Overview of IPTV systems

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1. Main features

1.1 Extra value of ICT services

Traditional ICT systems provide basic value for most people, such as radio, TV, telephony, and Internet data. ICT systems introduced the last 20 years provide extra value beyond the basic value. A service with **extra value** is often referred to as value-added service. The extra value spurs the subscriber to use their system more and allows the operator to drive up their average revenue per user (ARPU). ICT systems with a more pronounced extra value automatically gets a larger customer base. In some case (Irridium satellite mobile) the extra value is not large enough to support a positive business case, and these services will disappear from the market. Experts in the field tend to believe that to become successful, IPTV operators must offer significant extra value compared to other DTV options such as DVB-T, DVB-S and DVB-C.

1.2 Customers' choice of DTV operator

Operators around the world are preparing for the transition from analog TV to digital TV. In Europe, some countries have already made the transition (e.g. Sweden and Finland in 2007) and the remaining European countries will do so by 2012. In countries with high coverage of broadband access networks, this could lead the high adoption of IPTV. It could also lead to more intense competition with other DTV offerings.

From a customer point of view, the meaningful differences between alternative DTV offerings are functionality, quality and price. The **functionality** offered by the IPTV operator is given by the system portfolio, which includes the services, applications and content. Note that a service is an application that can serve other applications. IPTV offers both regular TV broadcast services (BTV), video-on-demand (VoD), near video-on-demand (NVoD), and even time-shifted TV (tsTV). Standard Definition TV (SDTV) and High Definition TV (HDTV) formats are available for IPTV. A variety of applications already exists, or is under development, including viewer-to-viewer communication, camera angle selection, intelligent/associative search, feedback/voting in TV shows, betting, and karaoke on demand. Leading IPTV operators offers a large content mix in terms of BTV channels and VoD titles. Future IPTV networks will also provide contents originating from the users themselves as done on Internet by YouTube. The **quality** perceived by the users is expressed by Quality of Experience (QoE) metrics. The **price** for using the IPTV service is given by the subscription and transaction tariffs, and rental charges for subscriber equipment.

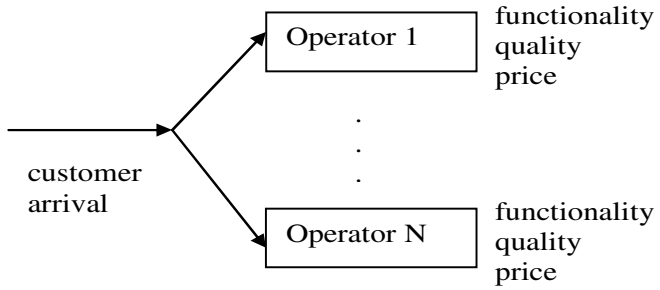

Figure 1. Customers' choice of DTV operator.

1.3 IPTV players

IPTV players include telecommunication operators (telcos), equipment providers, and content providers. Telco operators are expected to directly provide IPTV service to subscribers, in which the operator takes the role of a service provider. In addition, operators may indirectly support IPTV services by through the provision of network services over common data networks, in which case the operator takes the role of a network provider. Equipment providers include manufactures of IPTV network devices, and IPTV terminal devices. Content providers include both major media producers, such as motion picture studios, as well as other professional and amateur content originators, such as participants in peer-to-peer content sharing.

1.4 IPTV market

Today (2009), there are almost 600 commercial IPTV launches worldwide. The world-wide IPTV market contains 19.6 million customers (end users) corresponding to 1.1% of households worldwide. In 2012, the subscriber base will grow to 2.8% of the households worldwide. IPTV subscribers in Western Europe will reach 8.2 million subscribers in 2008 and grow to 18.8 million in 2012. Italy and France have most IPTV subscribers in Europe. Asia-Pacific will reach 6.5 million subscribers in 2008 and grow to 8.7 million in 2012. Hong Kong has the largest number of IPTV subscribers in Asia. The number of IPTV subscribers in the world is modest in comparison with the number of cellular subscribers and Internet users which is approximately 4 billion and 1.4 billion, respectively, at the end of 2008. Some analysts believe it will take several years before the customer base for IPTV will become significant (2013: 90 million; 2016: 300 million). The Swedish IPTV market is divided among several operators with TeliaSonera (500 thousand customers), Bredbandbolaget/Viasat, CanalDigital, and FastTV dominating the market.

2. IPTV standardisation

NGN model

The NGN concept has been addressed, thoroughly discussed, and well defined from both the research and development sector and the standardization and regulatory bodies; among these are foremost, the International Telecommunication Union-Telecommunication (ITU-T), the Third Generation Partnership Project (3GPP), and the European Telecommunications Standards Institute (ETSI) TISPAN. There are several architectural proposals available; nevertheless, they all share certain basic characteristics, represented within the following generic NGN model (Fig. 1a):

- IP multimedia subsystem (IMS), providing core session control, service triggering, and authentication, authorization, and accounting(AAA) mechanisms
- Network attachment subsystem (NASS) for the end user's device initialization and network attachment procedures
- Resource and admission control subsystem (RACS) for policy enforcement, admission control, and resource management

Vertical IPTV model

From the architectural viewpoint, current IPTV deployments are typically proprietary-based vertical solutions, comprising four segments (Fig. 1b).

- Content provisioning, where content and the associated metadata are ingested, aggregated, and prepared through adapting processes and digital rights management (DRM)

- IPTV control, implementing service provisioning control and AAA functionalities (middleware)

- Content delivery, where content is packed into services and delivered to the end users

- Customer premises, represented by a set of content acquisition and processing functionalities and service execution functionalities within end user equipment

The content provisioning, IPTV control, and content delivery segments together are known as the head-end. One notable advantage of a vertical approach is a dedicated platform for a chosen service type, namely, IPTV. Two notable disadvantages are the maintenance of separate parallel vertical networks — typically, there are dedicated networks for voice over Internet protocol services, Web services and video streaming services — and the incapability of blending voice, data, video, presence, and messaging services due to separate and conceptually incompatible provisioning platforms. Moreover, a vertical IPTV solution was proven to be considerably walled and proprietary-based, which presents issues of interconnectivity, multi-vendor environments, and third party provisioning. The possible solution to these challenges is offered through the deployment of IPTV services within the NGN environment. This topic is thoroughly addressed, foremost by the ITU-T, which is very active through the contributions of its IPTV focus group, FG IPTV, which addresses the possible approaches of converged NGN IPTV deployments

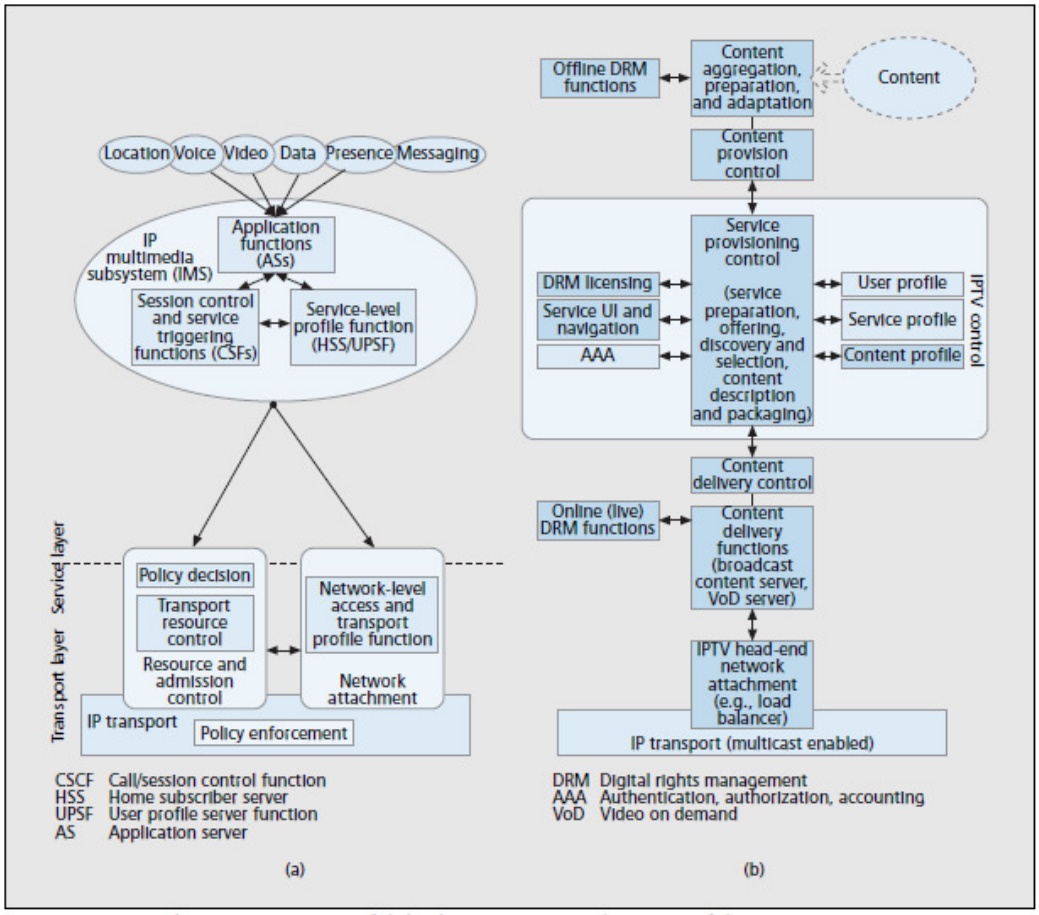

Figure 2. a) The generic NGN model; b) the generic vertical IPTV model (Jeffrey, 2008)

3. IPTV technology

Middleware

IPTV middleware acts as the IPTV core platform and enables customer interaction with the service. It implements IPTV by providing TV-Portal/EPG, user management, interactive service, channel/package and program together with pay TV solutions. The middleware provides API interfaces to integrate with the other components and deliver IPTV services in a large scale and faster way. In addition, it integrates with VoD system, Headend, CA/DRM, STB and the network realizing automatic service deployment and user access control.

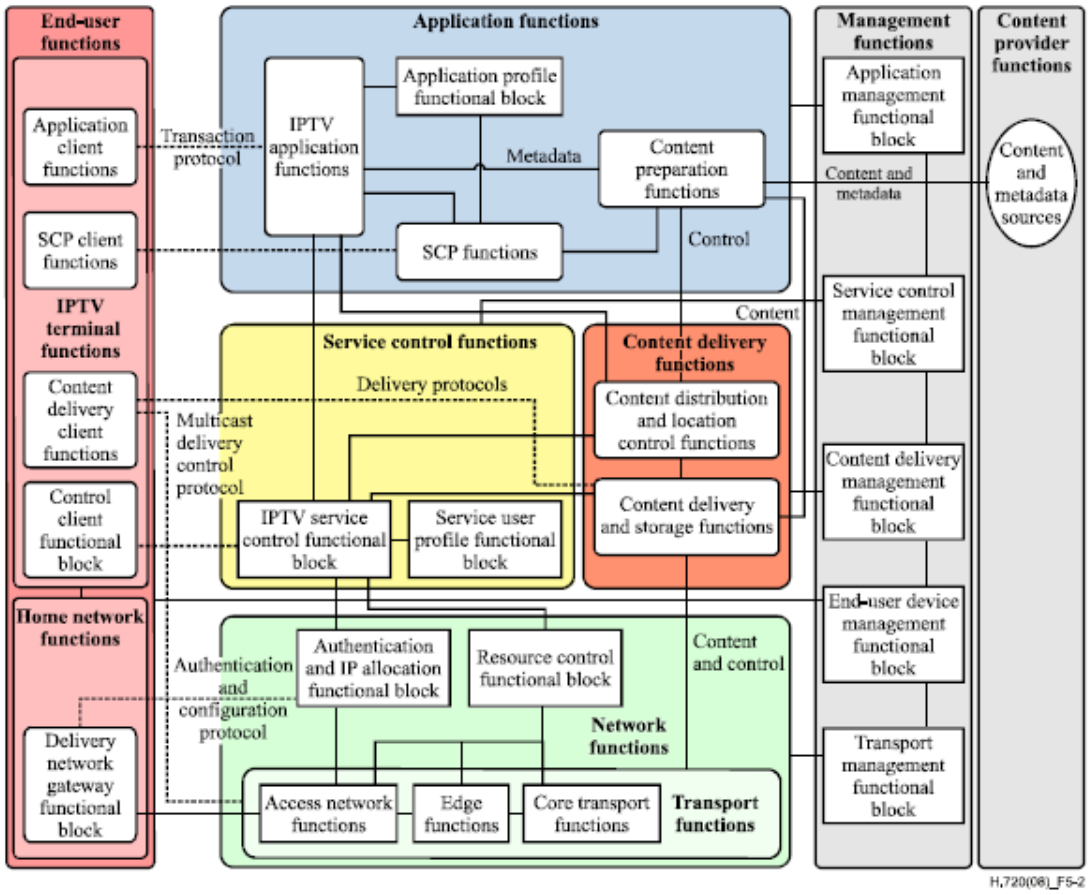

Figure 3. IPTV architectural overview (ITU-T Rec. Y.1910)

Content security

There are a number of topics that need to be addressed for a secure IPTV system:

- Service protection -- ensuring that subscribers are only able to obtain the services that they are entitled to access
- Content protection -- enabling subscribers to use the content they have acquired in accordance with the rights they have been granted
- Consumer privacy -- protecting personally identifiable information from unauthorized access and use

- Device protection -- guarding against attempts to abuse a box by hacking, denial of service attacks, virus infection, and so on
- Network protection -- guarding the IPTV service network from abuse such as denial of service attacks

When functioning as a service provider, an operator's concerns typically include theft of service, misuse of content, and damage to services or networks that deliver these services. As a network provider, an operator is typically limited to damage of the network (e.g. from terminal device malfunction or deliberate attempts to disrupt, such as denial of service attack).

Conditional Access System

Conditional Access (CA) is a service which allows content providers to restrict certain programs to certain viewers, by encrypting programs.

Digital Rights Management

Digital Rights Management (DRM) is any of several technologies used by publishers (or copyright owners) to control access to and usage of digital data (such as software, music, movies) and hardware, handling usage restrictions associated with a specific instance of a digital work.

Copy Protection

Copy Protection (CP) controls only when the user request copy to other storage, read and conversion via other CODEC, or re-transferring to other networked location. CP refers to technologies that control or restrict the use and access of digital media content on electronic devices with such technologies installed, acting as components of a DRM design.

Network architecture

The IPTV network connects the following devices:

- Super head-end (SHE): central video server location
- Video hub office (VHO): regional video server location
- Video serving office (VSO): video aggregation office
- DSL access multiplexer (DSLAM): connects metro and access networks
- Residental gateway (RG): connects access and home networks
- Set-top box (STB): user terminal for system interaction
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There can be 50-100 DSLAMs per VSO, and 500-1000 subscribers per DSLAM, meaning that over 50,000 subscribers can be handled by a single, very large VSO. The IPTV network architecture consists of multiple networks:

- Core network: video delivery from central server locations (SHEs) to metro areas (VHOs)
- Metro network: video delivery from regional server locations (VHOs) to aggregation offices (VSOs)
- Access network: video delivery from DSLAMs to residential subscribers
- Home network: video delivery from residential gateway to STBs

Available alternatives for realization of core and metro networks include:

- IP networking layer
- Multiprotocol label switching (MPLS)
- Generalized MPLS
- Virtual private LAN service (VPLS)

- Native Ethernet
- Resilient packet ring (RPR)
- Optical transmission

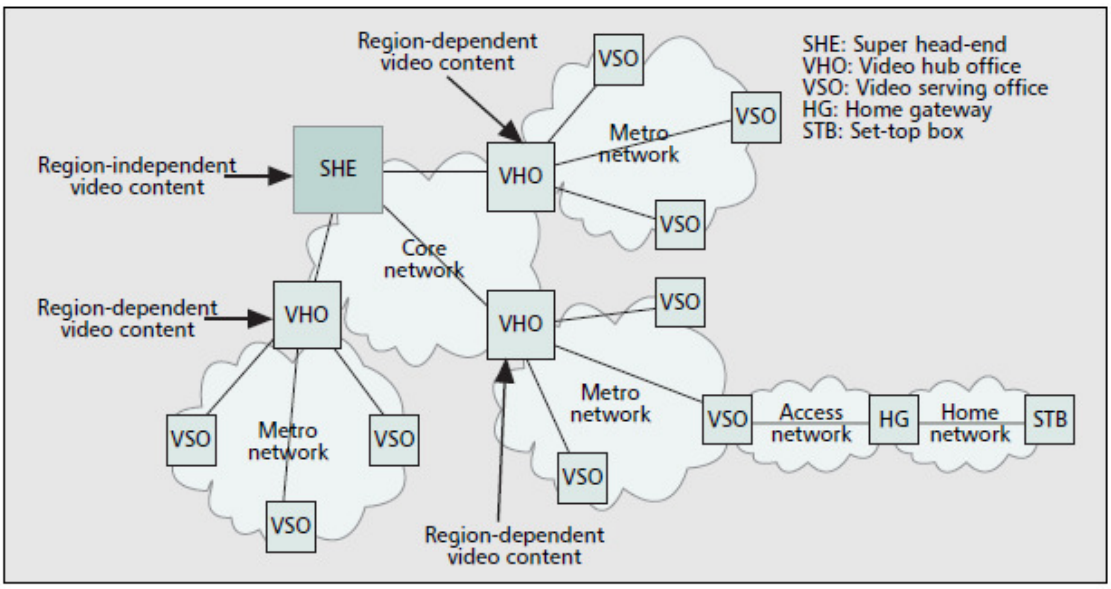

Figure 4. A typical IPTV network architecture (Degrande, 2008).

MPLS may be used inside an Ethernet over fiber (EoF) network to provide point-to-point and point.-to-multipoint service through VPLS. GMPLS is able provide an additional level of logical bandwidth management and it also supports VPLS. A set of GMPLS networks, known as virtual networks (VNs), may overlay the physical network (PN). The topology of the VNs can be different than for the PN.

Data centers in existing IPTV networks (SHE, VHO) typically encode video information by MPEG-2 or MPEG-4 AVC. The encoded video is transmitted using a CBR or capped VBR bit rate model. The CBR model gives constant bit rate at the price of variable quality. The VBR model gives constant quality at the price of variable bit rate. The peaks of the capped VBR stream are smoothed by introducing delay just as in the CBR case.

The packet routers consists of a switch core and multiple input and output controllers. Queueing of packets is possible at the input/output controllers. Most routers are able to switch the packets with no internal blocking in the core. The input controllers have queues to store packets waiting for switching to an output link. The output controllers have queues to store packets waiting to be scheduled for transmission. Popular schedulers at the output controller include Priority Queueing (PQ), Weighted Fair Queueing (WFQ), Weighted Round Robin (WRR), and Low Latency Queueing (LLQ) which combines PQ and WFQ.

There are many ways to configure the access network. Many operators use virtual LANs, per subscriber or per service. One shared multicast VLAN connects the DSLAM with the gateway router in the VSO. Either a VLANs per subscriber or per service is used to connect users with the VSO.

IPTV traffic flows

An unicast/multicast IPTV flow originates at the central data center (SHE) or regional data center (VHO) and crosses the core, metro and access network before it reaches the users TV equipment (STB). IPTV flows are classified into two categories:

- Stored video flow

    - Often requested video contents for BTV and VoD can be transferred in advance from SHE to VHOs based on channel and program popularity scores
    - Rarely requested video contents for BTV and VoD should not be prefetched and must be transferred on an on-demand basis
- Live video flow
    - Live video for BTV must be transmitted in real time can not be prefetched and must be transferred on an on-demand basis

The IPTV flow arrival process may contain both a stochastic part and a deterministic part:

- Core network
    - Stochastic flow arrivals driven by random viewing requests
    - Deterministic flow arrivals according to in-advance transfer schedule for stored video
- Metro network
    - Stochastic flow arrivals driven by random viewing requests

References

1. Alcatel-Lucent, "Converged video network security", *white paper*
2. Alcatel-Lucent, "A guide to setting up an IPTV service", *white paper*
3. Alcatel-Lucent, "How to approach IPTV solution integration -- a framework based on lessons learned", *white paper*
4. Alcatel-Lucent, “Assuring quality of experience for IPTV—the role of video admission control”, *application note*
5. B. Andrén, "Open multimedia platform framework", *Ericsson Review*, No. 1, 2009.
6. P. Arberg et al, "Network infrastructure for IPTV", *Ericsson Review*, No. 3, 2007.
7. C. Badulescu et al, "Delivering the optimal end.-user experience: Ericsson multimedia communication suite", *Ericsson Review*, No. 2, 2008.
8. T. Cagenius et al, "Evolving the TV experience: anytime, anywhere, any device", *Ericsson Review*, No. 3, 2006.
9. R. Chaudhuri, "End to end IPTV design and implementation - how to avoid pitfalls", *Tutorial*, Networks 2008 conference, 2008,
10. N. Degrande, K. Laevens, D. De Vleeschauwer, ”Increasing the user perceived quality for the IPTV services”, *IEEE Communications Magazine*, Vol.46, No.2, 2008.
11. M. El-Sayed, Y. Hu, S. Kulkarni, N. Wilson, "Comparison of transport network technologies for IPTV distribution, *Bell Labs Technical Journal,* Vol. 11, No. 2, 2006.
12. B. Erman, E.P. Matthews, “Analysis and realization of IPTV service quality”, *Bell Labs Technical Journal*, 12(4), 2008.
13. J. Gozdecki, A. Jajszczyk, R. Stankiewicz, “Quality of service terminology in IP networks”, *IEEE Communications Magazine*, Vol. 41, No. 3, 2003.
14. www.heavy readingcom, “Assuring quality of experience for IPTV”, *white paper*, 2006.
15. Irdeto, "CA/DRM solution for convergence platforn", IPTV evolution conference, 2008
16. ITU-T, *IPTV Focus Group Proceedings*, IPTV-GSI, 2008.
17. M. Jeffrey, S. Park, K. Lee, G. Adams, S. Savage, "Content security for IPTV", *IEEE Communications Magazine*, Vol. 46, No. 11, Nov. 2008.
18. S. Han, S. Lisle, G. Nehib, "IPTV transport architecture alternatives and economic considerations", *IEEE Communications Magazine*, Vol. 46, No. 2, 2008.
19. C. Hermsmeyer, E. Hernandez-Valancia, D. Stoll, O. Tamm, "Ethernet aggregation and core network models for efficient and reliable IPTV services", *Bell Labs Technical Journal*, Vol. 12, No. 1, 2007.
20. G. Holm-Öste, M. Norling, "Ericsson's user service performance framework", *Ericsson Review*, No. 1, 2008
21. Z. Hua, C. Chunxiao, Z. Li, Y. Shiqang, Z. Lizhu, "Content protection for IPTV-current state of the art and challanges", In *Proc. Multiconference on Computational Engineering in Systems Applications*, Vol. 2, pp. 1680-1685, 2006.
22. S. Hwang, "Content and service protection for IPTV", *IEEE Transactions on Broadcasting*, Vol. 55, No. 2, 2009.

23. S.V. Kartalopoulos, "A primer on cryptography in communications", *IEEE Communications Magazine*, Vol. 44, No. 4, 2006.
24. S. Lian, Z. Liu, "Secure media content distribution based on the improved set-top box in IPTV", *IEEE Transactions on Consumer Electronics*, Vol. 54, No. 2, May 2008.
25. J. Maisonnueve, M. Deschanel, J. Heiles, W. Li, H.Liu, R. Sharpe, Y.Wu, "Overview of IPTV standards development", *IEEE Transactions on Networking*, Vol. 55, No. 2, 2009.
26. U. Olsson, M. Stille, "Communication services -- the key to IMS service growth", *Ericsson Review*, No. 1, 2008.
27. U. Olsson, L. Dahlén. "Multimedia services overview", *Ericsson Review*, No. 3, 2008.
28. www.openiptvforum.org, *Open IPTV forum - functional architecture V 1.2*, Dec. 2008.
29. www.openiptvforum.org, *Open IPTV forum - Services and functions for release 2 V 1.0*, Oct. 2008.
30. S. Pasqualini et al., "Influence of GMPLS on network providers' operational expenditures: a quantitative study", *IEEE Commuications Magazine*, Vol. 43, No. 7, 2005.
31. D.H. Ramirez, *IPTV security: protecting high-value digital contents*, Wiley, 2008.
32. D.H. Shin, "Potential user factors driving adoption of IPTV. What are customers expecting from IPTV?", *Technological Forecasting and Social Change*, pp. 1446-1464, vol. 74, 2007.
33. Siemens-Juniper, "High-quality and resilient IPTV multicast architecture", *white paper*, 2006.
34. M. Seery,"Packet transport trends: IP/MPLS success challenged as deployment footprint expands", *IEEE Communications Magazine*, Vol 46, No. 7, 2008.
35. W. Stallings, *Cryptography and network security: principles and practices*, 4th edition, Prentice Hall, ISBN 0-13-187316-4, 2006.
36. A. Takahashi, D. Hands, V. Barriac, "Standardization activities in the ITU for a QoE assessment of IPTV", *IEEE Communications Magazine*, Vol. 46, No. 2, pp. 78-84, 2008.
37. www.tektronix.com, "A guide to IPTV: the technologies, the challenges and how to test IPTV", *primer*
38. D. Veen, M. Weldon, C. Bahr, E. Harstead, "An analysis of the technical and economic essentials for providing video over fiber-to-the-premises networks", *Bell Labs Technical Journal*, Vol. 10, No. 1, 2005.
39. M. Volk, J. Guna, A. Kos, J. Bester, "Quality-assured provisioning of IPTV services within the NGN environment", *IEEE Communications Magazine*, Vol. 46, No. 5, 2008.
40. D. Wu, Y-T Hou, W. Zhu, Y-Q. Zhang, J.M. Peha,"Streaming video over Internet: approaches and directions", *IEEE Transactions on Circuits and Systems for Video Technology*, Vol. 11, No. 3, 2001.
41. Y. Xiao, X. Du, J. Zhang, F. Hu, S. Guizani, "Internet Protocol Television (IPTV): the killer application for the next-generation Internet", *IEEE Communications Magazine*, Vol. 45, No. 11, pp. 126-134, 2007.