White Paper

Transforming the network for advanced broadband services

Introduction

The transformation of the network across access and core is mandatory to support the delivery of advanced triple play and quadruple play services. The question that must be answered is, “How will this transformation best be achieved?” Many of the new services will impose stringent requirements on today’s networks, such as on-demand end-user behavior driving high volume of unicast traffic, high-speed data increasingly creating more symmetrical traffic patterns (i.e., gaming, peer-to-peer traffic) and adoption of High Definition TV (HDTV) consuming high network bandwidth.

This paper assesses the bandwidth and traffic requirements at various access and aggregation points in an ILEC/IOC/CLEC network and makes recommendations for balancing capital and operational costs of transport, servers and storage elements in order to successfully leverage the telco’s investments in FTTx access technologies. In addition, the impact of centralized and/or decentralized servers on network traffic is quantified.

The methodology used in this work encompasses consumer service models delivered over a reference network. The reference network employs switched digital video using multicast, unicast and IGMP for video delivery; MPEG2/MPEG4/WM9 for formatting and shaping video content; and a packet-optical architecture in the core. Traffic impacts from voice, high-speed data and command and control streams are also considered in the study.

Service landscape

Telephony service providers throughout the world are recognizing that a base-line triple play service offering (voice, high-speed data and video) is essential to offset declining voice revenues and enhance their company’s profitability. Most are in the process of defining and rolling out advanced broadband service offers and upgrading their access/metro networks to support these services.

While the service set varies from one service provider to another based on regional differences, a number of service trends have emerged and continue to evolve in the IPTV market.

Video services — Service providers have realized the baseline aspect of video services through their satellite service offers, as such, video has become a necessary component of a baseline broadband service bundle. A bundled service that includes video helps to reduce churn and increases the chance for customer retention, which ultimately aids in service profitability. It is also a significant driver of bandwidth demand which is necessitating access network evolution.

Advanced/interactive services — The convergence of communications and entertainment is enabling the development of more interactive and thus, differentiated, services. For instance, TV Internet services such as web browsing, e-mail, VoIP calls with all the typical voice features, Interactive Program Guide (IPG) providing IP search engine capabilities to end-users, online gaming with multiple players in real-time, video telephony, home security monitoring, remote meter reading and event notification are but a few examples of advanced services.

The implications of these advanced services on the network are three-fold:

- The need for a converged control plane with SIP capability at the edge (set top box — STB) to enable session authorization
- The need for service-awareness to allow class-of-service differentiation, security and dynamic control
- Overall increased service bandwidth, particularly in the upstream direction

Personalization — Entertainment patterns are shifting towards a more personalized, on-demand model. This goes beyond just video-on-demand (VoD), to offering all types of content and programs to subscribers. To enhance the user experience, many of the on-demand channels will be offered using HDTV. The bandwidth impact on the network can be significant since on-demand traffic is unicast in nature, which means there is a dedicated content stream for each end-user session. STBs with Digital Video Recorder (DVR) capability may alleviate the bandwidth requirements on the network if the service provider downloads the content during off-peak hours and allows the end-user to view them at their preferred time. In this model, the end-user requires a more expensive STB — one with a built-in hard drive. Multiple video streams to each subscriber will also place additional demand on last-mile and core bandwidth requirements. Targeted advertising is another aspect of personalization. As with IPTV, the service providers know more about the channels that are being watched. It gives them more insight in packaging the ads and content to their target audience. Channel statistics and viewer profiles are easier to collect when IPTV delivers the video channels.

Shift to mobility — The next frontier in services evolution is wireless video. Consumers will want access to entertainment, newscasts, weather updates from any device, wireless or wireline. This will enable a whole new set of integrated services accessible from multiple devices. In parallel, production processes are morphing to accommodate digital content creation, and this digitization of content is occurring for new content, and for archived and media libraries. To fully exploit these service trends, service providers will have to move to a converged packet core infrastructure that enables the efficient delivery of IP traffic to any device.

Designing an end-to-end network that mitigates the service and bandwidth requirements highlighted in this section is crucial to a successful broadband service offering.

Service models and traffic profiles

This section defines the service models used in this analysis, as well as the many service parameters that are modeled. This approach generates an accurate view of the service bandwidth requirements and the change over time. Table 1 depicts a baseline and differentiated service offering. It is expected that baseline pressures and customer expectations will drive IPTV service providers to an introductory service offer of 20 Mbps per subscriber as defined by the Baseline Service Model. This model allows for the delivery of three video streams to each home — one standard digital TV stream and two high-definition TV streams. Broadcast video services as well as Video-on-Demand are offered via the three video streams. Two voice lines, a high-speed data service at 7 Mbps downstream, and some dedicated bandwidth for gaming applications complete the service offering.

The Differentiated Service Model represents the continued evolution of video and data services. For instance, a greater availability of HD content will increase the penetration of HDTVs. It is also reasonable to expect that the evolution of multi-player gaming and

Table 1. Triple play service models

Baseline service model		
Service	**Downstream**	**Upstream**
2 SDTV video streams 1 HDTV video stream	12 Mbps	<50 kbps
2 voice lines	200 kbps	200 kbps
High-speed data	7 Mbps	512 kbps
Gaming	128 kbps	128 kbps
Total	**~20 Mbps**	**~1 Mbps**

Differentiated service model		
Service	**Downstream**	**Upstream**
2 SDTV video streams 2 HDTV video streams PVR video stream (HD)	28 Mbps	<100 kbps
2 voice lines	200 kbps	200 kbps
High-speed data	15 Mbps	1 Mbps
Gaming	1 Mbps	1 Mbps
Total	**~45 Mbps**	**~2 Mbps**

Internet applications will drive bandwidth needs for these services, in particular in the upstream direction. It also assumes that the penetration and usage of Personal Video Recorders (PVRs) will increase, and for high-end consumers a separate HD video channel will be required. The Differentiated Service Model predicts that an average of 45 Mbps is needed to each subscriber on the network.

Service take rate

The model assumes a video and high-speed data service take rate in the range of 25 percent to 30 percent. Given that this is a highly baseline market with the MSOs having the incumbent advantage, most ILEC/IOC/CLEC service providers are expecting to achieve a penetration rate in the range of 20 to 30 percent, at least in the first few years of service deployment.

Video Broadcast Service parameters

The model assumes that a total of 350 broadcast channels are available, 300 channels are delivered as standard definition (SD) video channels, and 50 are high definition channels. MPEG4 encoding is assumed on both SDTV and HDTV video channels in the base case scenario. Additional details of the base case scenario are discussed in the Bandwidth Modeling section.

Video on Demand Service parameters

A peak simultaneous usage (PSU) of 10 percent is used for VoD for the Baseline Service Model, and 30 percent PSU for the Differentiated Service Model. MPEG4 encoding is used for VoD channels. The VoD PSU represents the maximum utilization by video subscribers who will be using the VoD service at any given time.

Oversubscription or dedicated bandwidth

There are two factors driving transport and aggregation requirements in the metro edge offices. The first is related to the number of uplink ports, i.e., OC-12 or GE uplink ports carrying triple play traffic to the end-office, and the second relates to the number of lines and service take rates. The number of uplink ports is not only driven by the number of triple play lines but also by the topology and geographic characteristics of the serving areas. Sparse areas where remotes are scattered requires numerous remotes; however, the take rate on the services may not result in full utilization of the uplink port capacity. In such cases, the metro end-office needs to provide fan-in for aggregation of numerous uplink ports as well as supporting the line interfaces for transport over metro core.

A similar effect takes place when a specified amount of bandwidth on the uplink ports is dedicated to each subscriber. If uplink ports can be provisioned with oversubscription of the data traffic (i.e., non-dedicated bandwidth per sub), higher utilization of the uplink ports is achieved.

From transport requirements, the non-dedicated and dedicated bandwidth per sub is similar in the core, as long as aggregation of the data traffic is considered at the end office (oversubscription in the metro core). High Speed Data (HSD) services are typically designed with high oversubscription in the core, generally by a factor of 25 to 40; in contrast, voice and multimedia services have a small oversubscription applied.

Compression technology moving towards MPEG4/WM9

Compression techniques relieve the bandwidth requirements on per-subscriber and hence at the network level. The use of compression does drive a more costly service offering — more expensive STB, more expensive encoding in the core, transcoding is needed given that most of the content is presented to the encoder in MPEG2 format. The model assumes all content is encoded in MPEG4 prior to transport to the various video hub and serving offices. A bandwidth of 2 Mbps is used for SDTV signals, and 8 Mbps is used for HDTV signals.

In summary, service bandwidth requirements are dependent on three main factors:

- *Service parameters* such as take rates, number of video streams per home, amount of broadcast traffic, VoD peak simultaneous usage, amount of downstream and upstream bandwidth required per service per user, oversubscription ratio and HDTV proliferation
- *Timing and impact* of encoding technology as video compression enables using lower bandwidth for video streams
- *Network topology* in terms of scale and hierarchy — this topic will be further addressed in the following section.

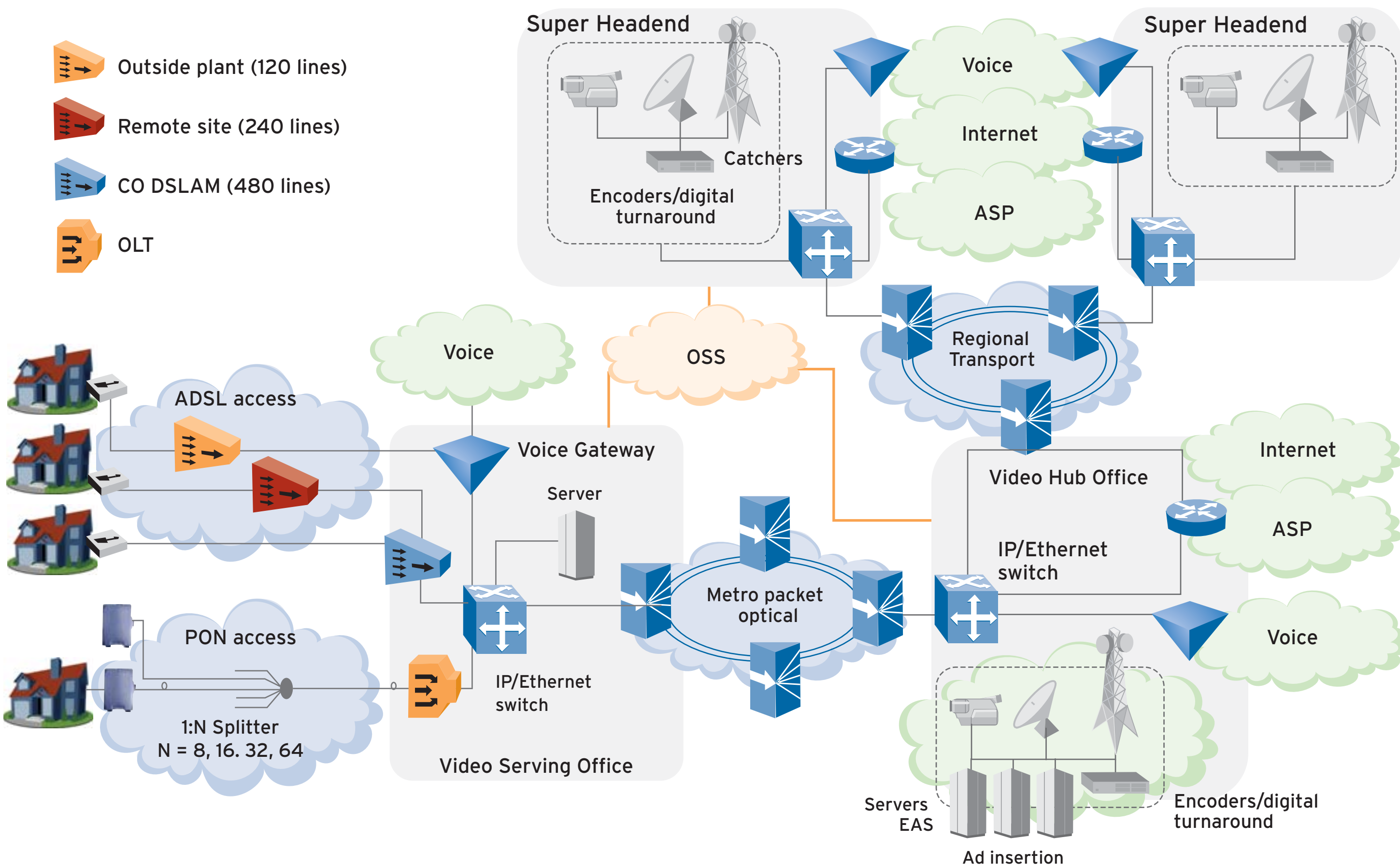
Reference network model

The end-to-end reference network architecture is shown in Figure 1. Delivery of triple play services is not restricted to one type of network architecture; however, there are similarities in the functional building blocks for triple play networks and what differs from one network model to another is where and how those building blocks are implemented.

To describe the reference model, four segments can be defined:

1. The access segment corresponds to the access network infrastructure delivering the services bandwidth to the end-user via FTTN and FTTH solutions. There are several technology choices within each of the FTTN and FTTH solutions that enable delivery of high-bandwidth triple play services such as ADSL2+ with bonding (for 24 Mbps and above) and VDSL for FTTN solution or BPON and GPON for the FTTH solution. The methodology used in this work takes into account the services bandwidth and is agnostic to the technology solutions used in the last mile.

Figure 1. Reference network model



2. The Video Serving Office (VSO) is the serving office closest to the subscribers. Since the uplinks from access sites are aggregated in this facility, the VSO is logistics for IP/Ethernet aggregation and switching functions. For most carriers, this office is physically the same facility as the Class 5 voice switching office. Video serving offices can also be the facility holding the VoD servers. Variations of the network architecture with respect to location of the VoD servers are described in more detail in the next section. VSO traffic is transported to Video Hub Office (VHO) via the metro packet optical transport architecture. The reference architecture assumes Optical Ethernet transport in the metro. In this work, Optical Ethernet is viewed as the architecture that brings about the most optimum means of transport in terms of cost, operations and minimum latency and jitter, which are crucial in reliable delivery of the services to meet the quality of service and quality of experience.
3. Video Hub Office is the main headend office where the content is acquired and distributed to the VSOs. Most of the broadcast content is distributed to VHOs via the regional transport infrastructure and the VHO will add local broadcast and advertisement content for distribution to smaller offices (e.g. VSOs). Gateways and routers for interconnection to ISPs, voice providers and Application Service Providers (ASPs) can be located in the VHOs.
4. The Super Headend (SHE) is the regional office where most of the broadcast and advertisement content is acquired. For resiliency purposes, there are two Video Super Headends as these sites are core for broadcast services. Encoders and servers are located in Super Headends for national channels and in VHOs for local channels. Emergency Alert Systems (EASs) are deployed in the SHE and VHOs as well.

Video network topology

The reference topology for video network includes a regional video headend, aka Super Headend (SHE) where the content is acquired from content providers via satellite dishes or in the form of storage. Two SHE sites are common for resiliency purposes.

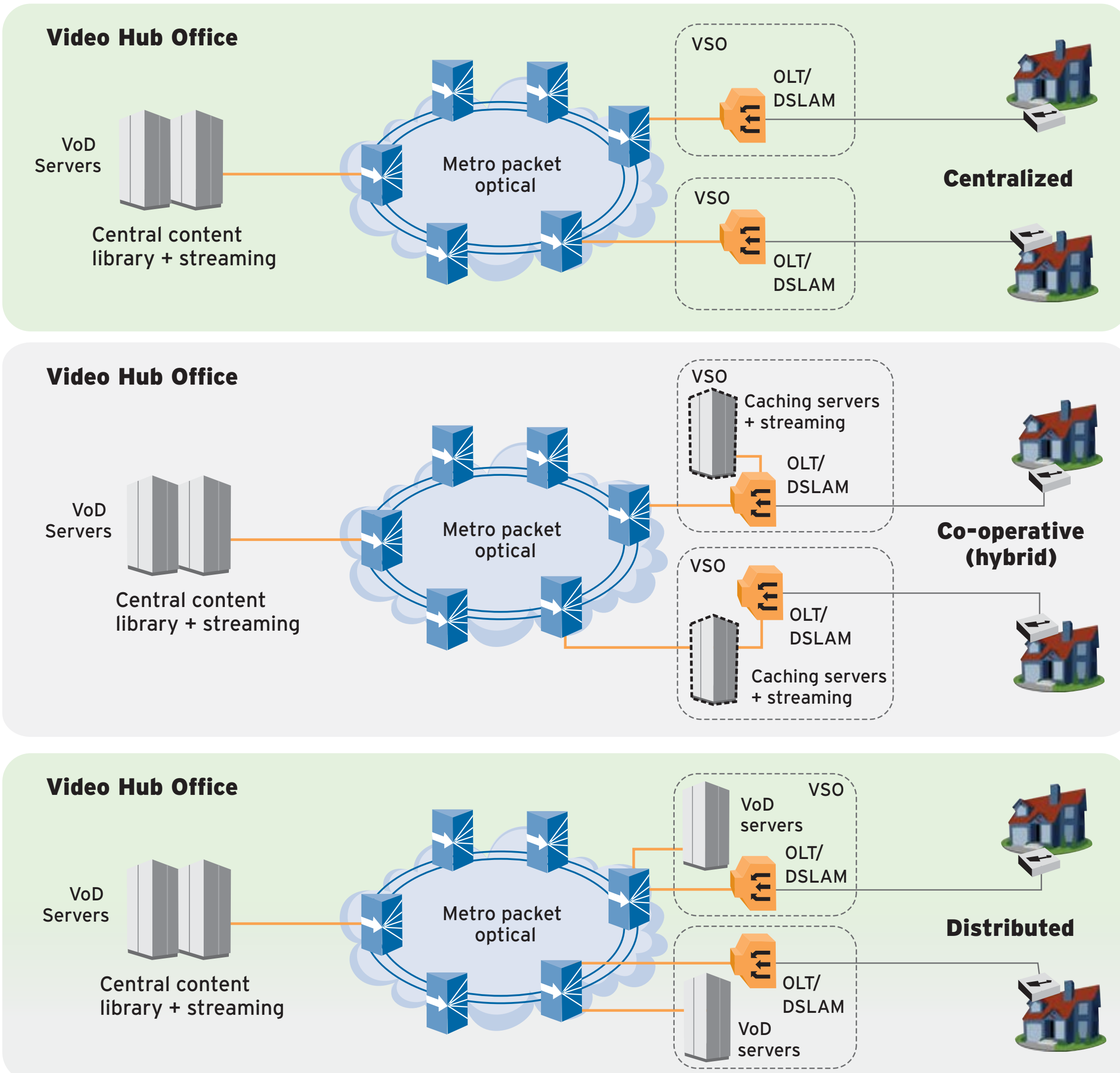
In order to benefit from economies of scale and reduce costs, the video Super Headend is supporting several smaller metro areas. The video content from Super Headends is delivered to the metro video hub office (VHO) using Optical Ethernet transport. In this model, the broadcast traffic is distributed to VHO using drop and continue in optical layer. Distribution of the broadcast video traffic is enabled by multicast routing to the remote DSLAM/OLT sites.

VoD streams are one of the most significant drivers of the traffic; hence, architectural variations related to delivery of this service have significant impact on the transport traffic and overall network bandwidth. Figure 2 shows three variations of the VoD network models. In the centralized model, the VoD servers are centralized in a Video Hub Office. The storage and streaming functions are all centralized in this location and video serving offices receive the VoD streams via optical transport in the metro core. As is evident, this model drives higher transport bandwidth in the core; however, it leverages lower operational complexity and economy of scale for server equipment. The centralized architecture is the preferred choice for the initial phases of the VoD service offering where the take rates are not predictable. This architecture alleviates the uncertainty related to scaling the network and managing the content. This work examines the impact of each network model on the transport traffic. Over time as video penetration and peak VoD usage increase, the VoD servers will become more distributed towards the VSO sites.

The cooperative (hybrid) architecture referred to in this paper separates streaming and storage where storage of all the VoD content/assets mostly remains centralized with only most popular titles, i.e. hot assets[1], is located in the VSO. The VSO also streams the content to the end user; therefore, less traffic needs to be transported in the metro core. Evolution to the cooperative architecture demands understanding of the asset popularity and time periods in which the peak usage occurs.

The distributed model refers to an architecture where the VoD servers are deployed in all the VSO sites and the streaming and storage is handled in each site. Due to operational complexity and management implications of this type of architecture as well as its vulnerability to take rate and peak usage, this architecture appears to be among the least favorable choices when it comes to designing a VoD network.

Figure 2. Video-On-Demand network models



Internet access network topology

The services capabilities to support Internet access are either converged with video capability in the edge office or VSO or can be centralized in the VHO. A common architecture for HSD service aggregation is to have a subset of BRAS functionality and feature sets in the first level of traffic aggregation with the IP/Ethernet switch, and keep the full feature set of the BRAS centralized in the VHO. This approach alleviates the cost of implementing a full-feature BRAS function in a VSO. The traffic modeling in this work assumes a centralized BRAS model where the Internet access traffic is routed to a larger metro office or a VHO and hence accounted for the traffic that needs to be transported over the metro core.

Although the Internet access service is one of the key components of the service bundle due to statistical multiplexing (oversubscription), the impact of it is less significant compared to unicast video streams, which drive high amounts of bandwidth in the core for transport. Hence, the centralization or decentralization of the Internet access service platforms has lower impact on the modeling outputs as opposed to VoD variations.

Voice and multimedia network topology

This paper focuses on voice services carried by way of packets. Traditional baseband voice is carried through the existing TDM voice network and, hence, has no impact on the traffic carried by packet core. Packet voice service can be viewed as a subset of multimedia services.

Triple play services have created a fundamental change in service models. In the past, the service models were based on an interconnection model with centralized switching centers. In the case of triple play services, the same interconnection model cannot be adopted; the service model is now distributed throughout the network in a number of service-specific locations. The control plane functions are provided by video application servers and voice call servers.

The VSO can be supporting the Call Server/Session Control function by routing the voice traffic through a voice gateway.

Access network key characteristics

The access infrastructure is capable of delivery of the triple play services via DSL or PON technology. In fact, the reference model in this work is agnostic to the last mile technology, as the traffic in the network will be based on the service attributes. However, the uplink from the remote access sites is impacted in terms of the ports and connectivity requirements in the VSO and is taken into account in the modeling. Ethernet is becoming the currency for network interconnections and, as such, the uplinks from the remote site are modeled assuming GE uplink ports. There is a minimum of at least one aggregation point (normally the DSLAM/OLT in the VSO) to concentrate the uplink traffic.

In order to have a fair representation of the access infrastructure, for any given number of households served, a combination of various sizes of remotes is assumed. The modeling assumes that a small remote passes 120 households, whereas a medium-sized remote passes 240 lines. The model makes assumptions on number of remotes deployed and the triple play lines served off each type of remote versus served in the central office. Multicasting is supported at the VSO and the remote sites by sending IGMP snoop/reports to the VSO to enable the viewers to receive the broadcast channels of choice.

Bandwidth modeling

Services traffic profiles are driven by a number of variables and it is crucial to examine the impact of these variables in order to gain understanding of network transport requirements. This paper presents the sensitivity results that have the most impact on traffic. To better understand the impact of each parameter, a base scenario is defined and, in a step-by-step approach, each parameter is changed to observe the traffic profile. The base case scenario is representative of a medium population metro with about one million total households. In this scenario, the carrier broadband infrastructure has passed more than half of the households. For modeling purpose, 576,000 households are passed through the access infrastructure that is capable of offering high-bandwidth services, with 25 percent take rate of the Baseline Service Model shown earlier. The Base Scenario is defined as shown in Table 2.

Channel raw bandwidth, which is the output of encoders in the SHE and VHO, is the first factor studied in this work. To date, with MPEG2 compression, the digital content can be transmitted at up to 4 Mbps for Standard Definition (SD) and at up to 16 Mbps for High Definition (HD) content.

Table 2. Base scenario input parameters

Homes passed	570K
Take rate	25%
Encoding	MPEG4
VoD servers	Centralized in VHO
VoD Peak Simultaneous Usage (PSU)	10%

The exact rate of the content is dependent on frames per second and on content itself[2]. Where high quality is essential to capture the motions, e.g., sports content, the rate is higher; whereas for content that can be encoded at lower rates without compromising quality, lower bit rates suffice. The compression gain of the channel raw bandwidth is improving over time and with the advent of MPEG4 or WM9/AVC, the channel raw bandwidth can be reduced up to half. As was described earlier, the video streams for on-demand/personalized content have the most contribution to the traffic since each stream needs to be unicast to the service subscriber. Therefore, technology used in encoders (MPEG2/MPEG4/WM9) directly impacts the video streams driving the traffic in the metro.

Figure 3 shows the impact of compression on the traffic per VSO using the reference network model*. As is shown in this example, with 10 percent Peak Simultaneous Usage (PSU) on VoD and centralized VoD servers in the VHO, the MPEG4 encoding can reduce the traffic from each VSO by 40 percent.

The network architecture and the layout of servers relative to transport throughout the network is another factor driving overall traffic.

The reference network model section described variations of the video network architecture with respect to centralization or distribution of the VoD servers. It is expected that with emergence of more on-demand or personalized services that the peak usage on VoD will increase and, hence, may drive economics towards a decentralized approach for VoD servers. Published reports from various sources, including video rental stores, indicates that selection of a few titles is much higher than other titles and that about 10 percent of the total titles available are viewed by more than 50 percent of the viewers (popular assets, new releases, etc.). These viewing habits provide grounds for decentralization of the VoD servers, where a higher percentage of the VoD picks can be served locally by the VSO and only picks for less popular content may be directed to VHOs. The updates on VSO content may occur during off peak hours.To illustrate the impact of decentralization in various degrees, two scenarios are examined.

One scenario assumes 50 percent of the VoD picks can be served locally and the second scenario assumes 70 percent of the VoD picks can be served locally. There is significant impact in the second scenario compared to the base scenario.

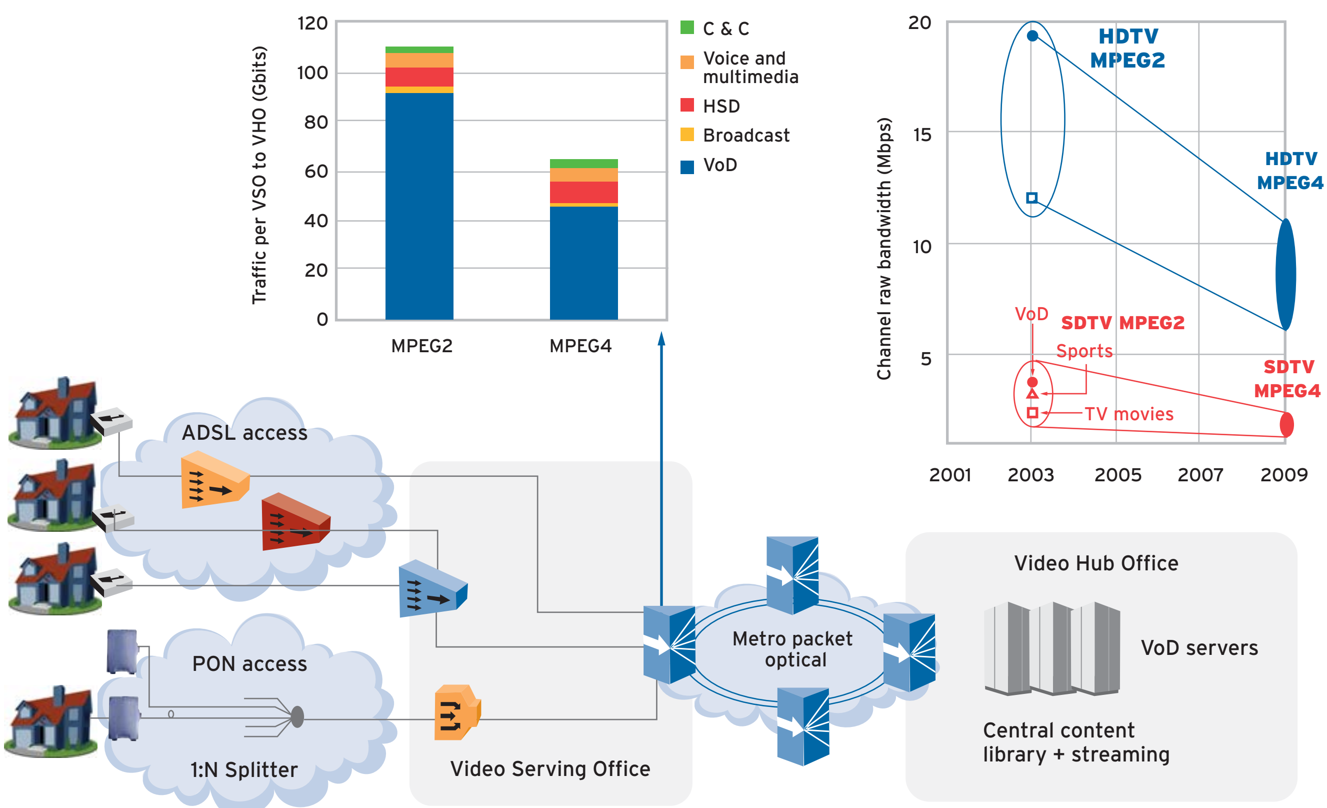


Figure 3. Compression improvement, MPEG2 to MPEG4

* In this example, the peak simultaneous usage for VoD is assumed to be 10 percent. The VoD servers are assumed to be centralized in the VHO, as described in Base Scenario. C&C is referring to Command and Control traffic, which carries the control signals from the subscriber to the network.

Figure 4 shows the sensitivity of the traffic to centralized and decentralized VoD servers.* Other service parameters including services take rate or penetration rate, Peak Simultaneous Usage (PSU) of VoD, oversubscription ratios used for HSD and gaming services, downstream/upstream traffic ratios, network-based PVR versus real-time video streaming of content and many other factors impact the traffic requirements. Table 5 provides a summary of the parameters that have the most impact.

Table 5. Summary of sensitivity analysis

Sensitivity parameter	Change to parameter	Traffic per VSO to VHO	
Service			
Baseline	~20 Mbps per home	64 Gbps	+50%
Differentiated	~45 Mbps per home	96 Gbps	
VoD peak usage			
Moderate peak usage	10%	64 Gbps	+100%
High peak usage	30%	128 Gbps	
Technology			
MPEG2	SD 4 Mbps, HD 16 Mbps	110 Gbps	-40%
MPEG4	SD 2 Mbps, HD 8 Mbps	64 Gbps	
Network			
Centralized	All servers in VHO	64 Gbps	-34%
Decentralized (Cooperative)	50% of subscriber VoD picks served locally at VSO	42 Gbps	-24%
Decentralized (Cooperative)	70% of subscriber VoD picks served locally at VSO	32 Gbps	

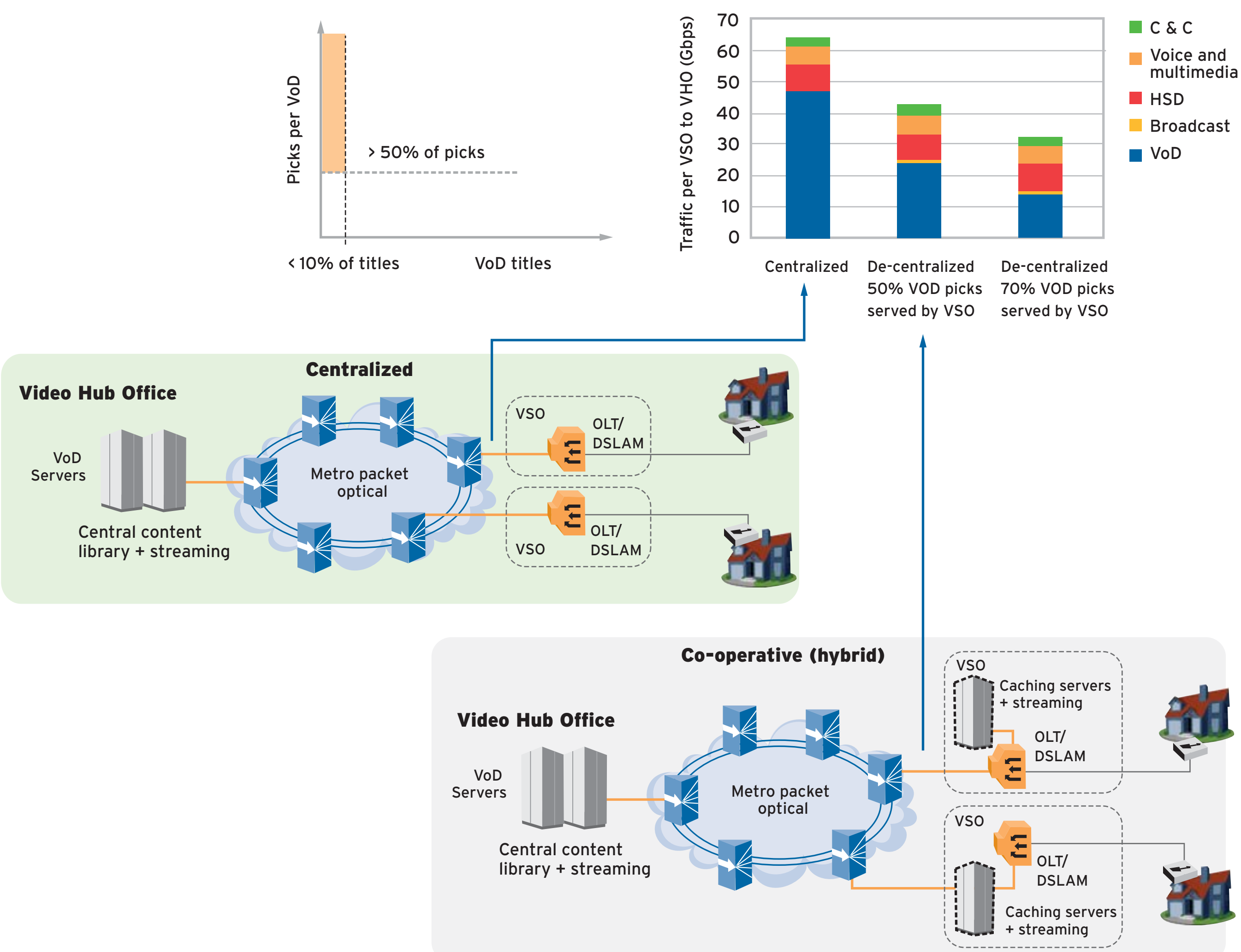


Figure 4. Decentralization of VoD (titles picked)

* In this example, the Peak Simultaneous Usage (PSU) of VoD is assumed to be 10 percent and MPEG4 encoding assumed for video content.

This table shows the sensitivity of the traffic with respect to changes on each parameter. There is at least one parameter shown for service characteristics, technology and network attributes and the overall impact on traffic.

With the impacting parameters in mind, the analogy to make is that the combination of all these 'moving parts' creates an interesting spin on the overall traffic in a serving office and for metro transport and interconnecvity to servers provided by IP/Ethernet switches in the VSO and VHO. The trend will be a steady growth of traffic, which is the result of the balancing act between higher demand and improvements in encoding, as well as network optimization.

Figure 5 provides our view of the evolution of traffic in the serving office taking into account technology, services and the network parameters trend over time.

Architectural considerations

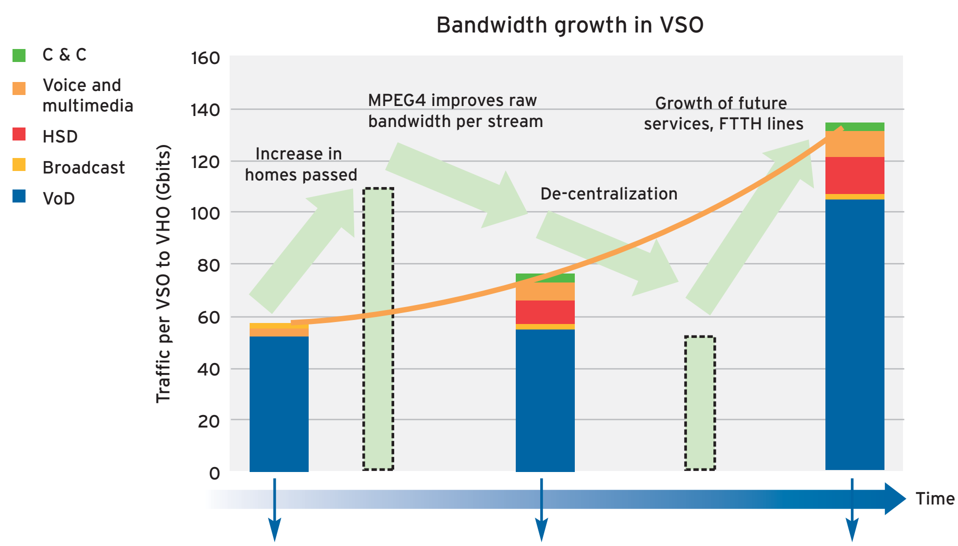
The evolution to advanced services is going to change network infrastructure in metro and access networks as well as the operational and subscriber management infrastructure that is in place today.

IP Ethernet switching and transport — GE is fast becoming the currency for the interconnection of the access segment to the remaining network. The traffic modeling work presented in this paper demonstrates the need for high GE port density on the metro edge switching and transport platforms. This also demands convergence of optical transport with Layer 2 aggregation, which will enable packet aggregation at the metro edge.

Integration of service intelligence/awareness into these platforms will optimize the network cost and operations, as well as enable faster turn-up of new services. This will facilitate provisioning the Quality of Service levels and traffic policies to meet the tiered service offerings.

Service awareness — In the early days of broadband deployments, the service focused on one service offer — High Speed Internet access. Hence, a centralized BRAS and edge routing architecture met the needs of the service offering. With more diverse service bundles offered to subscribers, the source of each service is no longer a single point in the network. Some services invoke applications and functions residing on servers that are distributed in the network, bringing subscriber management and service intelligence functions closer to the subscribers. However, a full-feature BRAS function support is costly when it is distributed to all the serving offices and is highly complex operationally. Therefore, a middle-ground approach, where a sub-set of BRAS functions are distributed to the service-specific locations, is more likely to be adopted as the architecture for delivery of advanced services.

Access infrastructure — It is becoming apparent that due to the installation cost for FTTH, the most economical initial deployments will be in greenfield applications. Typically, greenfield deployments occur in suburban/new residential areas where smaller Tier 2/Tier 3 central offices are possibly



Homes passed	288K	570K	750K
Take rate	25%	25%	30%
Compression	MPEG2	MPEG4	MPEG4
VoD servers	Centralized	Centralized	Decentralized
VoD peak usage	10%	15%	30%

Figure 5. Evolution of traffic in the serving office

not fully manned. Integrating PON functionality into existing access and transport platforms can bring about significant operational and capital savings.

Network and services reliability — The single service offerings in broadband to date have been a best-effort service without stringent reliability requirements. Higher quality of service and higher reliability will be service differentiators and a baseline advantage that ILECs may capitalize upon for advance service offerings.

Layer 0/1 optimization — Finally, as is shown by the service models in Table 1, the upstream traffic per subscriber is considerably lower than downstream traffic in the order of a 1:20 ratio. Hence, L0 transmission in the metro can be cost-optimized to better match the highly asymmetrical traffic patterns and directionality of advanced services. This can be accomplished by implementing asymmetric transmit and receive rates on the line interfaces carrying the transport traffic to VHOs. The asymmetrical transport will avoid the expense of operating under-utilized symmetric systems.

Summary and conclusions

In this paper, bandwidth and traffic requirements at various access and aggregation points in the network were analyzed taking into account several service models, technology parameters and end-to-end network hierarchy.

Personalization, media on demand, content anywhere/anytime will become table stakes in the ILEC service offerings of the future. These are elements of the Differentiated Service Model driving significant bandwidth per subscriber. Real-time delivery of personalized content from servers to the subscriber will generate a significant amount of traffic directed to the video serving office. This traffic will grow with increased service take rates, higher penetration of future service models enabled by FTTH/PON, higher peak simultaneous usage of personalized content, higher number of video streams per home and the rise in use of HDTV.

The following are the key takeaways of the bandwidth modeling analysis:

- Services evolution is inevitable; service providers must address the access infrastructure to enable baseline service offers of greater than 40 Mbps per subscriber.
- VoD and personalized content services and their peak simultaneous usage are a key bandwidth driver, as shown in the sensitivity analysis summarized in Table 5.
- Increased video penetration and VoD peak usage will drive the decentralization of VoD servers. Centralized server architecture is the preferred choice for low take rate service offerings.
- Traffic growth will be mitigated by improvements in encoding and higher compression gains along with distribution of the content servers. However, the combination of all these factors still points to an overall steady growth of bandwidth in the metro.

It is evident that video services are the key drivers for the network transformation — they dominate the bandwidth, they have the most stringent quality of service and quality of experience requirements, they are the cornerstone to differentiated service offers and they are driving the access infrastructure transformation. Although design and planning of the network and services infrastructure will be driven by video services in the near term, the ultimate goal is to provide full service mobility. With this in mind, the next challenge is to determine where in the network the service delivery functions are best implemented.

Service providers face a dynamic environment in which to plan and design their networks. They shall require solutions that are scalable, flexible and resilient to meet their overall deployment strategy and business objectives.

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