# IPTV Evolution Towards NGN and Hybrid Scenarios

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*Internet Protocol-based television (IPTV) concerns video entertainment and represents a solution for interactive television-like services over IP-based networks. Operators and vendors are currently working on IPTV standardization efforts (e.g., ATIS/IIF, ITU-T IPTV-GSI, ETSI TISPAN) to bear wider availability and interoperability of IPTV as a secure, reliable, managed multimedia service. In this paper, we present a generic IPTV architecture, and explain standardization efforts such as TISPAN, OIPF, ITU-T and ATIS specifications for the next generation IPTV. We review new approaches in multimedia services and media delivery, and present open issues in IPTV networks. Finally, we give research directions for future work.*

*Povzetek: Članek naredi pregled televizije IP, njene arhitekture in standardov.*

## 1 Introduction

Television in IPTV is distributed to subscribers using a broadband connection over the IP. IPTV is expected to grow rapidly as broadband is now available to more than 500 million households worldwide [1]. Currently, most of telecommunication companies (telcos) and cable operators are actively providing IPTV-based services. Total IPTV subscriber numbers have now reached 48.2 million at the end of the first quarter 2011 [1] with growth over 34% in the last 12 months (till Q1 2011). Telcos acquire and manage video content for distribution, and ultimately deliver this content to the end-user using various transmission techniques (i.e., unicast, multicast, or broadcast). As far as the content in IPTV is concerned, there are three different categories:

- *Linear content.* In this case, viewers adapt to the usual grid-style programming schedule that now exists on cable, satellite, and over-the-air TV. This is a conventional multichannel pay-TV service.
- *On-demand content.* Programming is streamed "on-demand" to the viewer from a video server system to a set-top box (STB) device. Accessible cable-based VOD services provide many programming choices such as movies at the request of individual subscribers.
- *Exclusive content.* It is programming that is unique to an individual service provider (SP). Exclusive content can provide consumers with a reason to choose one SP's service over another SP's (e.g., movie blockbusters, sport events).

The distinctive feature of IPTV service is that interactivity can be easily provided, as the end-user can compile the program according to his/her individual preferences. Actually, available IPTV services include: (1) targeted advertising (e.g., banner advertising in an electronic programming guide); (2) (EPG) or sponsored advertising for on-demand content; (3) in-program electronic messaging; (4) personal TV channels; (5) sharing of photos, movies, and interests; (6) walled garden portals – weather, sports, recipes, etc.; (7) EPG-based electronic messaging and social networking; (8) home security and management services; (9) whole home DVR; (10)

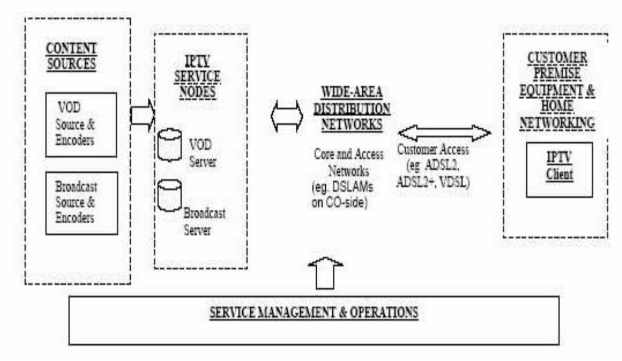


Figure 1: IPTV network architecture [Source: http://www.networkdictionary.com/networking/IPTV.php]

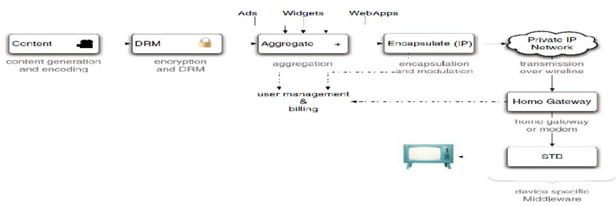


Figure 2: IPTV developments [23].

network-based time shifting archive; (11) sports participation and gaming; (12) integration with Voice over IP telephony for TV display of call information and call routing, as well as caller ID and blocking, displayed on the screen and call forwarding; (13) PVR programming via mobile phone; (14) accessing Internet services via TV; (15) voting.

The rest of the paper is organized as follows. Section 2 presents a generic IPTV architecture, while section 3 describes standardization efforts such as TISPAN, OIPF, ITU-T and ATIS specifications for the next generation IPTV. Section 4 reviews new approaches in multimedia services and media delivery. Section 5 presents open issues in IPTV networks, while section 6 concludes the paper.

# 2 IPTV Architecture

The architecture of an IPTV network is shown in Figure 1, while current IPTV developments are depicted in Figure 2. In an IPTV network, telcos acquire and manage video content for distribution, and deliver this content to the end-user over broadband IP infrastructure. This is a complex process with precise business and technical requirements.

## 2.1 Content acquisition and management

Not all-video content is produced equal. However, compression efficiency and visual quality should be maximized with existing content types dictating the outcome. For example, a static news program dictates that may require less bandwidth than a fast moving sports program. From another viewpoint, a complete IPTV solution requires effective content management that refers to programming and advertising. Content management encapsulates a number of critical systems, which can be categorized into three distinct aspects [2]:

- *Reception and encoding*
- *Rights management*
- *Back office billing, provisioning, activation, and monitoring.*

*Reception and encoding*: A usual IPTV deployment employs advanced compression technologies to deliver content most efficiently. The encoding process uses sophisticated compression technologies such as H.264 which may potentially help SPs reduce the bandwidth required to deliver a standard or high-definition video stream by as much as 50% (compare MPEG-2). SPs receive often content via satellite or terrestrial broadcasts. The requirements of the content distribution system then dictate how the received content is encoded. Typically, encoding national content occurs only once at the master head-end, assuming the SP has the required infrastructure ready to distribute national content to regional head-ends or hubs. The master head-end then passes the encoded content to the regional hub. The regional hub also receives and encodes local content. This is a cost-effective way of managing the encoding process as it greatly reduces the need for high-capacity encoding at the regional level, thus minimizing the expense of purchasing costly encoding equipment.

*Rights management*: When SPs implement an IPTV solution, pay-TV content must be protected during transmission, from the head-end to the set-top box. The methods in which end-users consume content dictate how the content must be protected and the nature of the content protection. Cable and satellite operators have utilized conditional access security systems that serve to restrict content usage to only those authorized to view the content. As illegal copy and re-distribution of IPTV content now become easier and simpler, SPs should design proper digital rights management systems (DRM) with a look at the rising digital home. It is required to protect IPTV content or service. Consequently, flexible usage rules must accompany a part of video content throughout its usage lifespan, which may include storage within the *customer premise equipment* (CPE) itself (Local PVR), distribution to client devices within the home, and finally distribution outside the home to a mobile device as well. The work in [3] analyzes the security threats and requirements, and addresses interoperability issues among different content and service protection systems for IPTV.

## 2.2 Back-office billing, provisioning, activation, and monitoring

An IPTV system includes a master head-end and a host of regional hubs. IPTV network architectures need back-office content management systems that handle billing for subscriptions to linear and on-demand content. For example, linear content is billed on a subscription basis according to the specific tier of service being subscribed to. On the other hand, on demand content is more complex in that different types of pricing and packaging models are often offered, including subscription and a la carte at various price points with potentially different usage rules. Content management systems must also handle service activation in such a way that subscribers get what they pay for. In an IPTV system, content must be accessed on the fly from wherever it resides. In addition, the system needs to keep track of content once it has been delivered to the consumer for billing and rights management purposes. From another perspective, the IPTV system must be intelligent with respect to targeted advertising campaign management and digital asset location and delivery.

Within an IPTV framework, the delivery of video content based on multicast and unicast over IP network (e.g., IP MPLS) is what really differentiate IPTV from legacy radio frequency (RF) cable systems. Most of IPTV providers use IPTV middleware with centralized or distributed server infrastructure connected over IP network operator core, aggregation and access network to IPTV end-device in home network.

IPTV providers or content providers can use also dedicated infrastructure *Content Delivery Network* (CDN) where content is replicated over several mirrored CDN servers in order to perform transparent and effective delivery of content to the end-users [4],[5]. In particular, content can be pre-recorded or retrieved from live sources; it can be persistent or transient data within the system [6]. CDNs provide services that improve network performance by maximizing bandwidth, improving accessibility, and maintaining correctness through content replication. Some of the most popular commercial CDNs (e.g., Akamai, Limelight, EdgeStream, Jetstream, etc.) that provide distribution of content (contained in web pages) are also delivering video content over the public Internet. CDNs actually handle significant part of overall Internet traffic and video content ratio growth (e.g., Netflix video service traffic has accounted more as 20% of total downstream traffic during peak period in North America in 2011). CDN provider uses its own CDN infrastructure on top of existing broadband connectivity over consumer cable or ADSL modem connections around the globe, be able deliver video streaming over paths that have no more as 20 router hops between their server and end-user (move content as close to end-user as possible). Generally, a CDN system is composed of three main entities: content provider, CDN provider, and end-users.

- A *content provider* (or customer) is one who delegates the Uniform Resource Locator (URL) name space of the video objects to be distributed.
- *CDN providers* use caching and/or replica servers located at different geographical locations to replicate content. CDN cache servers are also called *edge servers* or *surrogates*. The edge servers of a CDN are called *Web cluster* as a whole. CDNs distribute content to the edge servers in such a way that all of them share the same content and URL. Client requests are redirected to the nearby optimal edge server and it delivers requested content to the end-users.

The typical functionalities of a CDN include:

- *Request redirection and content delivery services*, to direct a request to the closest suitable CDN cache server by using mechanisms to bypass congestion. The request-routing component directs client's requests to appropriate edge servers and interacts with the distribution component to keep an up-to-date view of the content stored in the CDN caches. The content-delivery component delivers the content and consists of the origin server and a set of replica servers that deliver copies of content to the end users.
- *Content outsourcing and distribution services*, to replicate and/or cache content from the origin server to distributed Web servers. The distribution component moves content from the origin server to the CDN edge servers and ensures consistency of content in the caches.
- *Content negotiation* services, to meet specific needs of each individual user (or group of users).
- *Management services*, to manage the network components, to handle accounting, and to monitor and report on content usage. The accounting component maintains logs of client accesses and records the usage of the CDN servers. This information is used for traffic reporting and usage-based billing by the content provider itself or by a third-party billing organization. CDNs support an accounting mechanism that collects and tracks client usage information related to request-routing, distribution, and delivery [7].

## 2.3 End devices and home networks

The final part of IPTV architecture is home network connected to IPTV service provider access network with home gateway. The parts of the home network are also end-devices that receive and present IPTV service to subscriber TV. End devices, also called CPE (*customer premise equipment*), are usually set top boxes connected to home gateway and TV. In the future, we expect interconnection of the multiple type of devices with IPTV client software like for example connected TVs, game consoles, PCs, mobile or tablet devices.

# 3 Next Generation IPTV in Standardization

Most of the current IPTV middleware solutions have been developed before standardization bodies start working on specification for Next Generation of IPTV systems. In the following section, we describe the most important standard specifications that in the next years it is expected these to be implemented and bring new IPTV services and advanced user experience as it was provided with the first generation of proprietary IPTV systems.

It is noteworthy that ETSI TISPAN specifies (next-generation network) NGN-based IPTV as "*Multimedia system that provides IPTV services over the NGN architecture and may be implemented as an integrated subsystem with the NGN (NGN integrated IPTV) or may use the IMS subsystem (IMS-based IPTV) in the NGN*".

## 3.1 Overview about TISPAN, OIPF, ITU-T, ATIS specs

In the last years, IPTV has received significant attention from several organizations and standard bodies. Standardization activities on IPTV have resulted in different technical specifications covering the architecture and functions of an IPTV system, which have been made available to the telecommunication market. Hereafter, we describe the most relevant initiatives related with IPTV standardization.

One significant initiative corresponds to the standardization activities carried out by the ITU-T (International Telecommunication Union, Telecommunication Standardization Sector). ITU-T work on IPTV was initially addressed by the IPTV Focus group, which resulted in a first set of draft specifications. From 2008, IPTV Global Standards Initiate (IPTV-GSI) coordinates all the ITU-T activities related with IPTV. ITU-T recommendations for IPTV cover different topics related with home networking, applications and end-systems, architecture, QoE and security. The Recommendation Y.1910 [8] describes three IPTV architecture models: (a) non-NGN IPTV; (b) NGN without IMS IPTV; and (c) NGN with IMS IPTV.

ETSI TISPAN (European Telecommunications Standards Institute, Telecommunications and Internet converged Services and Protocols for Advanced Networking) is also conducting a relevant work on IPTV standardization. Release 2 of specifications of TISPAN NGN (April 2008) introduced IPTV as a service in the NGN architecture. This release describes an IMS-based and a non IMS-based IPTV system. In 2011, TISPAN work on IPTV has concluded to the IPTV specification in NGN release 3.

The Open IPTV Forum (OIPF) aims at developing open and interoperable end-to-end specifications for IPTV. Currently, OIPF has completed release 1 and 2 of specifications [9]. These specifications cover the different aspects of IPTV such as media delivery, session management, service discovery and security.

The Alliance for Telecommunications Industry Solutions (ATIS) IPTV Interoperability Forum (IIF) develops an end-to-end solution for IPTV [10]. ATIS IIF specifications comprise a set of deliverables that describe the different aspects related with the delivery of IPTV service to the end-user, such as the IPTV architecture, QoS, security and interoperability.

## 3.2 IMS vs. non-IMS IPTV

Release 2 of specifications of TISPAN NGN adds new features and services to the NGN such as IPTV. To leverage investments made on the IMS, this release addresses the specification of the IMS-based IPTV service architecture. This architecture implements a set of service layer requirements defined in [11]. On the other hand, NGN release 2 also defines an NGN integrated IPTV system, with the aim of supporting the aforementioned requirements and allowing the integration of existing IPTV solutions defined by other organizations, such as DVB, ATIS IIF or ITU.

TISPAN release 2 defines three main services for the IMS-based IPTV system: (a) Broadcast TV; (b) Content on Demand (CoD); and (c) Network-Personal Video Recorder (N-PVR). Release 3 adds a broad set of value-added services, such as push CoD, interactive TV, communications and messaging, interaction between users, user generated content, content recommendation, games, personalized channel, personalized service composition, service continuation fixed-mobile and remote control of IPTV services, to name some of them.

The NGN integrated IPTV subsystem (as shown in Figure 3) provides basic integration of IPTV functions to NGN architecture and other NGN subsystems especially with the User Profile Server Function (UPSF), and the transport control Resource and Admission Control Subsystem (RACS) and Network Attachment Subsystem (NASS) [12].

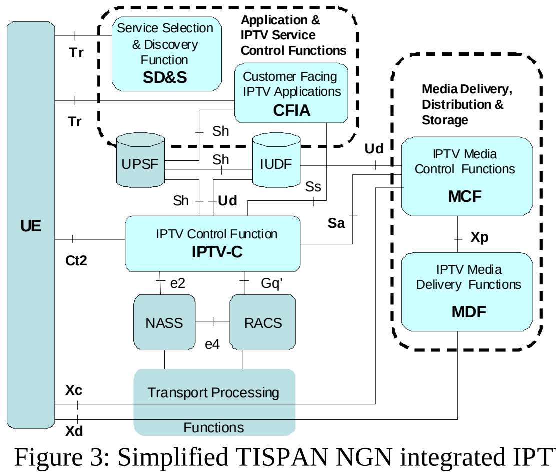


Figure 3: Simplified TISPAN NGN integrated IPTV subsystem functional architecture [12].

A user can access with his/her user equipment (UE like set-top-box STB) the service description via SD&S service, selection and discovery procedures that follow DVB IPI specification and use HTTP protocol. The same Tr interface can be used by UE for accessing the user interface and service selection over Customer Facing IPTV application (CFIA). CFIA provides this interface IPTV service provisioning, selection and authorization. IPTV control (IPTV-C) is enabled over HTTP or RTSP control. Media (e.g., content on demand – CoD) can be streamed by unicast or multicast over the Xd interface from a Media Delivery Function (MDF) and controlled via the Xc interface by a Media Control Function (MCF). UE can also access common services in NGN via interactions with NGN applications. Figure 4 shows an overview of the functional architecture defined by TISPAN for the IMS-based IPTV system in release 3 [13]. In Figure 4, the Service Discovery Function (SDF) and the Service Selection Function (SSF) assist the UE in the process of selecting an IPTV service. The SDF provides a set of SSF addresses, and the SSF provides the UE with service selection information. For each IPTV service, the SSF provides (a) the identifiers corresponding to the service; (b) the network parameters that may be required to establish the service; and (c) data related to the service for human consumption. Service selection information may be personalized by the SSF, or this entity may provide additional information to do this personalization.

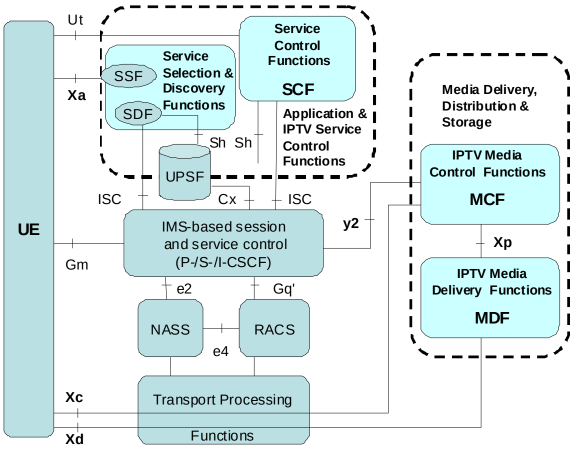

Figure 4: Simplified TISPAN NGN integrated IPTV subsystem functional architecture [13].

The IPTV Service Control Functions (SCF) is a SIP application server that performs tasks related with service authorization, during session initiation and modification, and with credit control. The UE interacts with the SCF via the Core IMS. This interaction (based on the SIP protocol) allows executing procedures related with the management of the media session. Additionally, the SCF can perform other tasks such as selecting the appropriate IPTV Media Functions, initiating the download of media content (e.g., CoD content) to the UE or detecting IPTV service state information. An exhaustive list of SCF tasks can be found in [12].

The Media Control Function (MCF) handles the control of the media flows that are delivered by means of the Media Delivery Function (MDF). The MCF interacts with the SCF and may control a set of different MDFs. The MDF handles the delivery of media flows to the UE. This entity supports additional functionalities such as storing media, behaving as a source of IPTV streams, may also be implementing media processing and transcoding facilities and collecting QoE reports from the UE.

The User Profile Server Function (UPSF) maintains the IMS user profile and the profile information that is specific to IPTV. The SCF can access the UPSF and use the IPTV profile to peronalize the user experience.

ETSI TISPAN specification for the IMS-based IPTV system and the NGN integrated IPTV system can be found in [12] and [13], respectively.

## 3.3 Unmanaged and hybrid scenarios

The specifications of Open IPTV Forum are partially based on TISPAN R2 specification for managed IPTV networks, but also specified IPTV for a non-managed networks (non-managed means without guarantee of QoS and Over Open Top – over Internet). The Open IPTV Forum focuses on standardizing the user-to-network interface (UNI) both for managed and non-managed network with their NGN based architecture [9].

The Hybrid broadcast broadband TV forum (HbbTV) specified [14] the HbbTV platform (in terminals) that combines a profile of the Open IPTV Forum specifications with a profile of the DVB specification for signalling and carriage of interactive applications and services in Hybrid Broadcast Broadband environments (broadcasted content delivered e.g., over DVB-T or DVB-S additional features or application provided via broadband Internet connection). In addition, HbbTV defines supported media formats, minimum terminal capabilities (e.g., browser capabilities based on CE-HTML), and the application life cycle.

Hybrid scenarios may be supported also by TISPAN NGN integrated IPTV platform, while more information about hybrid scenarios in TISPAN is described in [15].

In the Celtic Netlab project, a prototype has been implemented where IMS based IPTV has been integrated with DVB-H [16].

## 3.4 CDN evolution and standardization

As already mentioned, CDNs moved the content closer to the end-user, ensuring less delay. A CDN permits the optimization of the network use through a distribution of the content delivery servers in the physical network, and the optimization of the storage resources through a popularity-based distribution of the content on the servers. Server and storage architecture is critical to a successful IPTV deployment as both the linear and on-demand content needs to be addressed. Telcos must occupy integrated storage systems that can be upgraded with additional storage, and that can intelligently move content from master head-ends out to the network's edge. This multi-tiered approach can help operators minimize the costs associated with needless redundancy, while providing first-class reliable service to subscribers. This is needed for programming content and advertising assets, which will be required for insertion within the on-demand environment.

From another viewpoint, SPs need to take into account the client's requirements in order to adopt best-in-class scalable solutions. On demand is growing in importance with consumers beginning to expect larger libraries of content as they change from viewing linear content to viewing what they want, when they want. Standard and high-definition on-demand content is also increasingly being used for competitive differentiation as a way to attract and retain subscribers and represents an all-important incremental revenue stream for SPs.

Menaï *et al.* [17] proved that an IPTV service provider could rely on a standard architecture to achieve load balancing and geo-targeted request routing. Moreover, they proved the feasibility of the standards developed in the Open IPTV Forum. According to the Open IPTV Forum [9], a standard CDN consists of three functions:

- *CDN Controller*: It analyses a client's location, media availability and CDN servers' load, and redirects the client's request to the appropriate *Cluster Controller* (CC) or to another CDN controller if no CC can be assigned.
- *Cluster Controller* (CC): It is a server that manages a set media servers placed in the same geographic location. When a CC receives a request from a CDN controller, it performs a second level of request filtering, to decide which *media server* will provide the media content to a client. When the choice is made, the request is assigned to a specific media server called Content Delivery Function (DCF).
- *Content Delivery Function (DCF)/Media Server*: A server where the media content is stored and from which it is delivered. It is the lowest element in the CDN's hierarchy, controlled by the CC and providing media flow directly to the client.

Existing IPTV systems are generally based on proprietary implementations that do not provide interoperability. Recently, many international standard bodies have published, or are developing a series of IPTV related standards. TISPAN defines the CDN architecture and its interconnection with TISPAN IPTV architectures. ETSI's Media Content Distribution Technical Committee (TC MCD) is running a global study on the various CDN solutions and defines the use cases and requirements for CDN interconnection. It is noteworthy that Maisonneuve *et al.* [18] give an overview of the most significant recent and upcoming IPTV standards [19]. ETSI MCD and IETF CDNI are working on specifying architecture and interfaces for CDN interconnection.

# 4 New Approaches in Multimedia Services and Media Delivery

Telcos may adopt next-generation standards-based on-demand solutions that will offer both the power to deliver a competitive service today, while being scalable enough to migrate to an increasingly on-demand world tomorrow. As the NGN has gained attention for the IP multimedia service delivery platform, IPTV has been recognized as the way to provide the key value-added services. However, IPTV differs from typical NGN-based voice and data services by the fact that it combines three conceptually unfamiliar (until now) components: (a) streamed video; (b) Web services; and (c) NGN-based service control [20]. Another difference is in the sense of the quality-assured service delivery that in the case of IPTV is much stricter for two reasons:

- it is more challenging to meet an end-user's satisfaction in the case of television services.
- there are issues of quality assured provisioning of real-time multimedia services in an environment that is best-effort in its nature.

Volk *et al.* [21] present possible approaches to NGN-based IPTV services assurance from the QoE and QoS viewpoints. Current environments and an overview of the standardization efforts are also given. A proposal for a fully NGN-integrated quality-assured IPTV provisioning model is presented with an associated converged profile structure. The service-aware quality assurance approach is argued. Volk *et al.* investigate further NGN service delivery enhancements for quality-assured provisioning of IPTV services that until now remained unresolved. They present the design of a realistic quality assurance model, establish the associated framework for NGN-based IPTV services delivery, and contribute to discussions and research activities. The evolution of IP-based next-generation networks (NGN) will be largely driven by video service delivery requirements. Ahmad and Begen [22] review trends in the underlying technologies, extrapolating out to the 2015 timeframe, and drawing on the developments in standardization for IPTV, cable networks, and the IP NGN. These evolution trends lead to the notion of a *medianet* as a useful way to think of all of the enabling video and multimedia technologies. A *medianet* is essentially an IP network that is optimized to deliver video services to any or multiple display devices, and uses any of optical, cable, wireline, and wireless networks for this purpose. Finally, Montpetit *et al.* [23] address the architecture, the value chain and the technical and business challenges of implementing the new connected mobile and social TV experience. To put the architecture into a context, they present a use case of the distributed community Digital Video Recorder (DVR) as an implementation of this vision.

## 4.1 Enhancements in personalization, context awareness and social networking

The profiling and personalization capability that enables personalization of IPTV services based on user preferences and the user profile is crucial to further enhance user experience and to differentiate Next generation TV systems from usual non-NGN IPTV services. The provider can also use the information about the user behaviour and content consumption to improve interaction with user [24] and provide the targeted applications (e.g., personalized EPG, targeted advertising, content recommendation, etc.) by using the user's current presence state and service/content state to perform service personalization based on user service history, user preferences and content bookmarks or user indication of preference store in user profile.

If the IPTV system wants to personalize its services it has to react precisely on user action/expectation and any changes on actual service state based on identifying related changes in context (relation of user, preferences, actual expectation, changes in environment/situation, location, content, end device, etc). Therefore, the IPTV system has to be context awareness.

We can expect also improvements in the interaction of IPTV applications with social networks information to enable socialized watching TV and interaction among users.

## 4.2 Advances in user interfaces and interactive apps

One of the most important features that affects user's perception and his/her quality of experience is the user interface and the way (s)he interacts with the IPTV system. The first generation of IPTV systems was using a user interface that was based on simple menus. In such user interfaces, user navigates by using remote control and also the interactivity is limited to "color" or function buttons (e.g., red button for start apps, guide, VOD buttons).

The first interactive applications have been simple information pages with weather forecast, news, etc. As IPTV technologies were evolved, interactive applications also were improved and became more complex and more personalized. The new generation of STB also support OpenGL [25] specification for 3D graphics that can bring new way of designing IPTV user interfaces. Game consoles already use cameras and sensors to control game by player movements and in future we can expect that similar technologies will be available also for hi-end TV set or STBs.

## 4.3 Over the top delivery, hybrid, web/tv and adaptive streaming

Advances in TV delivery are coming to unmanaged networks where the public Internet is used to deliver TV or multimedia content over the top (OTT) to end devices with Ethernet connection and browser. The connected TVs are the best example that shows dramatic changes in TV capabilities where a TV set is able to directly connect to a TV manufacture application store and access TV apps. Some of the TV use HbbTV [14] specified browser, while others use proprietary technologies. ITU-T H.760 [26] identified several important technologies that can be used for TV browsers (CEA-2014, DVB-HTML, SVG, etc.).

The W3C (that defines most of the Web standards) has established the Web/TV interest group [27] to consider issues related with the delivery of web content and apps to TV. HTML-5 [28] is expected as a further standard not just for Internet browser, but also for other devices like mobile or TV browsers.

The main issue for over the top content delivery is to assure that content will be not negatively affected with changeable condition of Internet connectivity (i.e., changed bandwidth, delay, packet loss, etc.). Such conditions can be overcome with some of the new developed technologies like CDN, packet retransmission, adaptive streaming, etc.

In the future, standardization of adaptive streaming may have significant impact on the availability of OTT on multiple devices. MPEG DASH (Dynamic Adaptive Streaming over HTTP) was finalized as ISO Standard (ISO/IEC 23009-1) [29]. We can expect that MPEG DASH has the potential to replace in the future existing proprietary technologies like Apple HTTP Live Streaming (HLS), Microsoft Smooth Streaming, Adobe Dynamic Streaming. The global application of unified adaptive streaming standard could have a dramatic impact on significant growth of OTT delivery since in this case content providers publishers can produce one set of files that play on all DASH-compatible devices.

The combination of a CDN infrastructure and the adoption of open DRM (or DRM interoperability technologies for right authentication and licence systems like *UltraViolet* [30]) demonstrate a lot of potential to these new ways of delivering video content to end-users.

### 4.4 Hybrid P2P/Multicast media delivery based on popularity

Many existing commercial IPTV deployments provide a high-quality and reliable service by using dedicated network infrastructures, commonly referred to as *walled-gardens*. Due to their limited external access and custom capabilities, the streaming of the TV channels from the IPTV head-end server to the customers is done using IP multicast. Although the walled-garden design offers the best path toward a high-quality IPTV service, it has a number of drawbacks, especially in the context of continuously evolving digital services.

First, the approach comes at the cost of decreased flexibility in terms of supporting third-party providers for both economically (i.e., how to price multicast) and technical reasons. In addition, IP multicast does not scale easily with large number of TV channels. This effect is further amplified by newer service options, such as near-video-on-demand (NVoD) that delivers time-shifted programs multiple times. Finally, hypothetical future services introducing user-generated live video content simply do not make IP multicast an option due to the limited number of multicast addresses.

In order to mitigate these issues, Bikfalvi *et al*. [31] propose an alternative solution: using peer-to-peer streaming techniques between customer's IPTV set-top boxes to forward the unpopular TV channels, or to generalize, live video content. Towards this end, their study analyzes the efficiency of the peer-to-peer solution from three different perspectives: (a) overall bandwidth utilization; (b) video quality; and (c) scalability properties. Using extensive simulations, the findings from their study suggest that peer-to-peer offers a viable alternative for a selection of unpopular TV channels. While for low-popularity channels, the bandwidth utilization is similar to the IP multicast approach, the video quality approaches the multicast implementation.

### 4.5 IETF peer to peer streaming

Peer to peer streaming protocol (PPSP) is an IETF working group with the main goal of standardizing the signalling and control in P2P streaming systems, for exchanging media content. The working group considers two types of nodes in the P2P system: *peers* and *trackers*. Peers are fixed and mobile terminals that exchange streaming media. Trackers are well-known nodes that record information about media content and peers, making it available to other peers. The PPSP working group is currently working on the draft specifications of a tracker protocol [32] (i.e., a control protocol between trackers and peers) and a peer protocol [33] (i.e., a control protocol between peers).

## 5 Open issues

Some aspects that have been identified [34] as future topics and open issues for NGN based IPTV are the following ones:

- Evolution of NGN based IPTV in the context of Future Networks requirements (re-design of Internet Architecture discussed in scientific community as Future Internet).
- New IPTV services (e.g., enhanced Release 3 services, TV communities, TV commerce, multi-screen approach, public interest services, fully personalized IPTV, etc.).
- Support for new media (Ultra-HD, 3D Content, Virtual Realities, Networking/Social Media).
- Hybrid IPTV models (partial delivery of TISPAN IPTV services over "non-TISPAN" networks e.g., DVB-H/T/S/C/SH, OMA BCAST, 3GPP MBMS/PSS, DOCSIS3.0, unmanaged networks/over-the-top).
- IPTV interconnections (roaming support, interconnection with Media Content Delivery/Content Providers/Media Sources) and integration with Content Delivery Networks, Peer to Peer.
- Home network support for managed/unmanaged models, integration of IPTV services with future home networks (smart homes services, metering, near field communication, etc.)
- Convergence of end devices (converged end devices for IMS/non-IMS IPTV or hybrid models).
- Enhanced IPTV security (Service & Content Protection in converged and open environment, content mobility).
- IPTV management (content distribution management, interconnection aspects).
- Interoperability issues, consolidation in standardization of NGN based IPTV architecture.

## 6 Conclusions

The evolution of IPTV architecture and services will depend on the acceptance of the NGN based IPTV concept by operators and vendors. However, satisfied end-users (as paying subscribers) will play a crucial role to any commercially successful service. Therefore, not only the used technology but also definitely simple usability and a rich set of IPTV services/content will be dominant on the market in the future. Such ideal IPTV services/content will constitute perfect solutions for satisfying the higher expectation of user by adopting personalization and context awareness capabilities. In this paper, we have provided an overview about current NGN based IPTV standards and several new technologies and developments that can impact on content services for the next years.

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