A FRAMEWORK FOR A CONTEXT-BASED HYBRID CONTENT RADIO

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ABSTRACT

The aim of this paper is to propose hybrid content radio, a new framework for radio content, enhancing the traditional broadcast radio experience and augmenting it with context related audio content. Differently from most of the commercial recommendation-based internet streaming services (Spotify, Pandora), here we consider systematically adding audio content to an existing, linear audio structure. The purpose of the hybrid content radio framework is to enhance the broadcaster's programme schedule with context-aware and personalised audio content from the internet. The context can be the listener's profile, emotional state and activity, her geographical position, the weather, and all factors contributing to characterize the state of the listener. The final purpose of the enhancement is to improve the service user's' listening experience, decreasing their propensity to channel-surf and giving them more targeted content, such as local news, entertainment, music and also relevant advertisements. In this way, the hybrid content radio approach enables both a functional enhancement to radio and network resource optimization, allowing the use of both the broadcast channel and the internet.

INTRODUCTION

This paper gives an overview of the recent experimental services proposed by a group of European Broadcasters exploring the potentialities of a hybrid approach for audio in radio. *In hybrid content radio (HCR), traditional linear broadcast radio is the foundation upon which a new, enriched service is built, using enriching audio content from the broadcaster's archives or from trusted third party providers*. The paper presents experimental services and outlines key technical requirements for the creation of an HCR radio framework. Different from most of the internet streaming services, here we consider adding audio content to an existing, linear audio structure: the broadcaster's programme schedule. Specifically, HCR allows enhancement of the broadcaster's linear schedule with context-aware and personalised audio content. The context can be the listener's emotional state, her geographical position, her group, the weather and all factors contributing to it [1]. The final purpose of the enhancement is to improve the service user's listening

experience, giving her more targeted contents, such as news, entertainment, music and also relevant advertisements. The proposed technique achieves content personalisation at a minimal bandwidth cost, as the broadcast channel is used if possible, differently from existing internet music playlists. In this way, HCR allows an optimized bandwidth usage. Figure 1 illustrates the concept: broadcast linear audio content is enriched by personalised content from the internet.

The proposed framework can be applied to both audio and video content. However, audio is well suited as a background medium, and can be enjoyed while people are doing something else. It's common to see people listening to radio while walking, biking or driving or engaged in different activities. In this sense, context has a more complex impact on radio than on television.

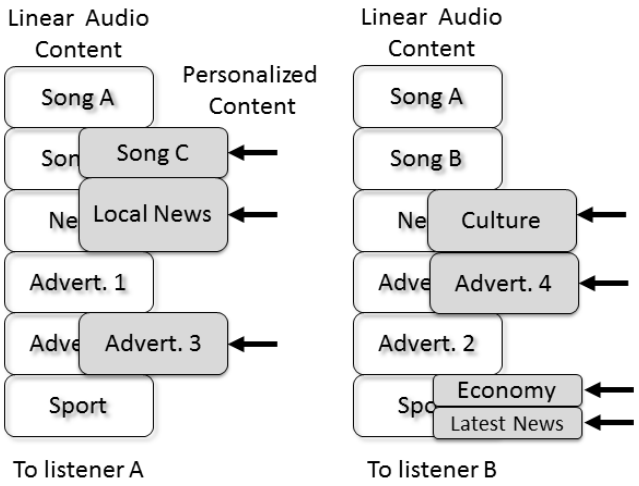

Figure 1 - The hybrid content radio concept: broadcast linear audio enhancement by audio content replacement

RELATED WORK

There are already several mobile music streaming services creating highly personalised playlists, exploiting different content recommendation techniques: Pandora, based on content features extracted by experts, the Music Genome Project [2], others mainly based on collaborative filtering or hybrid techniques like Spotify [3]. Music streaming services generally use recommender systems exploiting collaborative filtering, content-based or social-based techniques [4-6] and exclusively use the internet channel to reach listeners with wholly customized playlists. Different from those services, *hybrid content radio addresses all the scenarios where the linear audio content is partly and flexibly replaced by personalised audio content, and the broadcaster maintains overall control.* Several IST European Projects have considered enhancing broadcast video content, recombining broadcast objects at the client and downloading them from the broadband network. Specifically, the iMedia and Savant IST Projects [7-9] used targeted, personalised advertisements or recommended content lists for television services; however context-awareness was not considered. In past years, music and video recommenders generally suggested personalised playlists and dynamic content only focusing on user or item-similarity, the customer profile and navigation history. In contrast, recent research and commercial services have started addressing contextual information, leveraging the context such as the user's position, mood or activity [10]. Most recently, a number of studies analysed the proposition of context-aware audio content. Contents and services related to the listener's location are emerging, like the Foxtrot prototype [11], a mobile location-based and crowd-sourced audio application playing an automatically generated

playlist from geo-tagged music. Other examples are MIT BusBuzz [12], creating a social music experience while on bus, and the MIT Loco-radio Project [13], a mobile, augmented-reality system creating an audio landscape while on the move. HCR maintains the broadcast schedule as the framework to build a new service upon, also considering it as part of the context, so that the enhancing audio content has to be included in accordance with the schedule. This is a novel element compared with previous studies. HCR has its roots in the work carried out by the RadioDNS project. RadioDNS has addressed hybrid radio, focusing more on the enrichment of audio content with images, text and metadata, and also allowing to link external content, see the ETSI technical standards [14].

PROOF OF CONCEPT

The following sections will give an overview of the experimental HCR services developed by partners Rai, IRT, TPC and NPO.

GeoRadio: Geo-referenced HybridContent Radio

Rai has developed an HCR proof-of-concept based on contextual information, leveraging geo-referenced audio, called "GeoRadio". The listener's context is the primary source of information to create a more personalised radio experience. In particular, the user's position and destination play key roles in making better content recommendations (see Figure 2). Position information has already been used by other audio streaming systems, specially audio-based city guides, geographically and POI (Point of Interest)-based music, ambient sounds, audio information and user-generated content [11]. The GeoRadio prototype is the first demonstrator developed by Rai to show the potential advantages of adopting a more flexible framework for radio. This service uses the listener's position and destination to select and recommend part of the audio content. A simple scenario will give a quick overview of how the prototype works. The listener, while driving in Turin, is listening to the radio with her smartphone, and the app is tuned on Radio2 channel. When the national news program is about to finish, the recommender proposes the regional news (and the app connects to the internet to get the audio clip from the Rai servers). Then, when approaching the old Filadelfia stadium, the radio proposes to her a related historic audio document. During the advertisements break, the app proposes a targeted advertisement: "Amici Miei" restaurant, in the neighborhood - easy to reach at lunchtime, as the recommender keeps track of her habits during the day. In this scenario,

Figure 2 - Audio content recommendations depending on position and itinerary

the traditional linear radio channel from Rai was enhanced with on-demand content: local news, geo-referenced audio clips and location-based advertisements. In the prototype, listeners connect to the radio station using a radio app. When the app starts, traditional linear radio content is delivered to the app using a broadcast protocol. While delivering linear content, the app should use broadcast delivery channels like DAB+ or FM Radio with devices with built-in radio tuners and a standard radio API. Internet streaming is used as a backup solution when broadcast radio is not present. The enrichment process relies on a recommender system suggesting additional, non-linear audio content to be used to replace part of the linear content. At the end, a synchronisation and adaptation component decides the instant in which the additional content is to be played on the device. In this way, the broadcast audio content schedule can be modified in a personalised way for each listener. The possibility of detecting and addressing groups of listeners (e.g. at home, in a car, in a gym) has been analysed in another work [20].

Context based audio: the HbbRadio Project

IRT has analysed hybrid content radio within the HbbRadio Project. A first area of investigation targeted dynamic user profiles and context recognition. Novel methods have been developed to understand how to enrich the static radio live stream with personalised elements. These personalised elements are content pieces which are selected to fit the

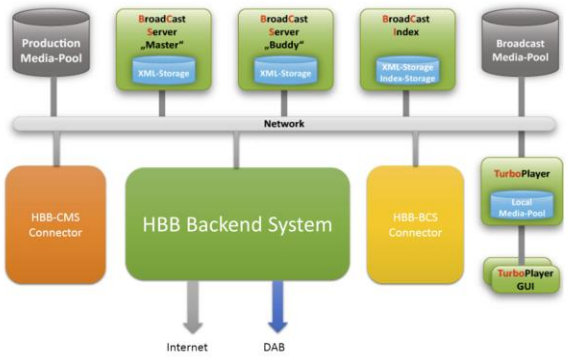

Figure 3 - The Hbb radio architecture scheme

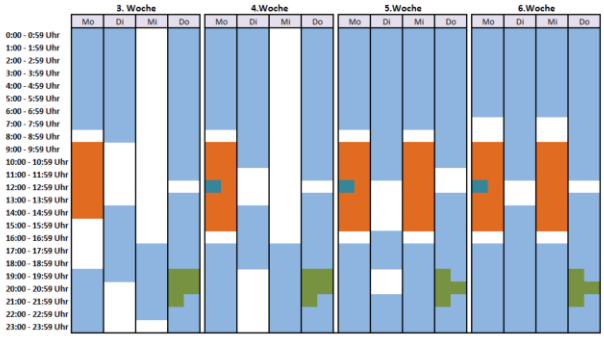

Figure 4 - Example of personalised content replacement during several days

personal preferences of the user and additionally fit into the current context the user finds herself in. In order to achieve this, the first goal is to recognise both the personal preferences and the current usage scenario (context). Based on these findings, a recommendation engine can select suitable content elements and embed these elements into the live stream. One important research topic is the definition of the listening context. The definition of a listener's context is given as: "*A recurring period of time, in which the user is either in the same geographical area or in the same personal activity while interacting with the HbbRadio system"*. Therefore the HbbRadio system tracks information such as time, location and actual activity of the user. Figure 4 shows the results of an early stage of the listening situation modeling. The coloured segments show recognized listening situations: blue is work at home, orange is the daily break for lunch, green is the sport once a week and white areas are caused by a lack of power by the device. A

second area of interest is personalisation and delivery. Figure 3 shows the components for a general broadcast planning and playout system. All these components communicate via an XML-based interface and exchange planning data and content in real-time. Embedded in this infrastructure, HbbRadio developed a HbbRadio backend component which is responsible for the generation of live data such as SlideShow images , DL/DL+ messages and EPG programme data as well as the provision of archive information for the recommendation engine and on-demand playout services. For the live playout services, a REST API was developed which provides functionality for the HbbRadio backend to request data regarding channels, shows and content of the current schedule. It also provides a callback mechanism for the HbbRadio backend, should changes (e.g. the contents of a single show) be made and need to be propagated into the broadcast. The DAB-EPG Server and DAB-SLSServer components are responsible for gathering the data through the REST API, listen for updates through the callback mechanisms and generate the data formats to be played out over the DAB multiplex. Using a REST API the HbbRadio Engine collects metadata of content which is not scheduled for a live playout, but will be available for the recommendation engine to be integrated into a personalised programme guide. The result is that a user who switches on the HbbRadio functionalities receives a personalised EPG, which is based mainly on the planned live schedule of her favourite station but is enriched with on demand content items at suitable locations. Figure 5 shows the user interface either on the stationary DABerry client or on the mobile Android based HbbRadio client. If personalised content has been inserted into the EPG, the user would see a special icon beside the event. Additionally the HbbRadio client provides a “skip” function for the end user. If the listener is not satisfied with the current audio content, she can skip the audio content to an item from local storage or alternatively to a proposal from the recommendation engine. The linear programme is recorded into a time-shift buffer and segmented with the 'item running' and 'item toggle' signalization in the DAB broadcast stream. These cue points in the time-shift buffer are then re-entry points from on-demand content back into the linear service.

Figure 5 - HbbRadio Interface

DIY.FM and musicBan: Swiss individual radio

Started as a pilot project during 2012, the diy.fm radio player created by TPC AG combines linear and nonlinear content from the 17 Swiss public broadcaster radio stations. This new radio player allows listeners to create their own personal radio programme by combining linear and non-linear audio content from the Swiss public broadcaster’s (SRG SSR) radio stations with other streams and on-demand services from all over the world. To name one example, one could choose to play the non-stop music programme from "Radio

Swiss Pop", but have the player switch automatically to the newsflash of another channel at every full hour. The player also remembers the exact play position, so that a user can change playback devices while listening to on-demand content. When resuming playout on a new device, the on-demand content will continue at the exact position where it was previously stopped. It is now also possible to share the playout position using social networking tools. diy.fm is therefore not only a playout platform, it also provides application programming interface (APIs) for the radios of the Swiss broadcasting corporation. With the diy.fm API, external developers can access the diy.fm content from within their applications or the broadcaster itself can use it for new applications. Diy.fm allows enriching broadcast content with local music saved on a device. The whole diy.fm API is documented on wiki.diy.fm and is currently being used by internal and external developers to create new applications. The diy.fm APIs consists of a REST API, Java Script Player API and the Push API including News On/OFF, DLS, Traffic announcement On/OFF. The data formats of the APIs are XML, JSON, JSONP. One new prototype based on the diy.fm API is musicBan. MusicBan (Figure 6) is an audio player which combines the diy.fm API and another API from the Swiss music platform mx3.ch. If a user blacklists a song on her player, the song will be replaced by another song with a similar length. The player asks the music platform API for the best song to overlay the blacklisted song. The Dutch broadcaster NPO is working on a similar prototype (code name "Skippy"), proposing another song when the listener indicates she wants to hear an alternative choice from the DJ. This will be implemented in the current 3FM Radio smartphone app but the principles should work for any Radio device, making use of the Cross Platform Authentication (CPA) protocol and the RadioDNS RadioTAG service. The context will initially be limited to the listener's wish to hear an alternative, but other contexts will be considered in subsequent versions.

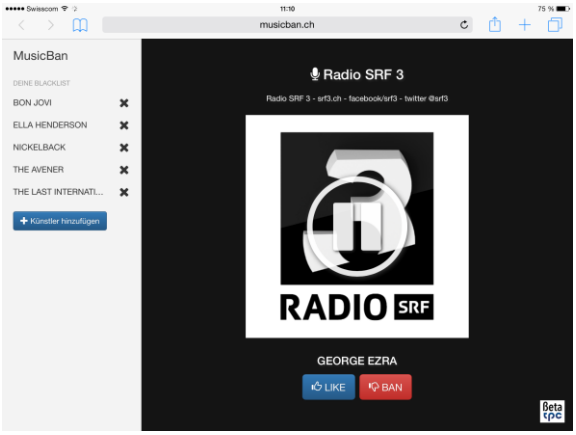

Figure 6 - musicBan web app interface

GUIDELINES TO THE CREATION OF A HYBRID-CONTENT RADIO SERVICE

The previous descriptions of the prototypes demonstrated the common vision for hybrid content radio. The key technical issues towards enabling HCR will be outlined in the following sections, describing a path for further development and research.

Programme Metadata and Link to Enriching Content. The first technical requirement for creating an HCR service is to have metadata for the current and future programmes. Metadata must have accurate time and programme details, allowing additional content to be played at the right moment. The recommended specification for metadata is the ETSI Service and Programme Information (SPI) [14]. We propose the following simple mechanism to link the enriching content to the programme schedule. The SPI `<link>`

element describes how to link external content: based on that, SPI allows the following syntax:

```
<link uri="http://broadcaster.example/hcr.xml"
mimeValue="application/hcr+xml" description="hybrid
content radio recommendation list"/>
```

The receiver will find the link element, e.g. in a programme, looking for the correct MIME type, and it will trigger the enriching audio clip selection from a linked list.

Synchronisation. The enriching audio content has to be precisely synchronised with the linear content it is going to replace. The main problem with HCR is that the linear audio content could come from different sources: DAB+ digital radio, FM, or even the internet, each one with a different delay from the nominal schedule time. The simplest solution is to specify, for each transmission technology, the estimated delay between the schedule time and the actual reception time. Another proposed technique is the use of a sample-based matching technique [15] to realign the Service and Programme Information time base to the receiver's time base, independently from the transmission technology and delay.

Listeners' Context and Standard Recommendations. The receiver has to gather accurate context (e.g. location, mood, activity) and user profile information to help create relevant content recommendations. The information can then be used to propose additional and personalised audio content to the listener. So, a standard format to describe recommendations, for example MPEG-21 user description, can be advantageous for a number of reasons. First, it enables the exchange of recommendations between trusted entities, allowing cross-domain recommendations and reducing the cold start problem. Second, it promotes an interoperable recommender engine market.

Cross-Platform Authentication (CPA). Nowadays, an increasing number of radio listeners switch from one device to another during the day: from a home radio, to the car radio, to the smartphone or PC. A common authentication method for all of these devices would help to maintain the listener's preferences and context across devices. The CPA [16] EBU recommendation precisely targets this need. The CPA protocol can be used to identify listeners across different devices, allowing cross-platform HCR. CPA provides a way of securely associating an internet-connected media device with an online user account. This association enables the delivery of personalised services to the device such as media recommendations, bookmarking, and pause/resume of media playback between devices. In its first version CPA focuses on devices with limited input and display capabilities such as hybrid radios (i.e. those capable of receiving broadcast radio and having a connection to the internet) but it has also been successfully applied to connected TVs and set-top boxes.

Adaptation of the Enriching Content. Another challenge is a proper blending between broadcast content, governed by a fixed schedule independently from the transmission

media (digital radio, internet streaming), and personalised content. An optimal usage of the bandwidth is possible by properly calibrating the non-linear, personalised content to be added to the broadcast content. However, it is unlikely that additional content can be overlaid on a traditional broadcast stream without any adaptation, especially regarding the content length. The production process should include means to allow flexible content length. The object-based broadcast system [17] or similar solutions can be used during production to address the adaptation step.

The Need for an Interoperable Radio Tuner API. One key advantage of an HCR approach is that a major part of the content can be delivered with the efficient and economically sustainable broadcast channel, using the internet channel to address specific users characteristics. So, smartphones and connected radios are a natural target for an HCR service, as they often have both a broadcast radio tuner and an internet connection. However, a route to the mass market must tackle the critical obstacles of accessing the radio tuner and the lack of a standard API to access that tuner. These facts currently prevent the opportunity to take full advantage of hybrid devices for HCR. The effort to bring radio tuners and a universal API to smartphones has been led by the EBU Smart Radio initiative [18] and by the Universal Smartphone Radio Project [19].

CONCLUSIONS

The paper defined hybrid content radio as an enhanced radio service, where both linear broadcast audio and recommended audio content are used to give listeners a better radio experience, while preserving the central role of the broadcaster. HCR can both increase listener satisfaction and optimise bandwidth usage. The service prototypes created by three European broadcasters' research centres were described, exploring the potentialities of a hybrid approach for radio content. A common framework for HCR was then proposed, allowing listeners to personalise the audio of traditional linear radio with context-related audio content, addressing key requirements like metadata availability, synchronisation and authentication.

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