Interactive television in Europe is normally associated with the provision of a return path from the user to the broadcaster. Since terrestrial television is the predominant technology, setting up an efficient interaction channel to the content provider was a research topic of its own at the turning of the century. According to [87], currently discounted solutions such as SMS voting are most widely used and accepted. This was due to the fact that previous implementations of the return channel did not allow for much more than control signals and short messages.

A symmetrical return channel would allow bidirectional distribution of audiovisual content. Today, on the other hand, IPTV standards and cable TV would provide a full working return channel.

Video-on-demand was the central element in the early vision of iTV services [105]. Correspondingly, the academic community put effort into server-side architectures, broadband delivery, and thin network clients [29, 70]. In terms of the commercial success, a retrospective evaluation of the respective research might lead to the conclusion that video-on-demand was not worthwhile pursuing. Nevertheless, a more careful examination may reveal that there were also numerous benefits from that approach, such as the broadband Internet, current IPTV standards, and Web-based TV systems (e.g., Joost,[20] Miro,[21] YouTube,[22] Amazon video on Demand[23]) which are becoming very popular services ten years after.

If we consider graphics capabilities, iTV set-top boxes have only provided the lowest common denominator. The main reason has been that the graphics are controlled at a high level in the middleware, resulting in slow execution and in a complex application composition model. Such inefficiency clearly contrasts with latest game consoles or even with DVDs, where the video-graphics are fundamental to the product architecture. Their architectures are optimized for sequential video presentation with graphics and mainstream DVD titles such as Minority Report include elaborate forms of interactivity linked with good visual effects, which are part of the user interface.

Finally, in terms of content gathering, there were high expectations for the combination of dynamic information coming from the Web with broadcast data. Still, a seamless integration of the different networks bringing video content at home has not been achieved. Basic broadband Internet access and advanced peer-to-peer systems (e.g., BitTorrent) have enabled efficient distribution of content on the PC. While wireless broadcast distribution is becoming suitable for the delivery of high-demand, high-bit rate items, which have a real-time appeal

[20] http://www.joost.com/
[21] http://www.getmiro.com/
[22] http://www.youtube.com/
[23] http://www.amazon.com/Video-On-Demand/b/ref=sv_d_7?ie=UTF8&node=16261631

(e.g., popular sport events, news, and movies). Nevertheless, we can foresee that an EPG could be employed for re-scheduling the favorite show of a family into a more convenient time and day that fits that family's particular schedule, independently of the delivery infrastructure. The fact that some of TV viewing is considered to be 'ritualistic' [160] does not preclude the exploitation of out-of-band techniques for collecting the content at user's premises.

1.4.2 Content Navigation and Personalization

During the 1990s there had been a lot of speculation about the 500 channels[24] to be provided by the future iTV [99]. As a matter of fact, new technologies such as video recorders, cable television and the Web have increased the channel repertoire of TV viewers [63, 90]. This increased availability of TV channels and content has become one of the main drivers for the development of technologies that assist content selection and navigation, such as the EPG and content personalization.

The EPG technology has been mostly associated with the products and services of the Gemstar company. Gemstar began to operate in Europe in 1991, when it launched the patented ShowView VCR recording technology, which simplified the process of taping television programs through the use of unique barcodes associated with each TV show (Figure 1.11). Although there have been some popular consumer products (e.g., TiVo), currently there is no standard navigation method neither for the input, nor for the output human interface [49].

Communication scientists reported that viewers could recall fewer than a dozen of TV channels [64]. Moreover, it has been estimated that one needs at least 15 minutes to browse through 500 channels, assuming a less-than-a-second channel switch delay and assuming an approximately one second glance before pressing the next-channel button. These two issues often have not been adequately addressed by research on EPGs. At the same time, studies have revealed that in some cases TV watching is a planned activity, which is a finding that contrasts with the monolithic focus on the EPG as a method to select a program

[24] 500 Channels and Nothing to Watch, Time, Dec. 14, 1992 http://www.time.com/time/magazine/article/0,9171,977204,00.html

Fig. 1.11 Gemstar has patented several technologies and services related to EPG and print-based input of recording data.

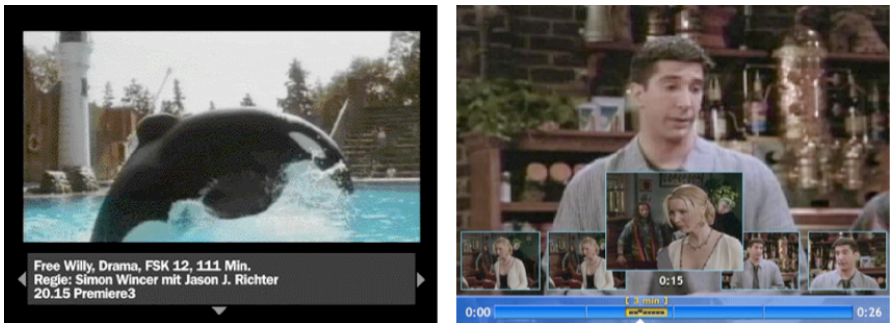

Fig. 1.12 An EPG does not have to take over the whole screen and it could also allow relaxed navigation through the information on available channels without changing the current one [34]. In addition, an EPG could employ additional modalities, such as summarization [58, 94].

to watch each time a user switches-on the TV. On the other hand, there is a fraction of the viewers that impulsively selects a program to watch, especially among the younger demographic [71].

The majority of previous research about iTV applications has addressed the EPG (Figures 1.12 and 1.13) and has proposed a few design guidelines for it [16, 34, 27, 180]. Unfortunately, the EPG as a file explorer-like UI is not appropriate for long TV listings, since it contains less information per screen than a printed TV magazine. Moreover, both methods for navigating TV content are based on a

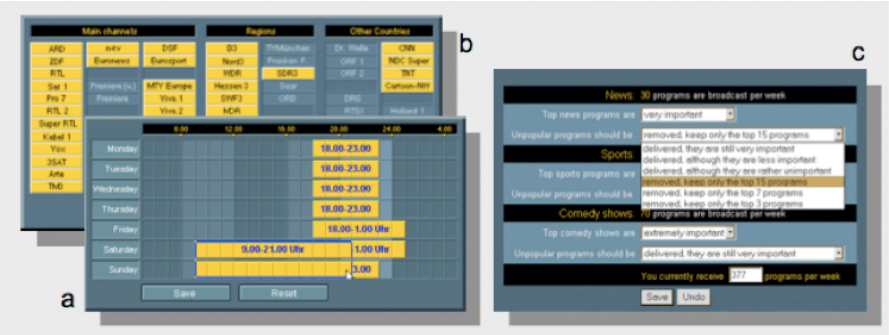

Fig. 1.13 The Electronic Program Guide has been a popular theme in HCI and user modelling research [16].

simple visual mapping of the underlying data structures, without much consideration for the established TV channel selection behavior.

The envisioned 500 channels future was turned upside-down by the user modeling research community [10], as well as from industry, who put forward the vision of a single personalized channel. Nevertheless, it is acknowledged that TV content is a conversation starter [109] and, thus, personalization reduces the chances that any two might have watched the same program.

TV personalization has been one of the most important research directions applying and extending recommendation methods from other interactive media (e.g., Web). Adomavicius and Tuzhilin [6] referred to a number improvement to current recommender systems such as a better understanding of the users and items, inclusion of contextual information, and a provision of less intrusive types of recommendations. He wrote "However, in many situations, the utility of a certain product to a user might depend significantly on time. It may also depend on the person(s) with whom the product will be consumed or shared and under which circumstances." Even though mainstream research focused on imported models from the Internet [170], there are a number of systems that actually followed the main four categories indicated by Adomavicius. Some examples included Masthoff [117], Masthoff et al. [118], and Goren-Bar [76] who considered television watching as a shared experience, and other researchers [11, 17] who considered contextual information for television program recommendations.

Finally, we believe that personalized TV should take into account the social value of the shared TV experience as well. If content recommendation algorithms are indeed tuned and successful to discover new content all the times or content that satisfies the particular tastes of each viewer, then there will be less opportunity to watch and to discuss about the familiar content. Therefore, personalization researchers should also consider the sociability dimension of content recommendation and tune their algorithms accordingly [117]. In summary, EPG research should consider television as a planned activity or television as a shared experience before reaching its full potential.

1.4.3 Designing Interactive Content

The "red-button" of the 1990s[25] from BBC interactive television system, in which the user had to press the red button to launch interactive applications,[26] was an interesting trial about interactive content. According to Baker [13], there are many reasons why the red button has not fulfilled the expectations; the most relevant for our discussion are the following: intrusiveness of the extra content in the main screen, poor resolution of the standards, and slowness of the solutions. In addition, we can argue that such standards did not take into account the social nature of television consumption. Moreover, most of the services provided to users, such as online banking (Figure 1.14), did not fit the television paradigm and were services directly imported services from the Internet.

The introduction and wide adoption of the Web has been promoted by and attributed to the interactive nature of the new medium. It often goes without much thought, that if something is interactive then it is also better and it will be preferable [182]. Interactivity with the user might seem as the major benefit of iTV, but this does not necessarily need to be true and designers should further evaluate it in the context of entertainment applications [92]. Most notably, there is evidence that in some cases interactivity may be disruptive to the entertainment experience. Vorderer et al. [183] found that there are some categories

[25] BBC Red Button, http://en.wikipedia.org/wiki/BBC_Red_Button
[26] Using the red button, http://www.bbc.co.uk/digital/tv/tv_interactive.shtml

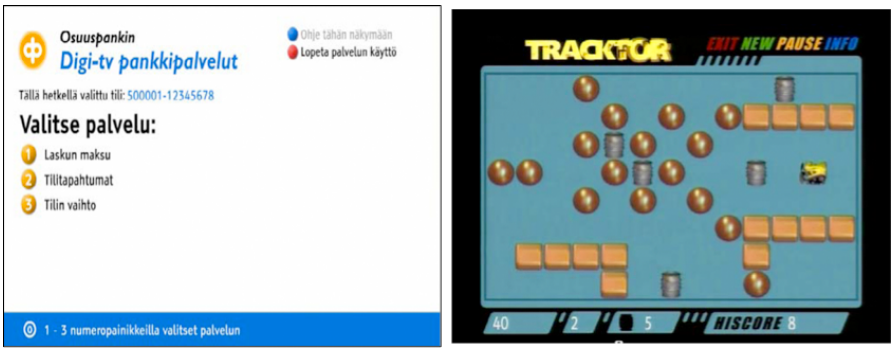

Fig. 1.14 Television banking application and game. These are examples of interactive applications not connected to the television program.

Fig. 1.15 The show 'Pyramid Challenge' by BBCi encourages the viewer to get in the place of the main hero, to make choices and to follow alternative paths along an interactive storyline.

of users who do not like to have the option to change the flow of a TV story (Figure 1.15); they just prefer to watch passively. Nevertheless, there are also situations that users appreciate some extra interactivity, such as sports, where users have enjoyed the control of camera angles.

Indeed, the passive uses and emotional needs gratified by the broadcast media are desirable, [159]. Unfortunately, many iTV applications support the presentation of generic information on the screen, instead of considering the augmentation of the entertainment experience. Although TV offers a wide variety of content that spans from pure entertainment to pure information, the content is usually presented in a captivating way, regardless of the type (e.g., documentary, news).

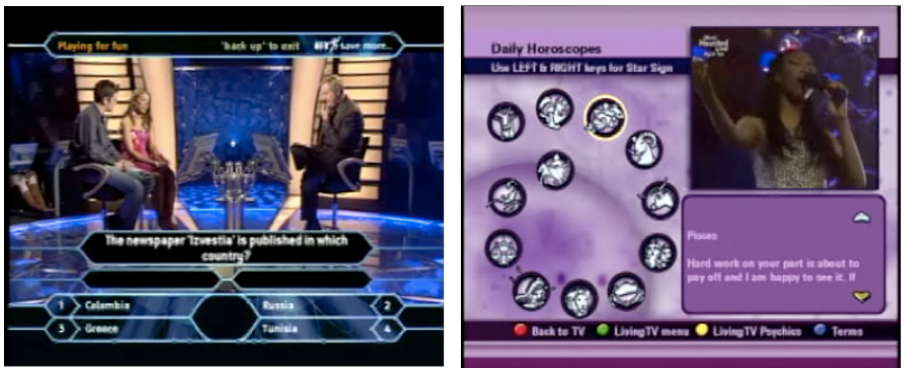

Fig. 1.16 Quiz games such as the "Who wants to be a millionnaire" have been a straightforward domain for adding interactivity with the audience. The Living TV channel on Sky offers on-demand horoscopes, which matches the gossip, celebrity, and paranormal programming of the channel.

Therefore, it is suggested to employ informational elements, in order to augment the entertainment content [106]. For example, a music video channel could insert interactive information related to the video clips, such as trivia, discography, or motivate direct sales and downloads of music (Figure 1.16). Furthermore, a quiz game might introduce an iTV application that allows viewers to play-along the contestants in the studio, to compete in the home or over distance. As a principle, designers should provide interactive entertainment elements or on-demand information elements that match the main TV content.

Another popular research stream has considered iTV for educational programs. Aarreniemi-Jokipelto [1] provides a historical description of educational content offered through TV in Finland. The background information about Finnish educational TV is complementary and runs almost in parallel with that of USA, as reported by Revelle [153]. Both of the above efforts started with the motivation to use traditional TV to educate children in the home and in the classroom. The main rationale cited for the adoption of TV as a learning medium is its pervasiveness. Television watching is a familiar and reliable consumer device with more than 90% penetration in developed countries. Although computers and the Web have been very popular in some developed countries too, they have not reached the pervasiveness of TV [15]. Nevertheless,

iTV systems hold many opportunities for enhancing distant education, such as messaging between the students and the eventual formation of online learning communities, which are interlocked with TV content.

A common belief is that TV viewers are always concentrated on the TV content, but there is ample evidence that TV usage takes many forms, as far as the levels of attention of the viewer are concerned. Jenkins [86] opposes to the popular view that iTV will support only the needs of the channel surfers by making an analogy: "With the rise of printing, intensive reading was theoretically displaced by extensive reading: readers read more books and spent less time on each. But intensive reading never totally vanished." Indeed, an iTV study has empirically confirmed the existence of readers and skimmers, as two distinct groups of TV viewers [35]. Therefore, the creators of content should consider the full continuum of viewer roles between skimmer and reader.

1.5 Lessons Learned and Open Research Issues

Notably, the most successful use of interactivity in TV has been achieved by external means, such as the VCR, the DVD, and game consoles. In fact, interactivity on the DVD players was in creative terms much better than any concept devised by the broadcast industry. It was so good that at one point it seemed as if the DVD middleware would become the default standard for all TV platforms. Another successful story has been the one of TiVo (Figure 1.17). It offers a UI for stored programs and has been popular in the USA for sometime already.

Due to the diversity of scientific subfields, 20 years of research on interactive TV has not produced a unified set of results. Interactive TV research as a whole is a loosely interwoven body of findings, broadly divided into a collection of separate research fields (e.g., content distribution system, graphics architectures, user interface development, user modeling, etc.) and commercial products. Each scientific field brought its expertise to bear on a separate facet of interactive TV, generating important results but not assembling them into common threads that could define how the main issues relate to one another or ideally how each finding builds upon each other. Moreover, most of the innovations

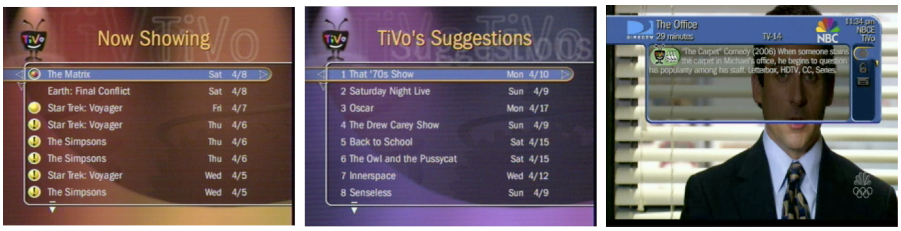

Fig. 1.17 The popular TiVo system (a combination of set-top box and service) always provides a choice of pre-recorded content and suggestions about what to watch, based on collaborative filtering. Information related to the running program is placed in a semitransparent box that does not distract viewing.

have been introduced by the industry in commercial products. As a matter of fact, the design process for those developments has remained very much undocumented. In contrast to the broadcast TV area, the networked TV one has been initiated on pragmatic expectations, feasible infrastructures, and most importantly lower barriers of entry for researchers and users.

In the following sections, we organize iTV research into three concepts, which stand as an evolutionary step over the traditional model of production–distribution–consumption: (1) editing, (2) sharing, and (3) controlling content. In particular we consider the end-user having an active role in each one of these activities, instead of being just a "viewer." In the rest of this article, we organize existing literature into these three distinct concepts.

References

[1] P. Aarreniemi-Jokipelto, "Instant messaging in informal learning via interactive television: Online communities among children in a "get along" program," *Computers in Entertainment*, vol. 5, no. 2, article number 9, 2007.

[2] G. D. Abowd, M. Gauger, and A. Lachenmann, "The family video archive: An annotation and browsing environment for home movies," in *Proceedings of the ACM International Workshop on Multimedia Information Retrieval (MIR)*, pp. 1–8, 2003.

[3] J. F. Abreu, P. Almeida, and V. Branco, "2BeOn: Interactive television supporting interpersonal communication," in *Proceedings of EuroGraphics*, pp. 199–208, 2001.

[4] J. F. Abreu, P. Almeida, R. Pinto, and V. Nobre, "Implementation of social features over regular IPTV STB," in *Proceedings of the European Conference on European Interactive Television Conference (EuroITV)*, pp. 29–32, 2009.

[5] P. C. Adams, "Television as gathering place," *Annals of the Association of American Geographers*, vol. 82, no. 1, pp. 117–135, 1992.

[6] G. Adomavicius and A. Tuzhilin, "Toward the next generation of recommender systems: A survey of the state-of-the-art and possible extensions," *IEEE Transactions on Knowledge and Data Engineering*, vol. 17, no. 6, pp. 734–749, 2005.

[7] S. Agamanolis, "At the intersection of broadband and broadcasting: How interactive TV technologies can support human connectedness," *International Journal of Human-Computer Interaction*, vol. 24, no. 2, pp. 121–135, 2008.

[8] S. Agamanolis and V. M. Bove, "Viper: A framework for responsive television," *IEEE Multimedia*, vol. 10, no. 3, pp. 88–98, 2003.

[9] A. Al-Hezmi, O. Friedrich, S. Arbanowski, and T. Magedanz, "Interactive multimedia services over open NGN testbed," in *Proceedings of the International Conference on Testbeds and Research Infrastructures for the Development of Networks & Communities*, article number 39, 2008.

[10] L. Ardissono, A. Kobsa, and M. T. Maybury, eds., *Personalized Digital Television Targeting Programs to Individual Viewers*. Kluwer Academic Publishers, 2004.

[11] L. Aroyo, P. Bellekens, M. Bjorkman, G. J. Houben, P. Akkermans, and A. Kaptein, "SenSee framework for personalized access to TV content," in *Proceedings of the European Conference on Interactive Television*, pp. 156–165, 2007.

[12] L. Aroyo, F. Nack, T. Schiphorst, H. Schut, and M. KauwATjoe, "Personalized ambient media experience: Move.me case study," in *Proceedings of the International Conference on Intelligent User Interfaces*, pp. 298–301, 2007.

[13] K. Baker, "Intrusive interactivity is not an ambient experience," *IEEE Multimedia*, vol. 13, no. 2, pp. 4–7, 2006.

[14] K. Baker, "Jules verne project: Realization of reactive media using MPEG4 on MHP," in *Proceedings of the IEEE International Conference on Consumer Electronics*, pp. 439–440, 2006.

[15] P. J. Bates T-learning Consultation Paper. pjb Associates http://www.pjb.co.uk/t-learning.htm, November 2002.

[16] P. Baudisch and L. Brueckner, "TV scout: Guiding users from printed TV program guides to personalized TV recommendation," in *Proceedings of the Workshop on Personalization in Future TV*, 2002.

[17] P. Bellekens, G.-J. Houben, L. Aroyo, K. Schaap, and A. Kaptein, "User model elicitation and enrichment for context-sensitive personalization in a multiplatform TV environment," in *Proceedings of the European Conference on Interactive Television (EuroITV)*, pp. 119–128, 2009.

[18] S. Benford, C. Greenhalgh, M. Craven, G. Walker, T. Regan, J. Morphett, and J. Wyver, "Inhabited television: Broadcasting interaction from within collaborative virtual environments," *ACM Transactions on Computer-Human Interaction*, vol. 7, no. 4, pp. 510–547, 2000.

[19] F. Bentley, C. Metcalf, and G. Harboe, "Personal versus commercial content: The similarities between consumer use of photos and music," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pp. 667–676, 2006.

[20] A. Berglund, E. Berglund, A. Larsson, and M. Bang, "Paper remote: An augmented television guide and remote control," *Universal Access Information Society*, vol. 4, no. 4, pp. 300–327, 2006.

[21] A. Berglund and P. Johansson, "Using speech and dialogue for interactive TV navigation," *Universal Access in the Information Society*, vol. 3, no. 3–4, pp. 224–238, 2004.

[22] R. Bernhaupt, M. Obrist, A. Weiss, E. Beck, and M. Tscheligi, "Trends in the living room and beyond: Results from ethnographic studies using creative and playful probing," *ACM Computers in Entertainment*, vol. 6, no. 1, article 5, 2008.

[23] Y. Blanco, J. J. Pazos, A. Gil, M. Ramos, A. Fernandez, R. P. Diaz, M. Lopez, and B. Barragans, "AVATAR: An approach based on semantic reasoning to recommend personalized TV programs," in *Proceedings of the World Wide Web Conference*, pp. 1078–1079, 2005.

[24] E. Blankinship, B. Smith, H. Holtzman, and W. Bender, "Closed caption, open source," *BT Technology Journal*, vol. 22, no. 4, pp. 151–159, 2004.

[25] S. Bocconi, F. Nack, and L. Hardman, "Supporting the generation of argument structure within video sequences," in *Proceedings of the ACM Conference on Hypertext and Hypermedia*, pp. 75–84, 2005.

[26] E. Boertjes, "ConnecTV: Share the experience," in *Adjunct Proceedings of the European Conference on Interactive Television*, pp. 139–140, 2007.

[27] S. Bonnici, "Which channel is that on? A design model for electronic programme guides," in *Proceedings of the European Conference on Interactive Television*, pp. 49–57, 2003.

[28] B. Brown and L. Barkhuus, "The television will be revolutionized: Effects of PVRs and filesharing on television watching," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pp. 663–666, 2006.

[29] H. Bryhni, H. Lovett, E. Aaartmann-Moe, D. Solvoll, and T. Sorensen, "On-demand regional television over the internet," in *Proceedings of the ACM International Conference on Multimedia*, pp. 99–107, 1996.

[30] D. C. A. Bulterman, "A rationale for creating an interactive-TV profile for SMIL," in *Adjunct Proceedings of the European Conference on Interactive Television*, pp. 593–597, 2006.

[31] D. C. A. Bulterman, "User-centered control within multimedia presentations," *Multimedia Systems Journal*, vol. 12, no. 4–5, pp. 423–438, 2007.

[32] D. C. A. Bulterman and L. Hardman, "Structured multimedia authoring," *ACM Transactions on Multimedia Computing, Communications, and Applications*, vol. 1, no. 1, pp. 89–109, 2005.

[33] D. C. A. Bulterman and L. Rutledge, *SMIL 3.0: Interactive Multimedia for Web, Mobile Devices, and Daisy Talking Books*. Heidelberg: Springer-Verlag, 2008.

[34] M. Burrnester, F. Koller, and T. Konig, "A user interface for interactive pay TV: PREMIERE goes online," in *Proceedings of ITV conference*, 1996.

[35] A. Cappelletti, M. Nardon, F. Pianesi, and M. Zancanaro, "Readers and skimmers watching iTV: Evidences from interactive video-on-demand," in *Proceedings of the Workshop on Personalization in Future TV*, 2003.

[36] R. G. Cattelan, C. Teixeira, R. Goularte, and M. D. Pimentel, "Watch-and-comment as a paradigm toward ubiquitous interactive video editing," *ACM Transactions on Multimedia Computing, Communications, and Applications*, vol. 4, no. 4, article 28, 2008.

[37] P. Cesar, D. C. A. Bulterman, D. Geerts, J. Jansen, H. Knoche, and W. Seager, "Enhancing social sharing of videos: Fragment, annotate, enrich, and share," in *Proceedings of the ACM Conference on Multimedia*, pp. 11–20, 2008.

[38] P. Cesar, D. C. A. Bulterman, and J. Jansen, "An architecture for viewer-side enrichment of TV content," in *Proceedings of the ACM International Conference on Multimedia*, pp. 651–654, 2006.

[39] P. Cesar, D. C. A. Bulterman, and J. Jansen, "Benefits of structured multimedia documents in iDTV: The end-user enrichment system," in *Proceedings of the ACM Symposium on Document Engineering*, pp. 176–178, 2006.

[40] P. Cesar, D. C. A. Bulterman, and J. Jansen, "Usages of the secondary screen in an interactive television environment: Control, enrich, share, and transfer television content," in *Proceedings of the European Conference on Interactive Television*, pp. 168–177, 2008.

[41] P. Cesar, D. C. A. Bulterman, and L. F. G. Soares, "Human-centered television: Directions in interactive digital television research," *ACM Transactions on Multimedia Computing, Communications, and Applications*, vol. 4, no. 4, article 24, 2008.

[42] P. Cesar, P. Vuorimaa, and J. Vierinen, "A graphics architecture for high-end interactive television terminals," *ACM Transactions on Multimedia Computing, Communications, and Applications*, vol. 2, no. 4, pp. 343–357, 2006.

[43] M. Cha, P. Rodriguez, J. Crowcroft, S. Moon, and X. Amatriain, "Watching television over an IP network," in *Proceedings of the ACM SIGCOMM Conference on Internet Measurement*, pp. 71–84, 2008.

[44] K. Chorianopoulos and G. Lekakos, "Introduction to social TV: Enhancing the shared experience with interactive TV," *International Journal of Human-Computer Interaction*, vol. 24, no. 2, pp. 113–120, 2008.

[45] K. Chorianopoulos and D. Spinellis, "Affective usability evaluation for an interactive music television channel," *ACM Computers in Entertainment*, vol. 2, no. 3, article number 14, 2004.

[46] K. Chorianopoulos and D. Spinellis, "User interface development for interactive television: Extending a commercial DTV platform to the virtual channel API," *Computers and Graphics*, vol. 28, no. 2, pp. 57–166, 2004.

[47] K. Chorianopoulos and D. Spinellis, "User interface evaluation of interactive TV: A media studies perspective," *Universal Access in the Information Society*, vol. 5, no. 2, pp. 209–218, 2006.

[48] M. Clancey, "The television audience examined," *Journal of Advertising Research*, vol. 34, no. 4, pp. 2–11, 1994.

[49] W. Cooper, "The interactive television user experience so far," in *Proceeding of the International Conference on Designing Interactive User Experiences for TV and Video (UXTV)*, pp. 133–142, 2008.

[50] T. Coppens, F. Vanparijs, and K. Handekyn, "AmigoTV: A social TV experience through triple-play convergence," *Alcatel, White Paper*, 2005.

[51] J. Cosmas et al., "CustomTV with MPEG-4 and MPEG-7," in *IEEE Colloquium on Interactive Television*, vol. 9, pp. 1–6, 1999.

[52] J. Cosmas et al., "Customized television: Standards compliant advanced digital television," *IEEE Transactions on Broadcasting*, vol. 48, no. 2, pp. 151–158, 2002.

[53] R. M. R. Costa, M. F. Moreno, R. F. Rodrigues, and L. F. G. Soares, "Live editing of hypermedia documents," in *Proceedings of the ACM Symposium on Document Engineering*, pp. 165–175, 2006.

[54] M. Craven, S. Benford, C. Greenhalgh, J. Wyver, C. Brazier, A. Oldroyd, and T. Regan, "Ages of avatar: Community building for inhabited television," in

Proceedings of the International Conference on Collaborative Virtual Environments, pp. 189–194, 2000.

[55] Y. Cui, J. Chipchase, and Y. Jung, "Personal TV: A qualitative study of mobile TV users," in *Proceedings of the European Conference on Interactive Television*, pp. 195–204, 2007.

[56] M. Deriu, "A viable approach to deliver television events, having multiple and selectable plots: MultiChannelStory," in *Proceedings of the ACM SIGCHI International Conference on Advances in Computer Entertainment Technology*, pp. 358–360, 2005.

[57] Digital TV Group (DTG), *Digital Terrestrial Television MHEG-5 Specification*. v1.06, 2003.

[58] S. M. Drucker, A. Glatzer, S. D. Mar, and C. Wong, "Smartskip: Consumer level browsing and skipping of digital video content," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pp. 219–226, 2002.

[59] N. Ducheneaut, R. J. Moore, L. Oehlberg, J. D. Thornton, and E. Nickell, "SocialTV: Designing for distributed, social television viewing," *International Journal of Human-Computer Interaction*, vol. 24, no. 2, pp. 136–154, 2008.

[60] A. Ekin, "Sports video processing for description, summarization, and search," Unpublished PhD thesis, Rochester Institute of Technology, 2003.

[61] S. Fallahkhair, L. Pemberton, and J. Masthoff, "A dual device scenario for informal language learning: Interactive television meets the mobile phone," in *Proceedings of the IEEE International Conference on Advanced Learning Technologies*, pp. 16–20, 2004.

[62] B. J. Felton, M. L. Moss, and R. J. Sepulveda, "Two-way television: An experiment in interactive programming for the elderly," *Experimental Aging Research*, vol. 6, no. 1, pp. 29–45, 1980.

[63] D. A. Ferguson, "Channel repertoire in the presence of remote control devices, VCRs, and cable television," *Journal of Broadcasting and Electronic Media*, vol. 36, no. 1, pp. 83–91, 1992.

[64] D. A. Ferguson and E. M. Perse, "Media and audience influences on channel repertoire," *Journal of Broadcasting and Electronic Media*, vol. 37, no. 1, pp. 31–47, 1993.

[65] M. Fink, M. Covell, and S. Baluja, "Social– and interactive–television: Applications based on real-time ambient-audio identification," in *Proceedings of the European Conference on Interactive Television*, pp. 138–146, 2006.

[66] M. Finke and D. Balfanz, "Interaction with content-augmented video via off-screen hyperlinks for direct information retrieval," in *Proceedings of the International Conference in Central Europe on Computer Graphics, Visualization and Computer Vision*, pp. 187–194, 2002.

[67] M. Finke and D. Balfanz, "A reference architecture supporting hypervideo content for ITV and the Internet domain," *Computers & Graphics*, vol. 28, no. 2, pp. 179–191, 2004.

[68] J. Fokker, H. Ridder, P. Westendorp, and J. Pouwelse, "Psychological backgrounds for inducing cooperation in peer-to-peer television," in *Proceedings of the European Conference on Interactive Television*, pp. 136–145, 2007.

[69] B. Fox, "Digital TV comes down to earth," *IEEE Spectrum*, vol. 35, no. 10, pp. 23–29, 1998.

[70] B. Furht, "Interactive television systems," in *Proceedings of the ACM Symposium on Applied Computing*, pp. 7–11, 1996.

[71] D. Gauntlett and A. Hill, *TV Living: Television, Culture and Everyday Life*. Routledge, 1999.

[72] D. Geerts, "Comparing voice chat and text chat in a communication tool for interactive television," in *Proceedings of the Nordic Conference on Human-computer Interaction*, pp. 461–464, 2006.

[73] D. Geerts, P. Cesar, and D. Bulterman, "The implications of program genres for the design of social television systems," in *Proceeding of the International Conference on Designing Interactive User Experiences for TV and Video (UXTV)*, pp. 71–80, 2008.

[74] D. Geerts and D. De Grooff, "Supporting the social uses of television: Sociability heuristics for social TV," in *Proceedings of the International Conference on Human Factors in Computing Systems*, pp. 595–604, 2009.

[75] S. Goldenberg, "Digital video recorders and micro-social networking: Recreating the shared watching experience of television," *Adjunct Proceedings of the European Conference on Interactive Television*, 2007.

[76] D. Goren-Bar and O. Glinansky, "Family stereotyping — A model to filter TV programs for multiple viewers," in *Proceedings of the Workshop on Personalization in Future TV*, 2002.

[77] R. Goularte, R. G. Cattelan, J. A. Camacho-Guerrero, V. R. Inacio, and M. da Graca C. Pimentel, "Interactive multimedia annotations: Enriching and extending content," in *Proceedings of the ACM Symposium on Document Engineering*, pp. 84–86, 2004.

[78] R. Goularte, E. S. Moreira, and M. G. C. Pimentel, "Structuring interactive TV documents," in *Proceedings of the ACM Symposium on Document Engineering*, pp. 42–51, 2003.

[79] M. Green and R. Jacob, "Siggraph '90 workshop report: Software architectures and metaphors for non-wimp user interfaces," *SIGGRAPH Computer Graphics*, vol. 25, no. 3, pp. 229–235, 1991.

[80] T. Gross, M. Fetter, and T. Paul-Stueve, "Toward advanced social TV in a cooperative media space," *International Journal of Human-Computer Interaction*, vol. 24, no. 2, pp. 155–173, 2008.

[81] M. Hamasaki, H. Takeda, and T. Nishimura, "Network analysis of massively collaborative creation of multimedia contents: Case study of hatsune miku videos on nico nico douga," in *Proceeding of the International Conference on Designing Interactive User Experiences For TV and Video*, pp. 165–168, 2008.

[82] G. Harboe, N. Massey, C. Metcalf, D. Wheatley, and G. Romano, "The uses of social television," *ACM Computers in Entertainment*, vol. 6, no. 1, article 8, 2008.

[83] G. Harboe, C. J. Metcalf, F. Bentley, J. Tullio, N. Massey, and G. Romano, "Ambient social TV: Drawing people into a shared experience," in *Proceeding of the SIGCHI Conference on Human Factors in Computing Systems*, pp. 1–10, 2008.

[84] P. Hulsen, E. Vlemmix, and K. Baker, "Peer-to-Peer Internet television," in *Proceedings of the First International Conference on Automated Production of Cross Media Content for Multi-Channel Distribution*, pp. 267–270, 2005.

[85] K. Jaaskelainen, "Strategic questions in the development of interactive television programs," PhD thesis, University of Art and Design Helsinki, 2001.

[86] H. Jenkins, *TV Tomorrow*. MIT Technology Review, 2001.

[87] J. F. Jensen, "Interactive television: New genres, new format, new content," in *Proceedings of the Australasian Conference on Interactive Entertainment*, pp. 89–96, 2005.

[88] J. F. Jensen, "The concept of interactivity — Revisited: Four new typologies for a new media landscape," in *Proceeding of the International Conference on Designing Interactive User Experiences for TV and Video*, pp. 129–132, 2008.

[89] J. F. Jensen, "Interactive television — A brief media history," in *Proceedings of the European Conference on Interactive Television*, pp. 1–10, 2008.

[90] M. H. Kang, "Interactivity in television: Use and impact of an interactive program guide," *Journal of Broadcasting and Electronic Media*, vol. 46, no. 3, pp. 330–345, 2002.

[91] A. Karanastasi, F. G. Kazasis, and S. Christodoulakis, "A natural language model for managing TV-Anytime information in mobile environments," *Personal and Ubiquitous Computing*, vol. 9, no. 5, pp. 262–272, 2005.

[92] C. Karat, J. Karat, J. Vergo, C. Pinhanez, D. Riecken, and T. Cofino, "That's entertainment! designing streaming, multimedia web experiences," *International Journal of Human-Computer Interaction*, vol. 14, no. 3 & 4, pp. 369–384, 2002.

[93] F. G. Kazasis, N. Moumoutzis, N. Pappas, A. Karanastasi, and S. Christodoulakis, "Designing ubiquitous personalized TV-Anytime services," in *Proceedings of the International Workshop on Ubiquitous Mobile Information and Collaboration Systems*, 2003.

[94] J. Kim, H. Kim, and K. Park, "Towards optimal navigation through video content on interactive TV," *Interacting with Computers*, vol. 18, no. 4, pp. 723–746, 2006.

[95] S. H. Kim, J. Ok, H. J. Kang, M. C. Kim, and M. Kim, "An interaction and product design of gesture based TV remote control," in *Extended Abstracts in Human Factors in Computing Systems*, pp. 1548–1548, 2004.

[96] D. Kirk, A. Sellen, R. Harper, and K. Wood, "Understanding videowork," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pp. 61–70, 2007.

[97] H. Knoche, J. McCarthy, and M. Sasse, "Can small be beautiful? Assessing image size requirements for mobile TV," in *Proceedings of ACM Multimedia*, pp. 829–838, 2005.

[98] H. Knoche and J. D. McCarthy, "Design requirements for mobile TV," in *Proceedings of MobileHCI*, pp. 69–76, 2005.

[99] R. Kubey, "TV and the Internet: Pitfalls in forecasting the future," *Knowledge, Technology, & Policy*, vol. 13, no. 2, pp. 63–85, 2000.

[100] R. Kubey and M. Csikszentmihalyi, *Television and the Quality of Life: How Viewing Shapes Everyday Experiences*. Lawrence Erlbaum, 1990.

[101] B. Lee and R. S. Lee, "How and why people watch TV: Implications for the future of interactive television," *Journal of Advertising Research*, vol. 35, no. 6, pp. 9–18, 1995.

[102] D. G. Lee, D. I. Fels, and J. P. Udo, "Emotive captioning," *Computers in Entertainment*, vol. 5, no. 2, article number 11, 2007.

[103] G. Lekakos and G. M. Giaglis, "A lifestyle-based approach for delivering personalized advertisements in digital interactive television," *Journal of Computer-Mediated Communication*, vol. 9, no. 2, 2004.

[104] C. C. Lin and M. S. Chen, "On controlling digital TV set-top-box by mobile devices via IP network," in *Proceedings of the IEEE International Symposium on Multimedia*, pp. 52–59, 2005.

[105] T. D. Little and D. Venkatesh, "Prospects for interactive video-on-demand," *IEEE MultiMedia*, vol. 1, no. 3, pp. 14–24, 1994.

[106] J. Livaditi, K. Vassilopoulou, C. Lougos, and K. Chorianopoulos, "Needs and gratifications for interactive TV applications: Implications for designers," in *Proceedings of the Annual Hawaii International Conference on System Science*, 2003.

[107] M. Lopez, J. J. Pazos, J. Garcia, Y. Blanco, and A. Gil, "Non-invasive and personalized advertising through MPEG-4 processing and semantic reasoning," in *Proceedings of the IEEE International Conference on Consumer Electronics*, 2007.

[108] A. Lugmayr, S. Niiranen, and S. Kalli, *Digital Interactive TV and Metadata Future Broadcast Multimedia*. Springer, 2004.

[109] J. Lull, "Family communication patterns and the social uses of television," *Communication Research*, vol. 7, no. 3, pp. 319–333, SAGE Publications, 1980.

[110] J. Lull, *Inside Family Viewing*. Routledge, 1990.

[111] K. Luyten, K. Thys, S. Huypens, and K. Connix, "Telebuddies: Social stitching with interactive television," in *Extended Abstracts of the SIGCHI Conference on Human Factors in Computing Systems*, pp. 1049–1054, 2006.

[112] N. Macdonald, "Can HCI shape the future of mass communications?," *Interactions*, vol. 11, no. 2, pp. 44–47, 2004.

[113] M. Maguire, "Applying evaluation methods to future digital TV services," in *Pleasure with Products Beyond Usability*, (W. Green and P. Jordan, eds.), pp. 353–366, Taylor and Francis, 2002.

[114] C. Malerczyk, K. Klein, and T. Weibeisek, "3D reconstruction of sports events for digital TV," in *Proceedings of the International Conference in Central Europe on Computer Graphics, Visualization, and Computer Vision*, 2003.

[115] T. W. Malone, "Heuristics for designing enjoyable user interfaces: Lessons from computer games," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pp. 63–68, 1982.

[116] C. Marrin, R. Myers, J. Kent, and P. Broadwell, "Steerable media: Interactive television via video synthesis," in *Proceedings of the International Conference on 3D Web Technology: Virtual Reality Modelling Language Symposium*, pp. 7–14, 2001.

[117] J. Masthoff, "Group modeling: Selecting a sequence of television items to suit a group of viewers," *User Modeling and User Adapted Interaction*, vol. 14, no. 1, pp. 37–85, 2004.

[118] J. Masthoff, W. W. Vasconcelos, C. Aitken, and F. S. Correa da Silva, "Agent-based group modeling for ambient intelligence," in *The AISB Symposium on Affective Smart Environments*, 2007.

[119] C. Metcalf, G. Harboe, J. Tullio, N. Massey, G. Romano, E. M. Huang, and F. Bentley, "Examining presence and lightweight messaging in a social television experience," *ACM Transactions on Multimedia Computing, Communications, and Applications*, vol. 4, no. 4, article 27, 2008.

[120] P. Meuleman, A. Heister, H. Kohar, and D. Tedd, "Double agent — presentation and filtering agents for a digital television *recording system*," in *CHI 98 Conference Summary on Human Factors in Computing Systems*, pp. 3–4, 1998.

[121] M. Milenkovic, "Delivering interactive services via a digital TV infrastructure," *IEEE Multimedia*, vol. 5, no. 4, pp. 34–43, 1998.

[122] S. Miller, "Interactive TV: Taking on the masses with mobile messaging TV," *ACM Computers in Entertainment*, vol. 3, no. 2, article number 6, 2005.

[123] A. Monk, "User-centred design: The home use challenge," in *Home Informatics and Telematics: Information Technology and Society*, (A. Sloane and F. van Rijn, eds.), pp. 181–190, Kluwer, 2000.

[124] S. Morris and A. Smith-Chaigneau, *Interactive TV Standards: A Guide to MHP, OCAP and JavaTV*. Focal Press, 2005.

[125] F. Nack and A. T. Lindsay, "Everything you wanted to know about MPEG-7 (part 1)," *IEEE Multimedia*, vol. 6, no. 3, pp. 65–77, 1999.

[126] F. Nack and A. T. Lindsay, "Everything you wanted to know about MPEG-7 (part 2)," *IEEE Multimedia*, vol. 6, no. 4, pp. 64–73, 1999.

[127] M. Nathan, C. Harrison, S. Yarosh, L. Terveen, L. Stead, and B. Amento, "CollaboraTV: Making television viewing social again," in *Proceeding of the International Conference on Designing Interactive User Experiences for TV and Video*, pp. 85–94, 2008.

[128] J. Nichols, B. Myers, M. Higgins, J. Hughes, T. Harris, R. Rosenfeld, and M. Pignol, "Generating remote control interfaces for complex appliances," in *Proceedings of the ACM Annual Symposium on User Interface Software and Technology*, pp. 161–170, 2002.

[129] J. Nielsen, *Usability Engineering*. Morgan Kaufmann, 1994.

[130] J. O'Brien, T. Rodden, M. Rouncefield, and J. Hughes, "At home with the technology: An ethnographic study of a set-top-box trial," *ACM Transactions on Computer-Human Interaction*, vol. 6, no. 3, pp. 282–308, 1999.

[131] M. Obrist, E. Beck, S. Kepplinger, R. Bernhaupt, and M. Tscheligi, "Local communities: Back to fife (live) through IPTV," in *Proceedings of the European Conference on Interactive Television*, pp. 148–157, 2008.

[132] M. Obrist, R. Bernhaupt, and M. Tscheligi, "Interactive television for the home: An ethnographic study on users' requirements and experiences," *International Journal of Human-Computer Interaction*, vol. 24, no. 2, pp. 174–196, 2008.

[133] K. O'Hara, A. S. Mitchell, and A. Vorbau, "Consuming video on mobile devices," in *Proceedings of the SIGCHI Conference on Human factors in Computing Systems*, pp. 857–866, 2007.

[134] V. Oksman, V. Ollikainen, E. Noppari, C. Herrero, and A. Tammela, "'Podracing': Experimenting with mobile TV content consumption and delivery methods," *Multimedia Systems Journal*, vol. 14, no. 2, pp. 105–114, 2008.

[135] S. O'Modhrain and I. Oakley, "Touch TV: Adding feeling to broadcast media," in *Proceedings of the European Conference on Interactive Television: From Viewers to Actors?*, 2003.

[136] M. Oumard, D. Mirza, J. Kroy, and K. Chorianopoulos, "A cultural probes study on video sharing and social communication on the Internet," in *Proceedings of the International Conference on Digital Interactive Media in Entertainment and Arts*, pp. 142–148, 2008.

[137] H. M. Ozaktas and L. Onural, eds., *Three-Dimensional Television: Capture, Transmission, and Display*. Springer Verlag, 2007.

[138] R. Pea, M. Mills, J. Rosen, K. Dauber, W. Effelsberg, and E. Hoffert, "The diver project: Interactive digital video repurposing," *IEEE MultiMedia*, vol. 11, no. 1, pp. 54–61, 2004.

[139] L. Pemberton, S. Fallahkhair, and J. Masthoff, "Learner centred development of cross platform language learning support system," *Journal of Educational Technology and Society*, vol. 8, no. 4, pp. 52–63, 2005.

[140] F. Pereira and T. Ebrahimi, *The MPEG-4 Book*. Prentice Hall, 2002.

[141] T. S. Perry, "The trials and travails of interactive TV," *IEEE Spectrum*, vol. 33, no. 4, pp. 22–28, 1996.

[142] E. M. Perse, "Media involvement and local news effects," *Journal of Broadcasting and Electronic Media*, vol. 34, no. 1, pp. 17–36, 1990.

[143] B. J. Pine and J. H. Gilmore, *The Experience Economy: Work is Theatre and Every Business a Stage*. Harvard Business School Press, 1999.

[144] F. Pittarello, "Time-Pillars: A 3D cooperative paradigm for the TV domain," in *Proceedings of the Workshop on Personalization in Future TV*, 2002.

[145] R. Pose, "Steerable interactive television: Virtual reality technology changes user interfaces of viewers and of program producers," in *Proceedings of the Australasian User Interface Conference*, pp. 77–84, 2001.

[146] R. Putnam, *Bowling Alone: The Collapse and Revival of American Community*. Simon & Schuster, 2001.

[147] R. Rafey et al., "Enabling custom enhancements in digital sports broadcasts," in *Proceedings of the International Conference on 3D Web Technology: Virtual Reality Modeling Language Symposium*, pp. 101–107, 2001.

[148] G. Ramos and R. Balakrishnan, "Fluid interaction techniques for the control and annotation of digital video," in *Proceedings of the Symposium on User Interface Software and Technology*, pp. 105–114, 2003.

[149] T. Regan and I. Todd, "Media center buddies: Instant messaging around a media center," in *Proceedings of the Nordic Conference on Human-Computer Interaction*, pp. 141–144, 2004.

[150] U. Reimers, "Digital television broadcasting," *IEEE Communications Magazine*, vol. 36, no. 1, pp. 104–110, 1998.

[151] U. Reimers, *DVB: The Family of International Standards for Digital Video Broadcasting*. Springer-Verlag, 2005.

[152] M. Ressin and C. Haffner, "Human-Centered design of interactive TV games with SMS backchannel," in *Proceedings of the European Conference on Interactive Television*, pp. 37–46, 2007.

[153] G. L. Revelle, "Educating via entertainment media: The sesame workshop approach," *Computers in Entertainment*, vol. 1, no. 1, article number 7, 2003.

[154] M. Rey-López, R. P. D. Redondo, A. F. Vilas, and J. J. P. Arias, "Entercation: Engaging viewers in education through TV," *ACM Computers in Entertainment*, vol. 5, no. 2, article number 7, 2007.

[155] M. Rice and N. Alm, "Designing new interfaces for digital interactive television usable by older adults," *ACM Computers in Entertainment*, vol. 6, no. 1, article number 6, 2008.

[156] S. Robertson, C. Wharton, C. Ashworth, and M. Franzke, "Dual device user interface design: PDAs and interactive television," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pp. 79–86, 1996.

[157] M. Robin and M. Poulin, *Digital Television Fundamentals: Design and Installation of Video and Audio Systems*. McGraw-Hill, 1998.

[158] A. C. Roibás and S. Johnson, "Unfolding the user experience in new scenarios of pervasive interactive TV," in *Extended Abstracts on Human Factors in Computing Systems*, pp. 1259–1264, 2006.

[159] A. M. Rubin, "Television uses and gratifications: The interaction of viewing patterns and motivations," *Journal of Broadcasting and Electronic Media*, vol. 27, no. 1, pp. 37–51, 1983.

[160] A. M. Rubin, "Ritualized and instrumental television viewing," *Journal of Communication*, vol. 34, no. 3, pp. 67–77, 1984.

[161] C. P. Sandbank, "Digital television in the convergent environment," *IEEE Computer Graphics and Applications*, vol. 21, no. 1, pp. 32–36, 2001.

[162] R. Schatz, S. Wagner, and N. Jordan, "Mobile social TV: Extending DVB-H services with P2P-interaction," in *Proceedings of the International Conference on Digital Telecommunications*, pp. 14–19, 2007.

[163] T. Schiphorst, F. Nack, M. KauwATjoe, S. de Bakker, L. Stock Aroyo, A. P. Rosillio, H. Schut, and N. Jaffe, "PillowTalk: Can we afford intimacy?," in *Proceedings of the International Conference on Tangible and Embedded Interaction*, pp. 23–30, 2007.

[164] D. A. Shamma, M. Bastea-Forte, N. Joubert, and Y. Liu, "Enhancing online personal connections through the synchronized sharing of online video," in *Extended Abstracts on Human Factors in Computing Systems*, pp. 2931–2936, 2008.

[165] D. A. Shamma, R. Shaw, P. L. Shafton, and Y. Liu, "Watch what I watch: Using community activity to understand content," in *Proceedings of the International Workshop on Multimedia Information Retrieval*, pp. 275–284, 2007.

[166] R. Shaw and P. Schmitz, "Community annotation and remix: A research platform and pilot deployment," in *Proceedings of the ACM International Workshop on Human Centered Multimedia*, pp. 89–98, 2006.

[167] J. A. Short, E. Williams, and B. Christie, *The Social Psychology of Telecommunications*. New York: John Wiley & Sons, 1976.

[168] T. Shrimpton-Smith, B. Zaman, and D. Geerts, "Coupling the users: The benefits of paired user testing for iDTV," *International Journal of Human-Computer Interaction*, vol. 24, no. 2, pp. 197–213, 2008.
[169] R. Silverstone, *Television and Everyday Life*. Routledge, 1994.
[170] B. Smyth and P. Cotter, "A personalized television listings service," *Communications of the ACM*, vol. 43, no. 8, pp. 107–111, 2000.
[171] L. F. G. Soares and G. L. S. Filho, "Interactive television in Brazil: System Software and the digital divide," in *Adjunct Proceedings of the European Conference on Interactive Television*, pp. 41–43, 2007.
[172] L. F. G. Soares, R. F. Rodrigues, and M. F. Moreno, "Ginga-NCL: The declarative environment of the Brazilian digital TV system," *Journal of the Brazilian Computer Society*, vol. 13, pp. 37–46, 2007.
[173] C. Södergard, ed., Mobile television — technology and user experiences. Report on the Mobile-TV project. *VTT Information technology*. 2003.
[174] S. Sperring and T. Strandvall, "Viewers' experiences of a TV quiz show with integrated interactivity," *International Journal of Human-Computer Interaction*, vol. 24, no. 2, pp. 214–235, 2008.
[175] A. Taylor and R. Harper, "Age-Old practices in the 'New World': A study of gift-giving between teenage mobile phone users," in *Proceedings of the Conference on Human Factors and Computing Systems*, pp. 439–446, 2002.
[176] E. Tsekleves, R. Whitham, K. Kondo, and A. Hill, "Bringing the television experience to other media in the home: An ethnographic study," in *Proceedings of the European Conference on European interactive Television*, pp. 201–210, 2009.
[177] A. Ugarte, I. García, A. Ortiz, and D. Oyarzun, "User interfaces based on 3D avatars for interactive television," in *Proceedings of the European Conference on Interactive Television*, pp. 107–116, 2007.
[178] M. F. Ursu, I. A. Kegel, D. Williams, M. Thomas, H. Mayer, V. Zsombori, M. L. Tuomola, H. Larsson, and J. Wyver, "ShapeShifting TV: Interactive screen media narratives," *Multimedia Systems Journal*, vol. 14, no. 2, pp. 115–132, 2008.
[179] M. F. Ursu, M. Thomas, I. Kegel, D. Williams, M. Tuomola, I. Lindstedt, T. Wright, A. Leurdijk, V. Zsombori, J. Sussner, U. Maystream, and N. Hall, "Interactive TV narratives: Opportunities, progress and challenges," *ACM Transactions on Multimedia Computing, Communications and Applications*, vol. 4, no. 4, article 25, 2008.
[180] J. van Barneveld and M. van Setten, "Involving users in the design of user interfaces for TV recommender systems," in *Proceedings of the Workshop on Personalization in Future TV*, 2003.
[181] E. S. Veinott, J. Olson, G. M. Olson, and X. Fu, "Video helps remote work: Speakers who need to negotiate common ground benefit from seeing each other," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pp. 302–309, 1999.
[182] P. Vorderer, "Interactive entertainment and beyond," in *Media Entertainment: The Psychology of Its Appeal*, (D. Zillmann and P. Vorderer, eds.), pp. 21–36, Lawrence Erlbaum Associates, 2000.

[183] P. Vorderer, S. Knobloch, and H. Schramm, "Does entertainment suffer from interactivity? The impact of watching an interactive TV movie on viewers' experience of entertainment," *Media Psychology*, vol. 3, no. 4, pp. 343–363, 2001.

[184] H. D. Wactlar, M. G. Christel, Y. Gong, and A. G. Hauptmann, "Lessons learned from building a terabyte digital video library," *Computer*, vol. 32, no. 2, pp. 66–73, 1999.

[185] J. Wang, J. Pouwelse, J. Fokker, and M. J. T. Reinders, "Personalization of a peer-to-peer television system," in *Proceedings of the European Conference on Interactive Television*, pp. 147–155, 2006.

[186] J. D. Weisz and S. Kiesler, "How text and audio chat change the online video experience," in *Proceeding of the International Conference on Designing Interactive User Experiences for TV and Video*, pp. 9–18, 2008.

[187] J. D. Weisz, S. Kiesler, H. Zhang, Y. Ren, R. E. Kraut, and J. A. Konstan, "Watching together: Integrating text chat with video," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pp. 877–886, 2007.

[188] A. R. Wellens, "An interactive television laboratory for the study of social interaction," *Journal of Nonverbal Behavior*, vol. 4, no. 2, pp. 119–122, 1979.

[189] D. Zillmann, "The coming of media entertainment," in *Media Entertainment: The Psychology of Its Appeal*, (D. Zillmann and P. Vorderer, eds.), pp. 1–20, Lawrence Erlbaum Associates, 2000.

[190] D. Zillmann and J. Bryant, *Selective Exposure to Communication*. Lawrence Erlbaum Associates Hillsdale, 1985.