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REVIEWS - LETTERS - REPORTS

Enhanced hybrid TV platform with multiscreen, advanced EPG and recommendation enablers

Tomas Kovacik, Rastislav Bencel, Jan Mato, Roman Bronis, Peter Truchly, Ivan Kotuliak *

TV watching dramatically changes with introduction of new technologies such as Internet-connected TVs, enriched digital broadcasting (DVB), on-demand content, additional programme information, mobile phones and tablets enabling multiscreen functions *etc* that offer added values to content consumers. In this paper we propose modular advanced TV platform and its enablers enhancing TV watching. They allow users to receive aside of EPG also additional information about broadcasted content, to be reminded of requested programme, to utilize recommendation and search features, thanks to multiscreen functionality to allow users to take watched content with them or transfer it onto another device. The modularity of the platform allows new features to be added in future.

K e y w o r d s: advanced TV, multiscreen, mobile devices, enhanced EPG, recommendation

1 Introduction

Television has been around for decades. It is having millions of consumers of linear content around the world. However, TV watching is dramatically changing with new technologies such as mobile devices, social networks, digital TV broadcasting *etc* [1]. Users nowadays demand to consume a content anytime and anywhere and want to choose just the content they are interested in to effectively spend their time (*ie* advertisement is not welcomed). Thus from analog linear television, where a consumer receives content as broadcaster sends it, we are moving towards environment bringing numerous possibilities utilizing ubiquitous mobile devices, Internet content and digital TV.

In addition to sharing content, TV platforms are being continuously improved and extended. DVB enables more audio and video content to be broadcasted and new functions are introduced. Data of various kinds can be transferred via DVB (*eg* EPG but also IP data [2]). New application possibilities are offered also by Hybrid Broadcast Broadband (HBB) [3]. These applications are mainly focused on providing additional information to television shows, EPGs and information portals, but HBB can be also used for education purposes as e-learning platform [4], [5].

TV watching can be extended by new possibilities such as receiving TV content on the mobile devices (*eg* multiscreen) [6]. Disadvantage of this approach is that these functions and applications are not provided to users in all-in-one solutions but only as a subset of this functionality, often as proprietary solutions which are difficult to extend. In this paper we proposed a modular platform which provides users with many functions related to TV watching, authentication, multiscreen and variability of user end devices.

This paper is organized as follows: Section 2 discusses in more details current situation in the research field, Section 3 contains description of proposed architecture and its components. Testbed details are introduced in Section 4. Section 5 concludes the paper.

2 State of the art

Mobility, Internet and digital television allow additional services and applications to be delivered to consumers flat Internet-connected TV *eg* via Hybrid Broadcast Broadband (HBB) [3], [7]. Banking, shopping and social networks available through TV interface become reality as well. Successful HBB-Next FP7 project [8] introduced even more features to TV world, such as security and identity management, face, voice and gestures recognition [9]. If operators and content/applications providers adopt a new paradigm of sharing services while they are interconnected [10], they can deliver even more services to paying consumers (*ie* if customers operator lacks demanded service, the customer can use it from another provider for higher price).

Social networks also become important in the TV environment. Consumers can share their ideas about the content with their friends on social networks, they can rate, share or recommend it to friends [11], [12].

Another important fact is the growth of number of TV channels available to consumers. Nowadays, there are thousands of channels available via linear broadcasting

Slovak University of Technology in Bratislava, Faculty of Informatics and Information Technologies in Bratislava, Ilkovičova 2, 842 16 Bratislava 4, Slovakia, peter.truchly@stuba.sk

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and even more on-demand shows and channels accessible via Internet. Users can use Electronic Programme Guide (EPG) [13] which gives them possibility to see current and future TV programs for each channel for few days ahead. However, when thousands of channels are available consumer is hardly able to find a show best matching his requirements using only the EPG. Current smart TVs and set-top-boxes equipped by access to the Internet allow to develop advanced and customised EPG applications [14] with new attractive functions such as integration of data from Internet [15], searching, tagging, ordering based on various parameters, frontend customization, intelligent personal agents, automatic recording, friend as well as machine recommendation of content [16]. With new mobile always-connected technologies, the content consumer can also instantly check additional information about currently available content in the Internet.

2.1 Second screen utilization

Additional information about watched program (*eg* actors, director, trailer, additional scenes *etc*) can be displayed on consumers second-screen device (tablet, mobile phone) [17] and sent anytime to Internet-connected TV. For this purpose, relationships-contexts have to be introduced between user and his devices (provided by *eg* identity management module [18]). Having many displays around us [6] they can be distinguished to personal ones and shared/family ones (*ie* owner of a personal device can *eg* capture photos and show them to his family by sending them to shared TV).

Second screen has different usage scenarios [19]:

- *Coherence and synchronization* – the same content is shown on different screens of the user (advanced synchronisation of content is discussed *eg* in [20]). This area can be extended by idea of co-watching and controlling the same content from different locations (*eg* friends share "virtual living room" they watch the same video from different locations and play/pause it anytime).
- *Screen sharing* – a screen is small for showing all information (mobile phone) thus second screen enlarges available display area (TV).
- *Device control/shifting* - master-slave scenario where *eg* mobile is used for video scene shifting or as remote control.
- *Complementarity/Group* - different devices work together to complete an activity, *eg* multiplayer game controlled via mobile phones and displayed on large TV screen.
- *Simultaneity/Cooperation* - TV watching is enhanced by retrieving additional information about watched content as well as by sharing consumers ideas at social network and by communicating with friends. This area includes also important usage of mobile-TV environment - mobile as a return channel to TV broadcaster [14] – where broadcaster receives feedback from consumers and TV shows can be more interactive and attractive [21].

We have identified a few more usage scenarios:

- *Content rendering* - second-screen device can be used to capture a content and share it with other users devices
- *Content transfer* - a user sends his live content from one device to another, *eg* while leaving house he takes a football match with him from TV onto tablet or phone.
- *Content retrieval* - one device accesses content stored on another device. UPnP protocol can be part of this scenario [22].

Results of Bulterman *et al* [23] show that users are enthusiastic about such new features of TV watching. Mostly they are interested in previewing and viewing content and accessing additional information on second-screen device. Also, sharing parts of seen show with their own comments and enrichments were admired.

2.2 Heterogenity and incompatibility

Another problem of current content delivery environment is its heterogenity. Even though there is an HBB standard for Internet-connected smart TVs, each big TV manufacturer develops its own smart TV platform with own user accounts, application stores and functionalities [3], [24], [25], [26]. This makes interoperability almost impossible and in this situation only over-the-top (OTT) applications [27], [28], expensively developed for each platform, make the interoperability real. There are initiatives as the one of Smart TV Alliance [29] which aims to provide universal SDK which developers can use to make applications for Smart TV Alliance compatible TVs.

Nowadays, there exist many solutions which enable sharing content between TV platforms and mobile devices. These solutions can be divided into:

- *open solutions* - often created by community (*eg* Open PLi, OpenRSi) and supporting devices of different producers.
- *closed solutions* - every producer creates own solutions which are not compatible with other devices.

Open solutions include various plugins for set-top-boxes (STB), which allow sharing content or controlling STB by a mobile device [30]. Moreover, it is necessary to use special applications installed on a mobile device (*eg* AndroidDreamer), which enables communication with STB.

Within closed solutions for TV platform, we can find various proprietary solutions utilizing DLNA (Digital Living Network Alliance) technology [31]. DLNA technology was developed for defining interoperability between multimedia devices to share media content. It enables to create a network among fixed and mobile devices. DLNA platform is using a Universal Plug and Play (UPnP) to control, discover and manage media content [22]. Currently, existing proprietary implementations of DLNA are such as AllShare (Samsung), SmartShare (LG), SimplyShare (Philips) [32]. These solutions are only available within facility of the same brand. However, there are 3rd

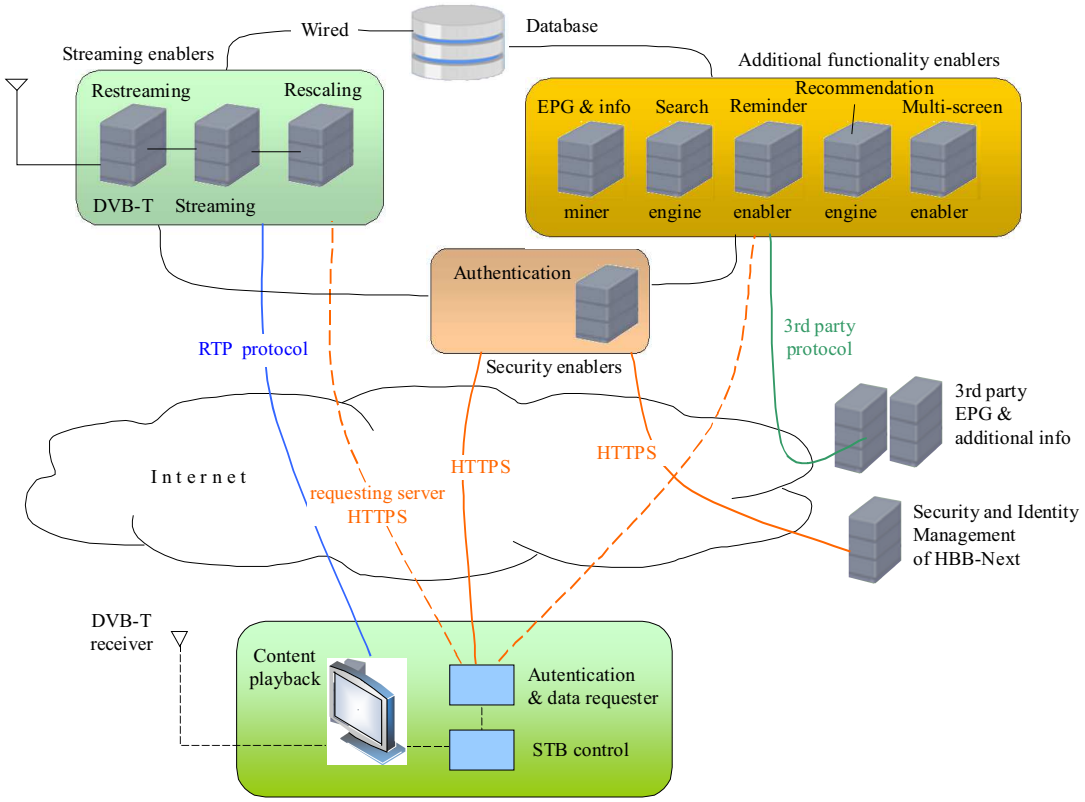

Fig. 1. Modular TV platform and its components

party applications, which are able to provide this functionality on other devices *eg* Apples AirSync application allows to use an Airplay technology on android devices or the application provides content to iOS devices by DLNA [33]. Google Chromecast [34] and some applications *eg* Youtube mobile application can also share content between mobile and TV platform. Wi-Fi Alliance developed functionality called Miracast [35]. Its function is mirroring screen from one device to another, it utilizes Wi-Fi Direct technology for it.

Based on aforementioned facts it is clear that there is no universal solution providing end users with common platform covering various multimedia devices and variability of services. Therefore we decided to propose and implement open multimedia platform (without mentioned limitations) which will be also open to future expansions. Architecture of our modular TV platform consists of several enablers which perform particular functions and new can be also added later. The TV platform we developed represents all in one solution. It integrates rich set of modern functions. These functions include:

- EPG on TV or second screen,
- additional information about programme on TV or second screen,
- searching through EPG data,
- recommending TV programme to consume,
- reminding chosen TV programme,
- multiscreen features
  - ... screen transfer to other device,
  - ... synchronization of screens on demand,
  - ... device control,
- authentication,
- streaming,
- stream rescaling.

3 Architecture of modular TV platform

The architecture of proposed platform is shown at Fig. 1. It consists of two layers:

- application/server layer
- user layer

The layers are interconnected via Internet and mostly HTTP protocol is utilized. User layer requests are realized through HTTP POST methods. Responses generated by the application/server enablers have form of JSON objects.

The application/server layer is composed of set of functional elements - enablers - which perform specific functions of the system. Enablers are implemented using different technologies (see below). In addition to the enablers, the application/server layer contains data repositories. Repositories contain independent parts characteristic for ensuring functionality of particular enabler. All enablers can be divided into three areas by their functionality:

- Security enablers (section 3.1) - this type of enablers provides security to the architecture. Nowadays only

one enabler is deployed in the platform and its role is providing authentication functionality.

- Additional functionality enablers (section 3.2) - additional functions for users *eg* recommendation based on user preference, content searching, reminder about favourite user content *etc.*
- Streaming enabler (section 3.3) - these enablers provide functionality for streaming content to user. Streaming functionality is divided into several enablers which provide functions such as restreaming of a terrestrial broadcast, and content rescaling based on user available resources *etc.*

The user layer includes various devices such as TVs, set-top-boxes and mobile devices - smartphones, tablets. The devices have client applications installed using which advanced functions are enabled to users.

3.1 Security enablers

Authentication enabler

This enabler performs user authentication, it is developed in form of server script (PHP) with which the client communicates in form of JSON objects. The authentication is essential for the system, so the enabler is informed about users authenticated on particular devices. For this purpose, the system uses contexts which pair users with their devices (stored in IdM). The mechanism also ensures security of users data. The system uses contexts also for enabling TV content for particular user if the TV channel is freely available or the fee has been paid for it. This method can also be used as a form of parental control.

Users sign-in data are:

- Username - unique, identifies a user,
- Password - string of characters,
- Security code (PIN) - consists of digits, used by particular enablers.

In order to verify users sign-in data, the authentication enabler communicates with IdM (Identity Management), which is part of HBB-Next platform [36]. IdM contains all information about users, devices and their contexts. Users can log in only to devices which are assigned to them.

Mobile or STB device (User terminal) sends request with the users sign-in data inside of HTTPS protocol. The request is delivered to the Authentication enabler (AE). The AE communicates with Security Manager (SM) of HBB-Next architecture which subsequently communicates with the Identity Manager (IdM). As the SM currently does not provide API, we utilize IdM API [8], [9], [37]. The IdM uses REST API with GET, POST, PUT and DELETE methods for handling objects. The result of sign-in data verification process is finally sent to requesting device which allows or denies access to services for the user.

Alternatively to described authentication mechanism, particular enablers can use security code (PIN) *eg* to unlock the device after a while it has been locked. The security code is convenient safety feature which is useful if the user does not want to constantly log in and out from the device.

Since every user has his unique username, the system can manage user profiles and personalized services can be offered in future.

3.2 Additional functionality enablers

EPG miner

Its main task is to obtain available information about TV programmes. In our testbed, the information about Slovak channels and programmes is obtained from 3rd party providers by WebGrabPlus script being launched every day at midnight by Linux Cron task. The data is stored in XMLTV format [38]. Information could be also obtained directly from a DVB signal from MPEG2 transport stream, however, usually there is only limited amount of information about limited number of programmes being broadcasted in the air.

The process of obtaining the data consists of two steps:

- the EPG miner acquires information about the TV programme and put it into XMLTV file. This format was developed especially for purpose of storing detailed information about TV content as well as the TV station in appropriate structured form.
- the file in XMLTV format is processed by EPG parser (utilizing Saxparser) and stored into the EPG data base in particular tables and their connections.

Additional info miner

The main objective of this enabler is to provide additional program information which is gathered from different sources. Different movie databases are accessed together with YouTube and Google information and provided to user as a mixture of data which can be accessed directly from the GUI. A program name is searched using Google and other selected web search engines to retrieve additional program/show information. Retrieved data are displayed to the user.

Recommendation engine

The Recommendation engine provides automatic recommendation of TV content to users based on their own preferences (stored in Recommendation database). The user defines 5 main preferences such as favourite category (film, series, both), genre, actors, directors and screenwriters and assigns priority to them which are taken into account by recommendation algorithms. In addition, in each category user can indicate at least 5 items which are also gradually prioritized (from 1 to N, where 1 represents the highest priority within a category).

The recommendation algorithm pulls user preferences from the Recommendation database, applies them to each TV program for current time interval. Output of the algorithm is a set of TV programs that are appropriately scored. Subsequently, the user terminal displays list of 10

or 20 TV programs (based on settings) which received the highest score and thus should be interesting to the user. The user can then start playback of the selected TV program or view detailed or additional information about the content so he can decide between several recommended TV programs.

In addition to the content recommendations based on user preferences, the system also performs automatic monitoring of user behaviour. The system tracks time which the user spent watching particular program. The user behaviour data from automatic monitoring are also recorded in the Recommendation database. Subsequently, this information is gradually applied to the content recommendation algorithm. Using this technique, we can improve the user content recommendations as well as we can improve a response system to change the user's preferences for popular formats of TV content.

Reminder

Alerting a user to watch a favourite TV program improves his user experience. It is closely associated with the Reminder database. At regular intervals the enabler checks whether the Reminder database does not contain any records which meet defined reminders. If there is such record in the database, the system automatically generates an alert for the end device the user is logged onto. Subsequently, the record is modified in the database and is accessible to the next level of warnings. Outdated records are automatically removed at regular intervals.

Search engine

It is used to search for information about TV content which is stored in the EPG database. Searching is carried out either by a phrase (*eg* news) or by genre (*eg* comedy, drama). The user can choose from the list of available genres. The search is initiated by HTTP Post request sent from user device to the enabler where it is processed by particular script.

The search process looks for a full or partial match in

- a translated or original version of the TV program name,
- a short program review,
- genres or names of actors, directors and screenwriter.

The user can afterwards use following functions: examine detailed information about selected program, add a TV program to the list of his reminders or start watching the program if it is currently broadcasted.

Multiscreen enabler

Multi screen enabler allows users to redirect the display system output from one device to another. This function can be used to facilitate the use of multiscreen scenarios mentioned earlier. If a user does not want to see results of the recommendation algorithm on the TV, he can redirect them to his personal mobile device. If a user activates and watches particular TV program and he would like to see more detailed or additional information about that program, this information should not restrict other users who are with him co-watching the TV broadcasting. Thanks to the multiscreen enabler the user can display this information on another device. The system also supports remote start of particular TV station on another device. This functionality is partially enabled thanks to the functions of developed Android application deployed on mobile and STB devices.

If a user initiates a request to redirect an output from one device to another one, the request is processed and stored in the multiscreen database. The system evaluates the request and tries to successfully execute it on the second device. Decision process processes ID and permissions of requesting user, his permission to execute such functionality on the second device and requested screen content (Fig. 2).

In case a user wants to see detailed information about actual movie and he doesnt want to disturb his co-watchers, he can send this content to his personal devices (2nd device at Fig.2). After choosing this function his 1st device sends a request to the multiscreen enabler. If all permissions are granted, the enabler gets content information about user related content and saves this content. If there is no error, this content is sent to 2nd device and displayed there. In this scenario, detailed information about watched movie is displayed. Information about final status of operation is sent to the 1st device.

To ensure correct operation of this feature it is important to create a context between the user and his devices. One user can have multiple contexts for different devices. These devices can be TV, STB or a variety of mobile devices such as smartphones or tablets. The context is created when the user is logged into the system through the appropriate device and is terminated when user signs out. The context is very important information to ensure a proper operation of several functions. Contextual information is stored in the Context database.

3.3 Streaming enablers

Streaming enabler

Its main function is to provide a video stream to end-user device (user equipment - UE) to meet its request. This enabler closely collaborates with the rescaling enabler who is invoked when it is necessary to transcode a source signal to a particular format or resolution suitable for the end-user device.

The Streaming enabler responds to following requests from UEs:

- *get channel list* - UE requests a list of available channels for streaming
- *start streaming channel* – UE requests information about an address on which it can receive the stream; the enabler starts streaming of requested channel

When a stream is successfully started with specific parameters (*eg* using rescaling functionalities), the address of the stream is sent to the UE. Information about started

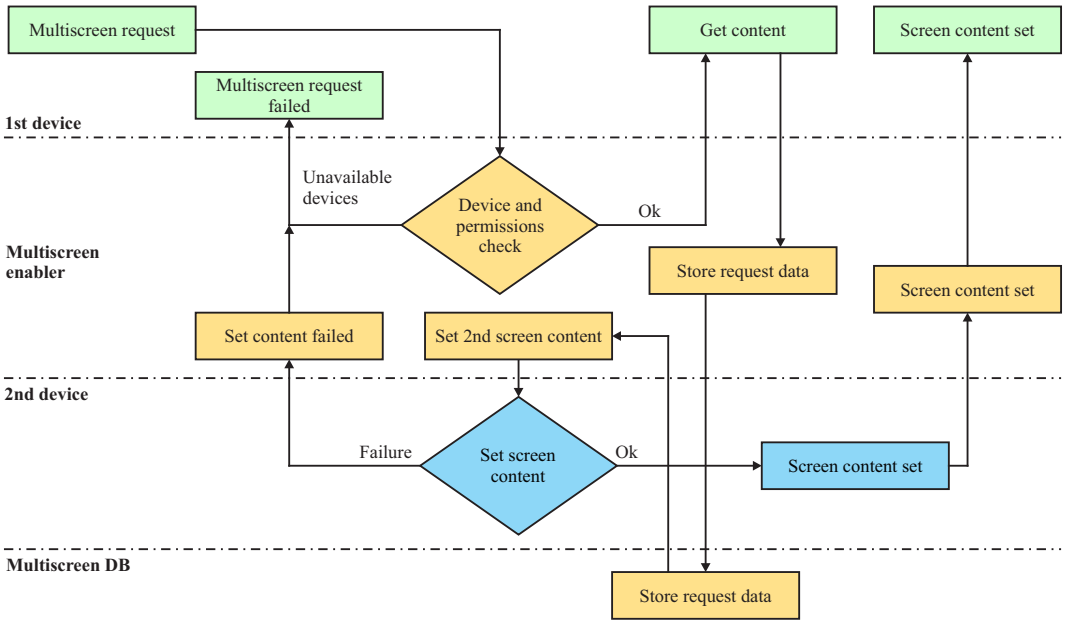

Fig. 2. Block diagram of multiscreen function

streams is stored in database so it is not started twice in case of a request from another UE. If a stream is not being watched by any UE any more, it is stopped to save resources.

This enabler also serves requests for content recording on UE. Enabler provides an address to UE from which requested content can be recorded.

Rescaling enabler

As user devices have different screen sizes, system performance, quality of connectivity *etc* , it is not necessary to stream a full resolution video towards them. The enabler transcodes a source television signal based on a request from UE and provided parameters. Current version of the enabler supports only a screen resolution parameter, however other parameters can be added in future. This enabler can be active or inactive depending on setup of the streaming enabler which is calling rescaling enabler.

DVB-T restreaming enabler

Received DVB signal is transformed into IP stream and delivered to enabler, which provides the content to end user device. DVB-T signal can be received by a DVB-T tuner which only allows to receive data from one multiplex at the time.

3.4 Data repositories

The architecture we proposed utilises a set of databases (DB) which are necessary for proper operation of particular enablers and they are characterised below.

EPG database

Information about TV programmes obtained from EPG is stored here. For each program delivered to user following data are stored (if available):

- name of TV station that broadcasts the program,
- name of programme in the original and Slovak language,
- date and time of broadcasting (start and end),
- subtitles,
- the category name,
- genre country of origin,
- year of publication,
- short summary.

In addition, each TV program is also provided with information about the actor, director and screenwriter.

Additional information DB

This database contains additional information about TV programme in order to provide users with a better overview of the content:

- detailed reviews of the program,
- user reviews,
- multimedia data (photos and trailers),
- other information.

IMDB and CSFD movie databases are sources of information as well as official websites of the movie studios which are searched using Google.

Reminder DB

The Reminder database ensures proper functionality of the Reminder enabler. For this purpose, we use information about the user and the TV program, whose broadcasting the user wants to be alerted on. The system works on the principle of multiple levels of alerts (*eg* day ahead, on the day of the program broadcasting, few minutes before the broadcasting). The Reminder DB is periodically checked whether it contains some alerts which the system should convey to a particular user.

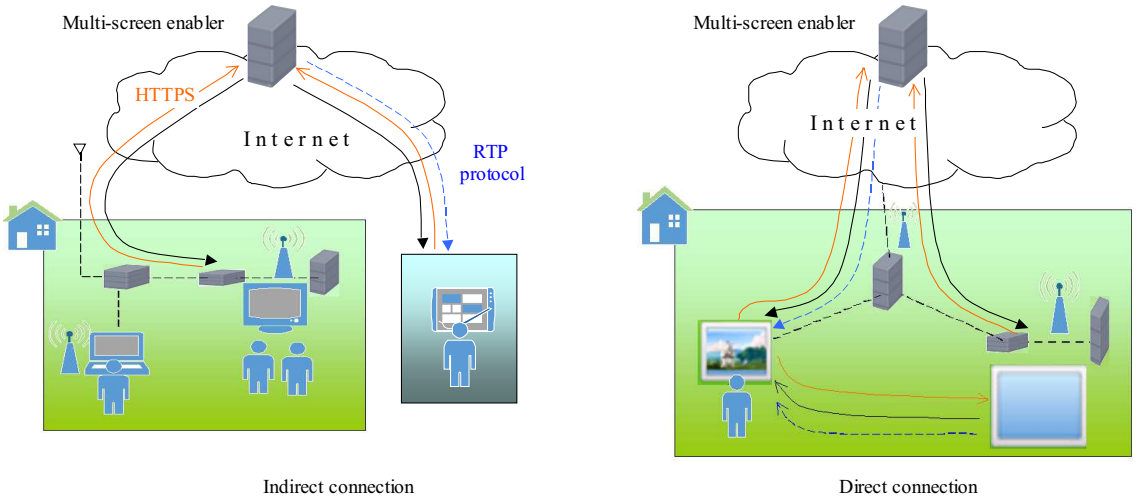

Fig. 3. Communication scenarios for STB and mobile device

Multiscreen DB

The multiscreen DB stores information about users requesting to perform an output redirection operation as well as information about how devices implement these requests. In addition to these main parameters of operation there are also additional information and parameters which are necessary for the successful implementation of redirecting output operations (*eg* TV channel ID, programme ID).

Recommendation DB

The Recommendation database ensures proper operation of recommendations of TV content to users. This database contains information about the user's personal preferences and favourite TV content watched by him. It provides information on the most popular categories, genres, actors, directors and screenwriters. Details acquired by automatic monitoring of user behaviour are also stored here.

Context DB in ID

The Context database is part of Identity management. It contains information about contexts between the user and his devices. Each context has an attribute which determines whether it is active or inactive. The context is very important information for security and personalization purposes. Based on this information, *eg* we can launch the multiscreen enabler function or remotely start playing a particular TV channel on chosen TV (with which the user is in context).

3.5 User layer components

STB and mobile device communication

The STB and mobile devices can operate in different communication scenarios based on a mobile device location (Fig. 3). This section describes following communication scenarios:

- *Indirect connection* - The mobile device is not situated in users home Local Area Network (LAN) and it cannot see the home STB from its network (Fig. 3 indirect connection). For exchanging messages they have to communicate using a server (*eg* multi-screen enabler). This scenario is common for communication outside of home network.
- *Direct connection* - The mobile device is situated in users home LAN (Fig. 3 direct connection). Both devices can exchange messages directly and they do not have to include a server to their communication. Some messages have to be sent to the server because of hardware limitation at user side.

Devices have to be aware of connection type between them, thus we created an attribute which indicates this property. Its name is direct_flag and it is stored on server side. Server is informed from a mobile device about actual value of this flag. Only the mobile device can update this flag because the requests are sent from a mobile device to a STB device.

Interconnection between STBs and mobile devices enables following functionalities:

- *Synchronization of TV channel* - this function means that on both devices the same TV channel is played. If user changes channel on his device, then the change automatically appears on associated devices. This functionality does not support synchronization of frames in video content between the devices.
- *Recording content on STB or mobile device* - function for recording video content is enabled on both devices, but their control is different. STB device has recording function natively, thus we created extension which allows to initiate the recording function remotely from a mobile device. The recording function on a mobile device is realized by a progressive download (method) using HTTP protocol.
- *STB content playback* - video content stored at STB is streamed to a mobile device. Communication is based on JSON objects exchange in HTTP; to deliver the

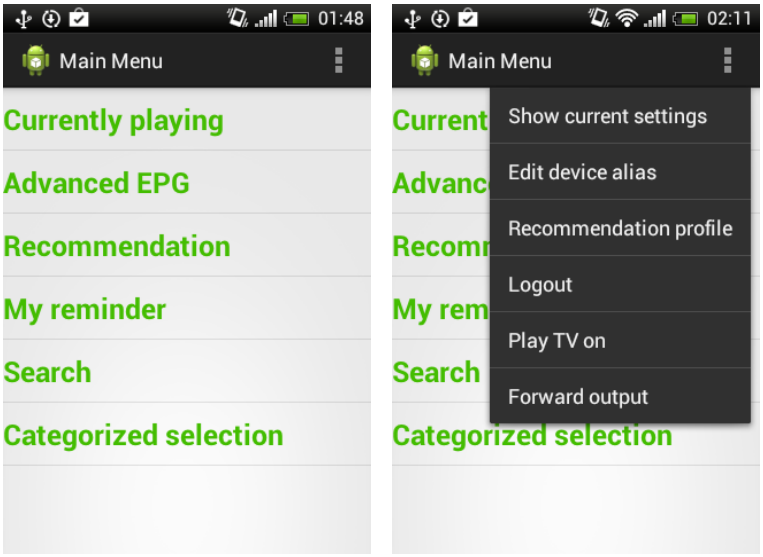

Fig. 4. Main menu and submenu

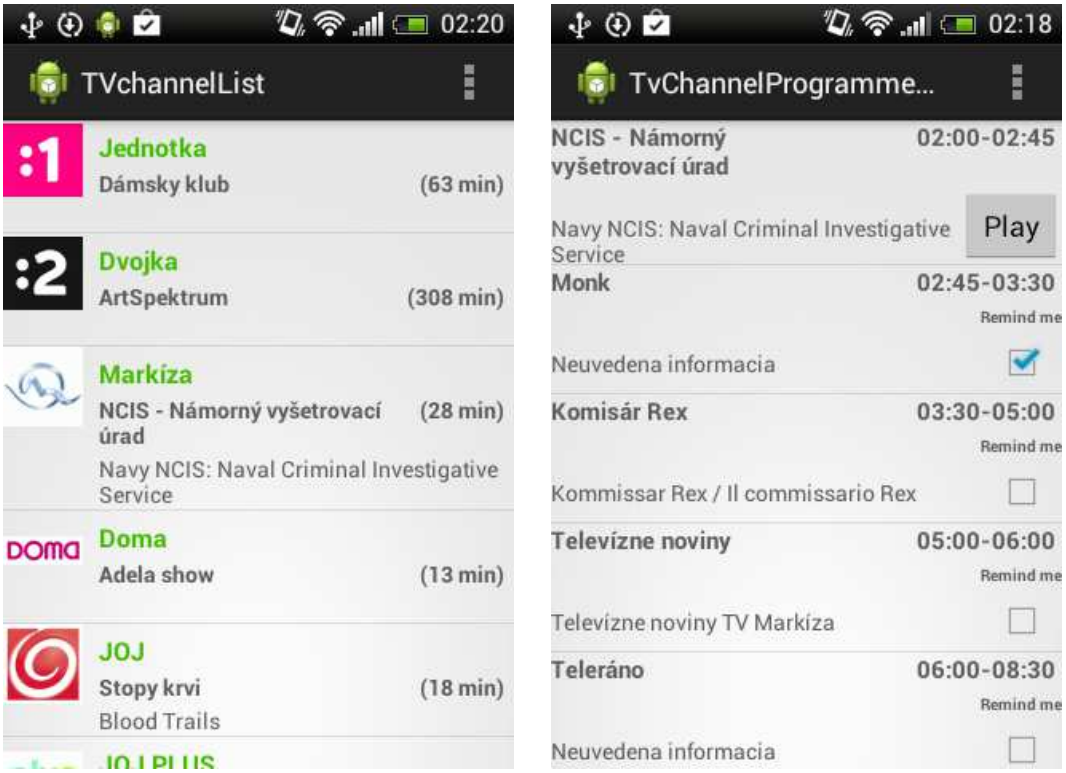

Fig. 5. List of available channels (left), list of current and future programs (right)

video, HTTP progressive download is utilized due to limitation of STB (HTTP server is present, no streaming server available).

In case of indirect connection, each device periodically asks server about a channel change on associated device and about requests for recording content on STB. In this type of connection it is not possible to use functionality for playing video content from STB to a mobile device.

4 Hybrid TV platform

In this section we describe architecture of our hybrid TV platform testbed with main focus on user interfaces. We present brief description for every platform interface.

Our platform enables screen sharing not only at home but also through mobile connections. However, to save mobile bandwidth, devices can connect also to WiFi networks and receive content through it. In our solution, the video content can be also streamed or recorded at STB

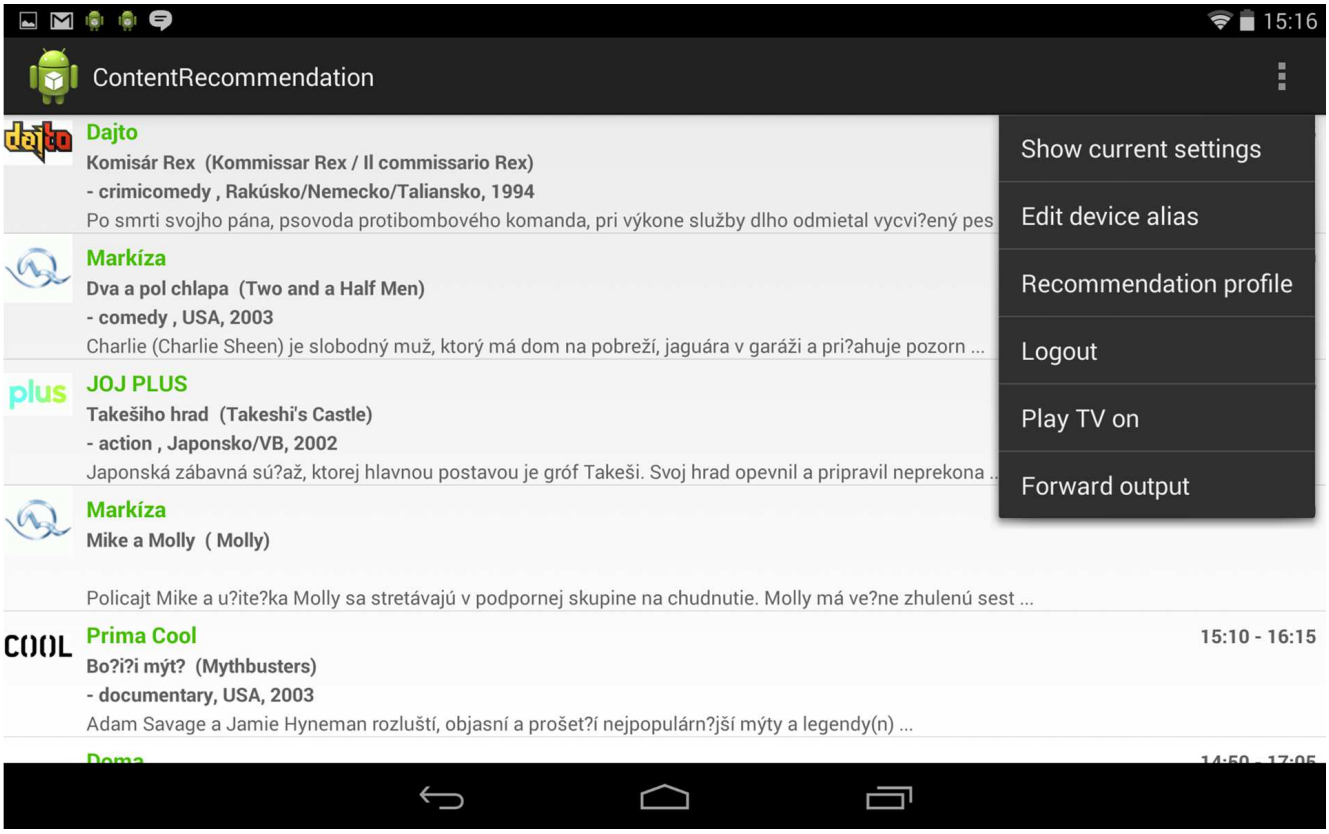

Fig. 6. Content recommendation GUI — Android mobile device

for later watching *eg* on mobile phone. Recordings can be managed locally at STB or via defined API interface from other locations and devices over network connection.

User authentication to the system realised by a mobile application is performed by checking username and password what is a standard procedure implemented in many mobile applications used nowadays.

Main menu

Menu shown after successful authentication enables to watch current programs, display additional information about programs, display recommendations and reminders and search through content information (Fig. 4). Submenu offers possibility to transfer the screen to other devices, edit user settings *etc.*

List of available playable contents is shown after choosing Currently playing. After choosing a channel, information about current and future programs is displayed, see Fig. 5.

Multiscreen

Multiscreen feature and recordings management was tested in laboratory environment using local wired and wireless networks. As set-top-box (STB) we have used AZBox HD Premium device with firmware OpenRSi. As testing mobile device we have used Google Nexus 7 with Android 4.4.2. Our custom plugins developed for the STB in Python enabled:

- HTTP server enabling re-streaming of DVB-T channels via IP network mobile devices
- receiving remote control commands from mobile phone

The Android 4.1 java application enabled:

- connecting to streaming content
- control of the STB - play channel, stop, record, play next and previous channels)

To provide video streaming functionality, the server was equipped with Intel Core 2 T5500 1.66 GHz CP, 2 GB RAM and DVB-T USB dongle A-LINK DTU. It was able to re-stream received DVB-T streams in MPEG-4 H.264 video coding. The stream was via Internet delivered to mobile device and played using native Android video player accessed in mobile application via API (Fig. 6).

There are other GUIs available to users. The first screen from STB device contains settings for enabling streaming and channels sync and second one allows users on a mobile device to control playback of re-streaming content

Additional information

Additional information about a program can be either viewed on a screen of Android device or can be transferred to the second screen - Android device. The information contains program information, list of actors, director, trailers *etc* . Currently, this information is processed

from multiple sources. For currently played program information, data from port.sk are used. For additional information YouTube, IMDB.com, CSFD.cz and Wikipedia are used. This part of the testbed has been tested using smartphones and tablets HTC Desire C, Nexus 7 and Samsung Galaxy Tab II.

Content recommendation

Content recommendation works based on user preferences entered at user registration. Example of the recommended content in Fig. 6 is a result of algorithm which processed user preferences - preferred genre: comedy, drama, preferred actor: Atkinson.

The Android application worked according to use-cases and consumed only 3.5% of whole device power consumption in background state and 29% in active state.

5 Conclusion

Usage of linear television content is slowly decreasing in favour of on-demand content and additional entertainment information services. This increase of on-demand data brings new challenges to providers and their networks. Changes to standard linear television are needed in order to provide enhanced TV services.

In this paper we presented our architecture which represents modular TV platform providing innovative TV functions to users. This architecture is based on set of enablers realizing specific functions and is using service databases which contain data about users, content and devices. Current proprietary solutions in the area provide limited options and are available only to the vendor-specific devices. We proposed and implemented open system which integrates several enablers providing innovative functions related to TV service. Our solution provides multiscreen transfer and playback, enhanced EPG, searching, recommending and reminding functions, video recording and device control.

Proposed architecture has been implemented and tested in laboratory environment with standard mobile devices and STB. From HBB-Next services we used Identity Manager node to provide authentication and also to improve the compatibility of our architecture with existing solutions. This modular open architecture can be extended by new functions in the future, such as synchronization of content with subtitles, information filtering, sorting functions and advanced recommendation techniques.

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Ivan Kotuliak received PhD degree from both Versailles University and Slovak University of Technology in 2003. From that time, he joined Slovak University of Technology and worked as researcher and Assoc Prof His research orientation is focused on network performance, including NGN architecture, wireless and mobile networking, VoIP systems and Future Internet. He has been author and co-author of more than sixty scientific papers and leads and participates on several international and national research projects.

Peter Trúchly is assistant professor at Slovak University of Technology, Faculty of Informatics and Information Technologies in Bratislava. He achieved his Master's degree in the field of informatics in 1995 and his PhD in applied informatics in 2004 at this university. He is interested in communications technologies, mobile applications and in the development of educational materials and e-learning platforms, the performance analysis of media access control and transport protocols in wireless and satellite systems.

Tomáš Kováčik (PhD) born in Topoľčany in 1984, graduated in telecommunications in 2008 and received his PhD in applied informatics in 2012, both from Slovak University of Technology in Bratislava. His research and teaching activities include IP telephony (VoIP), IP multimedia subsystem, hybrid television and mobile applications as well as alternative communication channels using audio signals. He participated in several Slovak national research projects, in EU FP7 HBB Next project and is part of ngnlab.eu initiative, www.katalyzer.sk and vytlky.fiit.stuba.sk projects.

Rastislav Bencel is a PhD student at Slovak University of Technology, Faculty of Informatics and Information Technologies in Bratislava. His research is focused on Internet of Things, WiFi technology, Software Defined Networking, hybrid television (master thesis), network simulations (bachelor thesis) and mobile applications.

Ján Mať o is a PhD student at Slovak University of Technology, Faculty of Informatics and Information Technologies in Bratislava. His research is focused on new paradigm of Internet of Things, IP Multimedia Subsystem (bachelor thesis), hybrid television (master thesis) and mobile applications.

Roman Broniš received his PhD degree at Slovak University of Technology, Faculty of Informatics and Information Technologies in Bratislava in 2015. His research was focused on data delivery in next-generation hybrid television HBB-Next, and on hybrid and smart television platforms. He participated in EU FP7 HBB-Next project as part of STUBA team. He is currently employed at webalyse marketing & consulting GmbH.