IPTV and Video Networks in the 2015 Timeframe: The Evolution to medianets

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ABSTRACT

The rapid progress being made in technologies that enable video content delivery over IP networks to consumers has prompted predictions that the evolution of IP-based next-generation networks will be largely driven by video service delivery requirements. This article surveys 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.

INTRODUCTION

Several forecasts on the future of IP-based networking have indicated that the evolution of future networks, specifically the IP next-generation networks (NGN), will largely be determined by the demands of video content distribution and services like IPTV. The recent explosive growth in the demand for video-based social networking applications such as YouTube, as well as the availability of ever more high-definition TV (HDTV) content, seem to be clear evidence pointing in that direction. If more and better quality video content is what consumers want and are willing to pay for, the content distribution networks must be able to satisfy this demand more effectively so that service providers can reap the revenue benefits that accrue.

It is not just a matter of predicting the use of more and more raw bandwidth capacity, for which there will obviously be the need, particularly in the access network bottleneck. It is well known that video content is bandwidth hungry if any level of quality of service is in question, so the bandwidth requirements of delivering video content to consumers will scale in proportion to the number of users multiplied by the number of sessions in play. Extrapolating these numbers to the 2015 time frame suggests that eventually fiber-to-the-home (FTTH)-based technologies will prevail over currently emerging access transmission technologies such as very high speed digital subscriber line (VDSL2) for wireline networks, or even DOCSIS 3.0 for cable networks.

Despite the pitfalls that inevitably accompany gazing into technological crystal balls, it is sometimes useful to step back and attempt to predict where the underlying video network technology direction will likely take us, and what the future landscape will look like based on the existing technology trends. This article attempts this daunting task, based on surveying current trends in video networking technologies for both IPTV and cable networks.

THE FUTURE OF IPTV TECHNOLOGY

The enormous growth and interest in IPTV services over the past few years is a trend that is anticipated to continue over the 2015 timeframe. Service providers globally view IPTV services as a major area of revenue growth and preservation, so investments in this area of technology deployments are likely to increase substantially, as new programming options and content choices become available to an increasing number of consumers all over the world. Such a projected growth will have a number of implications for the evolution of IPTV related technologies, as outlined below.

It is useful to bear in mind that what we commonly refer to as IPTV is actually a complex interplay of a number of technology areas, drawing from TV broadcast and storage technologies, video coding (e.g., MPEG2 and H.264) and encryption (e.g., digital rights management [DRM]), IP transport, quality of service (QoS), quality of experience (QoE), Web services, and so on. Advances in IPTV technology will be based on progress in any one or more of these areas and its relationship with the other components of the overall IPTV system.

An example of this interplay is the use of MPEG encoding of TV signals. The digitization, encoding, and compression of video images have been extensively studied and standardized over the past years jointly by the International Telecommunication Union — Telecommunica-

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tion Standardization Sector (ITU-T) and International Organization for Standards/International Electrotechnical Commission (ISO/IEC) Joint Technical Committee (JTC1/SC29/WG11, also called the Motion Picture Engineering Group [MPEG]). This work has resulted in the development of a series of MPEG specifications that are in widespread use in virtually all existing IPTV deployments in some form. Most currently deployed IPTV services use the ITU-T Recommendation H.262/ISO/IEC 13818-2 MPEG2 standard to digitize, compress, and encode TV signals [1]. The MPEG2 transport stream is then used to multiplex the encoded audio, video, and auxiliary data in a synchronized fashion [2]. The transport stream is subsequently packetized and encapsulated into the IP packets (increasingly with an additional Real-Time Transport Protocol [RTP] encapsulation [3]) for delivery to consumer set-top boxes or other end devices.

The introduction of the new MPEG4 part 10 codec (also called ITU-T Recommendation H.264 or advanced video codec [AVC] [4]) over the past few years has generated interest for future IPTV deployments. AVC achieves a factor of two or more in compression efficiency over the earlier MPEG2 codec, with little or no perceived degradation in video quality. Consequently, a typical standard-definition TV (SDTV) program encoded by MPEG2 will consume a bandwidth of between 3–4 Mb/s, whereas encoded in AVC it will use only between 1–2 Mb/s. A similar reduction in bandwidth consumption is also achieved for HDTV programs encoded with the AVC codec.

The implications of these advances in video encoding technologies on IPTV services are obvious: the bandwidth savings will enable more or higher-quality TV content to be made available over the typically bandwidth-constrained access links, whether it is wireline, wireless, or cable. AVC technology is already being deployed in many consumer electronics devices such as HD cameras and players, as the costs of the AVC chipsets respond to economies of scale.

It can therefore be reasonably predicted that in the 2015 timeframe, AVC codec technology will supplant the existing MPEG2-based encoding in most applications of IPTV deployments including set-tops and other consumer electronics devices. This is not to say that MPEG2 will somehow disappear, since some level of backward compatibility with existing content will likely still be a strong requirement. However, increasing amounts of new content will become available in AVC to enable IPTV service providers to leverage the resulting bandwidth savings, or reciprocally, the cost savings of providing a given amount of TV content in less bandwidth.

It is also feasible that new more efficient video compression and encoding techniques may become available by the 2015 timeframe. Research continues in both academia and industry on better algorithms and mechanisms to improve video compression and encoding technology, which may result in further bandwidth savings. In parallel to these efforts, the use of layered codecs such as the scalable video codec (SVC) may also find more interest in the broadcast world. Significant breakthroughs in this area are likely to have major impact in the evolution of IPTV and cable technologies.

Overcoming the Bandwidth Crunch

In parallel with these advances in compression technology, we must also consider the whole area of bandwidth capacity evolution and how it is managed to ensure IPTV QoS/QoE requirements. Scarcely a week passes without some study or trade article predicting the astronomical increases in bandwidth that will be required to satisfy the demands of video usage over existing IP networks. Traffic volumes in the order of tens and hundreds of exabytes (one billion gigabytes) and zettabytes (1000 exabytes) are proposed, as experts envisage exponential increases in demand for video content, not only over the public Internet, but also for subscribed video-on-demand (VoD) or IPTV services delivered to set-tops, mobile devices, and PCs. A detailed industry forecast is available on the Visual Networking Index Web site at http://www.cisco.com/web/go/vni.

The exact range of the astronomical traffic growth numbers may be debatable, but it is reasonable to anticipate huge traffic growth in the 2015 timeframe for video services, and its consequent impact on transport technology, including traffic management aspects of the IP NGN. The IP NGN infrastructure technology evolution (multiprotocol label switching [MPLS], carrier Ethernet, and optical technologies) was described in detail in the March 2008 issue of this magazine.

Without delving into the details of such technologies, it is nevertheless useful to examine the likely impact of video transport on the potential evolution of the access part of the IP NGN based on existing trends. Currently, the vast majority of video content is delivered to consumers either over cable or various digital subscriber line (xDSL) access links, with a small but rapidly growing proportion over optical fiber technologies (e.g., FTTx such as passive optical networks [PONs]).

The likelihood that optical transport infrastructures will become the technology of choice for the last-mile video content delivery does not preclude advances in either cable or DSL access technologies, or, for that matter, in wireless transport technologies such as Long Term Evolution (LTE) or WiMAX (refer to the February 2009 issue of this magazine for the most recent developments in the LTE and WiMAX standards). However, optical fiber transport technologies, such as Ethernet PON (EPON) and Gigabit PON (GPON) or direct FTTH, clearly have the requisite bandwidth capabilities to deliver multiple channels of HDTV and VoD content with high QoE that consumers demand.

It is therefore not surprising that many service providers and cable companies are exploring the potential of optical transport systems for their video delivery networks in some form. It would be reasonably safe to predict that in the

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2015 time frame, we would witness large-scale deployments of optical access transport networks. There are already clear indications of such a trend, notably in countries such as Japan and South Korea, where high-speed broadband access infrastructure has relatively high penetration, and the demand for HD video content is already substantial and increasing rapidly.

Such a trend would be equally applicable for the evolution of either wireline or cable-based technologies, since the underlying optical transport technology would be able to support either type of video encoding technology transparently. For the case of wireless video content delivery, the bandwidth constraints tend to be more severe for the relevant air interfaces, so inevitably the need for transcoding of video signals for mobile handsets arises for conversion between HD and SD sources. It seems evident that as mobile networks evolve to 4G/LTE and WiMAX-based technologies supporting larger bandwidth capacity, the demand for mobile video content tailored for handset availability will grow, providing service providers unprecedented opportunities for revenue generation.

The Way Out of the Middleware Maze

No discussion of the future evolution of IPTV technologies seems complete without consideration of the middleware that effectively glues IPTV services together, despite the fact that this area is arguably the most difficult to categorize, or predict in terms of discernable technological trends. This is partially because IPTV middleware is often the engine for service differentiation of video offerings by service providers as well as equipment vendors, and hence resistant to standardization efforts, and partially because IPTV middleware is itself a somewhat nebulous area of capabilities.

Despite these uncertainties, it is important to understand that developments in middleware technologies will inevitably impact the nature of future IPTV services significantly, so it is useful to summarize some underlying architectural aspects to elucidate potential trends.

The IPTV middleware typically comprises all those aspects of the service that enable consumers to access content from the provider and manipulate it for ease of viewing and/or storage. It may also include aspects of consumer entitlement/authorization for content use, the ability to store it or playback in real time as well as with so-called *trick modes*, such as fast forward, pause, or other manipulations of the video stream. The middleware is also responsible for capabilities such as program discovery and selection, as well as the type of display of the electronic program guide (EPG) and user control interface.

As may be expected, aspects such as the EPG and user control interface are always likely to be very provider-specific and key to service differentiation and packaging. However, technical developments that enable these aspects to become more user-friendly for mass market appeal will inevitably gain more widespread usage as IPTV services mature. There are a number of initiatives underway to develop a unifying underlying architecture for middleware applications, notably in the ITU-T as part of the IPTV Global Standards Initiative (GSI),[1] as well as in CableLabs[2] and the Digital Video Broadcasting (DVB) Project[3] under the auspices of the European Telecommunications Standards Institute (ETSI).

Although it is unlikely that all aspects of IPTV middleware, such as DRM or user control interfaces, will be standardized to the point that open application programming interfaces (APIs) will be available for all capabilities, the primary objective of specifying a standardized framework architecture for middleware is to enable definition of some of the open APIs to enhance interoperability and thereby reduce development costs. It is anticipated that in the 2015 time frame these standardization initiatives will bear fruit in the availability of lower-cost middleware applications and more user-friendly control interfaces.

The Role of IMS in IPTV

There has been significant interest and discussion on the relationship of IP multimedia subsystem (IMS) with IPTV and video content delivery technology in the recent past, resulting in extensive work in several standardization bodies such as ITU-T IPTV GSI, ATIS IIF,[4] and ETSI Telecommunications and Internet Converged Services and Protocols for Advanced Networking (TISPAN).[5] As developed by the Third Generation Partnership Project (3GPP), it is well known that IMS was intended to provide an IP-based control plane architecture for the evolution of mobile networks, to enable session initiation, authentication, authorization, and billing/charging interfaces based on the protocols developed by the Internet Engineering Task Force (IETF) such as the Session Initiation Protocol (SIP) and DIAMETER. Many service providers plan to use an IMS control framework for evolution of their wireline and cable networks as well, so IMS control of IPTV needs consideration.

Most existing deployments of IPTV and VoD networks do not use IMS interfaces, so IMS is not an essential ingredient of IPTV or VoD. However, many service providers plan to deploy IMS for their wireless and wireline networks, so it is natural for them to require a common platform for control and charging/billing for triple- and quad-play service offerings. With this in mind, scenarios for evolution of IPTV/VoD services toward IMS-based control have been described by the ITU-T in Recommendation Y.1910, using the well established concept of an interworking gateway between the existing deployments and IMS-based IPTV/VoD domains.

Depending on what specific IMS service needs to be supported, interworking of the signaling messages via the gateway provides the requisite protocol translation between the IMS domain and existing IPTV/VOD deployments. This enables current deployments to support IMS services as they are introduced while providing a graceful evolution path to introduction of the IMS control framework.

[1] *http://www.itu.int/ITU-T/gsi/iptv*

[2] *http://www.cablelabs.com*

[3] *http://www.dvb.org/groups_modules/technical_module/tmipi/*

[4] *http://www.atis.org/iif*

[5] *http://www.etsi.org/tispan*

It is important to recognize that for the case of video services, the IMS control plane is specified to provide only the IPTV or VoD session initiation, authorization, and charging functions. All the other middleware and video stream control capabilities like channel change, trick modes, DRM, and encryption/encoding remain the same. While it is feasible that this may change as new control technologies are proposed, it seems likely that the well proven existing protocols such as Real Time Streaming Protocol (RTSP) [5] and Internet Group Membership Protocol (IGMP) [6] will continue to provide the underlying control plane architecture for video delivery in the 2015 timeframe. It can be expected that these technologies will be enhanced to support additional video service requirements as they arise, but the underlying control protocols are unlikely to change radically.

The Evolution of Cable Networks

Many of the technology evolution trends described above apply just as well to the development of cable networks as to conventional wireline or wireless networks. For example, the drive to enhance access bandwidth to enable delivery of more HD content is likely to lead to demand for optical transport for last-mile deployments even for cable operators, a trend already in evidence.

Cable networks have specific technology aspects that need to be factored in when evaluating evolution trends for the 2015 timeframe. A primary element of these is the evolution of currently deployed DOCSIS 1.1 and 2.0 technologies toward the significantly higher-speed DOCSIS 3.0 technology (and its potential future enhancements, which may lead to DOCSIS 4.0), which is capable of supporting upstream data rates of 50–100 Mb/s or more for cable consumers. DOCSIS 3.0 also enables significantly higher downstream data rates by a factor of three or more, although the actual data rates available to consumers vary depending on the number of customers served. The trend for higher-speed Internet access in cable mirrors that already occurring for wireline/optical, and is likely to accelerate as cable operators and IPTV service providers compete to differentiate their offerings with more HD content.

In addition to significantly increased deployments of DOCSIS 3.0 technology in the 2015 time frame, we are also likely to see the further transformation of the existing hybrid fiber coax (HFC) secondary distribution networks toward an increasing optical fiber component, in keeping with the trend to FTTx. The increasing use of FTTH as a migration path for conventional cable networks is likely even though a cable plant has significantly more potential bandwidth capacity than a conventional twisted pair access plant.

There are other major technology trends that are likely to play increasing roles in the evolution of cable networks. An obvious trend is the increasing penetration of digital TV content, resulting from the push by most major cable companies to migrate from conventional analog programming to digital to accommodate more long-tail content and HD programming. In the 2015 time frame, based on current trends, it is safe to assume that substantially more video content will be distributed in digital format over HFC plants as consumers increasingly buy into the advantages of digital TV.

Just as significantly, another major trend is likely to be the transition to all-IP-based service delivery of video content. To some extent this trend is already in evidence, with the increasing push to IPTV services, enabling the promise of enhanced interactivity and flexibility for content manipulation. However, it is anticipated that a key driver for the transition toward all-IP service delivery will likely be the evolution of *connected home* technologies, which are primarily based on IP connectivity. An example of such an approach to connected home IP networking is the increasing use of architectures based on Multimedia over Cable Alliance (MoCA),[6] Digital Living Network Alliance (DLNA),[7] and Universal Plug and Play (UPnP) Forum[8] specifications for ubiquitous sharing of video content in residential environments.

Essentially, the transition to IP video service delivery is all about leveraging the flexibility made possible by IP connectivity. As this aspect is increasingly adopted in the consumer environment, the drive toward transitioning to IP-based service delivery will likely spread to the cable distribution networks and in some cases all the way back to the content provider. Such an evolution enables the advantages of IP connectivity for applications such as targeted advertising and local content insertion, in addition to the potential for lower-cost transport and distribution, from both the capital and operational expenditure standpoints.

The evolution toward all-IP-based service delivery will transform virtually all aspects of cable networks, from the development of hybrid set-top boxes to modular cable modem termination systems (CMTSs) and video headends. To some extent such a transformation has already begun with the interest in cable IPTV, so by 2015, it can be anticipated that most of the major cable service providers will be deploying some form of IP-based video delivery systems as part of their cable networks.

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Advanced (or Targeted) Advertising

New service provider offerings present significant opportunities and challenges for delivering advertising that matches delivered content with its audience. A solution that enables monetization of new services via advertising is essential since it not only justifies the service provider investments in deploying a new service, but is likely to be key in obtaining the necessary carriage rights from the content providers. The addressability of the devices such as IP set-tops, PCs, and mobile devices creates an ideal platform for the targeted advertising media buyers value highly.

In advertising, media buyers decide on the

[6] *http://www.mocalliance.org/*

[7] *http://www.dlna.org*

[8] *http://www.upnp.org*

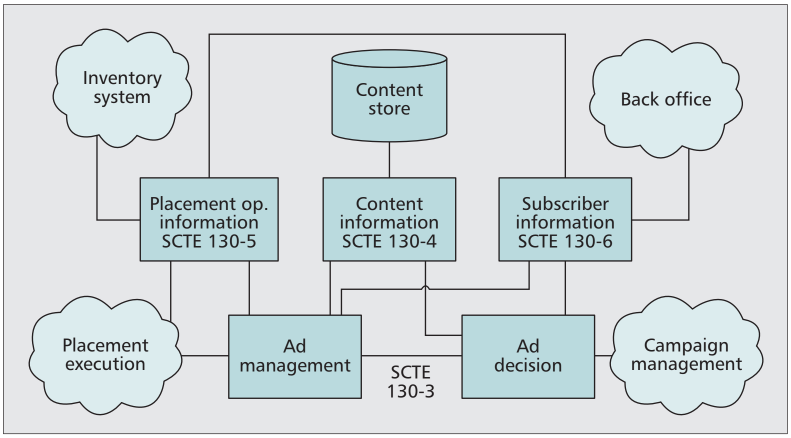

Figure 1. *SCTE 130 services in an advanced advertising system. The figure is reproduced from [7].*

details of the ad campaign that define what audience to reach with the desired message, and choose the period of the campaign and frequency. The service provider functions as the seller, who offers the ability to deliver the advertising message on its platform in association with the content. In traditional broadcast 30 s advertisements appear interstitially during a particular show, while in emerging addressable TV deployments the ad could be an ad on comedy genre content delivered to viewers between 18 and 29 years of age in the New York metropolitan region. This is made possible by dynamic ad decisioning.

In advanced advertising the campaign manager, typically a software tool hosted by or on behalf of the service provider, needs three classes of information:

- *Placement opportunities* are temporal and/or spatially constrained advertising instances defined by content owners and/or distributors.
- *Context* refers to information that describes the content (e.g., title, genre, and rating).
- *Audience* is the available viewer and device information, including demographic, geographic, behavioral, and so on.

This information is used to provision the campaign manager and for an ad decision when a placement request is made in response to a specific event such as the start of a VoD session, or a viewer pausing the DVR or tuning to the on-screen EPG. The ad insertion system then splices the ad into the stream and presents it in some form as a companion to the content. Finally, confirmation of ad delivery is reported back to the campaign manager for invoice and billing purposes and potentially captured into a data warehouse used to track measurement as well as analyze viewer behavior, which can then be used to refine the audience data to enable more precise targeted ad decisions.

An advanced advertising solution has the potential to be both sophisticated and complex. To enable interoperability between components and establish sufficient scale to attract both advertisers and content providers, the Society of Cable Telecommunications Engineers (SCTE) Digital Program Insertion (DPI) Working Group developed a set of standards known as SCTE 130 [7]. As depicted in Fig. 1, this new standard defines a set of logical services that implement extensible XML-based messaging interfaces to communicate placement opportunities, content and subscriber metadata, placement decisions, and event status necessary for accountability measurements. Industry adoption of SCTE 130 is expected to ease integration between advertising subsystems, enabling the rapid evolution of interoperable multivendor advanced advertising solutions.

SCTE 130 is designed to be highly flexible; in fact, no specific architecture, data model, or physical topology is imposed on the set of core services. For the most part each defined service has a public standard interface with which it communicates with other services, and a private interface, which integrates with the vendor-/provider-specific ecosystem components. Furthermore, while initially targeted at ad placement within the television domain, by virtue of its IP-based control plane and transport domain independence, SCTE 130 can easily be extended to broadband and mobile content delivery platforms, enabling multiplatform inventory buys, campaign management, ad placement, reporting, and reconciliation.

INTERNET TV

The term Internet TV is used to describe the delivery of TV programming over the public Internet, typically to personal computers as streamed or downloadable video content. A growing number of broadcasting organizations such as BBC and Swedish TV, as well as independent video content providers are providing direct access to TV programming over the Internet. This approach is also often referred to as over-the-top (OTT) video, since it essentially uses the Internet as a transport *pipe* to deliver the content. In some deployments solely server-based delivery schemes are used, whereas in others a hybrid delivery scheme is preferred to simultaneously benefit from dedicated servers as well as other peers in the system. The latter is achieved by running streaming-optimized forms of the well-known peer-to-peer (P2P) file transfer protocols.

The OTT delivery of television is likely to grow in popularity in the 2015 timeframe, as more broadcasters and independents compete for screen time or specialized content and niche interests. Internet TV is a topic now being addressed by the European DVB Project for potential standardization, a move that may further enhance its popularity as wider interoperability and consequent lower costs are made feasible via economies of scale. It has been suggested that the rapidly increasing popularity of Internet TV, as evidenced by the widespread use of social networks such as YouTube, and the amount of innovation the OTT providers are pursuing even threaten to supplant conventional modes of TV programming such as cable or IPTV. Whether this can happen in the timeframe envisaged here remains an open question, but given the increasing popularity of large-screen TVs and home theater systems capable of providing subscribers a rich viewing experience, it seems relatively unlikely that conventional viewing habits will change much in this timeframe.

Today, a major struggle in deploying high-quality OTT services is the disagreement in revenue sharing between the OTT providers and the Internet service providers. An OTT service offering HD content can easily chew up a lot of resources from the service provider's network. Although poorly engineered P2P technologies can result in significant additional costs to the service provider, users generally access the network indefinitely for a flat monthly fee, and, if applicable, only pay an additional premium to their OTT providers. This somewhat unbalanced revenue sharing naturally discourages service providers from allowing any OTT service to run in their networks. To enable the true potential of OTT services, both sides must work together and reach an agreement on how to share the service costs as well as the revenues from premiums and ads.

There are currently industry-wide efforts to bring Internet service providers and OTT providers together to develop network-friendly P2P file transfer and distribution protocols. One such effort is the P4P Working Group[9] at the Distributed Computing Industry Association (DCIA). Another one is the Application-Layer Traffic Optimization (ALTO) Working Group[10] at the IETF. The current work in these working groups is focused on developing a set of optimized protocols that will reduce the average download times for users as well as the transport costs for service providers. Early results from the preliminary field trials are promising [8]. Given that many participants from the service provider, content provider, and P2P industries are playing an active role in these groups, we can anticipate more widespread deployment of these new file transfer and distribution protocols by 2015.

This close interaction between service and OTT providers as well as content providers is an important development for the traditional content delivery network (CDN) providers. Typically, service providers allowed one or more CDN providers to physically operate within their networks to enhance the experience of their customers. Content providers also used to work with CDN providers to make their content available at as many places as possible. However, with the introduction of newer service models and distribution channels, service providers can transform their networks in such a way that they can deliver the content directly from the content providers. While this transformation may not be rapid, and existing CDN providers will evolve solutions to stay competitive, by 2015 we can expect some large service providers to collaborate closely with content providers.

Evolving the IP NGN into a Medianet Vision

The notion of a *medianet* was essentially envisioned as a vehicle to encompass all of the evolutionary trends summarized in this article in a comprehensive architecture for the future of end-to-end video and rich-media services evolution. It encompasses IPTV, cable, content delivery networks, and connected life at home as part of a media-aware IP NGN-based network that is optimized to support all envisaged rich media services for the future. The medianet essentially describes the evolution of an IP-based NGN toward a rich-media-aware optimized network that enables virtualization of capabilities to enhance the scalability of the network, as well as the potential to commercialize a range of multimedia services, including video delivery (IPTV, VoD, cable TV, and OTT services), enabling service providers to transform from being simply *content providers* to being overall *experience providers*.

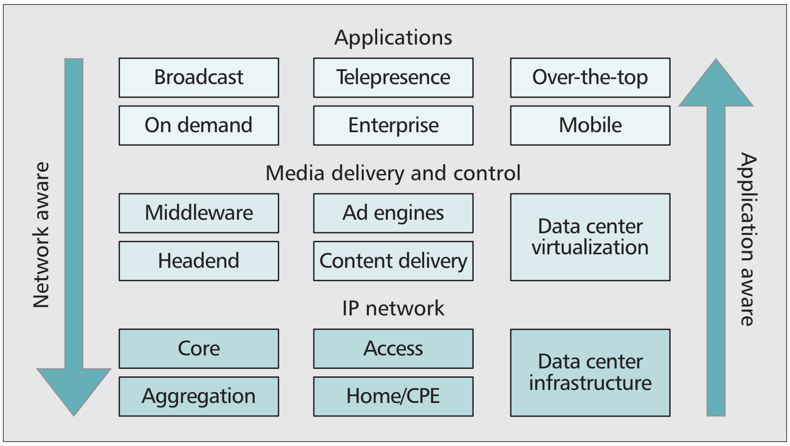

Figure 2. *medianet-enabled IP NGN framework.*

The medianet vision is built on the recognition that video services and technology evolution have the potential to transform consumer experience by effectively revolutionizing the IP NGN into a media-aware network that manages scale and complexity by incorporating a high level of virtualization, and enables generation of new revenue streams (monetization) by service velocity enhancement. For video applications, what this essentially implies is that the IP NGN needs to be endpoint-aware as well as media-aware, so services that rely on personalization, interactivity, or social networking can be brought into play more effectively. As shown in Fig. 2, the IP NGN architecture can be enhanced by the notion of a media-aware medianet to encapsulate a vision for the future evolution of rich-media based services.

Figure 2 shows that, as for conventional IP NGNs, a medianet relies on IP-based transport layers for media/content delivery, including essential NGN attributes such as QoS, security, and survivability. Overall service control capabilities are part of the media delivery and control layers, which include functionalities to support middleware, headend processing, bandwidth management, Tru2way services, and so on. As for the IP NGN, the application layer incorporates functionalities to support services such as telepresence, voice, multiscreen capabilities, and mobility. It should be noted that this layering is not intended to depict any particular implementation or deployment, but is simply a functional representation of typical medianet capabilities.

[9] *http://www.dcia.info/activities*

[10] *http://www.ietf.org/dyn/wg/charter/alto-charter.html*

The growing consumer demand for more and varied HD content will result in huge demand for access network bandwidth, and improved quality of experience and ease of both temporal and spatial control over content.

Concluding Remarks

The evolution of IPTV and cable network technologies capable of providing rich media and video services to multiple display devices, fixed or mobile, can be viewed as leading to the emergence of medianets, a concept that captures how these capabilities can be architected within the evolving IP NGN deployments worldwide. The growing consumer demand for more and varied HD content will not only result in huge demand for access network bandwidth, but also improved quality of experience, and ease of both temporal and spatial control over the content available.

These challenges are likely to trigger significant changes in IP network deployments as we look out to 2015, with increased penetration of optical fiber to homes, higher-speed mobile data networks, as well as more sophisticated content control and middleware architectures evolving from those currently being used for IPTV deployments and cable networks. It is useful to think of all these capabilities as a part of video-optimized medianets that are designed to deliver the optimum video experience to consumers using the attributes of IP NGNs and evolving IPTV and cable technologies surveyed in this article.

Acknowledgments

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