A SYSTEM FOR SEAMLESS COMBINATION OF ON-LINE, BROADCAST, AND STORED CONTENT

Raino Annala[1] and Raymond Causton[2], Markku Mäki[3], Teemu Varonen[4] and Pauli Kuosmanen[5]

Elisa Research, P.O.Box 40, FIN-00061 Elisa, FINLAND, [1]raino.annala@elisa.fi, [2] raymond.causton@elisa.fi, [3]markku.maki@elisa.fi, [4]teemu.varonen@elisa.fi, [5]pauli.kuosmanen@elisa.fi

ABSTRACT

This paper describes a recent system for seamless combination and super distribution of on-line, broadcast, and stored content. We illustrate its user-scenarios and technical solutions. The conducted research indicates that many exiting and practical uses can be found. New services utilizing the system can be made appealing to the consumers.

1. INTRODUCTION

Broadband access networks are becoming a more popular Internet connection method at the moment. One of the driving factors is the abundance of audio-visual content on the Peer-to-peer (P2P) networks. As different networks converge the threat of piracy through super-distribution is growing also in the broadcast industry. New digital end-devices are equipped with large storage devices and broadband network interfaces. To sustain the business of all actors a sensible model for sharing content between networks needs to be found.

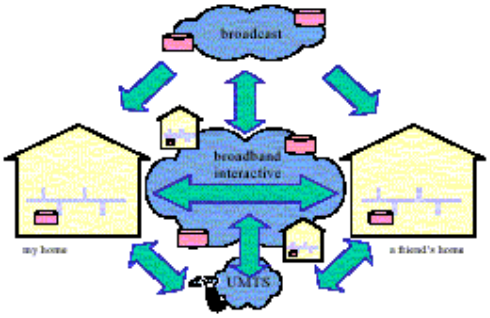

Figure 1. Seamless sharing between networks [1]

To explore this challenging environment an EU-funded project, Share It! (IST-2000-28703) [7] was set-up. A collaboration of several European broadcasters, device manufacturers, network operators and universities was created to develop an end-to-end system that enables easy access to and transfer of personal content between local storage devices using home-to-home (h2h) networks [6]. A positive consumer response is pursued with the creation of an innovative system that offers a seamless combination of content from different sources.

Project's work relies on years of research in the field of digital signal processing. This groundwork has enabled high efficiency content formats and transcoding between them, the two factors enabling low cost of audio-visual entertainment devices. Also broadband telecommunications has heavily relied on the advances in the field. Consequently the presented system is essentially a practical application of signal processing at its highest level.

In a more closely related level the project is based on the work of TV Anytime Forum (TVAF) [10]. Especially forum's work phase 2, which takes the development of specifications for locally stored audio-visual services to the next level of networked sharing [13]. The project also directly extends the work done by its predecessor MyTV in which local storage devices were used as end-terminals for TV Anytime services. In parallel to Share It! there are several projects such as NextTV [4], ICE CREAM [2] and SPATION [8], which also work towards personal home entertainment experiences.

The role of Elisa Research in the presented project has been to bring in relevant telecommunications industry perspective. Research group has actively taken part in the paper studies concerning networking and security. Elisa Research has also participated by creating a new networked service. Network storage device is an active network component that enhances the user experience in the P2P world.

2. USER SCENARIOS

In order to validate the need for the proposed features some 50 user scenarios were developed [6]. Scenarios described different applications for using capabilities of the system. Different perspectives were chosen according to the theme of each scenario. In this paper three of them are shortly presented.

2.1. Scenario 1: Portable profile

Mike and Jack are friends and Mike has had a personal video recorder (PVR) for a while. When Mike started using a PVR he downloaded a generic profile that best matched his interests. After that he has been adding and dropping shows on his favorites list. The friends have

similar interests and Mike proposed that Jack could download his profile now that he also has a brand new Share It! PVR. Mike agrees and downloads the profile

This scenario presented the existence of different viewing profiles and their portability from device to device in the system. It was written from the viewpoint of an ordinary system user. To implement the profile feature in the scenario a common viewer habit description would need to be devised.

2.2. Scenario 2: Networked Services

Sam is tired of watching the same old shows and peeps what has been automatically downloaded onto his PVR. He finds several shows that sound fun, but can't persuade Natalie to watch the one he likes. Sam looks at what other people have thought of this episode and shows Natalie that "Bella Cooking Show" got only one star where as the "Action Jackson" got three stars. Natalie is fast to point out that ratings are based on Sam's profile and demands to see what the ratings are according to the common profile. Sam has to admit his defeat.

The second scenario described the possibility of networked services in the system. Again the user perspective was used to communicate the idea of additional value-added services in the context of peer-to-peer networking environment. A ranking service in this scenario would require an additional field in the user group posts for judging the commented shows.

2.3. Scenario 3: Content Indexing

Mark watches a football match at home. Jari Litmanen from FC Liverpool scores a goal against Ajax Amsterdam. Mark marks the time by pressing a red button on his remote. PVR writes down the time of the goal. After 84 minutes of play the game is almost over and Liverpool is leading by four goals to none. It has become pretty clear that they are going away with the trophy. Mark decides to watch the goals again. He opens the indexing application with his remote and gets a list he has made while watching. He skims through the thumbnail size images to find the goals by Litmanen and Hyypiä. Mark thinks Joe might want to see the goals too. He deletes unnecessary items and saves the indexing metadata with the game into his PVR's shared folder. Next day when Joe is over to design a concert poster Mark shows the goals to him.

Our third example scenario exhibits the new possibility for the consumer to change from a passive couch potato to an active content producer. In this case the user is not actually creating new audio-visual content, but rather augmenting existing content with additional information, metadata. A special tool for creating and viewing the segmenting metadata is needed to accomplish the conceived functionality.

3. SYSTEM REQUIREMENTS

System requirements were derived from the earlier developed scenarios. The goals of the project were re-evaluated and the scenarios were compared to the re-established objective. In the process the existing user scenarios were refined and some, like the scenario 1 mentioned in Ch. 2, where actually dropped altogether. As a result of this process the following list of obligatory features were drafted.

The system has to be robust and scalable. The consumer market oriented product must be easy to install and use. Naturally also a broadband home-to-home connection is going to be needed for the transfer of data. Even inside homes different devices had to be easily connected regardless of firewalls or gateways. Each of these attributes present problems adopted technologies have to solve.

The users need to be able to share broadcasted television shows, home videos and interactive applications. It was found that seamless integration of broadcast channels, broadband IP networks and distributed storage at home was necessary. There needed to be ways for organizing content of distributed multimedia material. It was necessary also to be able to search for and navigate private and shared content. Once found the content location resolution of shared content was necessary. For security reasons user authentication, access rights, and mechanisms for security of communications and private content were necessary.

4. SYSTEM ARCHITECTURE

The system architecture design consisted of finding solutions for the technical requirements deducted from the user requirements. Three main problems were identified; digital rights management (DRM), file sharing and metadata specification. These areas were studies and the work contributed directly to platform design.

There were several elements to making the technology choices. One factor was the feasibility of the alternative technologies. Since an actual demonstration was to be built the technologies needed to be mature and cost-efficient to implement. Another key element was to ensure that the spirit of P2P-filesharing would not be lost in the way. In addition adherence to existing standards needed to be ensured. The chosen technologies will be discussed in more detail next.

4.1. JXTA

JXTA is an open P2P-protocol developed by Sun Microsystems. It was chosen to take care of device, service and content discovery tasks in the P2P-environment. Platform also allows identification of users with certificates [3]. JXTA uses TCP/IP and RTSP for file transfer and export of file systems. A broadband IP connection is naturally necessary to manage the heavy load of audio-visual content. The extreme network load set additional requirements.

Capacity in the fixed network needed to be load-balanced. JXTA offers two useful techniques to ease the strain on the network. The rendezvous-feature of JXTA was used to enhance propagation of messages in the distributed network [9]. Another important area is user groups, which allow targeting only portions of the user base with requests. Additionally by using HTTP-proxies

for caching the excessive long-distance bandwidth costs can be minimized.

4.2. Content referencing

To make it possible to identify and search for content descriptions were needed. It was decided to base the metadata specification on work done by TVAF [11]. Both content description and segmentation features of the standard were taken into use. Content descriptors allow users to navigate between programs with electronic program guides. Segmentation information allows the users to navigate within segmented content.

All the metadata can be embedded in the video content itself or the information can be available elsewhere in files or databases. A hybrid solution was chosen. Broadcast content is described with content resource identifiers (CRID), which allow users to find more information about the content from special metadata servers. Information about shared files is transmitted in XML files, but stored in local a database for quick access.

The new uses for the existing standard created distinct needs. The TVAF content referencing specification [12] in itself was not sufficient for the situation in the networked environment. Extending the specification was necessary and amendments were needed to allow existence of several sources for the same content.

4.3. DRM

P2P-applications have been associated with piracy, but the distributed technologies themselves are naturally useful for legal use too. It was obvious that the created system architecture must support the long term entertainment industry profitability. However this did not mean that it was necessary to rely on existing business models or practices. Nevertheless digital rights management issues lie in the heart of the problem.

The objective of DRM work was to ensure that the user has access only to specific content for which rights have been granted to. The situation was made more challenging by the fact that there are different sources for content on the network with different kinds of requirements. Home originated content needs to have special types of rules for viewing and re-distributing than content captured from broadcasts. Eventually two rights models were created. Light- and heavy touch systems corresponded to the different environmental constraints. The main difference between the two models is the existence of external rights brokers.

All DRM-models rely heavily on strong encryption algorithms used to encipher the content while in transit. Well defined user attributes and usage policies are needed, as well as the availability of trusted hardware to keep the encryption keys secret from malicious customers. The principal of DRM in media content streams is based on the concept of access tickets. Each piece and source of content has rights information associated with it. The authorization and rights negotiation procedure is conducted by exchanging tickets describing the rights a certain user has and what is needed for access.

5. DEMONSTRATIONS

Number of different mock-ups and demonstrators were developed in order to explore the feasibility of different features developed in the earlier phases of the project.

5.1.1. Mock-ups

Mock-ups are representations of system features for the actual demonstrators. They are characterized by limited implementation of actual functionality. Here shown in Figure is the network digital recorder (NDR) mock-up done by Elisa. The mock-up consisted of a server-side management tool and a graphical user interface (GUI) of the client. Simple non-dynamic HTML pages were used for the server-side mockup. The client GUI was created fully with XML and XSL style sheets. XML was originally chosen to facilitate easy conversion of mock-ups to real applications. For illustration purposes a streaming video clip is used in place of a real broadcast video stream. Conceptual design principles were depicted with flow charts and diagrams.

Figure 2. Elisa's NDR mock-up

5.1.2. Functional models

Demonstrators are functional models of features aimed specifically to be showed in demonstrations. In this project a real-time Linux based set top box with an integrated chipset is used. The hardware is a realistic real-life implementation and will be feasible to deploy later on to commercial markets.

Figure 3. Share It! set top box (Copyrights Alex Ashley, Philips Research Laboratories)

To illustrate system's functionality three different scenarios were decided on. These three represent system's basic functionality, networked services and content bun-

dling. Elisa Research's team has been actively participating in the development of the networked services demonstration. The functional models are planned to be published at IBC 2003. Work done on the networked services demonstration is presented in the next chapter in more detail.

6. NETWORK STORAGE DEVICE

Based on the mock-ups and the work done on system architecture it became clear that the goals for the networked services were very ambitious. Initially it was thought that the demonstration would consist of moderated user groups and a NDR. User group portal is a service operator's platform for publishing content in the peer-to-peer environment. It was quickly understood that it would be necessary to guarantee the accessibility of the promoted content.

A decision was made to prioritize the moderated user group functionality and the support it needed. Also the implementing difficulties of a real functioning NDR had an effect on the decisions made. Faced with demanding challenges (ranging from implementing a massive storage device, a multi-channel recording to balancing the network load) steps were taken to rationalize the objectives. As a result the NDR concept was transformed into another active network element, the network storage device (NSD).

The main difference is that the NSD does not record broadcast content. Instead the individual users still control the recording. The system simply facilitates content caching and is thus able to even out the network usage. This makes the most popular content more accessible to the end-users. The data is moved from the nodes to a storage device on the edge of the network. Content segmentation metadata added by individual users could now also be stored since the content comes from peers. Most importantly the air of P2P is conserved.

It was understood that implementing a simple client-server setup for serving broadcast content as video on demand (VoD) would not have created anything new. Naturally storing and serving all the content on all channels would have been technically possible. The task of building such a system would have been tedious, but the rewards small from the network operators' perspective. Additional intelligence was clearly needed. Alternatives for creating an adaptive network service were studied.

After careful evaluation of alternatives it was decided to build a system that caches the most popular content in the operator's network. The system gathers information about searches made to a certain user groups and stores it into a database. Classification of content is based on keywords and content identifiers found in TVAF metadata. The data is used to cache the most sought after content. Anonymity of the users is kept relatively protected by showing only the most popular content and by not logging any user identification information.

NSD is a java application run on a Linux computer with a database to store the queries and associated data. The NSD implementation is based on an extended version of the JXTA stack. The biggest challenges in the implementation work were in ensuring compliance with the set top boxes. It was necessary to ensure that rights negotiation works. NSD needs to act as a trusted party in the network.

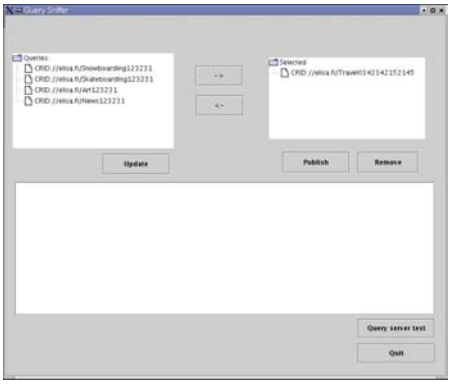

Figure 2. NSD screenshot

The NSD graphical user interface includes the following functionality:

1) Adding content to a moderated user group
2) Searching for content
3) Downloading chosen content to Network Storage Device (NSD)
4) Viewing/checking content on a separate box
5) Publishing content on moderated group
6) Identifying popular content in the moderated group

Different applications for the NSD are currently studied. One interesting prospective is to use the system to find useful content for use with mobile handsets. It has been claimed that the mobile content should be short and its resolution small [5]. Browsing lists of content on small portable devices is cumbersome. Thus it would be useful to have an agent to do the searching for the user. There are also other ideas for future study. For example integrating the service with TVAF metadata and broadcast service information servers might prove useful as the networks converge.

7. CONCLUSIONS

This paper presented research work done in research unit of Elisa Communications Corporation within a European research project Share It! [7]. The main results in the project are a systems specification and a functional prototype model of a future consumer electronics device. Elisa Research's contribution lies within creation of new networked services. The presented NSD application is an intelligent content storage device that actively gathers content available on the network.

Overall project's work will give valuable insights into the future of converging media. The output is to be submitted for standardization. The media landscape is defi-

nitely changing and the standards will have to follow. Seamless networking of tomorrow depends on the steering work of today.

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