OPTIMIZATION THE ARCHITECTURES OF THE CATV NETWORKS TO PROVIDING THE VIDEO-ON-DEMAND SERVICE

Lidia Totkova Jordanova[1], Jordan Iliev Nenkov[2]

Faculty of Communications and Communications Technologies, Technical University, Kliment Ohridski 8, 1700 Sofia, Bulgaria, e-mail : [1]jordanova@tu-sofia.bg, e-mail : [2]jordan_n2002@yahoo.com

In this article is presented the conception for designing the architecture of a VoD system and the possibilities for placing of the VoD servers. There are presented some of the imposed DWDM applications. Also, it is given a possibility of using of the GigE applications. It is presented a possibility for designing of flexible system, available for geographical growth and to adapt to the newcoming services with minimal expenses.

Keywords: VoD systems, MPEG 2 TS, set-top-box, unicast video

1. INTRODUCTION

Video-on-Demand (VoD) is widely deployed service for cable operators, which allows users to view almost instantaneously chosen program from large media catalog available. The systems that provide this service currently require large amounts of centralized resources and significant bandwidth to accommodate their users in order to provide quality service to their subscribers.

The main problems with designing the VoD systems are the installation expenses, the cost of equipment, reliability, flexibility and scalability.

The aim of the work is to present different opportunities for providing VoD service, using existed hybrid fiber coax (HFC) networks and to be done estimation for their efficiency by comparison of the advantages and disadvantages of different versions for service realization.

2. VOD SYSTEM ARCHITECTURE BUILDING CONCEPT

A VoD deployment over HFC system can be present as a block diagram which is shown on the fig. 1.

Desired information is recorded in the video server which location depends on the chosen architecture. From there it is transported to the block, named "Stream conditioning" which performs scrambling, multiplexing, filtering, routing, modulation and upconversion in a single device. Arranging in groups these functions into single device provides itself more options for the operator to implement the most appropriate network architecture. So formed RF signal is submitted to the cable distribution network. Subscribers receive digital video signal by the TV receiver with STB (Set-Top-Box). The "Conditional access" block serves for protection of content by requiring certain criteria to be met before granting access to this content. Both "System Resource Manager" and "Subscriber Management" blocks manage system resources and subscribers respectively. These blocks are managed by the interactive network adapter (INA) or cable modem termination system (CMTS).

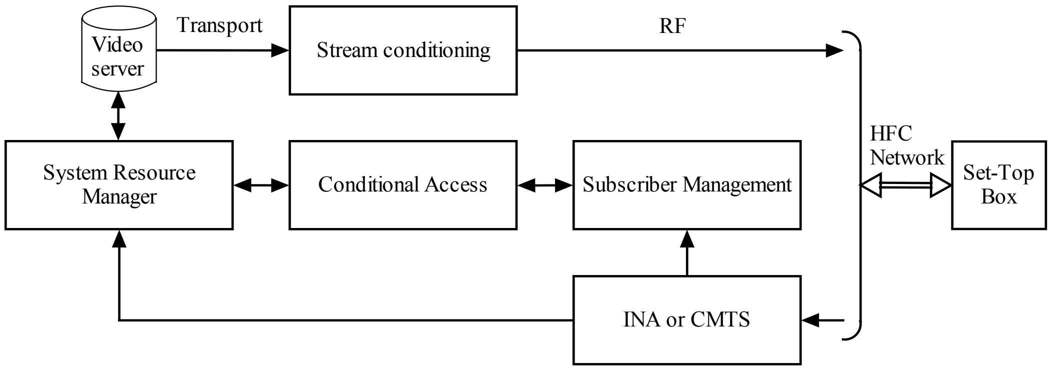

Fig. 1

Key aspect of a cost-effective system is the usage of open standard interfaces between the functional blocks. This usage gives an opportunity to apply high-quality components such as servers, INA and Conditional access.

VOD systems can be deployed in one of three fundamental architectures as illustrated in Fig. 2.

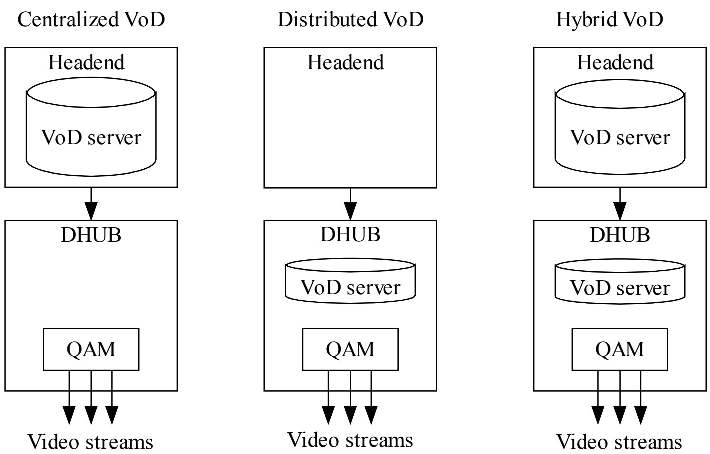

Fig. 2

The *Centralized VoD* method deploys a single, large VoD system at the Headend (HE) with VoD streams transported across the network to multiple distributed hubs (DHUBs). Since only one VoD system is required, this approach tends to lower VoD hardware and software costs. DWDM solutions have dramatically lowered the cost of these core transport networks, making DWDM and the centralized VoD architecture the preferred method for successful VoD services.

With *Distributed VoD* architectures, multiple VoD systems are deployed at each of the secondary or DHUBs. All programming content (assets) are duplicated at each of the DHUBs, with each distributed VoD system serving its own small area.This approach eliminates or reduces the bandwidth and transport costs across the core network.However, the approach requires many smaller VoD servers and associated storage to be deployed at multiple DHUBs, greatly increasing VoD equipment costs.

The *Hybrid VoD* architecture is a blend of the centralized and distributed models. Smaller VoD servers are deployed at the DHUBs but are limited in both size and storage to only the most popular movie selections. A larger VoD platform is installed at the headend with a deep library of movies and programming content. The hybrid approach has lower VoD equipment costs than a pure distributed model because the VoD systems at the distribution sites are smaller in size and capacity. However, this method still tends to be more expensive than a centralized approach, and the same asset management, asset distribution and multiple VoD operating expenses exists as with the distributed model. The hybrid approach has lower bandwidth requirements across the core transport network.

3. INCREASING THE CHANNEL CAPACITY WITH DWDM APPLICATIONS

3.1. Analog DWDM transport

Analog DWDM provides cost effective, high capacity transport in QAM format from a HE to a hub with economical fiber use. The general architecture is shown in Fig. 3.

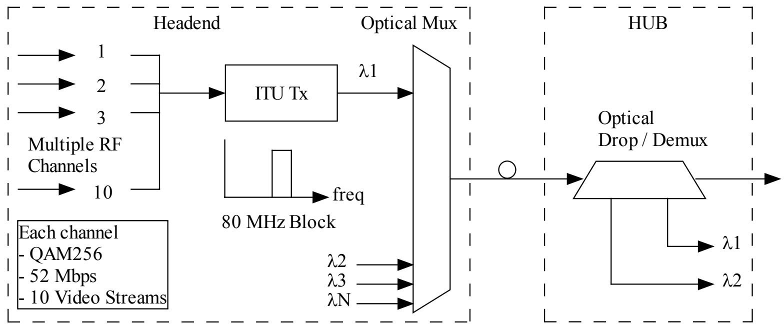

Fig. 3

Fig. 3 illustrates the structure in a ring architecture where for the 10 RF channels transmitting are used N wavelengths, which are multiplexing into a single optical fiber. One drops off a couple of wavelengths λ1 and λ2 at a hub location and sends to its served subscribers. Remaining wavelengths are sending to the subsequent hubs on the same single fiber. It is straightforward to modify this for a star headend-hub architecture as the optical drop now becomes a terminal optical demux.

In the fig. 4 is shown DWDM system in which for transporting signals from HUB to the optical nodes the optical envelopment around the 1310 nm is used. That requires in the hub to be included optical receivers, working at the λ1 and λ2 and modulating the dropped carriers, oscillated with λ=1310 nm. Before the 1310 nm modulation in transmitters the 256 QAM signals are adopted the signals for generally accessible services.

In the hub there are two main techniques for continuing the transport to the node:

1) Receive the optical DWDM signal at the hub and electrically combine with the broadcast signal at the hub (Fig. 4). This approach could be used if the operator has an existing 1310nm distribution network out of the hub.

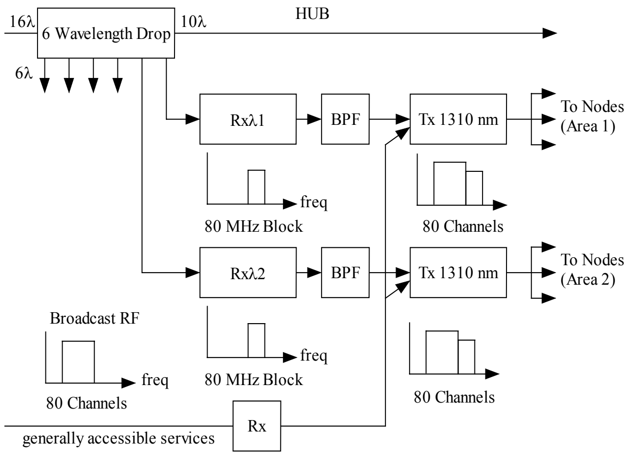

Fig. 4

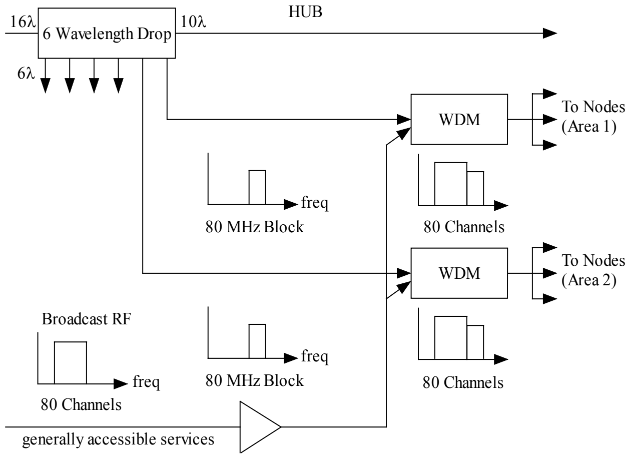

Fig. 5

2) Unbundle the desired DWDM wavelengths at the hub and optically combine with the generally accessible services signal with the distribution network, as is shown in Fig. 5.

3.2. High-speed digital DWDM transport

Architecturally, video servers and stream conditioning devices have IP interface hardware. This facilitates simple interconnection with the Gigabit Ethernet (GbE) transport solution. On the Fig. 6 is shown using the Gigabit Ethernet to interconnect HE and hub. For VoD, the transport needs to only be one-way – in this scenario only a Gigabit Ethernet DWDM transmitter at the HE is required, along with the associated mux/demux equipment.

Video information is passed from video servers to the cluster of optical transmitters, which form 1550 nm ITU grid. After the multiplexing in GbE Mux is performed DWDM signal. That formed signal is multiplexing and the QAM modulation is performed. It is formed QAM RF signal, which is suitable for transporting to the CATV network subscribers. If the destination between HE and HUB is very long it is necessary to place optical amplifier. On the fig. 6 it is shown with the dotted line.

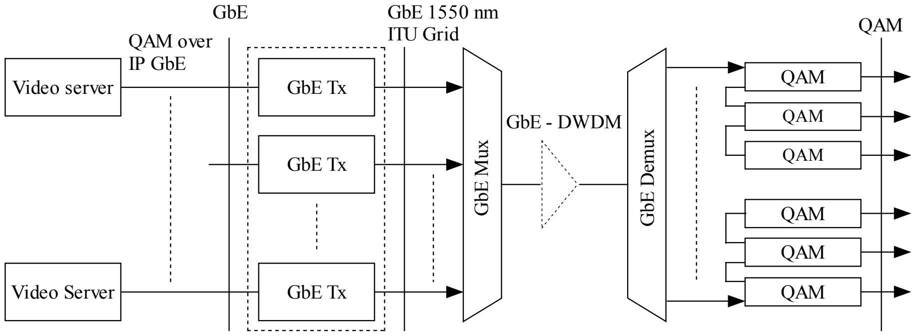

Fig. 6

Technology developed for this type of application will support up to 32 wavelengths over the same fiber. Assuming that the wavelengths are fully-utilized, this enables the operator to carry over 8,600 streams on one fiber.

4. DATA PROCESSING IN VOD SYSTEMS

IP is leading protocol for VoD networks, which is a major change for most cable networks. While IP may be the perfect choice for VoD output streams and network transport, the IP headers must be stripped of the MPEG-2 TS packets prior to QAM/RF modulation so that the digital video signal is compatible with the millions of deployed residential set-top boxes. Standard QAMs only provide a DVB-ASI input, so an IP to ASI gateway is used at the DHUBs to remove the IP headers from VoD streams prior to QAM/RF modulation as shown in Fig. 7. Newer GigE QAMs are being introduced that provide standard IP/Ethernet interfaces and remove the IP headers internally prior to the QAM/RF modulation.

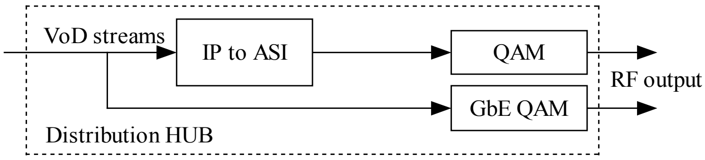

Fig. 7

5. VOD SYSTEMS DEVELOPMENT TRENDS

As interactive services expand, cable companies are looking to DWDM to connect HE end hubs and even fiber fed service nodes. In a typical scenario, and operator may choose to use 10 x 1 Gp/s Lambda's per fiber, or 10 Gb/s total capacity. Services placed in one wavelength are segregated from services in another. This allows the operator to first determine what services it needs to transport, then how much capacity each service requires (or it is planned for). Voice, data, broadcast and VoD services can then be assigned to their own Lambda (or multiple Lambda's) based on capacity planning. If new services emerge, or the operator wishes to further segregate services by class (TDM and VoIP voice, business and residential services, etc.) new wavelengths can be added. And, as services (or subscribers) grow, more wavelengths can be added for any service such as VoD.

On the Fig. 8 is shown flexible wavelength expansion. Cable operator may start out with a single, centralized VoD server at a main HE location as the demand develops. As demand increases, as well as content grows, the operator may add regional or local VoD server to handle demand and distribute content. While in the past VoD servers were only available with DVB-ASI or ATM interfaces, today they are available with GigE interfaces. Because demand increases along with expanded content, more servers are added. Now there are multiple Gigabit outputs streaming video to customers. Cable operators today are looking to deploy a flexible platform supporting not only VoD services-but also a whole new generation of video services.

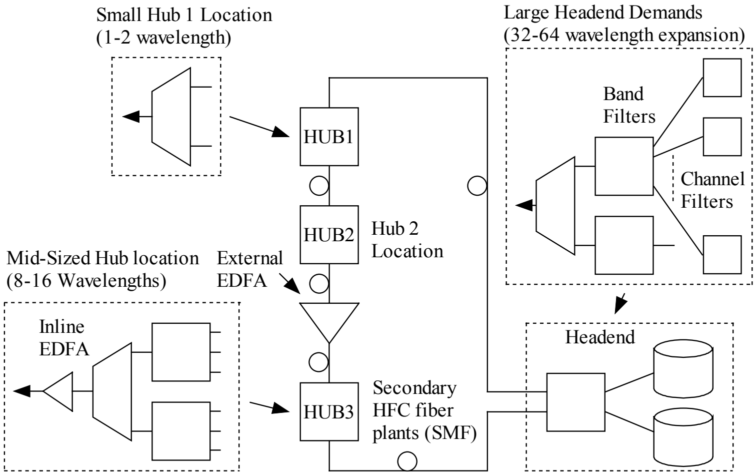

Fig. 8

6. CONCLUSION

VoD is an expensive service compared to broadcast (generally accessible) services. Using the analog and digital DWDM transmission as well as combining the VoD signal with broadcast signal and their joint transmission from the HE and HUB causes significant decrease of the equipment cost. From the above mentioned and discussed applications the best results have been received with digital DWDM transmission. Giving an account of GbE mass entering, can be considered that the high-speed digital transmission is the most suitable from the reviewed methods for providing video information from HE to HUB. The analog DWDM transmission is most suitable with cases where the VoD implementation over existing HFC network is needed (network upgrade) with minimal expenses.

7. REFERENCES

[1] Capacity Solutions with DWDM for broadcast and video-on-demand, Zhone, 2005.
[2] Advanced Optical and Digital Architectures for Video-On-Demand, Harmonic, 2003.
[3] Fujitsu Gigabit Ethernet VOD solutions, Fujitsu Network Communications Inc., 2004.
[4] Solution Architectures for Cable Video-on-Demand, Sorrento Networks Inc., 2002.
[5] Video on Demand A Review of VoD Network Architectures, Atoga Systems, Inc.
[6] Matthew S. Allen, Ben Y. Zhao and Rich Wolski: Deploying Video-on-Demand Services on Cable Networks. Department of Computer Science, U. C. Santa Barbara.
[7] http://erg.abdn.ac.uk/research/future-net/digital-video/ mpeg2-trans.html