CABLE-TEC EXPO 2007

CAPACITY UTILIZATION TRENDS AND ANALYSIS IN COMBINED HD/SD ON DEMAND NETWORKS

Case Studies & Empirical Data

by

Barry Hardek
VP/Marketing & Business Development
Everstream Inc.
Email: bhardek@everstream.com

and

Craig Schwabl
CTO
Everstream Inc.
Email: cschwabl@everstream.com

Website: http://www.everstream.com

March 30, 2007

TABLE OF CONTENTS

Background

High definition television is a phenomenon that has reached critical mass in terms of market penetration. By Q1 of 2007, it is estimated that 30% of US households have at least one HD-capable set. Going forward, decreasing set prices, increasing program offerings, competition and government mandates will make the proliferation of high definition technology ramp at even higher rate, creating greater expectations from cable subscribers in general, and from video on demand (VOD) users in particular.

Regardless of display technology, Video On Demand use is escalating on the same general trajectory as HDTV adoption. Interactive and on demand services have become a key differentiator for cable service providers, and the proliferation of free on demand (FOD) and subscription video on demand (SVOD) have made instant access services a part of the subscriber's regular viewing experience. Satellite providers, in turn, have responded by aggressively adding more linear HD content.

For the network architect, the associated challenge with combined advancement of HDTV and VOD is determining how-and-when to add on demand network capacity, especially in regards to high definition on demand. With MPEG-2 high definition programming consuming roughly 4 times the bandwidth of the typical standard definition stream, network capacity can be rapidly absorbed without careful planning. Still, the inclusion of high definition content to the VOD library does not automatically suggest a massive increase in VOD network bandwidth. Intelligent analysis must be applied to manage this initial phase of "HDVOD," as well as to prepare for its future.

VOD Market Snapshot

Within the cable industry, the rampant growth of VOD goes without saying. Many of us, including the authors of this paper, support the VOD industry, so we can rightfully be accused of subjectivity. Still, a host of studies and reports not only support what most of us sense, but add depth to our understanding of the current market dynamics. Consider for a moment these statistics:

- The reported mean number of total on-demand programs and movies ordered per week increased by 33% in the past year ('05 to '06) --- to 4.8 per week.
- Premium on-demand programs and movies account for half of all reported on-demand usage.[1]
- 64% of VOD users say that they usually watch recorded or on-demand programs when there is no regularly scheduled TV on that they want to watch.[2]

As these statistics indicate, Video on Demand services have advanced from being a kind of "pay per view on steroids" to becoming a regular habit, and an expectation of cable subscribers. Anecdotally, we've heard of budding program networks that choose VOD over other options because of its growing popularity. And with "Start Over" services and other fast turn broadcast-to-VOD replay offerings, consumers will be increasingly asking, "Why can't I get that on Video on Demand?"

There is also evidence that the return on investment for linear programming has decreased significantly. A Nielsen Media study released in March reported that in 2006 the average US home received 104.2 channels --- an increase of almost 8 channels from 2005, and a jump of more than 40 channels since 2000. In contrast, the average household tuned to only 15.7 of those 104 channels in 2006, versus 13.2 channels tuned by the average home in 2000.[3] For the capacity planner, adding more than 40 channels to acquire an additional 2 channels tuned must seem like a waste of precious bandwidth.

HDTV Market Snapshot

If Video on Demand is becoming a fact of viewing life, HDTV display technology is percolating through US homes in a similar manner. Numerous studies and reports peg US HDTV penetration at upwards of 25% of U.S. households. It comes as no surprise that adoption is skewed towards higher income buyers. As of October of 2006, the average household income of HDTV buyers was $89,500 — 42% above the national average and unchanged in the last year, even as prices for plasma HDTVs fell 30%, and LCD models fell 15%. [4]

Studies suggest that the placement and use of HDTV sets in the home is somewhat limited and, in some cases, more about perception than reality. First, HDTV sets are largely confined to the prime viewing area in the home, while standard definitions sets are moving to secondary outlets. Second, some consumers are purchasing high definition sets without much depth of understanding. According to the Leichtman Research Group, 25% of HDTV owners think they are watching high definition content when they, in fact, are not.[5] While limited understanding may work in the favor of capacity planners for some short period of time, consumers can be expected to become more educated and demanding as HD content proliferates.

VOD Network Capacity Studies

One core objective of our analysis was to get some early returns on the impact of high definition content when added to an overall VOD distribution strata that is significantly expanding. In order to do that, we extracted representative data from several real-world systems. Please note that these systems were not selected scientifically, but were chosen because they were subjectively felt to reflect markets, metrics, and situations that cable operators are beginning to experience today, and will increasingly do so in the future.

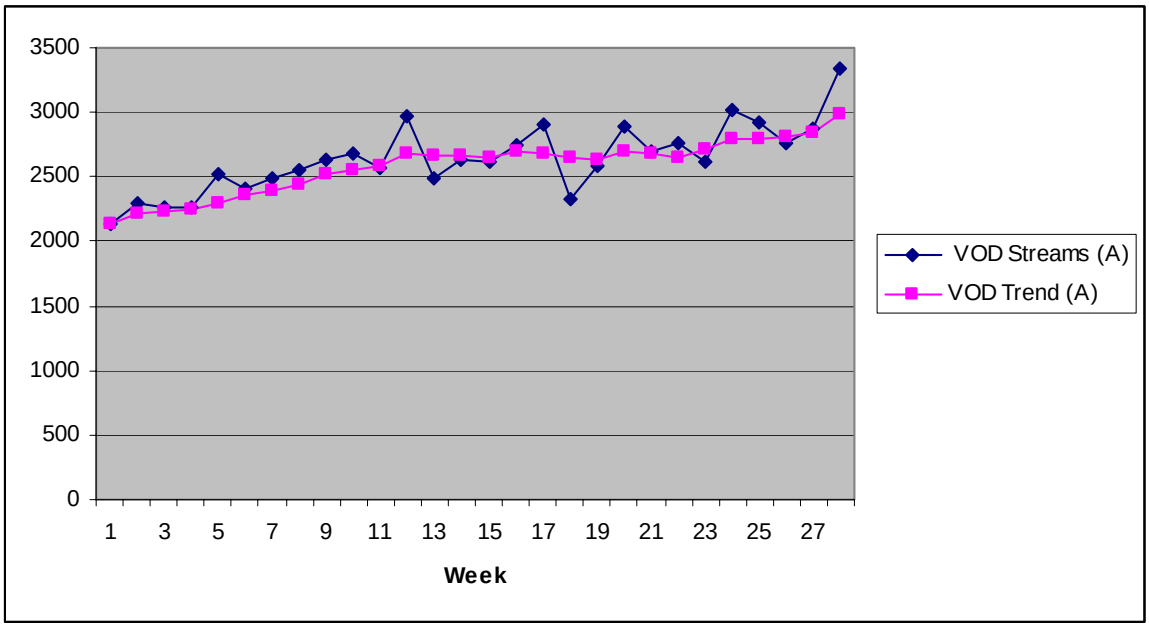
Initially, we want to establish an overall baseline for VOD usage. With the growing movement towards free on demand content and subscription Video On Demand (SVOD) subscriber usage and associated capacity measures are changing rapidly, but we needed some historical “runway” in order to establish overall trending. We also knew that TV viewership tends to fall off over the summer, when outdoor activities, vacations, and an associated reduction in compelling TV content pushes viewership down. A basic tenet of capacity planning is to design for peak utilization periods, so the summer season was clearly sub-optimal. Considering both duration of HDVOD availability along with seasonal downturn factors, we decided to focus on several systems with a minimum of the 26 weeks of measurable HDVOD activity, excluding the summer of 2006.

The first system we studied, referred to as “System A,” represents a mid-sized suburban network, serving less than 50,000 subscribers. The VOD library supporting System A is large and varied, with a mix of free, subscription, and pay VOD content. The time study of total VOD streams used by week in Chart 1 depicts a scenario that is representative of the cable industry at-large --- VOD usage is going steadily up. In the case of System A, the normalized VOD stream count usage trend began the measurement period just over 2100.[i] Twenty six weeks later, VOD usage was trending consistently above 3,300[ii] streams per week, representing an increase of over 23% over a 6-month period.

Finally, please note that certain metrics, although proportionately accurate and derived from actual field data, have been purposely obscured to protect customer anonymity.

[i] Not an absolute measure, but proportionate to the actual metric observed.
[ii] Ibid.

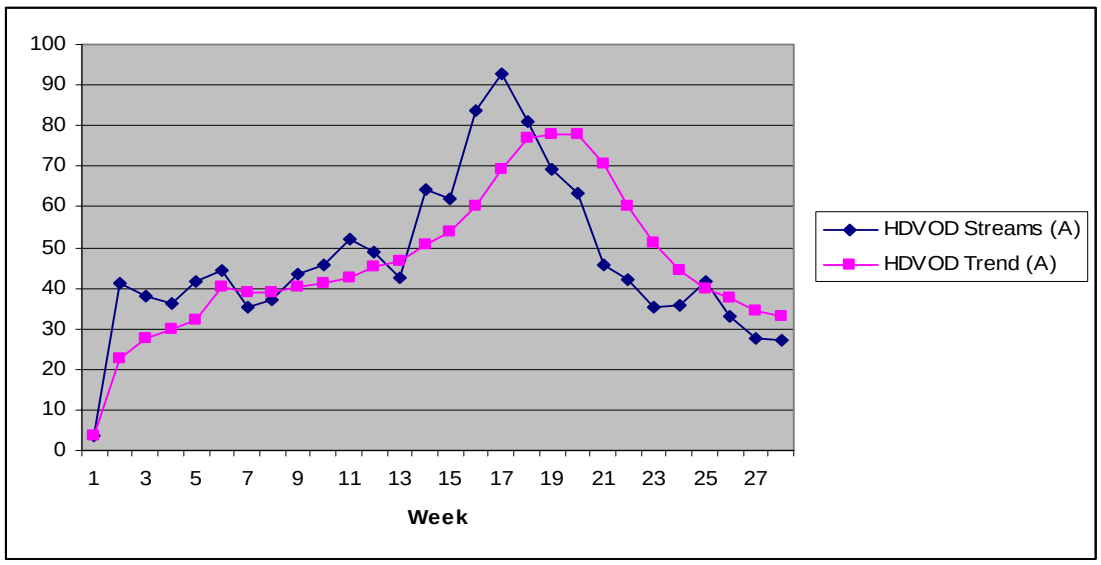
Chart 1 - Total VOD Streams/System A



Note: Trend points are calculated by averaging the current week's stream count plus the previous 4 readings with the exception of weeks 1-4, when the current stream count plus all previous measures are averaged.

The high definition component of System A stream counts, if viewed on the same scale, would be barely noticeable, but still exhibits some interesting characteristics when examined in isolation. Chart 2 depicts the HD On Demand content in System A, exhibiting a peak in the middle of the measurement.. Considering the entire measurement period, HD streams peak above 3%, leveling off between 1% and 2% thereafter.

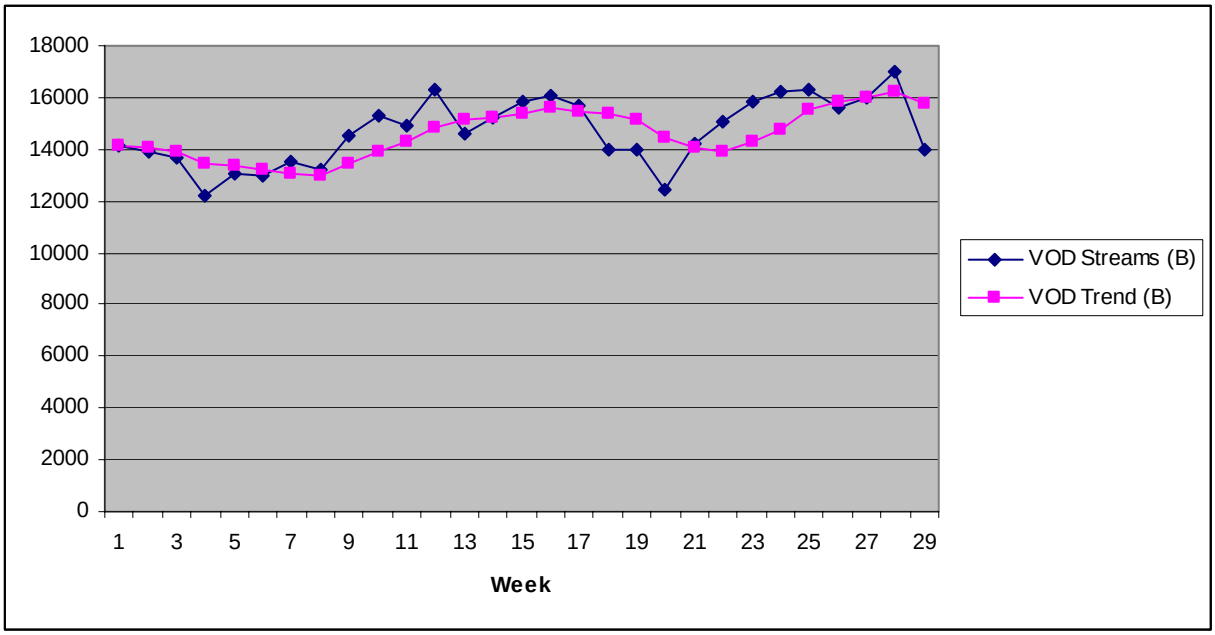
Chart 2 - HDVOD Streams /System A



Viewed from the stream count perspective, one might conclude that the introduction of high definition content was of negligible impact. Considered from a capacity perspective, however, the advent of high definition on demand was significant. Since MPEG-2 high definition streams consume roughly 4 times the bandwidth of their standard definition counterparts, the System A data suggest that HD On Demand had consumed as much as 12% of the total on demand bandwidth distributed at its highest point, and was nominally representing 4% to 8% of the network's VOD bandwidth going forward.

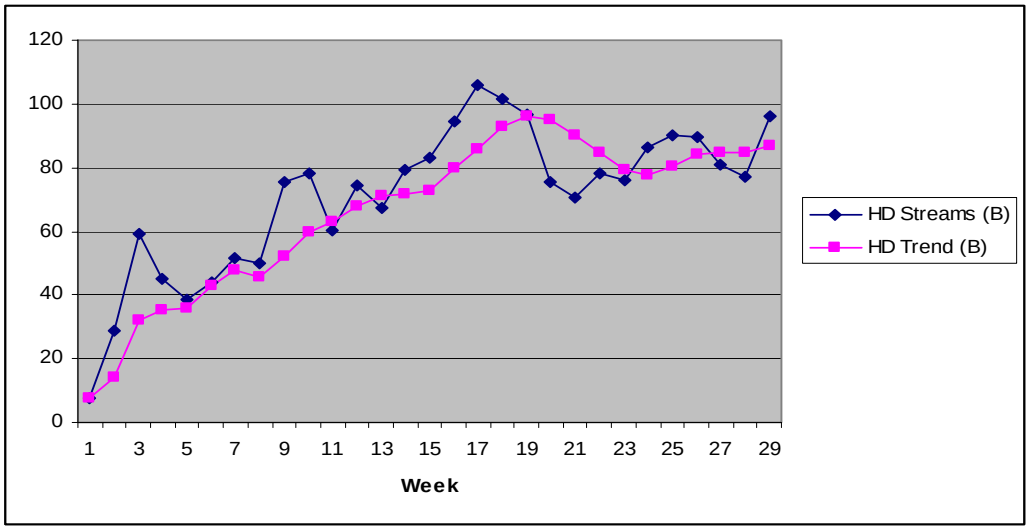
The second system we selected to examine exhibits some similar, but not exactly the same VOD streaming characteristics as System A. "System B," represents a large urban/suburban network, with well over 100,000 subscribers. Like System A, the VOD library supporting System B is large and varied, with a mix of free, subscription, and pay VOD content. But, unlike System A, the overall VOD stream count growth in System B has advanced only roughly 10% over the measurement period, as compared to 23%.

Chart 3 - Total VOD Streams/System B



Curiously, the HDTV component of total VOD streams, while still miniscule, exhibits a more consistent upward trend than System B. One might attribute that to more aggressive retail and service provider promotion over the holidays in System A, or the fact that System B is a larger system with a less affluent demographic. Regardless of the trend line, the actual percentage of HDVOD against all VOD streams in System B is well under 1%, while the high definition contribution in System A hovers almost a full percentage point higher.

Chart 4 - Total HDVOD Streams/System B



Once again, analyzing stream counts in isolation can be deceiving. Considering the relatively slight stream counts in System B can obscure the fact that HDVOD was regularly accounting for 2%-3% of total VOD system bandwidth.

A Closer Look at the Numbers

A service type that can rapidly account for up to 12% of total bandwidth is significant, especially when layered on top of the rising tide of VOD in general. Clearly, a deeper inspection is required to assess the true impact on the overall broadband VOD network. Hybrid fiber coax networks are remarkably adaptable, and an assumption of uniformity can lead to some erroneous conclusions. Still, for the sake of analysis, let's review some basic architectural assumptions that are representative of many, but not all, existing VOD network designs.

It is not uncommon for VOD Service Groups to be configured with 4 dedicated QAMs providing approximately 155 Mbps of available bandwidth capacity, or 40 SD streams, serving a group of approximately 1,000 households passed with roughly 300 VOD-enabled digital subscribers contained within. For the network architect, the critical factor in effective network design is to ensure that there is ample capacity during peak usage periods, without leaving excess capacity --- and the capital associated with this network overhead --- lying dormant.

Our previous analysis clearly showed that overall VOD usage was trending up, and that HD content, while not yet a substantial portion of overall stream count, was rapidly absorbing its share of bandwidth. Still, the critical question is not how much bandwidth is being used by VOD, but the whether systems are approaching or even exceeding capacity limits during periods of the peak usage. If we are approaching capacity limits, a deeper issue is whether the network is approaching bandwidth boundaries on a consistent and widespread basis.

Since one clear objective of our analysis was to examine and project what the growing impact of High Definition On Demand will be on network bandwidth, we decided to analyze capacity utilization by determining whether their Service Groups could readily support additional HD sessions. Simple math suggests that, based on the common architecture of 155 Mbps per service group, along with HD content

that consumes roughly 15 Mbps per stream, service groups approaching 80% to 90% utilization were considered "at risk" in our analysis. Service groups with an average peak[iii] of more than 90% were placed in the "Type 1" risk category since there was clearly no room for even one additional HDVOD stream. Service groups with an average peak of greater than 80% to 90% were recorded in the Type 2 risk category since they had enough bandwidth for, perhaps, 1 additional HDVOD stream, but definitely not 2. We recognized that the assumptions we established are subject to debate, but we felt that served as reasonable watermarks for network bandwidth related to growing demands for VOD capacity in general, and for HD content in particular.

Table 1 - Service Group Capacity "At Risk" Analysis/System A

Month	% Type 1	% Type 2	Total % Type 1 & 2
1	26.0%	14.0%	40.0%
2	22.0%	14.0%	36.0%
3	28.0%	18.0%	46.0%
4	26.0%	24.0%	50.0%
5	45.3%	20.8%	66.0%
6	41.1%	17.9%	58.9%

Although the boundary conditions for being "at risk" are somewhat arbitrary, System A's VOD headroom is clearly shrinking over time, and the network's ability to add streams, especially HD streams, is increasingly under pressure. Focusing only on the last column, the table above shows the total "At Risk" % increasing from 40% to roughly 60% over a 6 month period.

The VOD capacity situation in System B, as depicted in the following table, appears to be much less threatening. Although At Risk service groups are still trending upwards, total Type 1 and 2 service groups never exceed 10%, and suspect service groups are predominantly of the Type 2 variety.

Table 2 - Service Group Capacity "At Risk" Analysis/System B

Month	% Type 1	% Type 2	Total % Type 1 & 2
1	0.3%	1.0%	1.4%
2	0.3%	3.8%	4.2%
3	0.7%	4.2%	4.8%
4	0.3%	3.5%	3.8%
5	0.3%	3.5%	3.8%
6	2.8%	4.8%	7.6%

A network architect reviewing the metrics in Table 2 could easily develop a false sense of security, but a more thorough analysis reveals that both systems, while providing excellent service to the majority of the VOD customers, have some cause for concern, especially in regards to HDVOD service.

[iii] The average of each service group's 3 highest capacity utilization measures during the month under study.

Beyond the Percentages

While percentage metrics are often simple and accurate indicators, looks are deceiving in the case of HD capacity analysis. To truly understand the nature of available high definition bandwidth, one must consider how MPEG-2 HDTV content is transmitted on the broadband network.

Typical high definition program streams require at least 15 Mbps of *contiguous* bandwidth to transmit an HD stream. This translates into roughly 2.4 MHz of contiguous RF spectrum. Today's digital set-tops are not capable of separate streams into a single content unit, as is commonly done in IP networks and applications. The impact this contiguous payload phenomenon has on HD percentage measurements is striking. To illustrate this point, consider the following example scenario for Service Group X:

Table 3 - Contiguous HD Payload/Worst Case Example

SERVICE GROUP X	Available BW/QAM Output	QAM Utilization[iv]	Remaining BW/QAM Output	Can support a HD stream?
QAM1	38.8	67.70%	12.6	NO
QAM2	38.8	67.70%	12.6	NO
QAM3	38.8	67.70%	12.6	NO
QAM4	38.8	67.70%	12.6	NO
Total	**155.2**	**67.70%**	**50.4**	**NO**

As per our reference architecture, Service Group X uses a cluster of 4 QAM modulators with an aggregate bandwidth of 155 Mbps, to service the VOD-enabled subscribers in its coverage area. In this example, each QAM output is roughly two-thirds utilized, leaving 12.6 Mbps available per modulator, and a percentage of utilization of 67.7% for the entire service group. Such a percentage utilization would not even qualify Service Group X for either the Type 1 or Type 2 "At Risk" consideration, and one might develop a false sense of security because of it.

Further scrutiny reveals that, despite almost 33% of theoretical overhead, **no additional HD streams** can be delivered to within Service Group X**.** The reason is that an MPEG-2 high definition stream requires 15 Mbps of **contiguous** bandwidth, and no such block of spectrum exists within the service group. With this insight in mind, we returned to System A explore whether this deceptive "HD blocking" scenario was occurring in a real operating environment.

To test our hypothesis, we analyzed System A at a time and day around a traditional peak utilization time --- Saturday night from roughly 8:00 PM to 10:00 PM, looking for error conditions that indicate stream failures due to insufficient bandwidth.

[iv] 7 SD Streams at 3.75Mbps each

Table 4 - HD On Demand Blocking Query /System A

SESSION TIME	TYPE	SERVICE	PRICE
3/17/2007 20:39	HD	SVOD	FREE
3/17/2007 20:37	HD	SVOD	FREE
3/17/2007 20:56	HD	MOD	PAY
3/17/2007 20:54	HD	MOD	PAY
3/17/2007 20:54	HD	MOD	PAY
3/17/2007 20:54	HD	MOD	PAY
3/17/2007 20:54	HD	MOD	PAY
3/17/2007 20:54	HD	MOD	PAY
3/17/2007 21:58	HD	MOD	FREE
3/17/2007 21:58	HD	MOD	FREE
3/17/2007 21:32	HD	MOD	PAY
3/17/2007 21:31	HD	MOD	PAY
3/17/2007 21:26	HD	MOD	PAY
3/17/2007 21:24	HD	MOD	PAY
3/17/2007 21:23	HD	MOD	PAY
3/17/2007 21:22	HD	MOD	PAY

In this particular example, there were 16 such insufficient bandwidth instances reported, but in no instance was the available capacity reporting as greater than 80%. **In every case, the content type associated with the error was high definition**. It is also worth noting that the ratio of pay-to-free content recorded was 2-to-1, representing roughly the inverse of the ratio of pay-to-free streams on the System A network at-large. Sixteen instances of VOD service denial, occurring at a peak period of usage, initially suggest a serious problem, but more careful analysis reveals that:

1. Blocking occurred at only 4 service groups, representing well under 10% of total service groups within the System A network;
2. The above-mentioned service denials occurred during a 43 minute time period.

With those facts in hand, one may now be tempted to conclude that this particular problem was isolated in nature. While that perspective may in fact be justifiable, we believe that the old adage, “A stitch in time saves nine,” applies here. Considering demographic statistics presented earlier in this paper, cable operators run the risk of disappointing a very desirable market segment --- affluent early adopters who gravitate to pay VOD services --- if this problem is not expeditiously addressed.

A similar query of System B on the very same night and time slot yields data that, while not exactly the same as System A, exhibits a similar HD blocking phenomenon. As shown in the following table, there were 33 cases of insufficient bandwidth in this instance. Reported service group capacity approached, but never exceeded, 90%, making most of these instances the lower severity “Type 2,” problems by our previous standard. Once again, **the content type associated with the error was a high definition in every case**. Unlike our previous analysis, the percentage of pay VOD streams that were affected by insufficient bandwidth was dramatically skewed towards pay. For System B, pay VOD was impacted in 27% of the blocking instances, which is roughly similar to the pay-to-free VOD ratio across all time slots.

Table 4 - HD On Demand Blocking Query /System B

SESSION TIME	TYPE	SERVICE	PRICE
3/17/2007 19:26	HD	MOD	Free
3/17/2007 19:32	HD	MOD	Free
3/17/2007 19:32	HD	MOD	Free
3/17/2007 19:33	HD	MOD	Free
3/17/2007 20:17	HD	MOD	Free
3/17/2007 20:18	HD	MOD	Free
3/17/2007 21:45	HD	SVOD	Free
3/17/2007 21:46	HD	SVOD	Free
3/17/2007 20:08	HD	SVOD	Free
3/17/2007 20:08	HD	SVOD	Free
3/17/2007 20:09	HD	SVOD	Free
3/17/2007 19:02	HD	SVOD	Free
3/17/2007 19:02	HD	SVOD	Free
3/17/2007 19:02	HD	SVOD	Free
3/17/2007 19:03	HD	SVOD	Free
3/17/2007 19:03	HD	SVOD	Free
3/17/2007 19:03	HD	MOD	Free
3/17/2007 19:03	HD	MOD	Free
3/17/2007 19:51	HD	MOD	Pay
3/17/2007 19:51	HD	MOD	Pay
3/17/2007 19:51	HD	MOD	Pay
3/17/2007 19:57	HD	MOD	Pay
3/17/2007 19:58	HD	MOD	Pay
3/17/2007 19:58	HD	MOD	Pay
3/17/2007 20:01	HD	MOD	Pay
3/17/2007 20:05	HD	MOD	Pay
3/17/2007 20:08	HD	MOD	Free
3/17/2007 20:08	HD	MOD	Free
3/17/2007 20:09	HD	MOD	Free
3/17/2007 20:13	HD	MOD	Pay
3/17/2007 20:19	HD	MOD	Pay
3/17/2007 22:03	HD	MOD	Free
3/17/2007 21:07	HD	SVOD	Free

The time segment where these blocking incidences were observed was 181 minutes, running from 7 PM until 10 PM on Saturday night. And, similar to the System A analysis, despite the startling number of insufficient bandwidth events, the blocking problem was fairly well contained, as evidenced by the following points:

1. Blocking occurred in well under 5% of total service groups within the System B network;
2. 21 of the reported insufficient bandwidth events occurred in a single service group.

Future Scenarios and Potential Solutions

While high definition technology has quickly made its mark on consumers, media companies, and service providers, we've only seen the proverbial tip of the iceberg. Indications suggest that high definition content represents less than 5% of most VOD content libraries[v], and only 1% - 2% of the streams transported across HD-supporting VOD networks. And while HDTV is not yet a pervasive "2nd set" phenomenon, nothing suggests that high definition will not follow in the footsteps of TV technology advancements that have overtaken the consumer market (such as color and BTSC stereo), becoming the predominant display and content platform over a 10-to-15 year period. While cable operators have a unique opportunity to enhance their interactivity advantage while simultaneously tracking the irreversible trend towards consumer control and choice, care must be taken to avoid stumbling out of the gate.

A host of technologies can be applied to solving the capacity problem created by the advancement of HDTV, all solutions can be simply divided into 2 distinct categories:

1. Enabling additional network capacity for VOD in general;
2. More efficient use of available bandwidth;

It is beyond the scope of this paper to examine all of the engineering, operational, and financial considerations associated with any specific category or approach, but we will attempt to qualitatively examine the pros and cons of several potential options.

Enabling Additional Network Capacity

For many network engineers, the allure of advanced technology is compelling, tempting them to apply state-of-the-art solutions wherever possible. But, like the power hitting young golfer who loses to an elder statesman, straight and simple often wins the day. Along those lines, VOD bandwidth can readily be created the old fashioned way --- through a combination of node splits and/or adding RF spectrum to the VOD channel banks. Referring once more to our reference network, sharing the 4 channel/155 Mbps service group across 500 homes instead of 1,000 is a simple, straightforward way of creating bandwidth. With that said, this basic node-splitting option comes with its own set of costs and considerations, such as:

- A cost increase for optical transmit and receive elements to support the 2X increase in VOD bandwidth transmitted to the node.
- Incremental space requirements associated with the added optical and RF networking equipment mentioned above.
- A larger percentage of stranded bandwidth during non-peak time segments.

If one assumes that peak usage are the only time when service group capacity thresholds are threatened, and that peak periods largely occur from 8 PM to 10 PM on Friday and Saturday nights, adding capacity by splitting nodes suggests that an operator double their service capacity for a relatively isolated problem. Peak usage periods confined to the aforementioned time-and-day slots occur less than 2.4% of the time (4 peak hours per week/168 total hours per week available), and will likely do so inconsistently in regards to time and dispersion across the network.

Perhaps a more elegant way to address this intermittent capacity problem is to consider using the switched digital video (SDV) as a kind of "VOD levee." Since initial studies suggest that, even in peak times, roughly 25% of available channels are simultaneously viewed within a service group[6], leaving ample bandwidth for VOD when the situation calls for it

Creating bandwidth by re-configuring the network, as suggested in all of the solutions above, often sounds easier in theory than it is in reality. Re-wiring issues often mean network downtime and loss of

[v] Where HDVOD is being offered at all.

revenue, and the complexity of SDV is not to be minimized. So, rather than add either static of dynamic VOD bandwidth, operators might more closely evaluate options for using the existing capacity allocated for VOD in a more efficient manner.

Efficient Use of Bandwidth

Several possibilities exist for such using VOD capacity more efficiently. The first is to switch from constant bit rate (CBR) VOD streams to a variable bit rate (VBR) approach. Several companies are promoting such a solution but, like SDV, little empirical information exists regarding how to enable such an approach, what the associated costs are, and what the expected capacity gains might be.

The metrics are, in many ways, more widely understood with the second approach to better capacity utilization – MPEG 4. Several operators and vendors are moving rapidly to deploy MPEG 4-capable set tops, and the expectation is that such devices will see field deployment before calendar 2007 comes to a close. But the net capacity gain of MPEG 4 is only as good as the deployed universe of associated set tops in the field. A simple example illustrates this point.

If one assumes that, in Year 1, 10% of a service provider's MPEG 2 set tops and content are swapped out for MPEG 4 set tops, and that a 30% gain in bandwidth efficiency is acquired with MPEG 4[vi], the net gain across the affected network would be 3%. Certainly, MPEG 4-based set tops could be specifically directed to HDVOD customers, but associated issues such as multi-format QAM modulators and related statistical multiplexing issues have yet to be uniformly addressed across the industry.

Summary

High Definition On Demand is still in its infancy and much is yet to be learned about how it impacts network capacity as a layer of the VOD expansion movement at-large. Still, HDTV has become a consumer phenomenon with too much momentum to be denied, and broadband service providers will be well served to heed the early lessons presented in this paper, and others. Long term solutions, be they of the capacity expansion or bandwidth efficiency variety, need to be vetted more rigorously by the technology leaders. Still, we are confident that the cable industry will, as they have in the past, move quickly to develop a set of solutions that meet the needs of both operators and consumers.

[vi] Estimates are that MPEG 4 bandwidth efficiency gains range from 20% to 50% over MPEG 2.

About the Authors

Barry Hardek

Barry Hardek, an industry veteran with over 25 years of business development, marketing and sales experience in the broadband and cable television industry, leads the expansion Everstream's presence throughout the service provider, media distribution and advertising communities. Prior to joining Everstream, Hardek was vice president of marketing and sales at CableMatrix, a leading provider of Quality of Service (QoS) policy management solutions. His experience spans other leading companies as well, including: Chromatis Networks, Terayon Communications, 3Com, Scientific Atlanta and Zenith Electronics. Hardek received his BS in Business from Eastern Illinois University and his MBA from Boston University.

Craig Schwabl

Craig Schwabl is CTO and co-founder of Everstream Incorporated, a leading broadband media measurement firm whose data collection and reporting products are used by operators throughout the globe. Prior to Everstream, Mr. Schwabl worked at KeyBank, where he as lead architect, and at International Management Group (IMG) for three years where he was a Systems Engineer responsible for all North American networking operations. Mr. Schwabl graduated from John Carroll University in 1991 with Bachelors of Science in Business Administration, and went on to receive his MBA from Cleveland State University in 1994.

References

[1] Leichtman Research Group Press Release. “DVR and VOD Users and Usage Continue to Grow.” July 27, 2006. Retrieved March 12, 2007 from: http://www.leichtmanresearch.com/press/072706release.html

[2] Ibid

[3] Nielsen Media Research Press Release. “Average U.S. Home Now Receives A Record 104.2 TV Channels, According to Nielsen.” March 19, 2007.Retrieved March 13, 2007 from: http://www.nielsenmedia.com/nc/portal/site/Public/menuitem.55dc65b4a7d5adff3f65936147a062a0/?vgnextoid=48839bc66a961110VgnVCM100000ac0a260aRCRD

[4] Wang, Harry. “Looking Past the Living Room: How to Sustain HDTV Sales.” Tech News World/e-Commerce News, Technology Section.3/1/07. Retrieved March 14, 2007 from: http://www.technewsworld.com/story/56019.html

[5] Leichtman Research Group Website Home Page. Retrieved March 26, 2007 from: http://www.leichtmanresearch.com.

[6] Lei, Leland. “Waste Not, Want Not.” CED Magazine. March 1, 2007. Retrieved March 14, 2007 from: http://www.cedmagazine.com/article/CA6420226.html?text=switched+digital