Total Cost of Ownership Analysis of Multicast-to-Storage™ vs. Streaming Video for Video-on-Demand Services

Network Strategy Partners, LLC

MANAGEMENT CONSULTANTS TO THE NETWORKING INDUSTRY

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Executive Summary

Today's TV market is undergoing a major disruption. The traditional linear TV model is changing, driven by disruptive technological advancements. Consumers today are demanding a personalized, high definition and on-demand TV experience with rich content diversity and control over how, when and what they watch.

Comcast[1], the largest US MSO, has expanded its on-demand library to offer more than 10,000 selections each month. The company recently reported[2] that its Video-On-Demand (VOD) service has registered over six billion views since its launch in 2003 with 250 million views monthly (100 million more views in comparison to the previous year) equaling 100 views per second.

The rapid consumer adoption of Video-On-Demand (VOD) creates an opportunity for Service Providers to add value by offering new and compelling service bundles to drive additional usage of this consumer-centric service. VOD is not only a competitive differentiator, but can also provide an engine for future revenue growth.

While VOD represents an opportunity for Service Providers, it imposes several infrastructure challenges, of which the most significant is the build-out of a cost effective and scalable VOD infrastructure to support the migration from linear TV to personalized, on-demand video services. In addition, the rapid migration to HD programming significantly increases the service delivery and economic scaling challenge.

Currently VOD is distributed from a Video Head End using a Video Server through unicast delivery, requiring heavy bandwidth utilization and capital investments to support growing peak time bandwidth requirements. Insufficient bandwidth or hardware result in degraded video quality or service denial to the user, representing lost revenue opportunity and increased dissatisfaction with subscriber.

Alternatively, multicast delivery technology is scalable, network efficient and supports delivery of massive amounts of content to users, at a fraction of the cost, as compared to unicast delivery. However multicast is not personalized, and as such cannot support diversified consumer taste and the rapidly expanding content offering.

Therefore, Service Providers are faced with a dilemma: **unicast delivery is personalized but not scalable, while multicast is network efficient but not personalized.**

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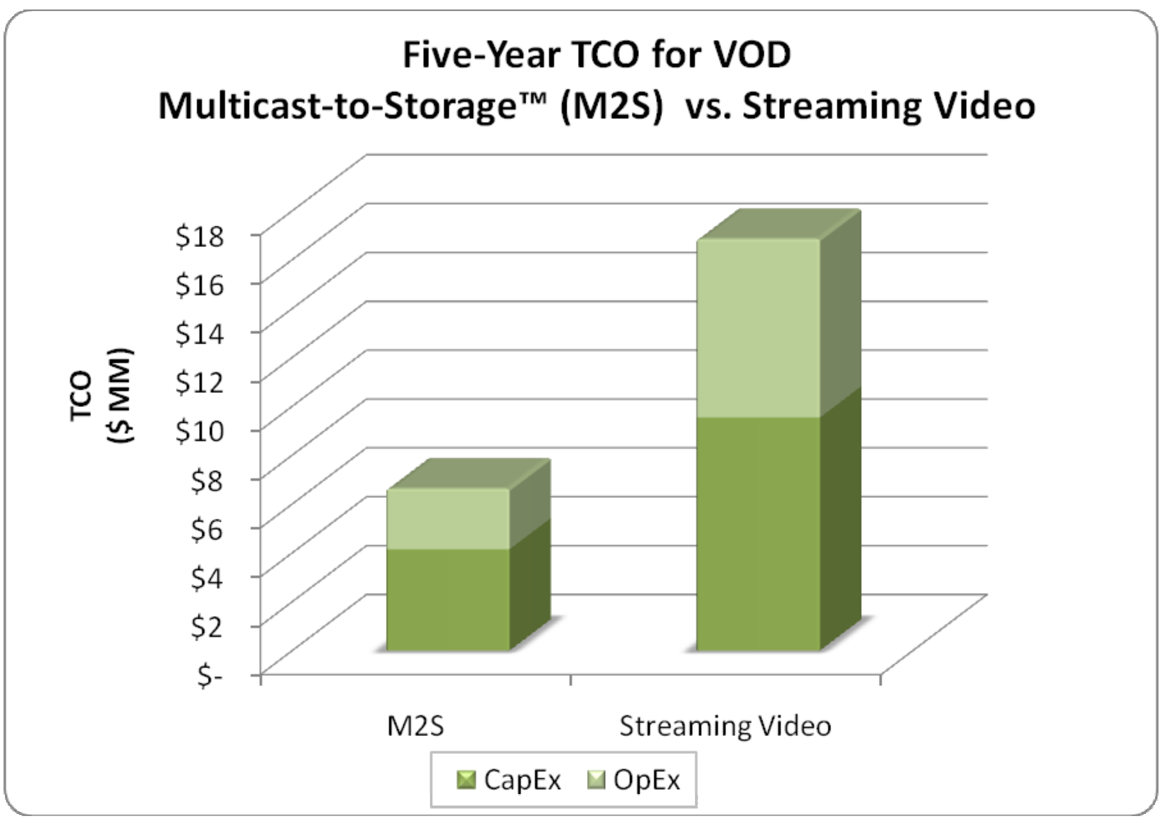
[1] "*Comcast CEO Brian L. Roberts Announces Project Infinity: Strategy to Deliver Exponentially More Content Choice On TV*", http://www.comcast.com/About/PressRelease/PressReleaseDetail.ashx?PRID=724. January 2008

[2] "*Consumers Demand Comcast's Signature Video-On-Demand Service — And Have Demanded It More Than Six Billion Times*," http://www.multichannel.com/article/CA6509888.html., December 2007

An emerging technology addressing this dilemma has been developed by **Intercast Networks (formerly Arootz)**, which deploys a **Multicast-to-Storage™ (M2S)** solution. This solution provides an innovative approach enabling the delivery of massive amounts of personalized, high quality content to storage-equipped devices in the home, such as PCs, Set-Top-Boxes (STB) and Internet devices. This creates broadcast-like network scalability and economic efficiencies, while still meeting consumers demand for control of their TV viewing experience.

By implementing this approach, Service Providers can scale their existing VOD infrastructure by leveraging investments in next generation STB/PVR and the dropping costs in storage, to migrate from a server centric network to a distributed storage-enabled video service architecture. As a result, Service Providers will experience significantly reduced delivery costs enabling the adoption of new and competitive business models and expanded service offerings.

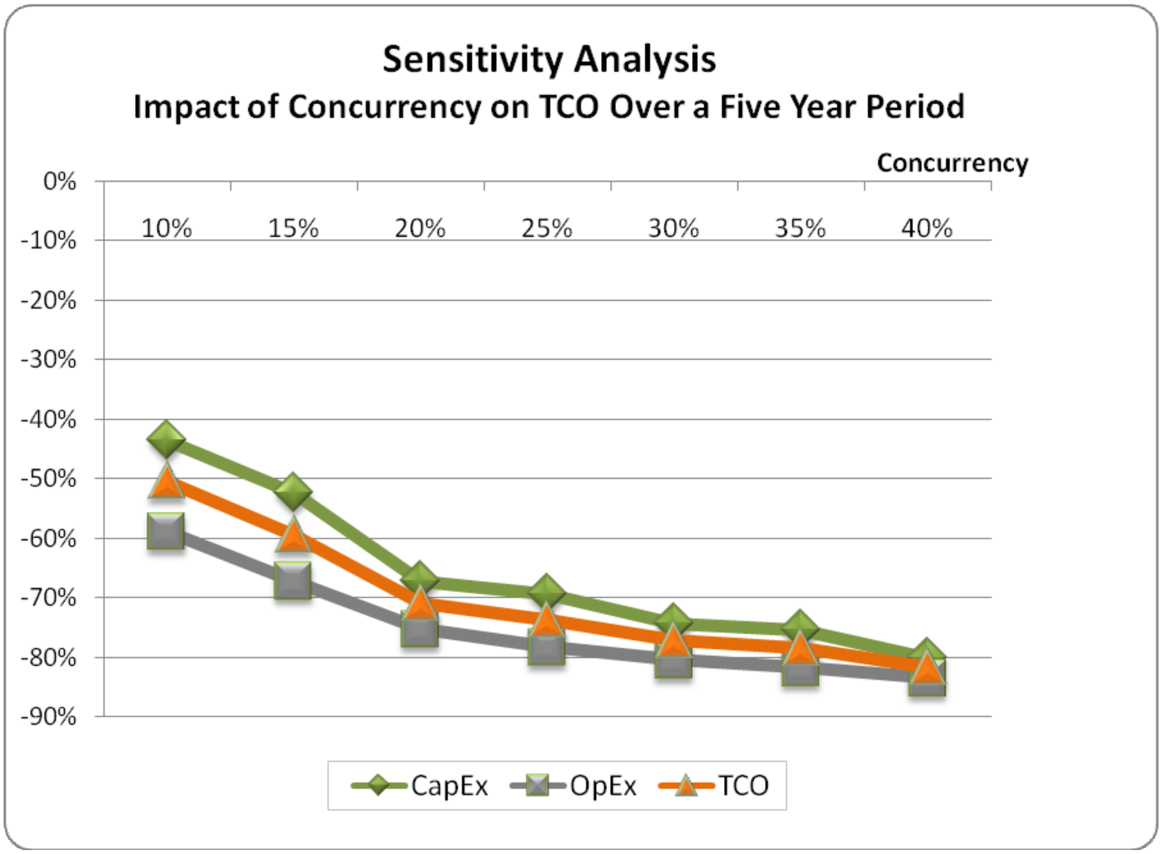
This study compares the TCO of the **Multicast-to-Storage™ (M2S) Architecture** to that of the **Server Centric Architecture** (we refer to this as **Streaming Video**) over a five-year period in a typical metro area. The study finds the M2S Architecture to have a 61% lower TCO over the five-year period as compared to the Streaming Video Architecture. This is comprised of CapEx savings of 57% and OpEx savings of 65%.



The largest sources of CapEx savings derive from the substitution of personal storage for Video Server capacity and M2S's dramatic reduction of Aggregation Network bandwidth. Reduced Aggregation Network bandwidth requirements also produce the largest single source of OpEx savings by decreasing 10 GE transport layer costs. Other OpEx savings accrue by shifting service delivery functions away from high cost Central Office/POP environments and carrier class networking equipment to the household, which leverages the economics of scale as experienced in the consumer electronics industry.

Sensitivity studies produce the following detailed findings:

- Annual price decline for personal storage of 20% result in 55% TCO savings for M2S as compared to Streaming Video. The savings further increase to 63% with an annual price decrease of 45%.
- Concurrency of 10% produces a 50% TCO savings for M2S as compared to Streaming Video. This increases to 82% TCO savings at 40% concurrency.
- Subscriber penetration of 10% by Year 5 corresponds to 37% TCO savings for M2S as compared to Streaming Video and increases to 64% TCO savings at 80% penetration rate by Year 5.



The above chart shows the resulting cost savings by M2S over a concurrency range of ten percent to forty percent. This corresponds to 21 to 84 minutes of viewing time during the busy period. The TCO savings is 50% at ten percent concurrency and increases to 82% at forty percent concurrency. This is a direct result of M2S's Architecture that breaks the linkage between peak period usage, network capacity requirements and storage capacity requirements.

Introduction

Today's TV market is undergoing a major disruption. The traditional linear TV model is changing, driven by disruptive technological advancements. Consumers today are demanding a personalized, high definition and on-demand TV experience with rich content diversity and control over how, when and what they watch.

The **rapid consumer adoption of Video on Demand (VOD)** creates an opportunity for Service Providers to add value to the service mix by offering new and compelling bundles of services. VOD is not only a competitive differentiator, but also provides the engine for future revenue growth. Comcast recently reported[3] that its VOD service has registered more than six billion views since its launch in 2003; with 250 million views each month (100 million more views in comparison to the previous year) equaling 100 views per second. ABI Research projects[4] VOD streams worldwide to increase from 1.67 million in 2005 to 163 million in 2011, and SNL Kagan estimates[5] that total VOD revenue will top $6 billion within five years.

In addition, **HDTV is becoming a global phenomenon.** The Consumer Electronics Association estimates[6] that by the end of 2007 52 million HDTV sets will be sold in the U.S. and household penetration will reach 36%. The establishment of HD standards has helped to fuel this growth as has the Consumer Electronics industry's development of low cost HD displays. HD growth is also being driven by Satellite, Cable, and Telco-based IPTV operators who are using video quality as a competitive differentiator.

While VOD and HD provide a great opportunity for Service Providers, current delivery technologies present some daunting challenges:

[3] "*Consumers Demand Comcast's Signature Video-On-Demand Service — And Have Demanded It More Than Six Billion Times*," http://www.multichannel.com/article/CA6509888.html., December 2007 "

[4] "*Video-on-Demand Evolution to IP and Ad-Insertion*," http://www.abiresearch.com/products/market_research/Video-on-Demand_Evolution_to_IP_and_Ad- Insertion], October 2006.

[5] "*Video-On-Demand: A Strategic and Economic Analysis*," http://www.snl.com/press/20071213.asp, December 2007

6 "*CEA's Shapiro: DTV Subsidy Program Will Work*", http://www.broadcastingcable.com/article/CA6482550.html, September 2007

Market Challenges

Bandwidth Requirements – VOD infrastructures are designed to support peak time bandwidth requirements, which forces inefficient investments in bandwidth and hardware to support high concurrency rates which remain underutilized throughout most of the day. VOD is distributed today from a Video Head End using a Video Server. The Video Head End typically is centrally located in a metro area and is connected to several Aggregation Networks serving thousands of subscribers. Consequently, the Video Server must handle thousands of concurrent VOD streams while most of the Aggregation Networks' bandwidth is used for VOD traffic[7]. With the accelerated adoption of VOD, concurrency is expected to grow rapidly.

High Definition – HD further strains bandwidth and storage capacity problems. Each HD video requires about three times as much bandwidth and storage as a standard definition (SD) video. Therefore, as HD becomes the predominant video format, bandwidth and storage capacity requirements will triple. The root causes of VOD traffic dominating the Aggregation Network is that each VOD stream's duration is twenty to ninety minutes, requiring two to six Mbps of bandwidth, and is unique to each subscriber.

Scalability – to support the growth in popularity of VOD, Service Providers will need to invest heavily in their infrastructure by adding additional server and storage capacity. The alternative is to keep the current network infrastructure and limit the usage of VOD services through pricing strategies, content quality or service denials.

While VOD can represent a growth engine for Service Providers, the existing VOD Server Centric approach will require significant capital and operational expenses to cope with the growing popularity for on-demand video. As a result of the introduction of SVOD (subscription VOD), Catch-up TV and other non-PPV (Pay Per View) packages the demand may further accelerate without significantly increasing Average Revenue Per User (ARPU) beyond current levels.

On-demand services are taking-off, indicating to Service Providers that it is time to prepare their networks accordingly.

Introducing Intercast Networks (formerly Arootz)

Intercast Networks' **Multicast-to-Storage™ (M2S)** solution provides a new technological approach to deliver massive amounts of personalized and high quality content to storage equipped user devices, such as PCs, Set-Top-Boxes (STB) and Internet devices, creating broadcast like network scalability and economic efficiencies for on-demand consumption. Consumers have proven their willingness to consume video content from personal storage, as seen by the rapid adoption of PVR's, P2P services and internet download services.

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[7] See Appendix Figure 6, *A Business Case Comparison of Carrier Ethernet Designs for Triple Play Networks*, January, 2007, Network Strategy Partners, LLC – www.nspllc.com (Whitepapers)

By deploying the Intercast Networks M2S solution, network operators are able to leverage their current network investments to meet consumer demand and profit from the migration to on-demand, network centric content services. M2S enabled networks can deliver an order of a magnitude more personalized content at a fraction of the cost.

Intercast Networks **Global M2S Content Delivery Network** (CDN) enables content providers to benefit from an innovative technology which delivers a high quality, personalized and on-demand TV experience while preserving broadcast economy of scale: **The more content is delivered the lower the delivery cost.**

This allows for the adoption of **profitable** internet business models, such as revenue share, pay-per-view, targeted and performance based advertising to multiple VOD environments, like TV or the PC.

Overview of TCO Analysis

A TCO comparison is made between the **Multicast-to-Storage™** (**M2S)** versus **Streaming Video** architecture by modeling the traffic and VOD usage for residential subscribers in a typical large metro area. The traffic forecast is made by characterizing residential demand for a Triple Play service portfolio consisting of:

- VOD video (HDTV and SDTV)
- Broadcast video (HDTV and SDTV)
- High Speed Internet Access
- Voice (VoIP)

TCO of the M2S and Streaming Video architectures is estimated over a five-year study period for network elements including:

- Set Top Box (STB)
- IP DSLAM (IP Digital Subscriber Line Access Multiplexer)
- L2/L3 Switch/Router (Aggregation Network Node)
- Transport Service Links between Aggregation Network Nodes
- L2/L3 Switch/Router (Within Super POP connecting Aggregation Network to Core Network)
- BRAS (Broadband Remote Access System)
- Video Server (Located within Video Head End)

A TCO estimate is made for a Base case that supports voice, broadcast video, and high speed Internet service. This is done so that the incremental TCO of providing a VOD service can be calculated.

The incremental TCO for the M2S versus the Streaming Video architectures is then analyzed. A drill down analysis is performed to isolate specific cost differences for both Capital Expense (CapEx) and Operations Expense (OpEx) components of the TCO. In addition, sensitivity studies are performed to illustrate the TCO effects of variation in:

- Concurrency/Video hours per user
- Price of personal storage
- VOD penetration rate

Intercast Networks Value Proposition

Multicast-to-Storage™ (M2S) provides additional non quantitative competitive advantages which are not reflected in the model:

Network

- **Coverage** – in this model we are assuming last mile bandwidth capacity of 20Mb, while in reality the average bandwidth is substantially lower. M2S enables a larger coverage of the network as it does not require real time access to the video stream.
- **Quality of Experience (QoE) –** in this model we are assuming equivalent QoE in both service offers, while in reality maintaining high QoE in real-time streaming over IP networks is a significant challenge.
- **Legacy** – this model assumes a greenfield deployment of best of breed technologies and high-end components, while the reality is that every network has to cope with legacy equipment, creating additional bottlenecks and constraints.

Service

- **Personalization** - unlike traditional Push VOD solutions, the M2S technology enables a high degree of content personalization down to the individual subscriber level, satisfying the long tail requirement for personalized content.
- **The connected home** - **storage based consumption** empowers users to place shift (DRM permitting) the consumption, using a wide variety of storage equipped end-user devices such as media players, laptops, PCs, gaming consoles, PDAs, mobile phones etc.
- **Content agnostic delivery** - the M2S infrastructure enables the delivery of a large variety of multimedia formats such as games (including HD games), software, download-to-own DVDs, etc.

Business Models

- **Targeted advertising** – the low delivery cost combined with high Click Per Thousand (CPM) resulting from targeted, personalized data, enables profitable and innovative business models.

Network Modeling Scenario

A network model is used to calculate TCO for a typical metro area. Figure 1 is a schematic of the network:

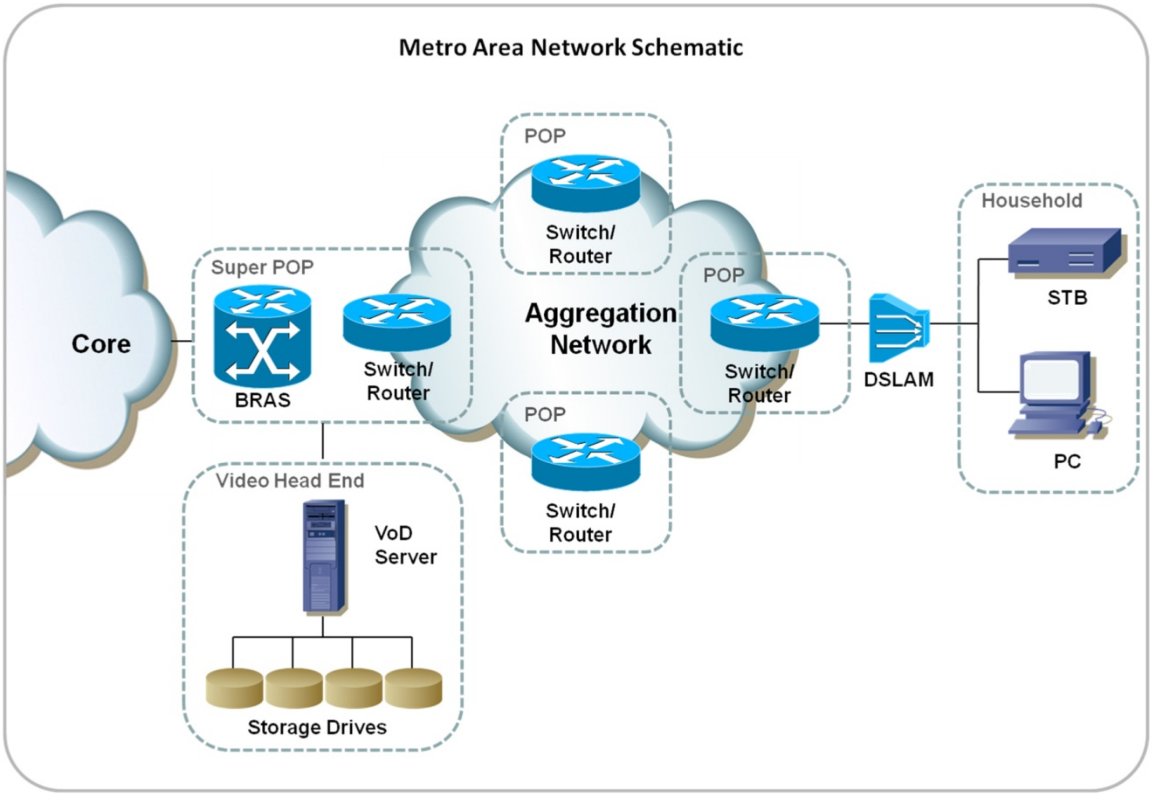

Figure 1
Metro Area Network Schematic

The following network entities are modeled:

- Household – the household terminates High Speed Internet Access, Voice, Broadcast video and VOD video services. A household has multiple TVs with a STB assigned to each TV.

- DSLAM – each DSLAM terminates several hundred households. The DSLAM may be located within the POP or in a remote cabinet—its location is determined by the distance that households are from the POP and the requirement that each DSL line be able to support a downstream capacity of 20 Mbps. The twisted-pair copper cables, fiber optic backhaul from the DSLAM to the POP, and outside plant apparatus and structures are not part of the TCO analysis.

- POP – each POP provides connections downstream to the DSLAMs and upstream onto the Aggregation Network. Each POP contains a L2/L3 Switch/Router that conforms to the Metro Ethernet Forum's Carrier Ethernet specifications.

- Aggregation Network – the Aggregation Network provides connections among each POP and the Super POP using an optical Carrier Ethernet design. A ring topology is used. The annual cost of the transport links between the POPs and the Super POP is included as an Operations Expense in the TCO calculations.

- Super POP – the Super POP connects each Aggregation Network to the Core Network and to the Video Head End. The Super POP contains a BRAS that is used to provision High Speed Internet and Voice services and a L2/L3 Switch/Router that provides Carrier Ethernet services between the POPs, BRAS, Video Head End and Core Network.

- Video Head End – the Video Head End provides video services to multiple Super POPs (Aggregation Networks). The Video Server used to provide VOD video streams is located at the Video Head End as are the systems used to broadcast video and distribute content for the M2S solution described below.

Table 1 provides data on the Equipment used in this analysis:

Equipment	Description
STB Storage	Cost of 1 Giga Byte of storage on STB
Video Server	Video server blade with a capacity to support 1,000 video streams at 3.75 Mbps per video stream.
Router 24 Port GigE	GigE i/o card for Aggregation Router
Router 4 Port 10 GigE	10 GigE card for Agregation Router
BRAS 1 Port GigE Half height Card	1 Port GigE Card for BRAS
DSLAM 48XADSL2+	48 port ADSL2+ line card for IP DSLAM
DSLAM 1 Port GigE	1 port GigE card for IP DSLAM (uplink)

Table 1
Equipment Data

Table 2 characterizes the network and customer configurations used in this analysis.

Item	Number
TV per Household	2
Households per DSLAM	300
DSLAMs per POP	33
POPs per Super POP	8
Super POPs per Video Head End	3

Table 2
Network Characterization

This network supports 237,600 households. With an average of two TVs[8] per household it can potentially deliver VOD to 475,200 TVs.

[8] *US Census Bureau - 50th Anniversary of 'Wonderful World of Color' TV*, http://www.census.gov/Press-Release/www/releases/archives/facts_for_features_special_editions/001702.html

Projection of Number of Subscribers

The next step in the estimation of network capacity requirements is to project the penetration rates (take-up rates) for voice, video and Internet services. Figure 2 shows the projections.

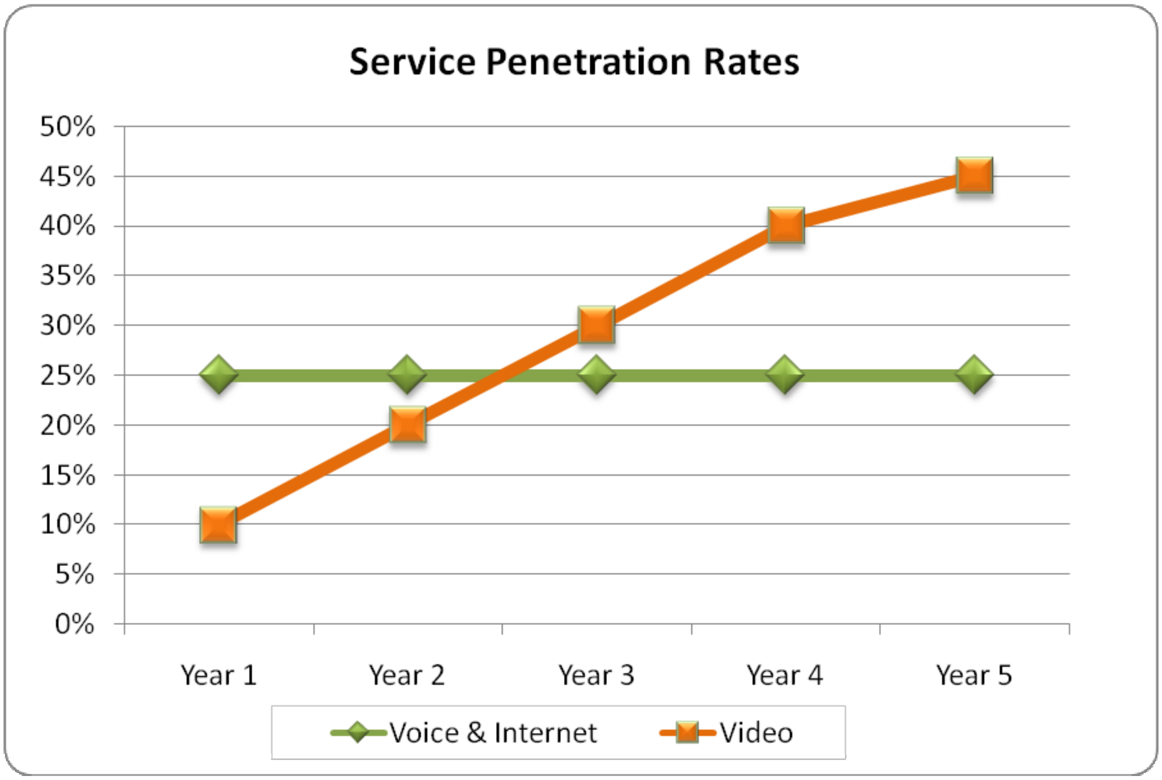

Figure 2
Service Penetration Rates

As shown both voice (VoIP) and High Speed Internet services are assumed to have 25% penetration throughout the study period. Essentially all digital video packages include VOD capabilities for no extra fee—this pricing encourages the spontaneous use of VOD. Consequently, broadcast video and VOD have identical penetration rates and top out at 45% penetration in the fifth year[9].

[9] The penetration rates are derived from Network Strategy Partners' experience in doing planning projects for its Service Provider and Systems Vendor clients.

HD versus SD Service Mix

It also is necessary to project the mix of High Definition versus Standard Definition service since this affects network bandwidth and content storage requirements. Figure 3 shows the service mix.

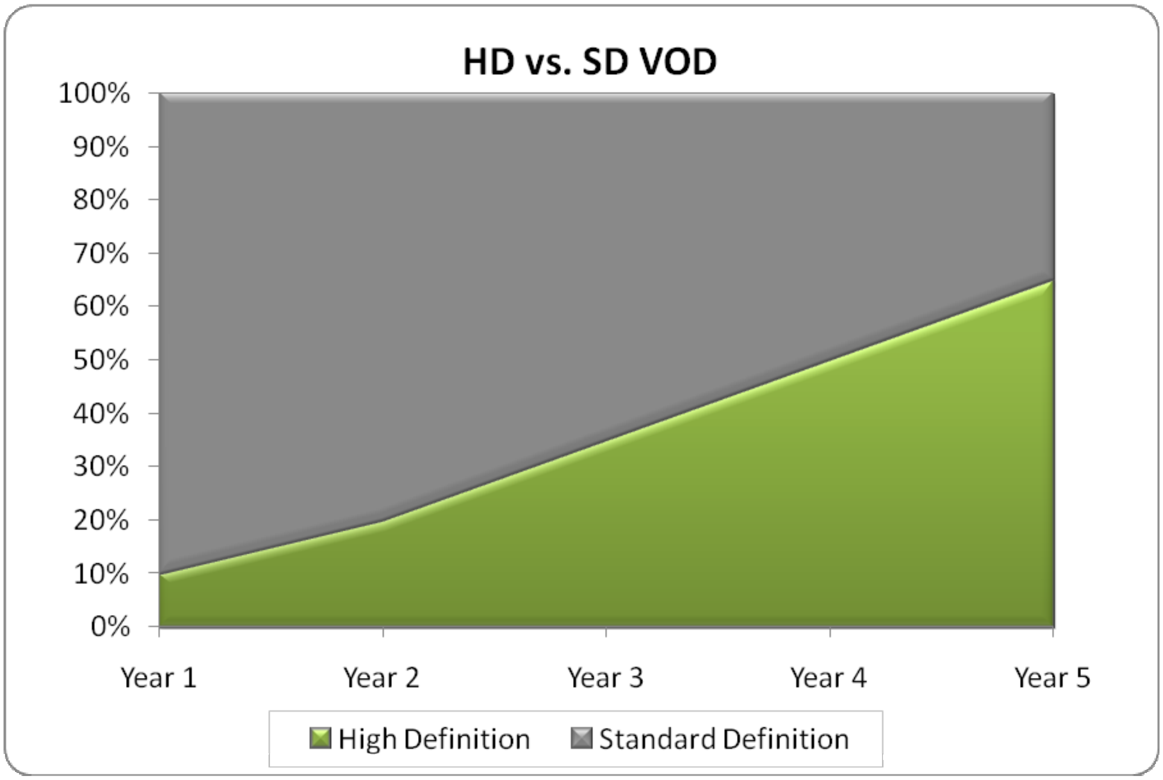

Figure 3
High versus Standard Definition Video Mix

HD video is expected to account for more than 65% of total video streams within five years[10].

VOD Usage

Definition of the addressable market and penetration rates is sufficient to project bandwidth requirements for Internet, voice and broadcast video services. It is necessary, however, to project VOD usage in order to estimate bandwidth and storage requirements for VOD. Bandwidth requirements for an average user are estimated as follows[11]:

1. Estimate average video hours used per subscriber in the peak hours of the day.

[10] Video 2.0, RBC Capital Markets September 2007
[11] Network capacity planning is based upon traffic during the peak period only.

2. Calculate the concurrency rate (Percent of TVs active during peak hours) as a function of Step 1.

3. Estimate average bandwidth requirements per subscriber[12] given Step 2, HD/SD Service Mix, and the data rates for HD and SD service.

Estimates of storage requirements are made in a similar way, however, it is also necessary to estimate total use rather than just use during the busy period. This is accomplished by studying usage patterns that show that total use is equally split with one-half in the busy period and one-half in the remainder of the day.

Figure 4 shows the projection of average video hours used per TV in peak hours—the busy period is 3.5 hours per day[13].

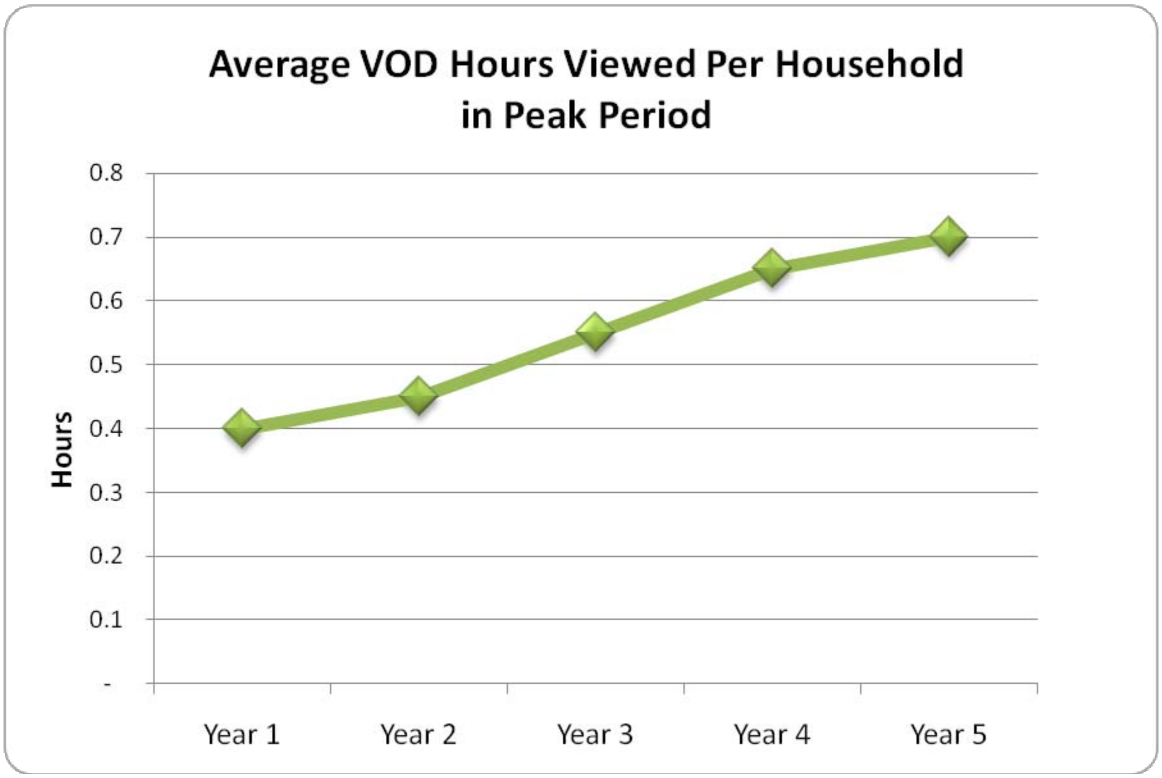

Figure 4
Average VOD Hours Viewed per TV in Peak Hours

[12] Each TV is treated as a separate subscriber since different videos are likely to be viewed on the various TVs in a multi-TV household.
[13] Prime time viewing in weekdays occurs between 8pm to 11pm and on weekends between 7pm to 11pm, comScore Research

M2S Architecture

The M2S Architecture is designed to reduce the network capacity needed to deliver VOD content and to substitute lower cost personal storage for higher cost Video Server storage.

The M2S Architecture uses the same Carrier Ethernet network design that is currently used to deliver Triple Play services within the metro area—See Figure 5 . Intelligent QoS treatment and Layer 2/Layer 3 Switch/Routers are used to deliver services based upon service type. High Speed Internet and voice traffic are routed through the BRAS located within the Super POP while video traffic (broadcast and VOD) are routed from the Video Head End to individual POPs.

The M2S solution employs a Content Distribution Switch (CDS) located at the Video Head End to multicast VOD content during off-peak traffic hours to each DSLAM. Each Set-Top-Box (STB) contains a software client (PSTV) and an incremental storage allotment so as to store content that is most likely to be of interest to each particular user of each STB[14]. A Video Server with associated Storage Drives is located at the Video Head End to fulfill VOD requests that are not loaded onto users' personal storage.

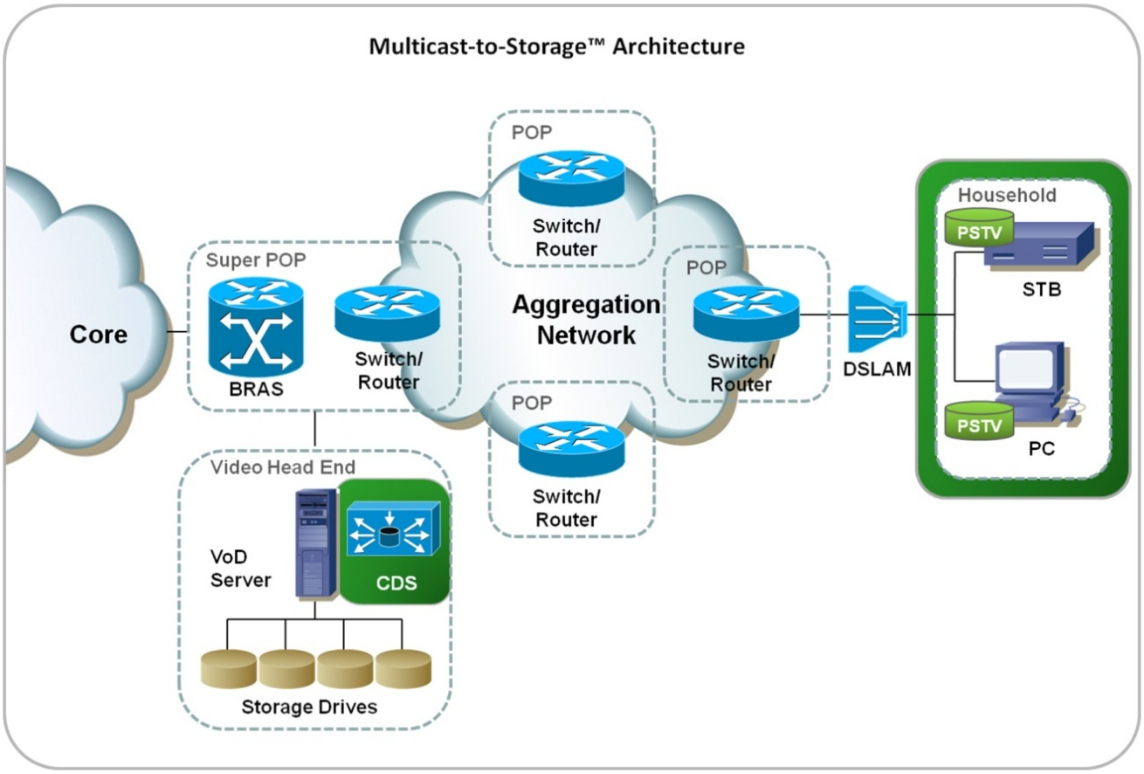

Figure 5

[14] Alternatively total personal storage can be stored centrally within the household and home networking can be used to deliver content to each TV—this does not change the analysis.

Streaming Video Architecture

The Streaming Video Architecture uses a network that is nearly identical to the M2S Architecture—See Figure 6. However, this Architecture relies exclusively upon the Video Server located at the Video Head End for distribution of all VOD requests using real time video streaming. This architecture requires less personal storage capacity and does not use the M2S Software.

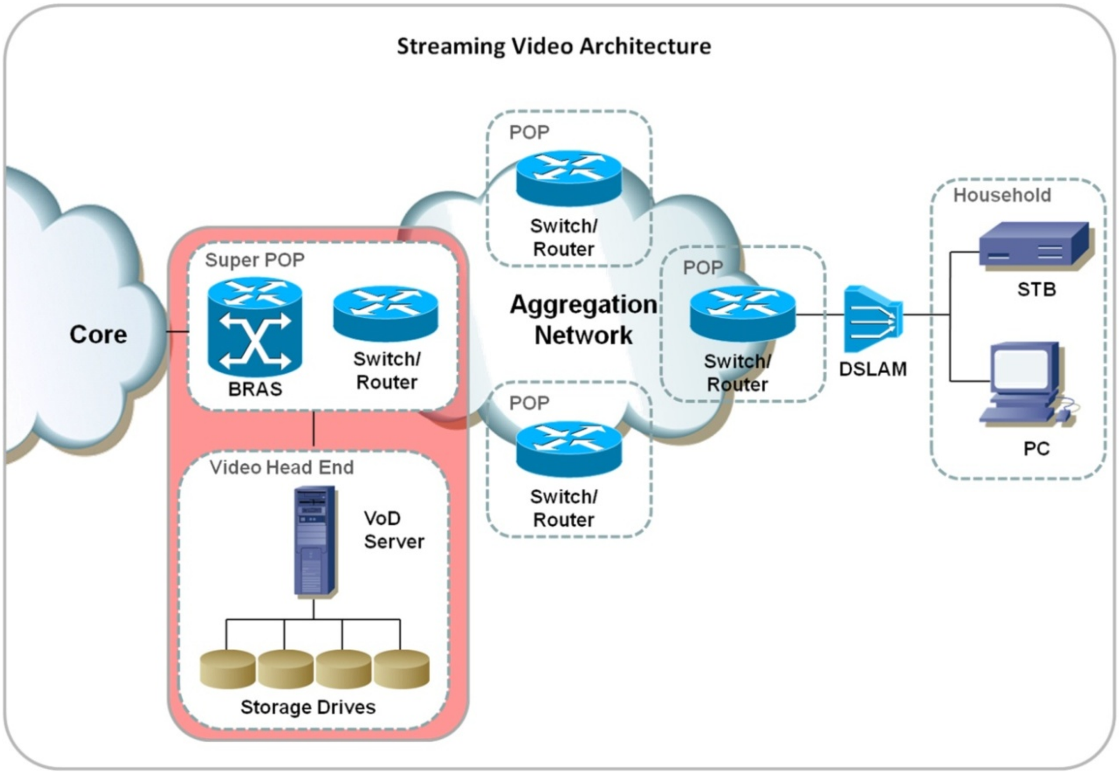

Figure 6
Streaming Video Architecture

Service Delivery, Bandwidth and Storage Projections and Requirements

Both architectures deliver identical services to the same number of TVs, taking into account an average of two TVs per household.

Each TV equipped (Subscribed) for VOD service has the usage characteristics shown in Figure 7. Both architectures are configured to meet this demand level.

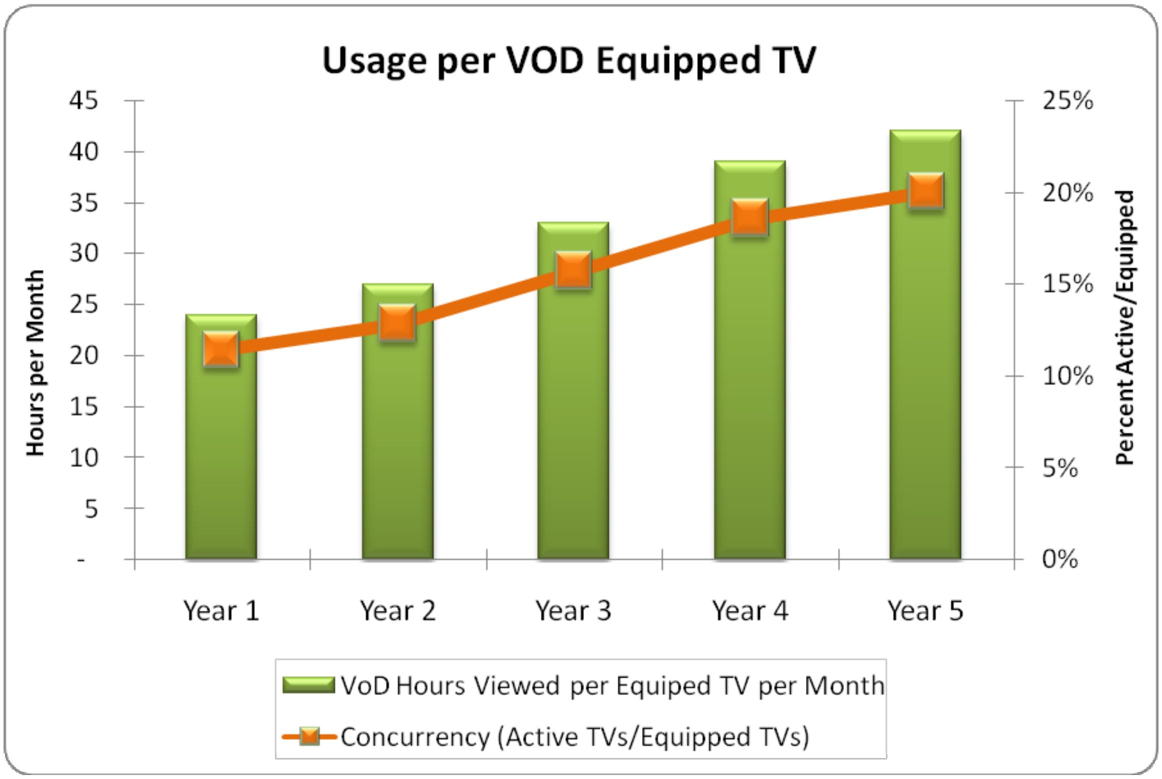

Figure 7
Usage per VOD Equipped TV

Per subscriber usage is expected to increase driven by consumer's changing viewing habits, demanding a personalized, high definition and on-demand TV experience.

Storage Requirements

Both architectures require Video Server and personal storage. The M2S Architecture relies primarily on personal storage for delivery of VOD; however, it also employs Video Server-based storage when a requested title is not available on the viewer's personal storage. The Streaming Video Architecture uses the Video Server exclusively for VOD service delivery. Both architectures use identical amounts of personal storage to support other IPTV functions such as DVR (Digital Video Recorder).

Figure 8 compares personal storage for the two architectures.

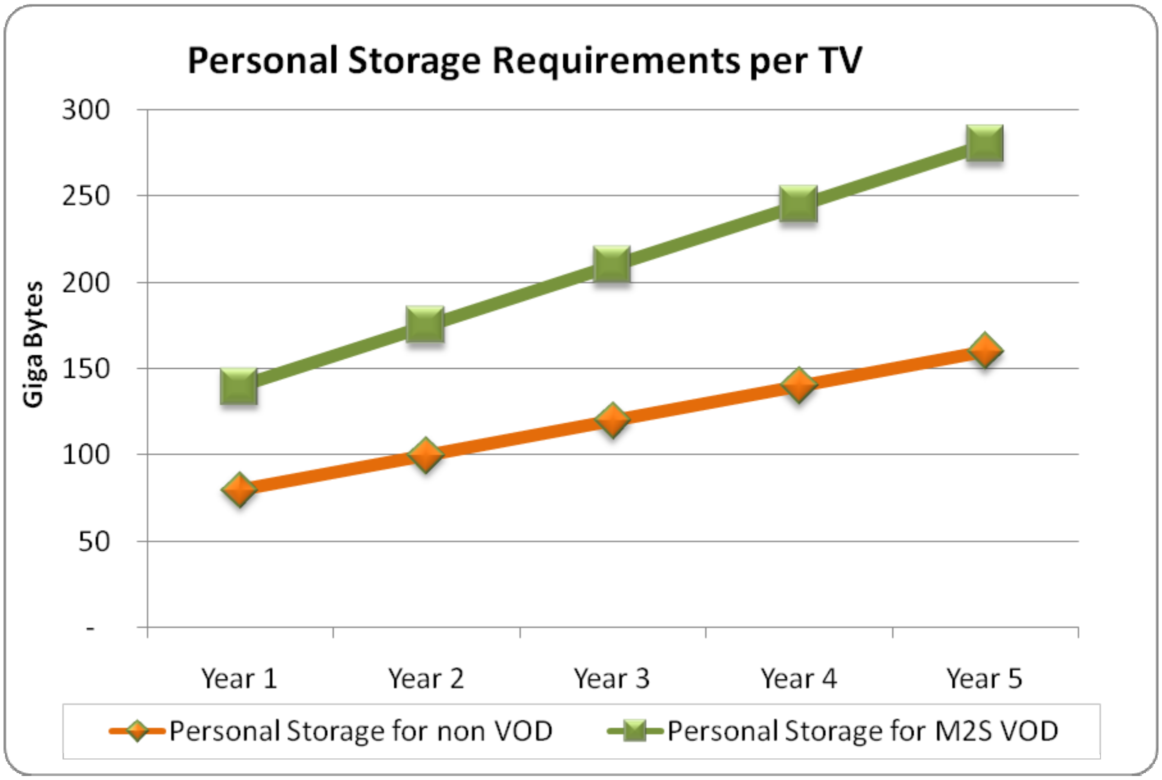

Figure 8
Personal Storage Requirements

The figure shows that total personal storage is expected to increase as the consumer electronics industry develops higher capacity storage devices and as applications continue to increase their personal storage requirements. The M2S incremental storage requirement will also increase reflecting the shift from SDTV to HDTV and the projected greater number of VOD viewing hours.

Figure 9 shows each architectures' demand for Video Server capacity. Whereas personal storage capacity is determined by storage capacity (GB) Video Server capacity is determined by the number of concurrent video streams that must be delivered in the peak period.

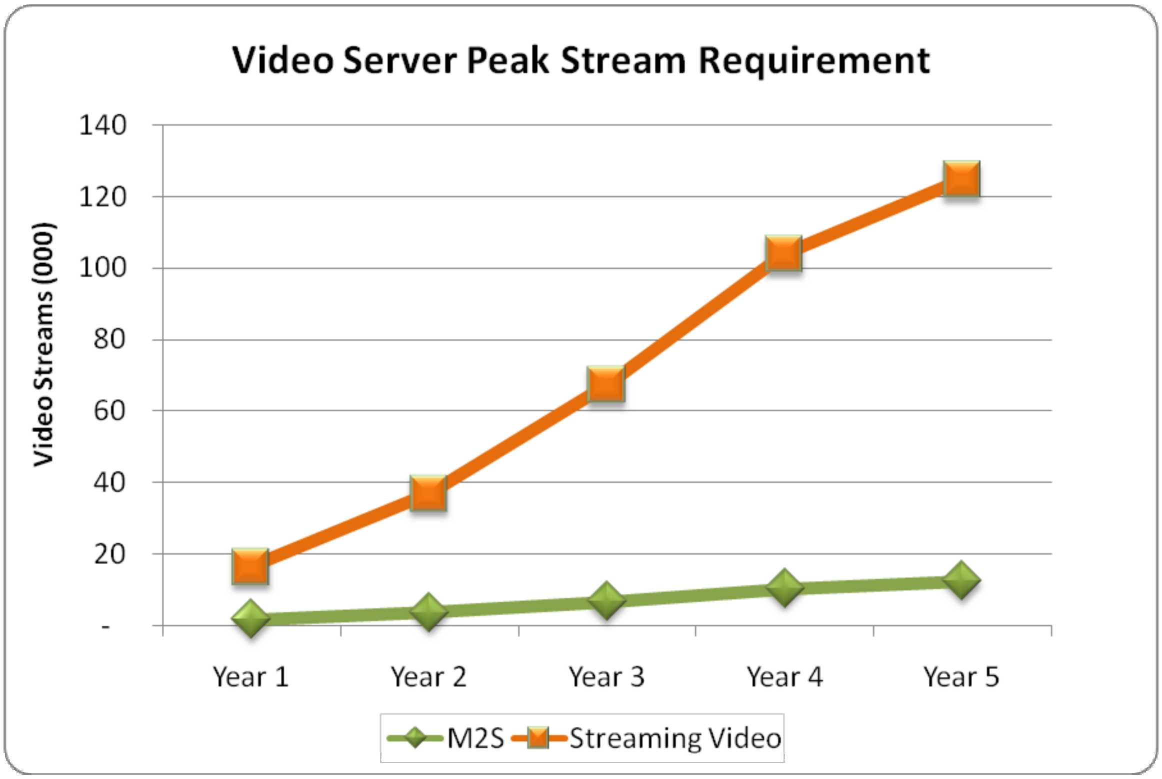

Figure 9
Video Server Peak Stream Requirement

The M2S Architecture dramatically reduces the requirement for Video Server capacity because Video Server capacity is determined by the number of simultaneous video streams it must support during the peak period. The M2S Architecture uses only the Video Server when a requested video is not present in the requestor's personal storage. This has a direct impact on storage costs since personal storage unit costs are far less than those of Video Servers. Furthermore, the indirect impact due to a decrease in the bandwidth requirement of the Aggregation Network is examined in the next section.

Network Capacity Requirements

The Streaming Video Architecture places a great burden on the Aggregation Network for the delivery of VOD content. This is caused by:

- The bandwidth requirement for each VOD stream is much greater than those for Internet and voice usage.

- VOD sessions are much longer than Internet and voice sessions.

- Users will tolerate high-levels of over-subscription for Internet use but over-subscription is unacceptable for IPTV viewing.

- Each request for VOD content is *unicasted* to an individual viewer while broadcast video is *multicasted* to each POP.

Figure 10 shows projected Aggregation Network bandwidth requirements and the associated Aggregation Network port capacities that are consistent with Carrier Ethernet design practices.

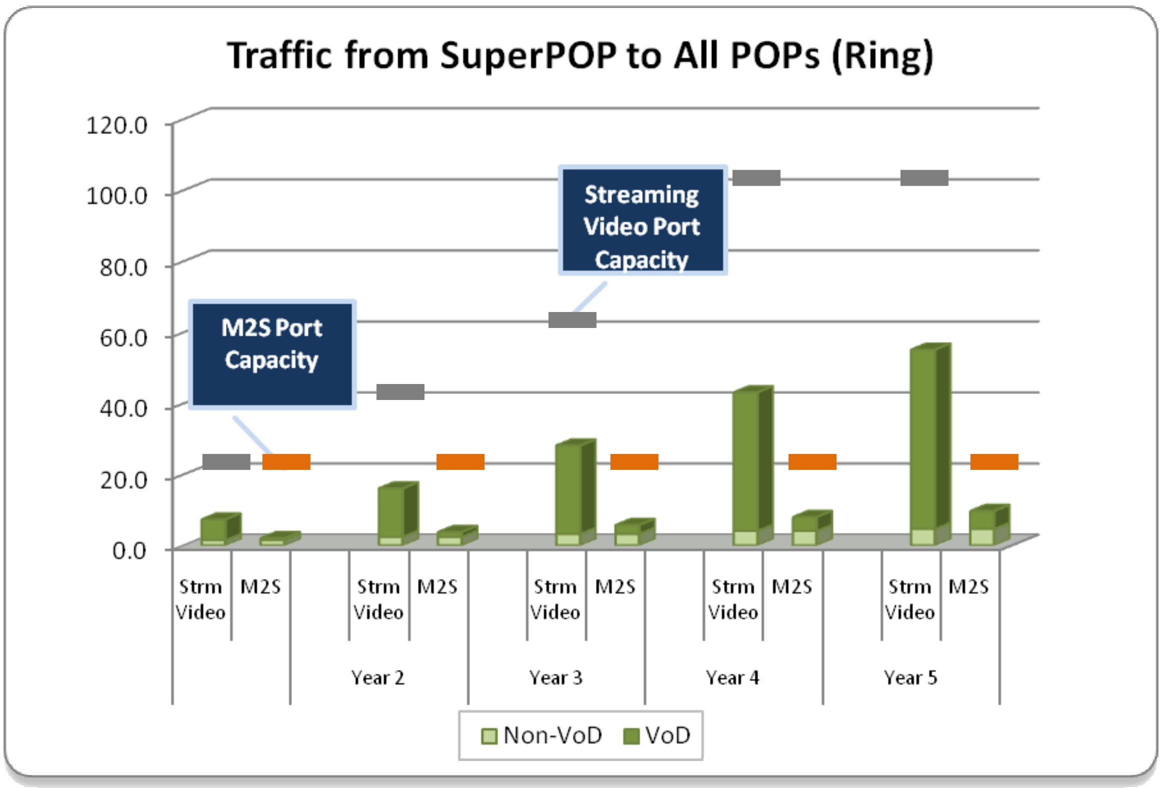

Figure 10
Aggregation Network Capacity Requirements

The vertical bars on the graph depict the Aggregation Network's bandwidth requirement for each switch/router port and the associated transmission link. The Aggregation Network employs a ring topology so that if any single transmission link (or port) fails an alternative path is available to connect each POP to the Super POP. Each port and link is redundant. The capacity estimates include a provision for partial failover protection. The maximum traffic utilization is set to 75% for each port. This implies that two-thirds of the total traffic will be protected in the event of a link or port failure. A Policy Manager is used to assure that the most critical traffic is fully protected while other traffic is only partially protected.

The grey and orange solid bars on the chart show the port capacity called for by the network design. Capacity jumps in 20 Gbps steps because 10 Gbps ports are employed and each port and transmission link is redundant.

The M2S Architecture never requires more than the minimum port requirement of 20 Gbps. This is because it only calls upon the services of the Video Server when a requested video title is not in the viewer's personal storage cache. In contrast, the Streaming Video Architecture requires frequent capacity additions. This results in additional capital expenditures for switch/router ports and large annual increases in operations expense for 10 GE transport services. TCO implications are examined in detail in the next session.

Note that the use of redundant 10 Gbps ports contributes to the lumpiness of network capacity increases. 20 Gbps is a large capacity increase compared to annual traffic growth. This introduces a certain amount of slack such that there is not necessarily a coinciding increase in port capacity for every increase in traffic.

TCO Comparisons

TCO comparisons are made for the incremental cost of supporting VOD services over five years. The increment is calculated by first computing total TCO for three scenarios as follows:

- Base – this scenario uses the Carrier Ethernet Design to estimate the cost of meeting demand for voice, High Speed Internet, and broadcast video services. VOD is not included in the Base scenario.
- M2S – this scenario meets the same demand for voice, High Speed Internet, and broadcast video services as the Base scenario but uses the M2S Architecture to meet the demand for VOD service.
- Streaming Video– this scenario meets the same demand for voice, High Speed Internet, and broadcast video services as the Base scenario but uses the Streaming Video Architecture to meet the demand for VOD service.

The incremental TCO to serve VOD demand is then calculated by subtracting the results of the Base scenario from the results of both the M2S and Streaming Video scenarios. Figure 11 displays the incremental TCO for the M2S and Streaming Video scenarios.

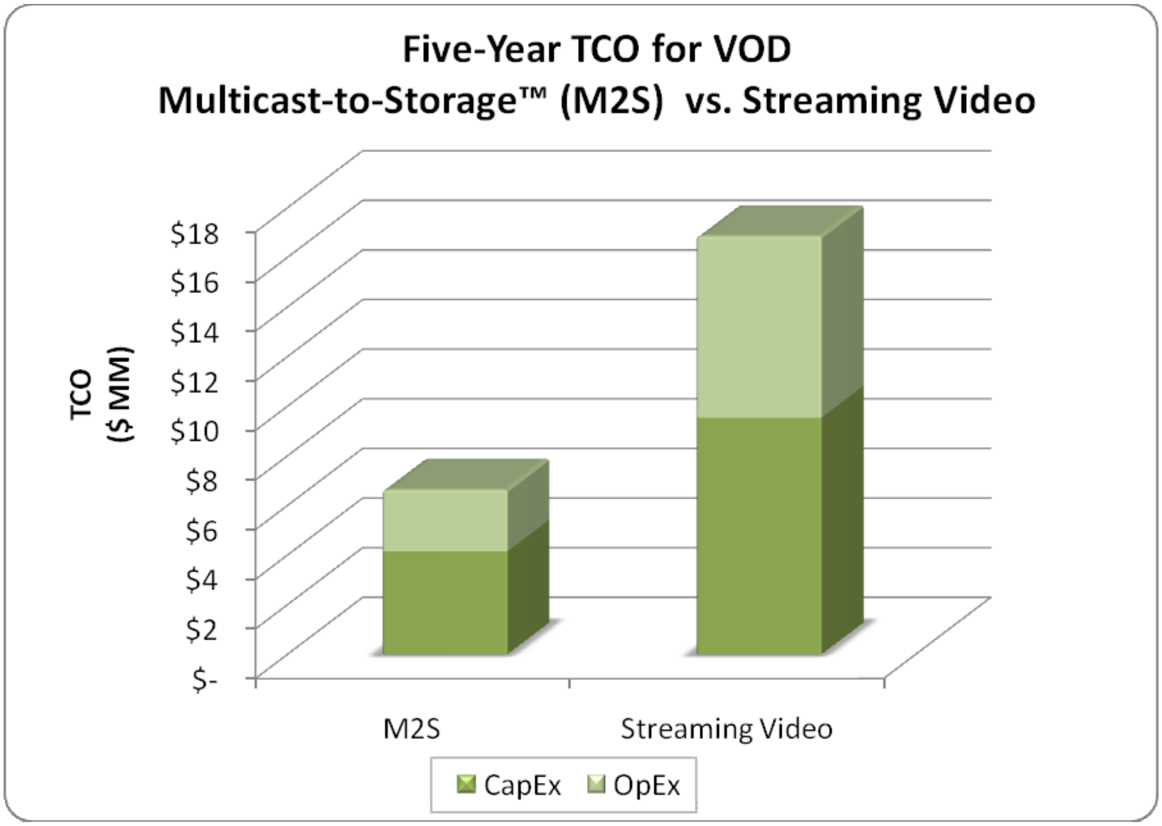

Figure 11
Incremental VOD TCO

The chart shows a substantial TCO advantage for M2S as compared to Streaming Video. The M2S Architecture has 61% lower TCO over five years as compared to Streaming Video. CapEx is 57% lower while OpEx is 65% lower. The following paragraphs drill down into the sources of the savings.

CapEx Savings

Figure 12 shows the incremental CapEx required to deliver VOD services for the M2S and Streaming Video Architectures.

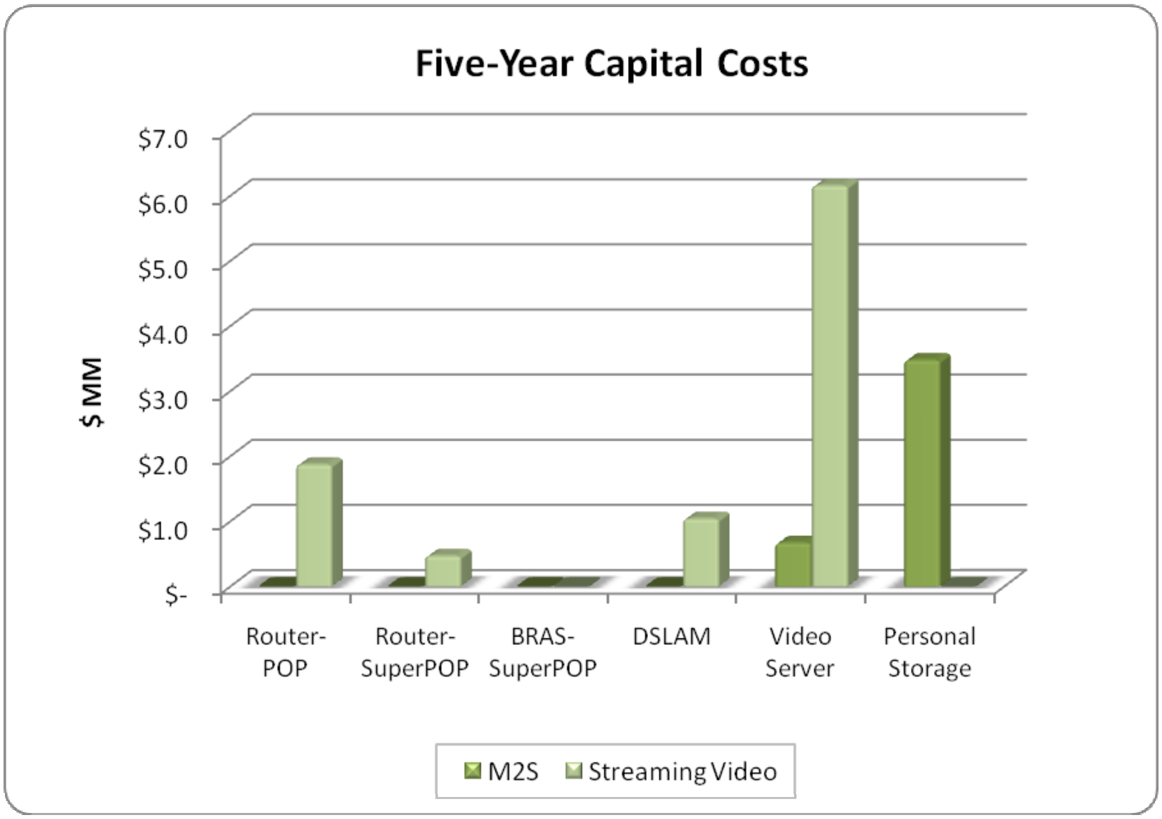

Figure 12
CapEx for VOD Service Delivery

The chart shows that the M2S Architecture incurs substantial CapEx for additional personal storage and a modest Video Server expenditure to provide videos that are not in the viewer's personal storage. It requires no additional network expenditures because video downloads to personal storage do not occur during peak usage periods—idle network capacity is used for downloads. The Streaming Video Architecture requires a very substantial investment in Video Server equipment because it is used to deliver all VOD services as well as additional capacity in Switch/Routers at the POP and Super POP—these are elements of the Aggregation Network. The lower cost of personal storage as compared to Video Server capacity[15] is an important source of M2S's CapEx advantage beyond its lack of an extended network capacity requirement.

[15] Note that Video Server CapEx is determined by the number of simultaneous video streams that must be supported during the busy period rather than by the amount of associated content storage.

OpEx Savings

Figure 13 shows the breakdown of OpEx differences of M2S versus Streaming Video.

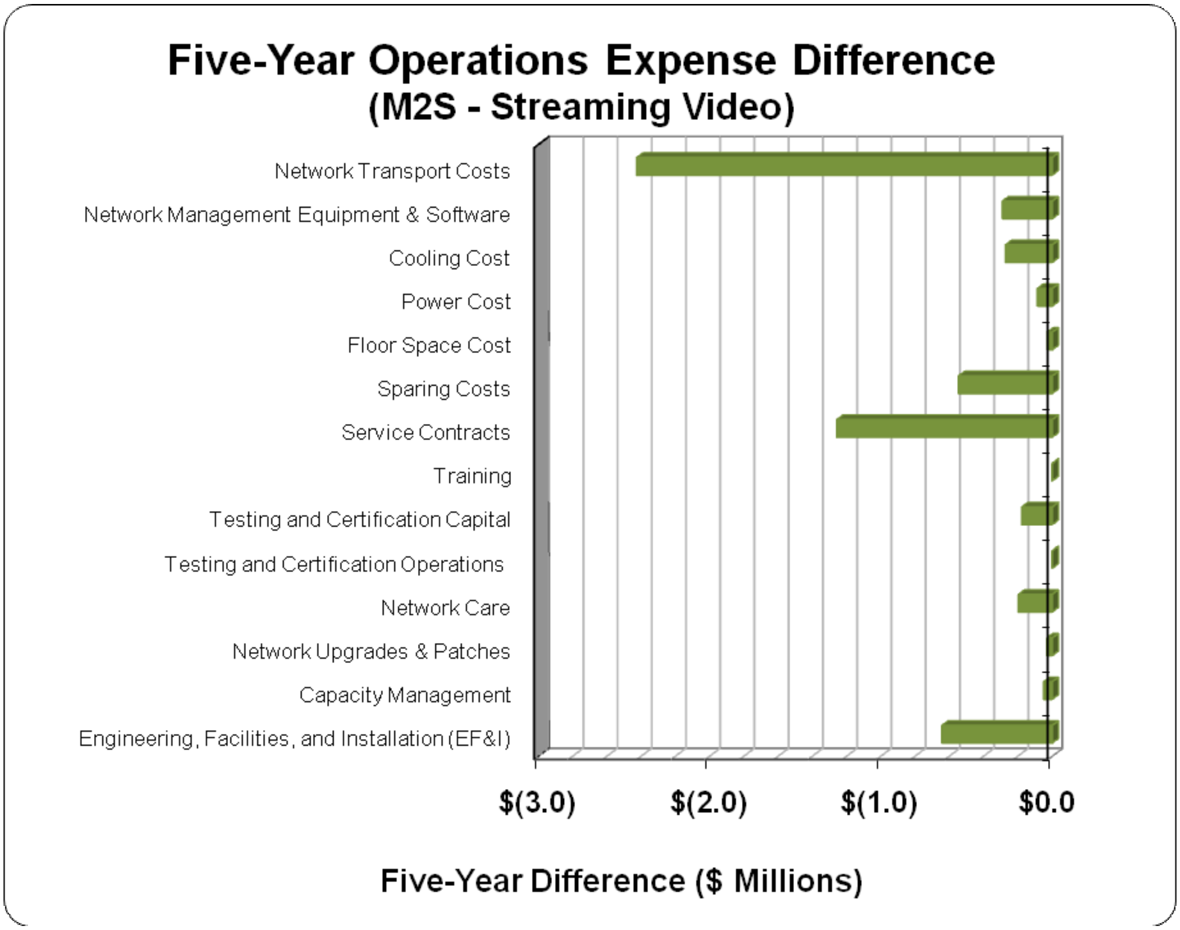

Figure 13
Five-Year OpEx Difference - M2S versus Streaming Video

The chart shows that Network Transport Cost is a significant portion of total OpEx savings. Transport services are sized to meet capacity requirements during peak periods. The cost of providing transport services is treated as an OpEx item and consists of an annual TCO estimate of the cost to own and operate optical transmission equipment and the associated outside plant—fiber optic cables and outside plant structures. M2S places no demand on transport during peak periods and thus eliminates this high cost service element. The other operations cost elements all either favor the M2S Architecture or are equal in cost. This is a result of M2S's use of personal storage for VOD delivery. It eliminates much of the need for housing equipment in the Central Office or POP. Support costs such as cooling, power, and floor space are extremely high in such carrier class buildings. M2S's substitution of personal storage for Carrier Class network equipment and the Video Server also puts other operations expenses on the low consumer electronics cost basis versus the carrier class maintenance levels required for Central Office grade equipment. This accounts for the large Service Contract cost advantage of the M2S Architecture.

Sensitivity Studies

This section examines the sensitivity of the TCO findings to three critical modeling parameters:

- Price of personal storage.
- VOD session concurrency (the percent of total TVs that are active in the busy period).
- Service penetration (the percent of households passed that subscribe to VOD service).

Price of Personal Storage

The price of personal storage is critical to the business case for M2S. M2S uses personal storage instead of a Video Server and network capacity to deliver VOD content. Figure 14 shows how M2S's TCO advantage varies as a function of the rate of decline in the price of personal storage.

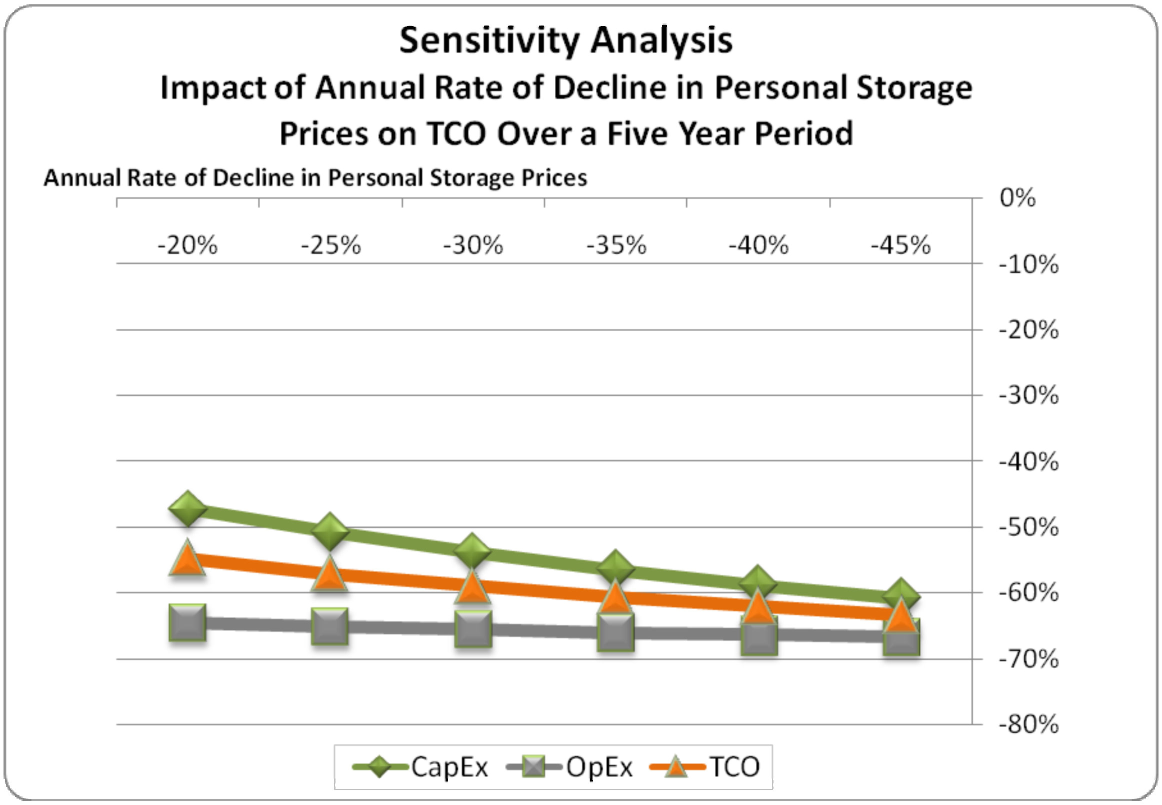

Figure 14
Personal Storage Price Sensitivity

The chart shows the difference in percentage of CapEx, OpEx and TCO of M2S versus Streaming Video given a price of $0.25/GB in Year-1 and an annual percent rate of decline in subsequent years ranging from -20% to -45%. The TCO saving is 55% when the price declines at 20% per year and increases to 63% when the price declines at a rate of 45% per year.

Concurrency

VOD session concurrency — the percent of total TVs that are active in peak hours — is a significant driver of the TCO difference between M2S and Streaming Video because the capacity required to support Streaming Video is sized to meet demand during peak hours while M2S capacity is driven by total daily viewing hours. Figure 15 illustrates TCO's sensitivity to concurrency.

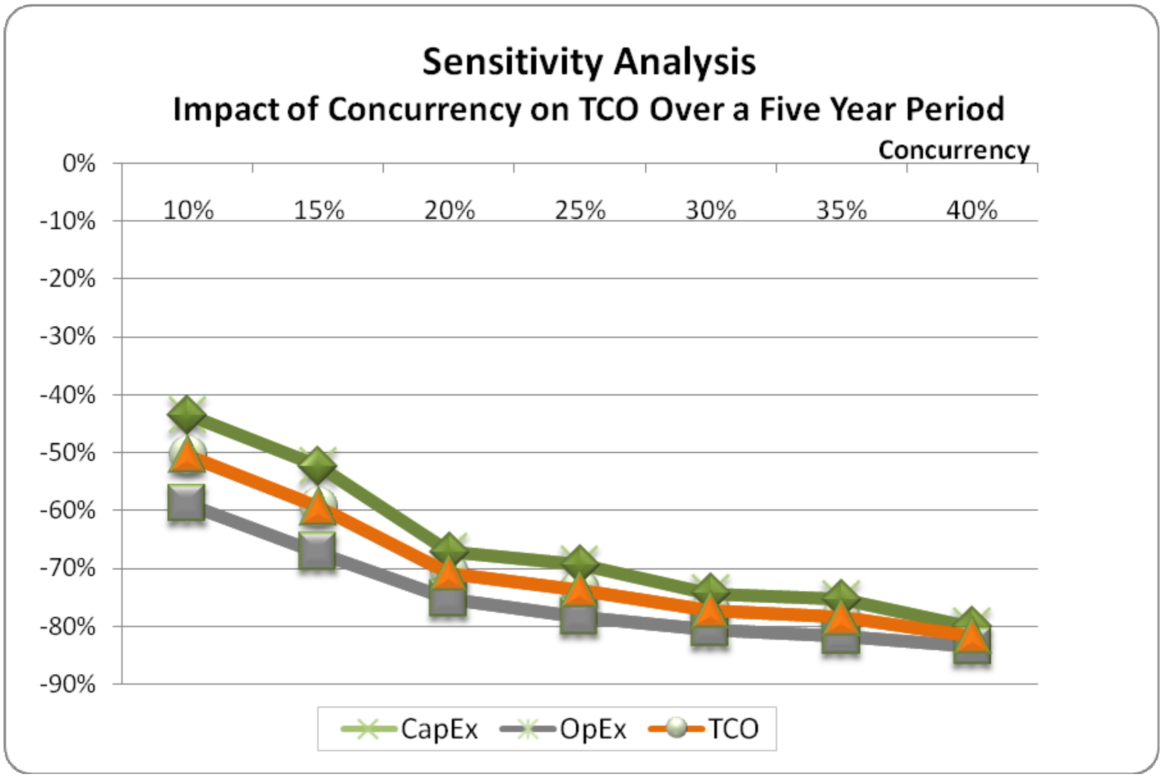

Figure 15
Concurrency Sensitivity

The chart shows the cost savings produced by M2S over a concurrency range of ten percent to forty percent. This corresponds to a range of 21 to 84 minutes of viewing time during peak hours. The TCO saving is 50% at a ten percent concurrency rate and increases to 82% at forty percent concurrency rate. This is a direct result of M2S's Architecture that breaks the linkage between peak period usage, network capacity requirements and storage capacity requirements.

Penetration

Penetration is another important measure of the effectiveness of M2S to meet the needs of increasing scale—penetration is the percent of VOD subscribers compared to households passed by VOD capable facilities[16]. Figure 16 illustrates the sensitivity analysis.

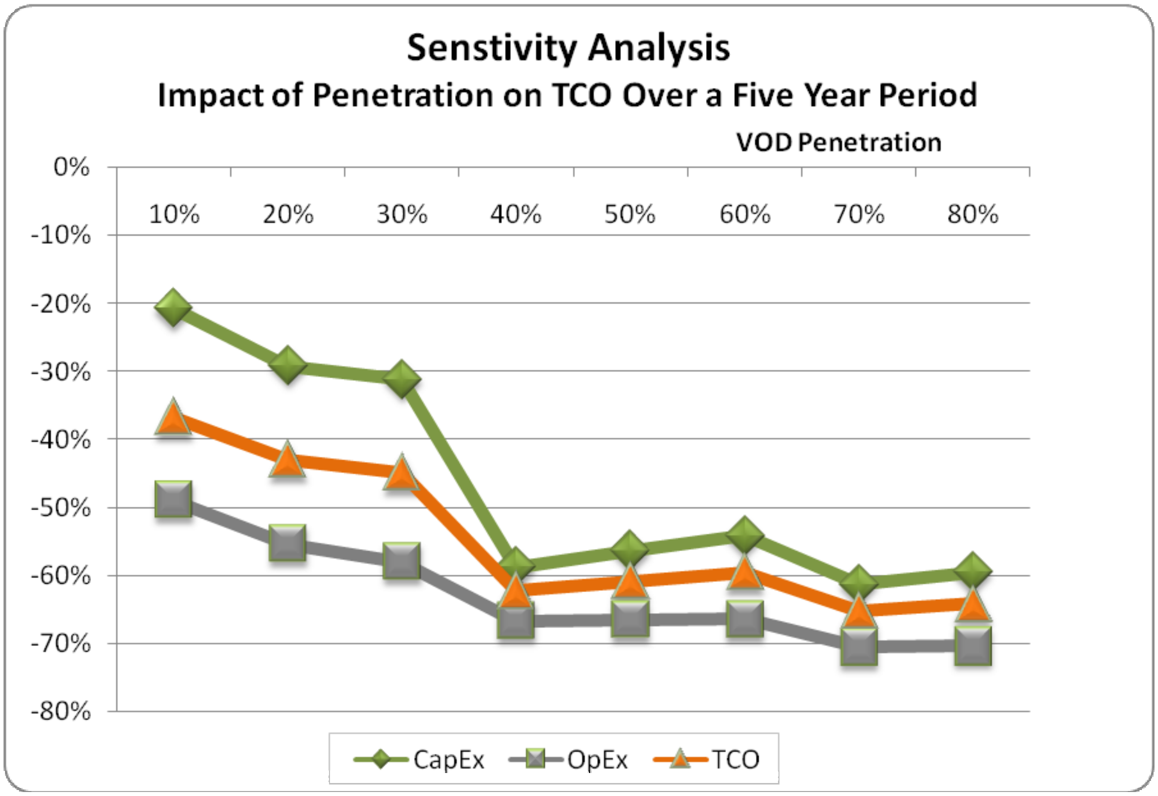

Figure 16
Penetration Sensitivity

The TCO savings from M2S compared to Streaming Video increases with higher penetration. This saving occurs because while Streaming Video requires more network and Video Server capacity as subscribers are added to the network, M2S requires capacity additions only to meet the occasional request for a video that is not resident in the M2S.

The chart shows that the TCO savings is 37% when penetration in Year 5 is 10% and increases to 64% when penetration in Year 5 is 80%. The chart also shows that the TCO savings tend to flatten out once a threshold of 40% penetration by Year 5 is reached.

[16] VoD penetration equals IPTV penetration. This reflects industry practice to make VoD services available to all IPTV subscribers so as to exploit the spontaneous nature of on-demand service.

Conclusions

The TCO for two VOD service delivery architectures—M2S and Streaming Video—was analyzed over a five-year study period for a metro area with an addressable market of 475,200 TVs. The M2S Architecture has 61% lower TCO over the five-years as compared to the Streaming Video Architecture. This is comprised of a CapEx savings of 57% and OpEx savings of 65%.

The largest sources of CapEx savings are the substitution of personal storage for Video Server capacity and M2S's dramatic reduction of required Aggregation Network capacity. Reduced Aggregation Network bandwidth also produces the largest single source of OpEx savings by decreasing 10 GE transport expenses. Other OpEx savings accrue by shifting service delivery functions away from high cost Central Office/POP environments and carrier class networking equipment to personal storage which enjoys the economies of scale of the consumer electronics industry.

Sensitivity studies produced the following detailed findings.

- Annual price declines for personal storage of 20% result in a 55% TCO saving for M2S as compared to Streaming Video and the savings increase to 63% with an annual price decrease of 45%.
- Concurrency of 10% produces a 50% TCO saving for M2S as compared to Streaming Video. This increases to 82% TCO savings at a 40% concurrency rate.
- Subscriber penetration of 10% by Year 5 corresponds to 37% TCO savings for M2S as compared to Streaming Video and increases to 64% TCO savings at 80% penetration rate by Year 5.

The increased TCO savings of M2S with increasing concurrency and subscriber penetration demonstrates the superior scalability of M2S versus Streaming Video.

About Intercast Networks (formerly Arootz)

Intercast Networks' Multicast-to-Storage™ (M2S) offers a new technological approach to optimize content delivery over IP networks. M2S delivers massive amounts of personalized, high quality content on-demand to various storage equipped consumer devices such as PCs, Set-Top-Boxes and Gaming consoles. Intercast Networks is pioneering the use of Multicast for the efficient delivery of large scale digital content such as standard and high definition video and next generation video games over IP infrastructures.

Intercast Networks' solution enables network operators to leverage their current infrastructure roll out to deliver an order of magnitude more personalized content at a fraction of the cost without additional network investments. M2S can be utilized to introduce a variety of profitable Internet based services including a personalized, high definition and on-demand TV experience with broadcast-like network scalability and economic efficiencies.

For further information, please visit www.intercast.com.