Converging Multimedia Content Presentation Requirements for Interactive Television

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1 Introduction and Problem Discussion

Media convergence may be perceived as phenomenon of the Information Society evolutionary process. Manuel Castells recognizes that "*. . .the growing interaction between horizontal and vertical networks of communication does not mean that the mainstream media are taking over the new, autonomous forms of content generation and distribution. It means that there is a process of convergence that gives birth to new media reality whose contours and effects will ultimately be decided by political and business struggles*" (Castells, 2011). This process is particularly important for interactive television, a domain influenced by technological advances, techno-social interaction and social media that currently demonstrate rapid convergence. One may historically identify the occurrence of these rapid processes precede the establishment of new standards, a time where in most cases opposing technologies try to gain a respectable market share and be adopted by the users. Take for example the battle of formats between the VHS vs. BETACAM and the more recent HD-DVD vs. the BLU-RAY technologies. In the first case the capability of content duplication offered by one of the systems and in the second case the extended availability of a wide number of content titles for one of the standards, forced the public to adopt the technologically less-advanced standard. User choice based on the availability of replication mechanisms in one and content in the other case is indicative of the convergence process that takes place within the information society.

Of course content and technical specifications cannot always be considered as the main deciding factor. One may recall the technological breakthrough that the introduction of interactive-CD and later DVD-interactive media offered to

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developers. Some identified the positive aspects of these technologies (Taylor, 1999) and predicted their applicability in areas of education (Bush, 2000) and entertainment (Kreuzberger, 2007). Today, although the majority of proprietary DVD-playback devices and computer-based media players support interactive content playback and one may use it to develop interactive movies (Argyriou, 2010) or games (Kreuzberger, 2007), a small number of interactive titles have been produced that take advantage of the content-manipulating capabilities. Clearly this phenomenon is not attributed to the limited user interest or media incompatibility, but to the complex and expensive production process that needs to be actioned in order to produce multimedia titles that increases the cost and production time. Today interactive titles are developed using computer game development environments and are distributed on DVD media or the WWW.

The above examples share common characteristics to interactive television as they describe the introduction of new technologies, which are novel and do not have to deal with already established competitive technologies. The case of Minitel is indicative of the issues arise in the adoption process when new competitive technologies appear. Minitel was a pre-WWW videotext service established at 1982 in France, enabling users to perform actions similar to those offered by the WWW services that include: messaging, bookings, reservations and purchases over their phone line. The availability of this service delayed the absorption of the WWW in France and in 2009 Minitel still totalled ten million users. The service was officially terminated in 2012.

Whether interactive broadcasting systems will eventually catch-up with society is a non-use non-adoption issue (Deliyannis, Antoniou, & Pandis, 2009) affected by the availability of other technologies, marketing, technological infrastructure cultural factors and consumer behavior (de Mooij & Hofstede, 2002). In order to research the factors of adoption or non-adoption of technological developments, the evolution of television is in this work addressed from the technological (Lugmayr, Niiranen, & Kalli, 2004; Zheng, Fu, & Lugmayr, 2012), social and ethnographic perspectives (Tay & Turner, 2009; Tsekleves, Whitham, Kondo, & Hill, 2009). Under this standpoint it is easier to examine how users often combine communication media and engage them constructively within their social context (Paradise, 2012). For example, in the case of television, evolution is influenced by a number of interrelated technological, content and user factors. Today the majority of networked mobile devices allow standard stream playback facilities, covering the content access user demands. At the same time, users capable to utilize the advance features of their mobile devices are able create, process, enhance with metadata and stream/broadcast/share audiovisual content on the WWW. This clearly transforms the user from content receiver to content provider, triggering an interactive content publishing cycle.

Political forces and media-providers do try to affect the users, but in the end the ability to retrieve and enhance content with metadata such as comments and links to other comments enables a new reality to evolve. The news reading service available from Google at http://news.google.com is a typical example that may be used to demonstrate the shift towards a more organized way to access and evaluate news

feeds. This service triggered by content published on websites providing news feeds, organizes content thematically allowing direct access to the sources. The user is able to scan the article titles and access the text across different sources, a process that often reveals that in some articles specific information may not be disclosed in its entity, offering a biased interpretation of facts. User comments and thoughts can then be posted on the source website, or other social media services. Clearly, social media may be considered superior to traditional broadcasting media as their interactive capabilities cover the need for immediate access to information while users are allowed to contrast, interpret and criticize published content on the same subject from various sources.

Interactive television functions in a similar way as it allows users to share their feedback and influence the live broadcasting process. The main aim of this work is to identify the key factors that affect the converging process in the field of interactive television, and provide solutions that may be applied in the media industry. Section 2 researches the literature, identifies and analyses the governing factors of the convergence process. As new technologies introduce advanced interaction capabilities, we do not limit this research to existing content types. Instead, advanced content case studies are developed in an attempt to reveal the converging multimedia content presentation requirements for interactive television content. Section 3 presents and evaluates the findings of these case studies designed to test the limitations of the interactive broadcasting architecture and Sect. 4 summarizes the results, proposes further research and development directions that if followed by content providers can aid convergence by advancing their products and services while directing users to voluntarily adopt this new medium.

2 Literature State of the Art/Literature Review

In the introduction we identified a number of standpoints under which one needs to examine convergence in the interactive television sector: the technological, content and user perspectives. Close interaction between these three interrelated entities is observed that influence each other and trigger evolutionary changes. A diagram (Fig. 1) is used to describe interrelationship using area-inclusive representation between the entities involved and represent the opposing interests introduced in the process of convergence. We choose to examine convergence from different standpoints: society, technology and content. It is informative to present the evolutionary perspective for each standpoint and contrast how it affects the other domains, in an attempt to view the changes from this collective prism.

We classify the convergence problem as a typical "*chicken or the egg*" causality dilemma. The transition to interactive television is a process that requires constant adaptation and resolution of technological, content and social issues. Within this context, one would expect various divergence issues to surface. From the technological perspective this is clearly not the case for a number of reasons: interactive television is an extended service designed to offer backward compatibility, enabling encapsulation of existing content, alongside the new interaction features.

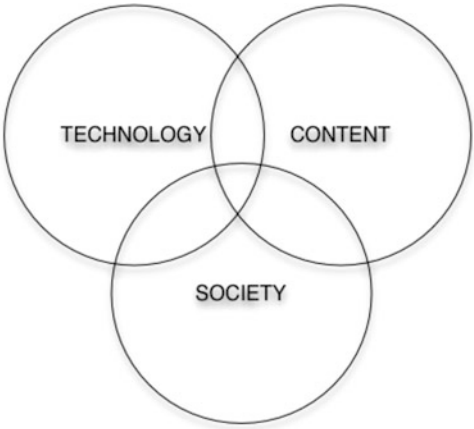

Fig. 1 Interrelationship diagram between society, technology and content

However, divergence is evident on the content and social perspectives, as content developers and users have to evolve and re-design their content in order to be benefited by the advanced content-projection capabilities offered by the proposed system. These issues are reviewed in the present section and specific application issues are discussed further within the case studies (Sect. 3). In order to describe the mechanics of the process and predict future developments, we start by examining the technological advances that spark the changes. Then we review the social implications introduced and investigate how users use this new technology to view, enrich, transform and redistribute content. This is accomplished by examining the content-related issues that arise and reveal the converging requirements, within the prism of related theories.

2.1 Technological Advances

Various theories and processes may be used to analyse the mechanics of the changes that occur during convergence. *Activity Theory* introduced by Lev Vygosky, Alexander Luria and Alexei Leont'ev in the 1920s describes convergence from the socio-technical standpoint. This is achieved by identifying and analyzing the influence between humans and interactive systems through a temporal perspective (Bertelsen & Bødker, 2003). "*A person is influenced and in turn influences the environment and others as human mind and human activities are linked under the model. As a result, the changes that a person introduces to the environment influence humans that are born within this environment*" (Deliyannis, 2012). It is informative to contrast the technological capabilities during the years where television was the only way for the general consumer to receive audiovisual information and today, where there are many different information sources. In the past, the most important issues that a content provider had to constantly balance in order to *stay on*

the air included high technological cost, the need for an independent broadcasting infrastructure, costly content production and licensing.

Today, the shift to digital production and broadcasting has greatly reduced the technological cost, the quality of reception has improved and there is no need to use costly broadcasting infrastructures as the Internet may be used to relay and distribute content to the public. Modern television stations are purely digital and various case studies have evolved offering high-quality and low-cost in-house broadcasting solutions (Deliyannis et al., 2009). This is identified as a stage of technological convergence where broadcasters had to invest into new technologies and provide content for other platforms. It is interesting to contrast how the media industry reacted to technological changes that provide additional communication channels to the public.

By reviewing the websites of major news-based broadcasting networks including CNN, NBC and BBC, one can easily observe that the WWW is used as a media-extension platform employed to stream and reference content. In addition to live or offline streaming, a small number of interactive options are available to the user. Commenting on pre-recorded video streams is sometimes permitted, while stream sharing via URI-linking for varying platforms and social media applications allows content to be shared further. In special interactive implementations, interactive content broadcasting is supported enabling users to select the camera viewpoint during live events. In other cases live videoconferencing or text-based user-feedback is linked directly to the studio (Long, Chei Sian, & Goh, 2012). The cycle continues as content that originates from broadcasting networks is combined with user-generated content and redistributed through the use of social media sites including, blogs, content-communities, collaborative projects, Internet forums, wikis, podcasts, video/photo sharing websites, review sites, virtual social and game worlds. In these environments, users capture content, enhance it by adding metadata and share it to a closed social circle or the whole networked world, triggering interactive dialogues, responses and reactions.

Interestingly, novel content types have already been produced and delivered using interactive experimental broadcasting systems based on multicast technologies that take advantage of the wider interaction spectrum offered by bidirectional communication (Chorianopoulos & Spinellis, 2006; Munson & Pimentel, 2012; Prata, 2009; Song, Moustafa, & Afifi, 2012; Ursu et al., 2008). Interactive television may safely be considered today as the leading candidate technology that may be used as a platform to cover extended user and content requirements, beyond the support for interactive broadcasting and selection/evaluation of content. We have already developed a candidate system termed iMediaTV (Fig. 2), which consists of a hardware and software architecture (Deliyannis et al., 2009; Deliyannis & Kanellopoulos, 2008; Deliyannis & Karydis, 2011) that may be adjusted to cover the requirements for user interaction within multiple content types, including interactive art, live performances and experimental interactive multimedia content (Deliyannis, 2012).

In our earlier research we investigated the implications including content-access and copyright issues that arise when users interact with the studio participants and

Fig. 2 The iMediaTV control panel featuring the audio mixer, the video mixer, the server and cameras that connects to the video mixer and the direct video server

alter the course of the show (Deliyannis, Karydis, & Karydi, 2011). The results indicate that two shifts are implemented simultaneously: the content is being gradually transferred through channels that do not offer exclusivity and that the users are able to develop low-cost broadcasting infrastructures offering new interaction capabilities that may in the future compete with existing broadcasting networks. Having equaled the technological production and broadcasting issues, it is a matter of time before content availability will shape the domain.

2.2 Social Implications

"*Diffusion of innovations*" is a process introduced in 1962 by Everett M. Rogers, used by many as an essential tool for media convergence analysis (Srivastava & Moreland, 2012). It describes the process with which an innovation (an idea, practice, or object perceived as new by an individual or other unit of adoption) is communicated through certain channels over time among the members of a social system (Rogers, Singhal, & Quinland, 2009). The Internet is clearly the way that new systems, ideas and most importantly content is transported and re-used today. Blogs, wikis, forums, codebases and repositories set a solid foundation enabling users to develop, search, communicate content (Brennan & Resnick, 2013). Users perceive the WWW as a content-sharing platform, where information is published, distributed, enhanced with metadata and recycled. It offers the ability for content to

be shared via URI-linking. This is a powerful feature as it provides a universal way to link content, enable communication and trigger innovation, provided that the correct applications are available at the user end.

Content transformation and technological advances create new products, user trends, demands and markets, which are mutually dependent (Elfving & Urquhart, 2013). Take for example the evolution of the music industry where technology combined with the portability of content transformed the whole industry: talent scouting, production, promotion and distribution (Tschmuck, 2012). Today users purchase music tracks electronically at reduced cost, as they do not pay the costs of storage media, distribution and retailer profit. The same applies for movies, television shows, podcasts, books and applications that are accessible through electronic stores like iTunes, enabling synchronization and playback throughout the user's media devices.

The social implications should be traced much deeper than the changing commerce and economy layers (Dutton, 2013), as networked users have already moved to "*platformed sociality*" (van Dijck, 2013) where content sharing is an essential interactive process. According to Jenkins, user-participation through the Internet is defined as convergence culture: "*where old media and new media collide, where grassroots and corporate media intersect, where the power of the media producer and the power of the media consumer interact in unpredictable ways*" (Jenkins, 2006). Clearly the social implications are different for each user group as new communication dynamics are introduced. Those who appreciate the new opportunities offered by technology and invest time to use media to their advantage, often increase their influence, for example when politicians use interactive and personalised online communication methods (Kruikemeier, van Noort, Vliegenthart, & de Vreese, 2013).

In interactive television, various technologies have been introduced offering various interesting social characteristics. Today, YouTube Live offers a basic infrastructure that may be employed to support such functionality without the need to setup a private multicast-broadcasting network (http://www.youtube.com/live/). A developer may deploy a web-based platform that links different services under a unique system similarly to iMediaTV. The most important feature at the user level is the integral system capability that allows them to broadcast back to the interactive TV studio their live streams. This phenomenally two-way communication between them and the studio is in fact a many-to-many communication instance, as it is also made available and can be re-broadcasted to the other viewers. Social software services utilize a similar information broadcasting process, which triggers other user's interest indicated by various digital responses. Similarly with social software, interactive TV users they may link via URI to the generated responses, search them using appropriate metadata and share them other users.

2.3 Content Transformation and Transportation

Our research in media policies shows that these are often outdated by technological developments that open new content processing and distribution routes. This becomes clearly evident when contrasting current research on the content aspects introduced by interactive television (Deliyannis et al., 2011) to the Australian reports on future media policies published that include the Convergence Review (Review, 2012) based on an independent media inquiry (Finkelstein, 2012) and the *Review of the National Classification Scheme* (ALRC, 2012). In these reports is recognized the technological infrastructure shift from broadcasting-centers that utilize telecommunications and radio technologies to new technological infrastructure, networks, devices, applications and content, a converging state where content providers need to adapt. However, the issue of content ownership remains and the reports do not address the main question: how can the industry distribute content to society using alternative technologies and methods and keep the strategic advantage of distribution control?

The main content issue observed today is that it can be transformed and transported using multiple ways. Digitization, streaming and file sharing enable direct or indirect content exchange, while application-layer protocols like the RTSP are openly available for network-based multimedia-content broadcasting. Take for example the case where geographical-based licensing is required in order to view a specific broadcast. Clearly, for those who know better how computer-broadcasted content is distributed today, it is apparent that the policy is already outdated. For a broadcast licensed to a network in order to be broadcasted only on a specific country on television and the WWW, all that is required for the stream to be relayed to another country is access on a proxy server hiding the user's true address, enabling content transfer to any other location worldwide. Beyond content access, the above policies ignore the user ability to capture, decode, possibly enhance, encode and re-broadcast content creating a new type of broadcasting that cannot easily be controller by content owners. Sometimes the situation is reversed. Take for example various traditional television programs that collect, edit, comment on and re-broadcast WWW-based videos. Content re-use is a new development that from our experience will raise serious content ownership issues, particularly as today cloud-based video editing software such as *JW Player Online Edition*, *YouTube Editor, Video Toolbox* any many more such applications are already freely available.

3 Methodology and Approach

iMediaTV offers an interactive broadcast infrastructure (Deliyannis et al., 2009, 2011) developed using low cost equipment, that provides a platform for new content development (Deliyannis & Karydis, 2011). The same system can also be used to house the requirements of experimental multimedia systems (Deliyannis, 2012) that present novel content and interactive features. The platform consists of

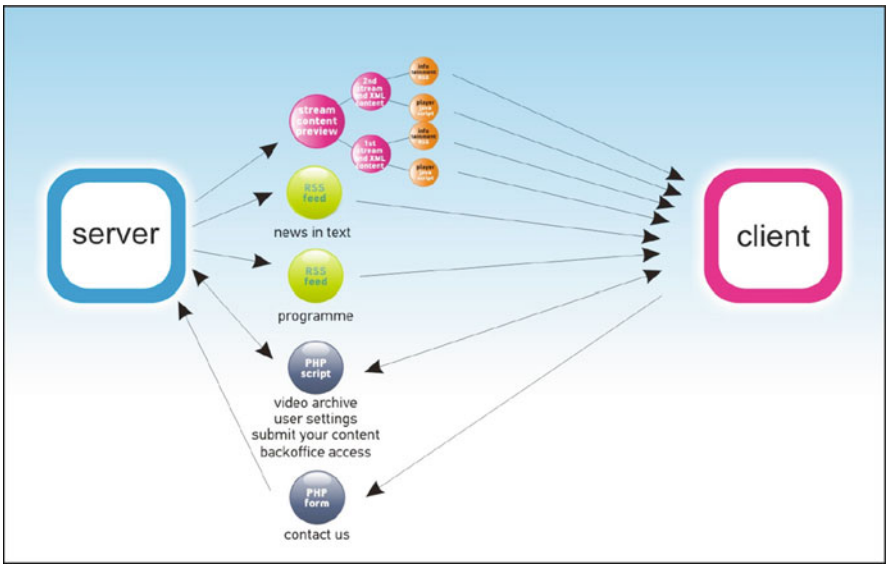

Fig. 3 The iMediaTV server providing various linking options to the client

hardware, software and content. Its hardware implementation depicted in Fig. 2 consists of a video and an audio mixer connecting two standard-definition cameras, a DVD-player and a computer used as a video source, linked through an appropriate standard-definition video/audio card. For each camera the video signal is directed both to the console and an individual streaming server using appropriate splitter connections, offering to the remote user direct camera access. On the software forefront, system-user linking is implemented using a WWW client-server-based user-interface structure that connects autonomous software communication components, as shown in Fig. 3.

Here RSS, PHP-MySQL technologies and multicast broadcast streams are combined under the user-interface enabling client-server linking. The user interface menu options shown in Fig. 4 (top) links the software and hardware components (bottom). Video-streaming flow is described in Fig. 5. In order to speed-up streaming, separate multicast RTSP streaming servers using the H264 codec (Richardson, 2006). The interactive nature of the station is supported on various content distribution levels. Offline content is categorized according to its nature to single or multiple streams, enabling the appropriate number of servers for its broadcast. Multi-stream broadcasting in parallel over the network enables multiple interactive modes to be implemented. Users can access offline content directly from the multimedia-database, while online content supports a number of interactive options. Originally the system was implemented using a single server. This computationally proved to be a quite demanding process introducing high latency rates of over 15 seconds.

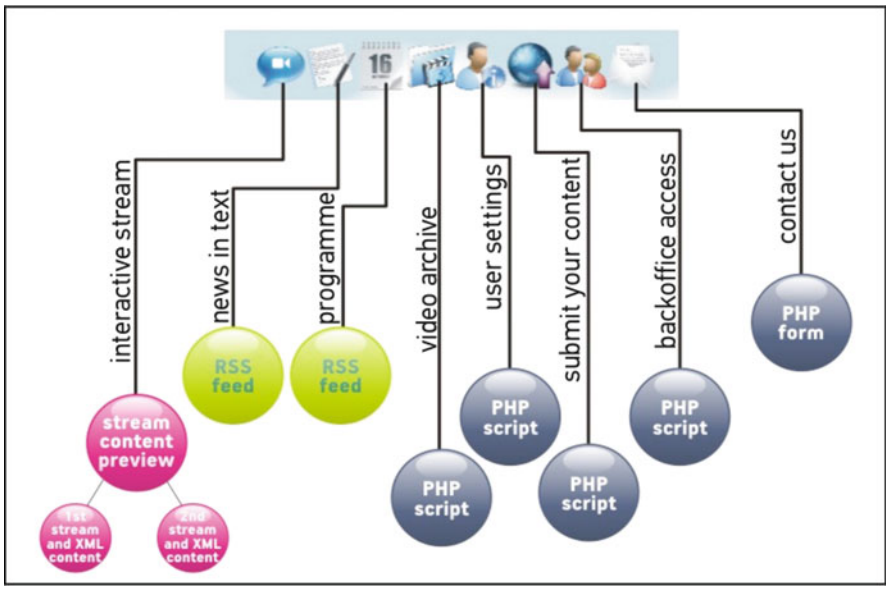

Fig. 4 iMediaTV user-interface options to data stream linking

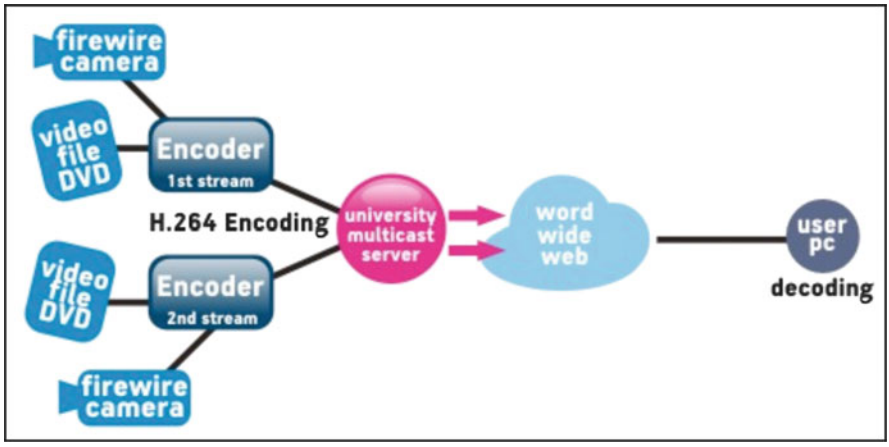

Fig. 5 iMediaTV video encoding and streaming diagram

As a result separate servers under the same network were employed for different streams: two servers support streaming content delivery via the use of separate but synchronized encoders (Fig. 5) and one server is dedicated for the creation of the RSS, PHP-MySQL pages and provides streaming access to offline content. This distributed access based on TCP/IP linking enables certain services to be relocated dynamically, easing the workload. Currently, all offline streaming content and

feeds are being relocated in order to increase the response time and save on bandwidth.

This platform enables the implementation of user interaction scenarios whose complexity may vary from linear stream switching to user-generated content. The following case studies present a wide range of cases that were implemented as an extension of existing streaming media, under the prism of convergence, while backward compatibility issues are discussed, in an attempt to cover the divergence cross-technology issues that often arise. This process is essential as it is important to provide a smooth transition to the new medium in order the convergence to be successful.

3.1 Broadcasting Interactive Content

The film REC. (Argyriou, 2010) is a multi-camera DVD-based title which as presented at the *Short Film Corner* of *Festival de Cannes* in 2011. It film consists of three simultaneous video streams and the user is able to alter the view interactively at any point, an action that changes the film's context as each view displays a different reality. Figure 6 displays the set during filming. The movie was originally produced for DVD media, enabling camera switching via the camera-view selector of the remote control. Our research indicated that content that is destined to be edited by the user interactively should contain as little as possible pre-defined

Fig. 6 Filming of REC. using three camera-view scenarios enabling a different reality to be viewed according to the camera selection

transitions, as they can actively be used to affect the meaning. This can be clearly demonstrated through an example: A person arguing loudly with his boss at work that also mumbles while returning home followed by a quiet scene where he makes a cup of tea conveys a totally different meaning when contrasted to a sequence of scenes where a person arguing loudly at work is followed by a scene where he is quietly brewing the same cup of tea at home. This is a problem that introduces backward compatibility problems, particularly if the interactive content has to be broadcasted through traditional television. One has to either view all three camera-views, or a director's cut version that highlights via editing the most important scenes for each view, a process that introduces the editor's perspective. This is clearly a compromise that reduces the value of the interactive audiovisual title, and it has to be downgraded before being shown in this medium. Transmitting it in interactive mode via the interactive broadcasting infrastructure was straightforward. The process involved copying and linking of the three MPEG-2 streams to three streaming servers, enabling the users to access each individual stream over the iMediaTV interface via selection of the appropriate stream URL.

Similar problems are introduced when interactive New Media Art is broadcasted through traditional television. Similarly to the REC. case study, editing is required in order to capture various perspectives of the work and transmit that to the viewer. Often, and for complex artwork instances this is not possible (Strapatsakis, 2008), as there is interaction between different viewpoints while capturing and broadcasting these requires long time periods. The use of multiple camera views offer within iMediaTV provides a flexible tool that allows viewers to experiment and explore with pre-set cameras allowing them to direct their attention to specific aspects of the work, while they can also observe the director's cut complete with commentary if they desire. As a result one may argue that the use of interactive television broadcasting provides the backward compatibility functionality that avoids divergence as it allows users to view standard non-interactive content, while at the same time it offers the freedom to both content developers and users to experiment and explore further the technological capabilities offered by this new medium.

3.2 Interaction and User Involvement

Within traditional television, user involvement is a powerful aspect that has in the past been implemented through a wide variety of technologies: mail, phone, voting systems, polls, e-mail, SMS messaging, blogs, Internet chat, video chat are all methods employed to support user to studio interaction. These methods when combined with a medium that offers only one feedback channel back the user often create communication bottlenecks, rendering them unusable or raising questions about the level of feedback. On the other hand, the personalised viewing experience offered by interactive television can be aided by the availability of user to studio feedback. To demonstrate how interaction can increase the level of user involvement a number of case studies featuring different content types and interaction have been developed.

3.2.1 Live User Participation

Students at the studio implemented a number of live programs in order to study user involvement, investigate how the pre-programmed sequence of content is altered via user-studio interaction and study the content implications. The most representative case study featuring a free interactive mode included a concert case study featuring a solo musician who performed at the studio while viewers watched the performance over the network. A number of interactive feedback channels were activated including the forum, text-based chat, video conferencing and SMS/MMS, and all screens were projected in front of the musician who engaged into a dialogue with the audience. Although there were difficulties in the communication process as they were not all immediate but ranged between a few seconds or even minutes for the forum feedback and interaction depended on the level of feedback attention the performer was prepared to receive, the users managed to alter the original concert program with their requests. This is a new development on the copyright forefront, as the broadcasted content sequence cannot be predicted. In our previous work we have proposed the development of a dynamic licensing system that enables studio staff to receive content licensing on-the-fly in order to cover interactive presentation requirements (Deliyannis et al., 2011). Content licensing is also an issue in other areas including music information research (Karydi, Karydis, & Deliyannis, 2012).

The next case study combines artistic creation and cross-studio interaction. Here, four preschool children participated in a remote "Art Class" program where an artist at the studio instructed them to each draw a flower that would be used to create a larger painting. For this purpose the network-drawing application COLLABORADOODLE was used shown in Fig. 7. The artist interacted with the children from the studio in a two-way communication mode via videoconferencing, while children used shared their creations interactively and accepted feedback from the artist while drawing. This example demonstrated how a traditional show could be converted to an interactive collaborative experience that enables multiple viewing and participation modes to the viewer. They may choose to view what other viewers are doing, interact by offering suggestions, sharing experience and personal preferences or collaborate in an active manner and share their creativity with others. This scalability of the medium in terms of interaction is important as watching television in lazy mode may be what the user requires at a certain time period. This introduces both technical and practical questions and issues, often observed in real-life shared-space creative classes. How does one deal with the refusal of users to participate, or the case where there are too many participants? The answer in the first part lies with the creativity of the presenter as within a traditional class, while for the latter case a maximum number of participants may be set for a show. Interestingly, these are questions that occur in real-life art classes and this indicates the communication and creative aspects of interactive television. In conclusion, previous case studies featured specific user-content-studio communication and interaction scenarios. "Experimental Multimedia Systems" (Deliyannis, 2012) that feature novelty in both interaction and content may also use the interactive television infrastructure to cover their presentation requirements, as the adaptability

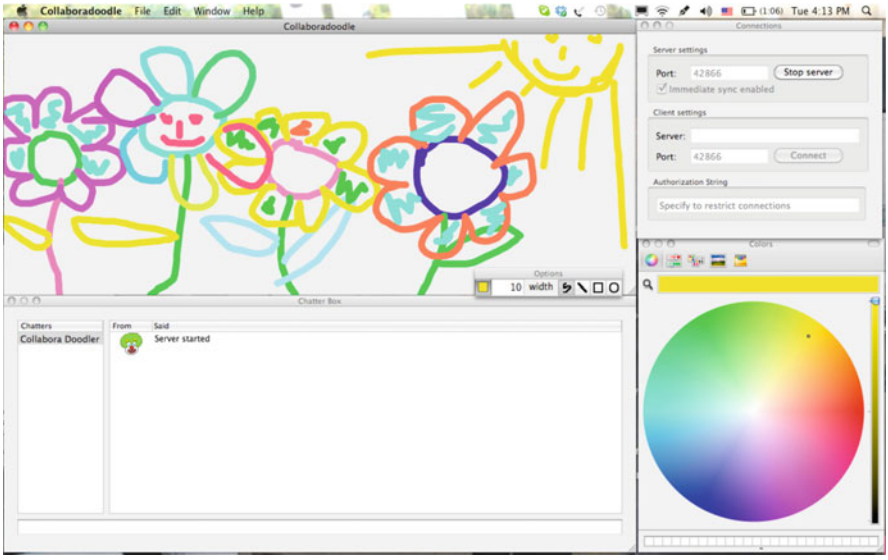

Fig. 7 The COLLABORADOODLE application used to implement within iMediaTV the creative interactive drawing mode across the network

of the medium is not limited to content sharing but with the appropriate control software and hardware it can support adaptive sensory experiences, under the MPEG-V standard (Waltl, Rainer, Timmerer, & Hellwagner, 2012).

4 Viewpoint on Convergence and Conclusion

The first television sets were advertised as *Radios with a Screen*, and their advertising campaign stated that viewers could both hear and view the orchestra performing. Advertising a new medium as an extension of an already established technology enables users to clearly view the technological advantage, although in the case of television, it did not predict its future uses and capabilities. Similarly, interactive television is today perceived by the general public as a mechanism that offers dynamic audiovisual content streaming, enabling users to select content or access live television over the network. The idea of dynamic content, user interaction and the communication aspects offered by interactive television are not well known.

Speeding up the convergence process and reveal the true potential of interactive television, requires further research on the user and content aspects, coupled with the development of new deployment strategies. Infiltration and wider acceptance of interactive television standards requires careful strategic planning aiming at users, targeting their familiarization with this new technology. Convergence is clearly aided by the fact that interactive television does not require specialized hardware

beyond a multimedia-enabled personal computer and Internet access. It is therefore critical for content providers and developers to reduce the non-use non-adoption factor. This work proposes the establishment a common standard designed to promote the advantages of interactive television, while it preserves traditional television features such as lazy playback.

A strategy designed to speed up the process should involve the deployment of a dynamically expandable service (offered as an open standard) designed to allow users to tune-in to specific broadcasts and automatically configure their devices to support interaction for each content instance. This development must be based on modular software components and codecs. Beyond the provision of direct access to content, it should allow its software components and interaction structures to be upgraded at any time, enabling new interactive features to be supported at the clients end. In addition to the proposed service, an open content indexing/filtering/suggestion mechanism (interface) should be developed to complete the user experience, enabling users to access broadcasts through an interactive TV content-access gateway that promotes the content and simplifies the "tuning" process. Appropriate strategies can be built upon this infrastructure, permitting the much-needed infiltration to take place, as this will allow the new medium to be perceived as a superior and cost-effective solution.

Successive to the infrastructure for content publishing and access described above, a number of content-based approaches should also be realized. The development of new content targeting to demonstrate the novel technological features and the social aspects of interaction is an essential system component that can speed-up the convergence process. The proposed content is categorized under three basic types:

"Hot" content that includes live broadcasting of sport events, concerts, performances, exclusive shows and unedited footage, offering when possible interactive features that include user-selected camera views, additional information and access to extra information.

"Early preview" content offering web-based viewing for series, documentaries and movie premieres before they are broadcasted on television.

"Purely-interactive content" production featuring interactive access that permits the user to take part in interactive talk shows, studio-based games where users are allowed to interact directly or with the players by providing their feedback, live performances where the audience is digitally present and user-generated news allowing commenting attachments.

New scientific challenges are introduced (Deliyannis & Karydis, 2011) when users and content creators are presented with novel expressive capabilities (Deliyannis et al., 2011). This work presented interactive television convergence issues and proposes numerous strategies that may be implemented to speed-up the process, based on system and content adaptation. It was suggested that in order interactive television convergence requires three major stages to be completed: a dynamically-adjusting standard combining all the required technologies under a

single specification; a user interface that will organise and provide centralised access to users, offering metadata-search capabilities and finally, in addition to traditional content, novel and innovative interactive content that will engage users in this new communication process. The case studies presented in this work and the experience shared publically clearly demonstrates the new capabilities offered by interactive television.

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