NIELSEN'S LAW VS. NIELSEN TV VIEWERSHIP FOR NETWORK CAPACITY PLANNING

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Abstract

Our industry is fully aware of Nielsen's Law of the maximum Internet service tier offered to consumers, also known these days as the "Billboard Internet Speed", and that this has been growing at a 50% CAGR since 1982. To date, some MSOs have sized their network on a method of multiplying the billboard speed by either doubling (2X) or tripling (3X) the billboard speed to determine the amount of DOCSIS capacity per service group, this is sort of a Rule of Thumb method for DOCSIS Network Sizing. This method worked for the most part, but this approach will break in the future and we will show why. Additionally, ARRIS plans to unveil a new Traffic Engineering and Capacity Planning Formula to help MSOs properly size their networks to accommodate Nielsen's Law, Traffic, and Competition. This is called the Network Quality of Experience (NQoE) Formula and is a unit of measure that may be used to size any service provider network and network technology.

Our industry is also fully aware that Internet Traffic or consumer bandwidth demand has seen explosive growth from historic averages. We are also aware that this is in large part driven by over the top (OTT) video services causing explosive growth in Internet Traffic, which may range from 40% to over 100% in annual growth rates. This has moved the symmetry between downstream and upstream traffic from 2:1 or even 4:1 from a decade earlier to now over 10:1. We will examine the impact of video service as a key driver for traffic consumption and growth rates. ARRIS will also show several Internet traffic growth rate predictions that may help network planners.

High-speed Internet is only one service that utilizes spectrum and drives network investment, and this paper examines the role of other services and delivery technologies on network utilization as well. We will show that Coax to the Home (CTTH) will be able to sustain the needs of the customer through the year 2030. Obviously, forecasting until 2030 is difficult, but we want to illustrate the controls the MSOs have and the visibility that traffic may not grow at this rate forever. We will also introduce new network architecture for accommodating 1) the Billboard service tier growth rates and 2) the Internet traffic growth rates. ARRIS will also introduce a new method for network architecture that should reduce capital costs and extend the life of the CTTH network, while competing or beating FTTH networks.

Should our industry migrate to DOCSIS as the unified video delivery network supporting both MSO delivered content and for OTT to extend the life of the HFC?

The paper will unveil:

1. *New Traffic Engineering and Capacity Planning formulas*
2. *New Video Traffic Growth Rate projections*
3. *A new approach to DOCSIS Network Architecture Capacity*
4. *A new forecast for Network Capacity through 2030*

DRIVERS FOR TRAFFIC ENGINEERING AND CAPACITY PLANNING

The MSO's competitive landscape has changed rapidly in just the last 12 months especially from Over the Top (OTT) video providers such as Apple TV, Amazon, Hulu, Netflix and others entering the On-Demand video market. In many ways, the consumer electronics companies, like Apple, are becoming service providers enabling the video experience across all platforms and across any carriers' network. The OTT competition affects the MSOs in lost revenues for On-Demand services and perhaps a reduction in the subscription service. Adding to the lost revenue are increased costs to the high-speed data network due to increased consumer usage.

SHOULD OUR INDUSTRY MIGRATE TO DOCSIS AS THE UNIFIED VIDEO DELIVERY NETWORK SUPPORTING BOTH MSO DELIVERED CONTENT AND FOR OTT TO EXTEND THE LIFE OF THE HFC?

Service Providers will have to forecast their video network resource requirements as well as the Internet Service Tiers and Traffic Growth rates to properly size the data network. What if our industry did something very different? What if we began to analyze the high-speed data traffic to determine use of video services being delivered OTT, would this influence our video network planning, and even our overall network planning? Our industry may consider the migration to IP Video in an effort to have a single video delivery network, whether the consumer selects an OTT video provider or the MSO video service the video traffic will be transported across a single network. Today, consumers select video from two separate networks: the Analog and Digital Broadcast network and the unicast MPEG-TS VoD network. Additionally, the customers are switching to a different video network, the high-speed data network and this may cause wide variations in network planning to allocate network resources for essentially two different video delivery networks. The MSO may actually extend the life of the HFC by transitioning to DOCSIS to enable a single video delivery network support regardless of the origin.

NIELSEN'S LAW OF INTERNET MAXIMUM SERVICE TIER OFFERED

The network traffic estimates need to consider the downstream and upstream high-speed Internet service tier, in other words the data speed package that the MSO offers to consumers. The highest data speed offered in either direction is a determining factor for sizing the network. The High-Speed Internet service tier and traffic will grow considerably during this decade moving from perhaps four 6 MHz channels downstream, which is less than 4% of the MSO's total spectrum allocation and may grow to perhaps 40-50% in the next 10 years.

This model illustrates that Data Service Tiers offered to consumers increase at about a 50% compound annual growth rate (CAGR) and this model also is used to forecast actual consumer traffic usage which also grows at roughly a 50% CAGR. This is based on Nielsen's Law of Internet Bandwidth or Max Internet Service Tier. We have also combined Nielsen's Law with the research of Dr. Thomas J. Cloonan, CTO of ARRIS and co-author. The research is captured in the "Max Internet Data Services Tier Offering Downstream and Upstream graphs in this section. Dr. Cloonan begins with the data rate offered since 1982 and charts growth through to the present day. This data, referred to as Cloonan's Curve, also reflects the historical 50% CAGR as does Nielsen's Law. The data service portion of the model is predictable but at some point, as with Moore's Law, Nielsen's Law may not continue on this 50% CAGR trajectory for another 20 years, and it may break.

The high-speed Internet service tier offering will be a key contributor to overall bandwidth drivers. Figure 1 below shows a thirty-year history of the max bandwidth offered or available to consumers. This figure also attempts to predict the max service tier we may see in the future, if the growth trend aligns with the preceding years. The models are a combination of Cloonan's Curve, a 30 Year History of Max Service Tier Offered, and Nielsen Law of 50% CAGR.

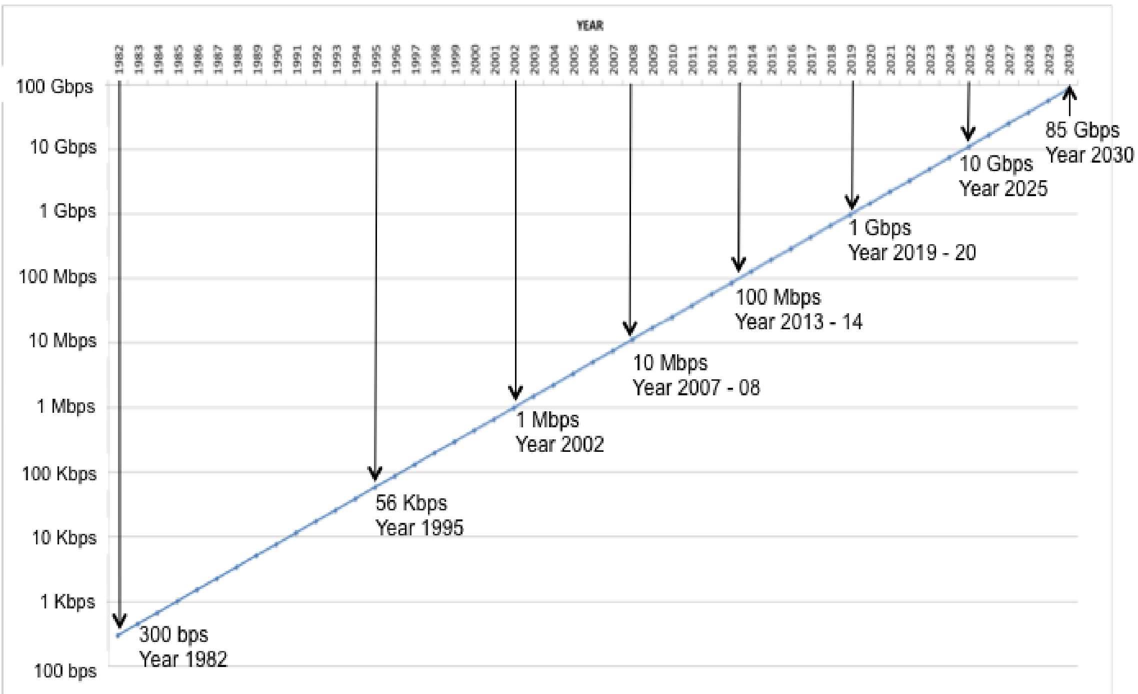


Figure 1 – Nielsen's Law Max Internet Service Tier Offered – Downstream (1)
Source: http://www.nngroup.com/articles/law-of-bandwidth/

Is it possible that a service provider will offer a residential 11 Gbps Internet service by 2025? When will Nielsen's Law Break? It is unlikely that a 50% CAGR for the Max Service Tier Offered will last forever. Moore's law broke and Nielsen's Law will too, but when and by what rate? The Internet service tier offered is ultimately a decision of the service providers and they may simply pull the lever of growth back, as this is a driver for investment that is desired for only a small percentage of their Internet customer base.

INTERNET TRAFFIC OR CONSUMER BANDWIDTH DEMAND

Measuring and Estimating Customer Traffic

In addition to the service tier offered to consumers, the actual usage of the network by the consumers is a critical factor for network planners. This is known as the bandwidth per subscriber (BW per Sub). The determination of bandwidth per sub is a measurement of the total amount of bandwidth or traffic in a serving area divided by the number of consumers in the serving area. This may be measured during busy hour(s) to drive operator traffic engineering limits. Dr. Cloonan has collected traffic data from many sources to determine the traffic per subscriber data rates as seen in Table 1 and 2. The bandwidth per subscriber is measured in the downstream and upstream direction. The downstream was measured at a 100 kbps per subscriber and the upstream at 43 kbps per subscriber in the year 2010, as illustrated in tables 2 and 3. The bandwidth per subscriber CAGR may vary, so we have used several growth rates for the downstream and the upstream. These numbers are used for planning purposes in this analysis, it is important that each operator capture their own CAGRs.

DOWNSTREAM DATA NETWORK TRAFFIC PREDICTIONS			
North Amer. & Europe	Per Subscriber Traffic (Shown in Mbps)		
Year	40% CAGR Downstream	50% CAGR Downstream	60% CAGR Downstream
2010	0.10	0.10	0.10
2011	0.14	0.15	0.16
2012	0.20	0.23	0.26
2013	0.27	0.34	0.41
2014	0.38	0.51	0.66
2015	0.54	0.76	1.05
2016	0.75	1.14	1.68
2017	1.05	1.71	2.68
2018	1.48	2.56	4.29
2019	2.07	3.84	6.87
2020	2.89	5.77	11.00
2021	4.05	8.65	17.59
2022	5.67	12.97	28.15
2023	7.94	19.46	45.04
2024	11.11	29.19	72.06
2025	15.56	43.79	115.29
2026	21.78	65.68	184.47
2027	30.49	98.53	295.15
2028	42.69	147.79	472.24
2029	59.76	221.68	755.58
2030	83.67	332.53	1,208.93

Table 1 – Downstream Bandwidth per Subscriber Table

UPSTREAM DATA NETWORK TRAFFIC PREDICTIONS				
North America	Per Subscriber Traffic (Shown in Mbps)			
Year	10% CAGR Upstream	25% CAGR Upstream	35% CAGR Upstream	50% CAGR Upstream
2010	0.04	0.04	0.04	0.04
2011	0.05	0.05	0.06	0.06
2012	0.05	0.07	0.08	0.10
2013	0.06	0.08	0.11	0.15
2014	0.06	0.10	0.14	0.22
2015	0.07	0.13	0.19	0.33
2016	0.08	0.16	0.26	0.49
2017	0.08	0.21	0.35	0.73
2018	0.09	0.26	0.47	1.10
2019	0.10	0.32	0.64	1.65
2020	0.11	0.40	0.86	2.48
2021	0.12	0.50	1.17	3.72
2022	0.13	0.63	1.58	5.58
2023	0.15	0.78	2.13	8.37
2024	0.16	0.98	2.87	12.55
2025	0.18	1.22	3.88	18.83
2026	0.20	1.53	5.23	28.24
2027	0.22	1.91	7.07	42.37
2028	0.24	2.39	9.54	63.55
2029	0.26	2.98	12.88	95.32
2030	0.29	3.73	17.38	142.99

Table 2: North America Upstream Bandwidth per Subscriber Table

The Internet Traffic CAGR is determined by the consumers, service provider speed tiers offered, and technologies that will influence network usage. The growth rate of traffic will vary widely even within a service provider, because usage patterns will be different between demographics. Traffic growth rates are very hard to forecast because there are many possible influences to drive traffic growth.

Key Questions

- When will Nielsen Law of 50% CAGR for Max Service Tier Offered Break?
- Which "Downstream Traffic" CAGR do you believe and when will it break?
- Which "Upstream Traffic" CAGR do you believe and when will it break?

Understanding the Composition of Customer Traffic

The Over the Top (OTT) video providers such as Apple TV, Amazon, Hulu, Netflix, You Tube and others entering the On-Demand video market are driving traffic and peak period consumption upward, this is called Busy Hour Busy Day (BHBD) traffic utilization. In the figure below, from the Sandvine, Global Internet Phenomena Snapshot: 2H 2013 North America, Fixed Access report this illustrates that 67% of the downstream traffic is Real-Time Entertainment from these OTT providers. The percentage of Real-Time Entertainment has gone up over the last several years and a decade ago this was a rounding error as traffic in that time frame was dominated by web browsing and file sharing. It is very important we understand those types of traffic and the volume of traffic as a percentage. We can begin to understand to separate out say Video traffic from the traffic data and estimate the amount of users watching video over the top (OTT) as they are not watching an MSO delivered video offering. This is key for network planning.

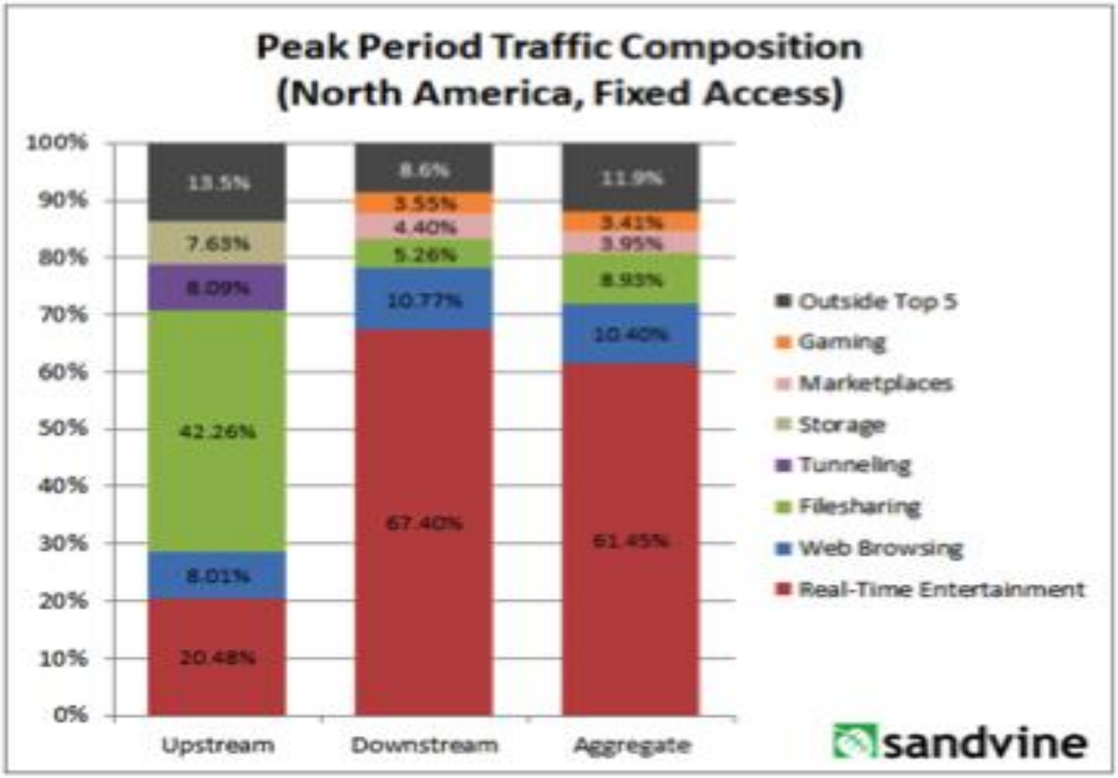


Figure 2 – Peak Period Traffic Composition Complied by Sandvine (2)

	Upstream		Downstream	
Rank	Application	Share	Application	Share
1	BitTorrent	36.35%	Netflix	31.62%
2	HTTP	6.03%	YouTube	18.69%
3	SSL	5.87%	HTTP	9.74%
4	Netflix	4.44%	BitTorrent	4.05%
5	YouTube	3.63%	iTunes	3.27%
6	Skype	2.76%	MPEG - Other	2.60%
7	QVoD	2.55%	SSL	2.05%
8	Facebook	1.54%	Amazon Video	1.61%
9	FaceTime	1.44%	Facebook	1.31%
10	Dropbox	1.39%	Hulu	1.29%
	Top 10	**66.00%**	**Top 10**	**76.23%**

Figure 3 – Traffic Application Share Upstream and Downstream Complied by Sandvine (3)

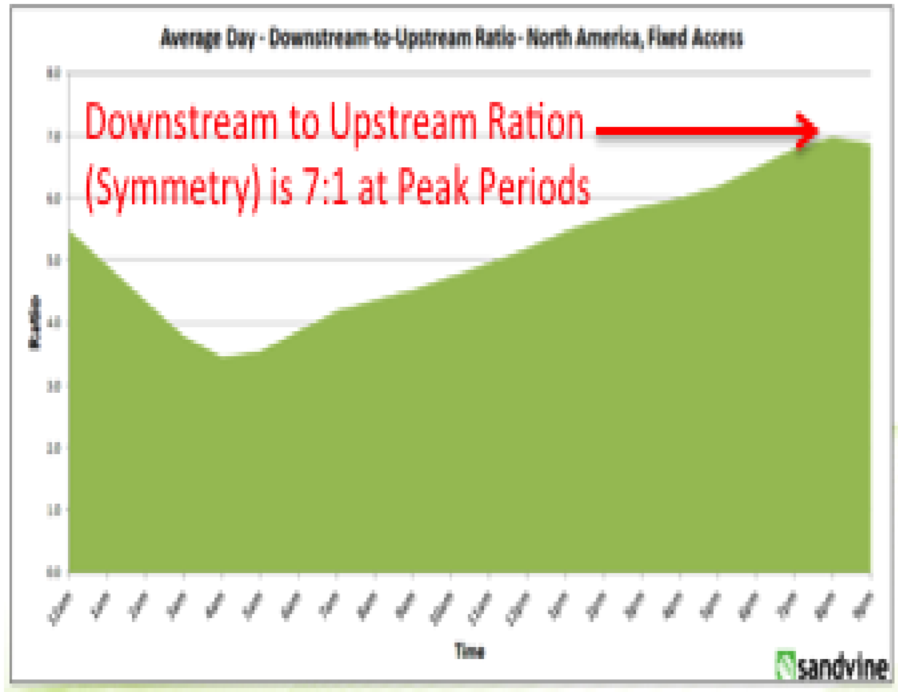


Figure 4 – Average Downstream-to-Upstream Ratio Complied by Sandvine (4)

In the figure above, the Downstream-to-Upstream Ratio is shown during an average day. This data useful to understand the ever increasing spread between the traffic directions. In the early 2000s, this number had far more symmetry during the peak of peer-to-peer some traffic assessments showed a near 1:1 ratio but more often, this ratio was 2:1. As seen in figures 2 and 3 the amount of video downstream is causing the ratio to spread dramatically. We will expect that until there is some upstream application that will consume bandwidth at a faster rate and duration during peak period this spread in the ratio of traffic will continue.

The Nielsen TV Research Company

In this section, we will examine the number of devices per home as well as the types of devices. The model will use both High-Speed Internet projections, like the Service Tier Offering and bandwidth per subscriber to predict Network Utilization and Capacity Planning. The number of TVs per household has been growing since 1975, but the rate of growth has declined in the last decade. According to the data from Nielsen, there is about 2.5 to 2.93 TVs per household according to year 2011 and 2010 data. The type of TV in each home is important for future network sizing as well as estimating the trend for the future like a transition from SD sets to HD sets and then HD set to UHD sets. Finally, according to the U.S. Census Bureau there are 2.61 persons per household between from the years 2008-2012. (7)

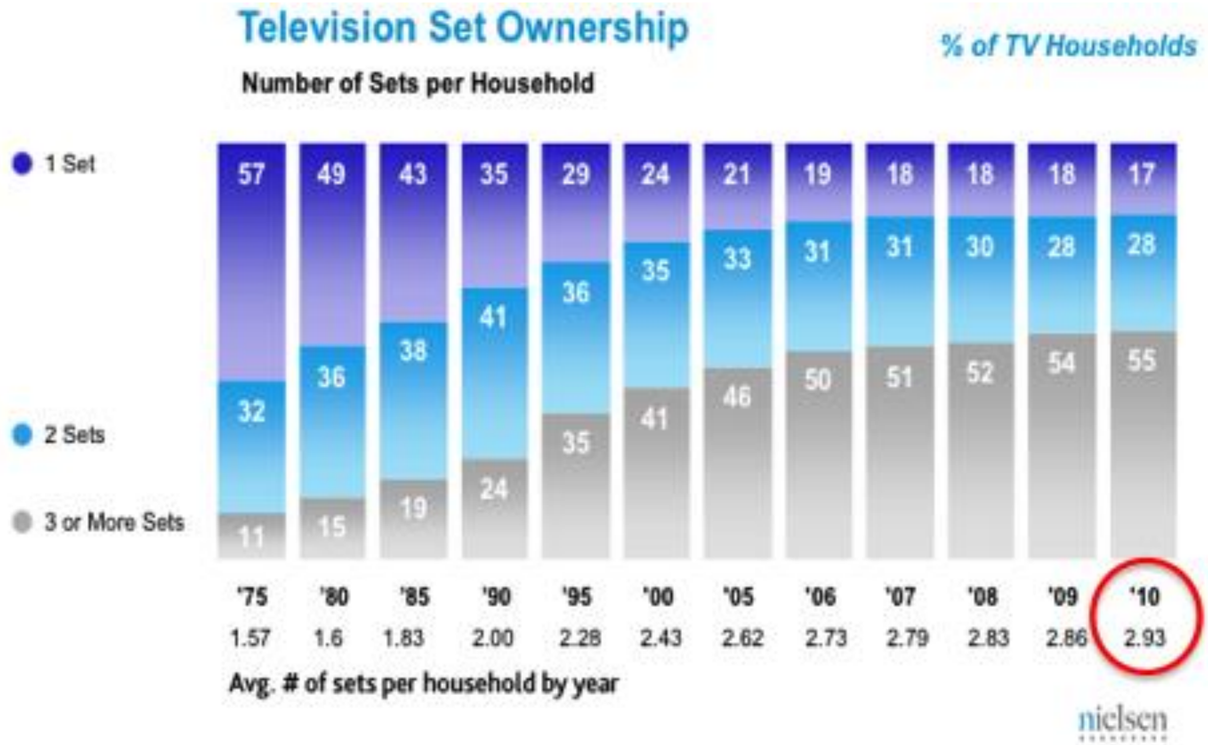


Figure 5 – Nielsen Data on TVs per Household – 35 Year Trending Model (5)

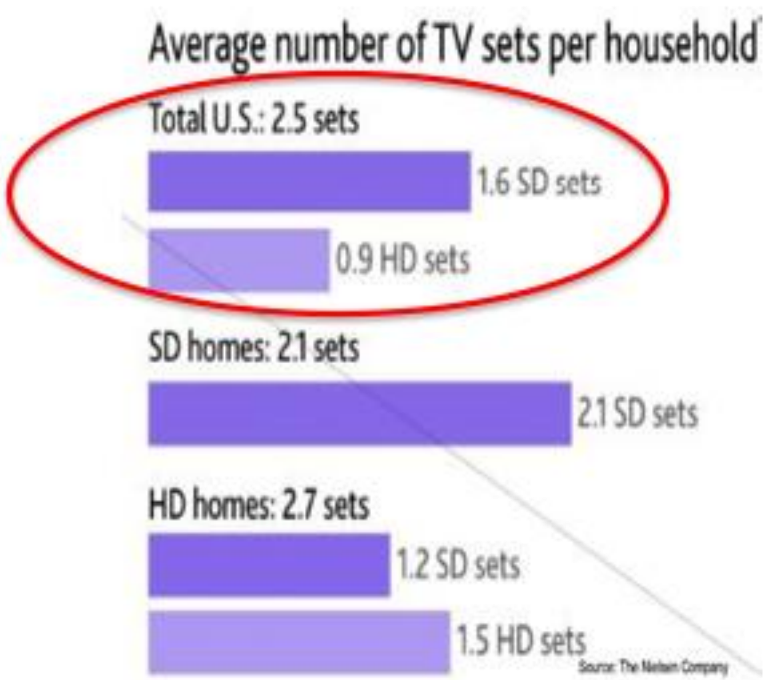


Figure 6 – 2011 Nielsen Data on TVs per Household U.S. TV Sets “Equal People per House (6)

SHOULD WE MIGRATE TO DOCSIS AS A UNIFIED VIDEO DELIVERY NETWORK FOR MSO "AND" OTT?

This question may seem a bit controversial, but if we consider some of the key points captured in this paper, then this may begin to become something that may be our target architecture. First, video is dominating the DOCSIS network and is consuming about 67% of the traffic during peak periods. We are building two highways and our customers pick which one to use. This will make capacity planning for parallel video delivery networks a challenge. What if we forecasted the traffic needs that would accommodate video traffic and whichever video content source it went over one network and that network was DOCSIS? What would be the capacity requirement if we applied some estimates based on the research collected in this paper?

According to Nielsen, the number of TVs per household is in the range of 2.5 – 2.93 sets. If we also consider the number of people on average per home which lines up with the number of TVs, as 2.61 we can start to forecast the support for video service needs. Therefore, we consider the migration of SD sets to HD sets, HD sets to UHD sets, and we use the HEVC data rates for HDTV and 4K UHDTV.

Resolution		Digital Compression Method and Bit Rate		
Resolution Terms	Frame Size / Scanning System / Frame Rate	MPEG2	H.264	HEVC
SDTV	480 / i / 30	3.7 Mbps	2 Mbps	1 Mbps
HDTV	720 / p / 30	6 Mbps	3 Mbps	1.5 Mbps
HDTV	720 / p / 60 (or 1080 / i /60)	12 Mbps	6 Mbps	3 Mbps
HDTV	1080 / p / 60	20 Mbps	10 Mbps	5 Mbps
4K UHDTV	4Kx2K / p / 60	80 Mbps	40 Mbps	20 Mbps
8K UHDTV	8Kx4K/ p / 60	320 Mbps	160 Mbps	80 Mbps

Figure 7 – Video Data Rates

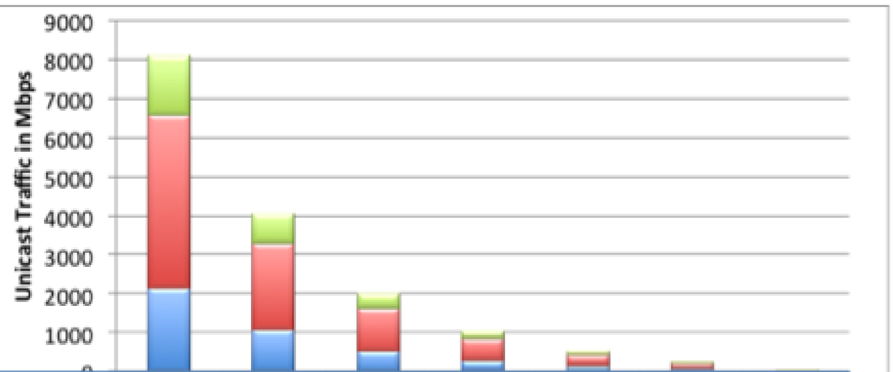
Key Observations Considered for Forecasting Capacity

- HSD traffic is growing at a faster rate than ever
- Traffic growth has not always grown at 50% CAGR
- 20-30% through most of 2000s was observed
- Symmetry Downstream-to-Upstream was not always 7:1 DS:US
- 2:1 through most of 2000s was observed
- OTT Video is the driver for the traffic growth
- Should we separate video planning from traditional HSD traffic?

- A person watching OTT video is not watching CATV service (and vice versa)
- Video Capacity Planning Factors
    - 2.61 number of people per household (2008-2012 U.S. Census)
    - 2.5 – 2.93 number of TVs per household (2010-2011 according to Nielsen)
    - 66% are SDTV and 34% are HDTV according to Nielsen
    - What if in the future 66% are HDTV and 34% are 4K UHDTV
    - What are some worst-case numbers for video planning?

Assumptions used in the figure below

- 2.61 number of people per household
- 2.61 number of TVs per household actively stream unique unicast content
- Assume the future mix of TVs with 66% are HDTV and 34% are 4K UHDTV
- Assume the use if HEVC for HDTV at 5 Mbps and 4K UHDTV at 20 Mbps
- Assuming a worst case of 100% of the TVs are receiving Unicast Video Traffic
- Year 2030 HSD Traffic Estimates Removing Video Traffic and use a 30% CAGR from 2010



Number of Customer Homes	250	125	62	32	16	8	1
Year 2030 HSD Traffic Estimates (without video)	1520	760	380	190	97	49	6
HEVC 4K UHDTV 4Kx2K / p / 60	4437	2219	1100	568	284	142	18
HEVC HDTV 1080 / p / 60	2153	1077	534	276	138	69	9

Values in Mbps

Figure 8 – Unicast Traffic Estimates for Video and Data Services

The main conclusion is that the migration to a single network for video delivery will likely extend the life of the HFC network and perhaps the service group levels. The figure above illustrates that a typical node and customer take rate could be served if we allocated capacity and spectrum to a single video delivery network. If there were two video delivery networks, MPEG TS and DOCSIS, the allocation of capacity would likely be higher, since it may be hard to predict which network a customer would use in a given evening.

HOW IS YOUR HIGH-SPEED DATA NETWORK MEASURED? SAMKNOWS

As many MSOs are aware, there are measurement services that measure the offered speed tier against the actual ability for the customers to reach those speed tiers and different test times and different test point. This figure below captures the architecture and test points of SamKnows.

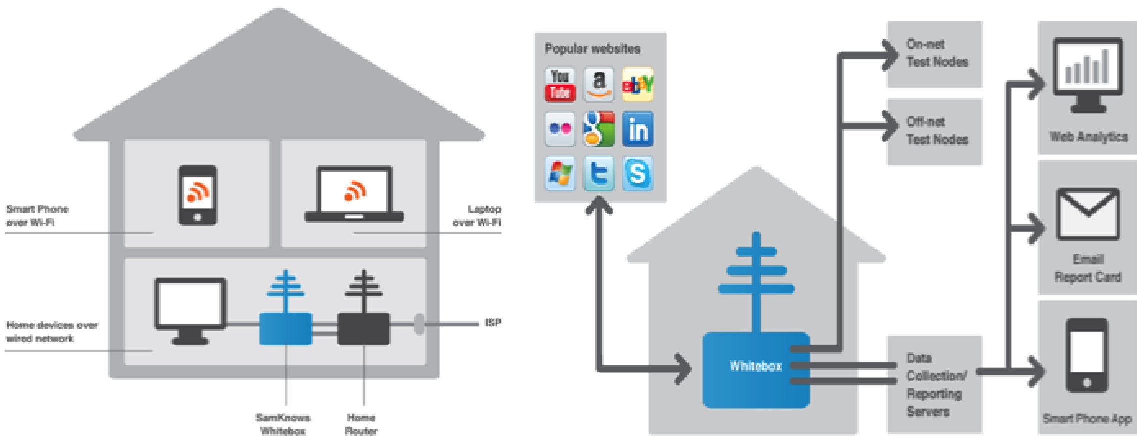


Figure 9 – SamKnows Installation Architecture and Test Points (8)

Service Providers believe it is very important to meet the service tier expectation of the customer and to do so at peak usage periods. As the service tier grows to higher data rates it is critical that we have methods to allocate the correct proportion of capacity. To that end, this next section will discuss traffic engineering and capacity-planning approaches used today and those possible in the future.

NETWORK QUALITY OF EXPERIENCE NQOE FORMULA (NQOE UNIT FORMULA)

This section will introduce a new method for sizing the service provider's data network, called the Network Quality of Experience (NQoE) Formula. The purpose of the formula is to account for traffic and service tier as well as growth rates to increase the probability of customers reaching the desired speed tier. The formula is described in more detail in the following three figures.

Rule of Thumb Approach for Network Sizing

To date some MSOs have sized their network on a method of multiplying the billboard speed by either doubling (2X) or tripling (3X) the billboard speed to determine the amount of DOCSIS capacity per service group, this is sort of a Rule of Thumb method for DOCSIS Network Sizing. If this rule of thumb approach is used as service groups get smaller, then too much capacity could be allocated.

NQoE Formula Goals

- Achieve Max Service Tier even during busy periods
- Allocate appropriate amount of network resources
- Configurable to accommodate any data network
- Accommodate estimates of Service Tier and Traffic Growth Rates
- Achieve Max Service Tier through next network capacity adjustment

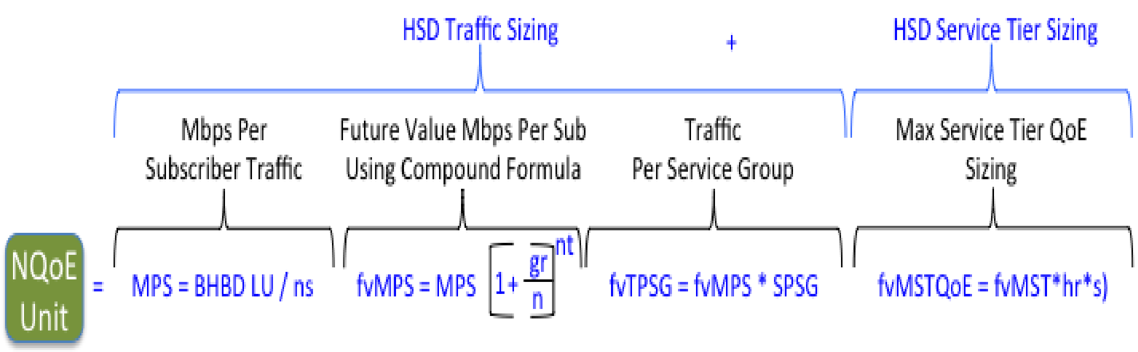


Figure 10 – Network Quality of Experience (NQoE) Formula

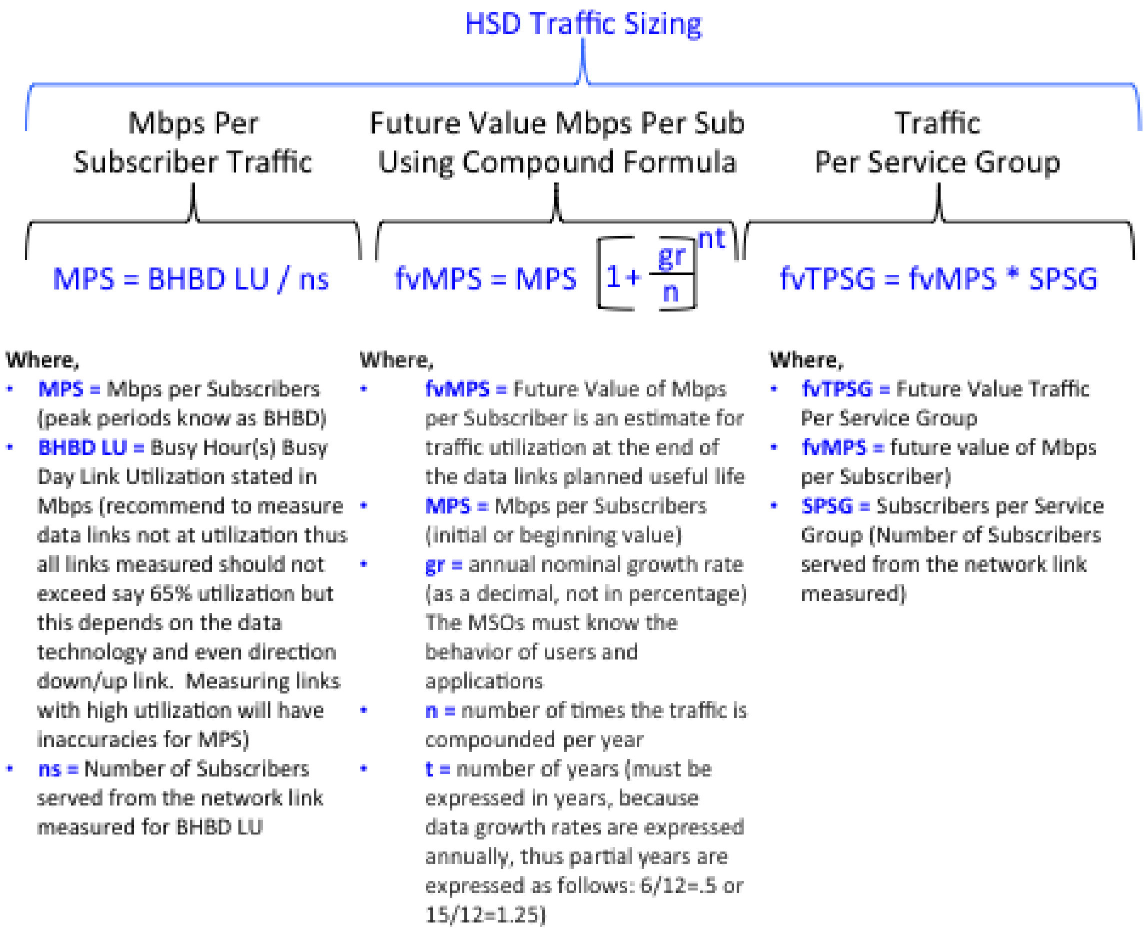


Figure 11 – Network Quality of Experience (NQoE) Formula – Traffic Sizing

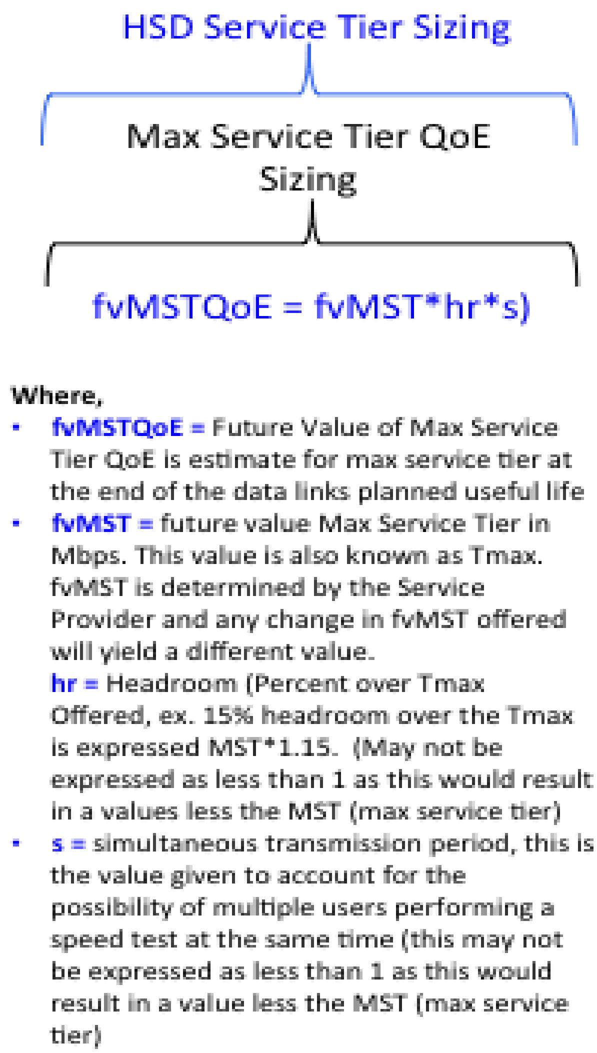


Figure 12 – Network Quality of Experience (NQoE) Formula – Service Tier

NQoE Unit is solved for Mbps in this example; however, the unit value may change if desired. NQoE Unit is a measurement for required data link throughput capacity, not link speed, and thus service providers will need to account for data link overheads and desired operational link utilization thresholds. ARRIS does have models that incorporate these factors.

NETWORK UTILIZATION AND CAPACITY PLANNING

Capacity Planning for High-Speed Internet Max Service Tier plus Data Traffic per Service Group

The downstream High-Speed Internet service tier growth from 2010 through 2030 is estimated and direction is used to forecast the date when the downstream may be at capacity see figure 13.

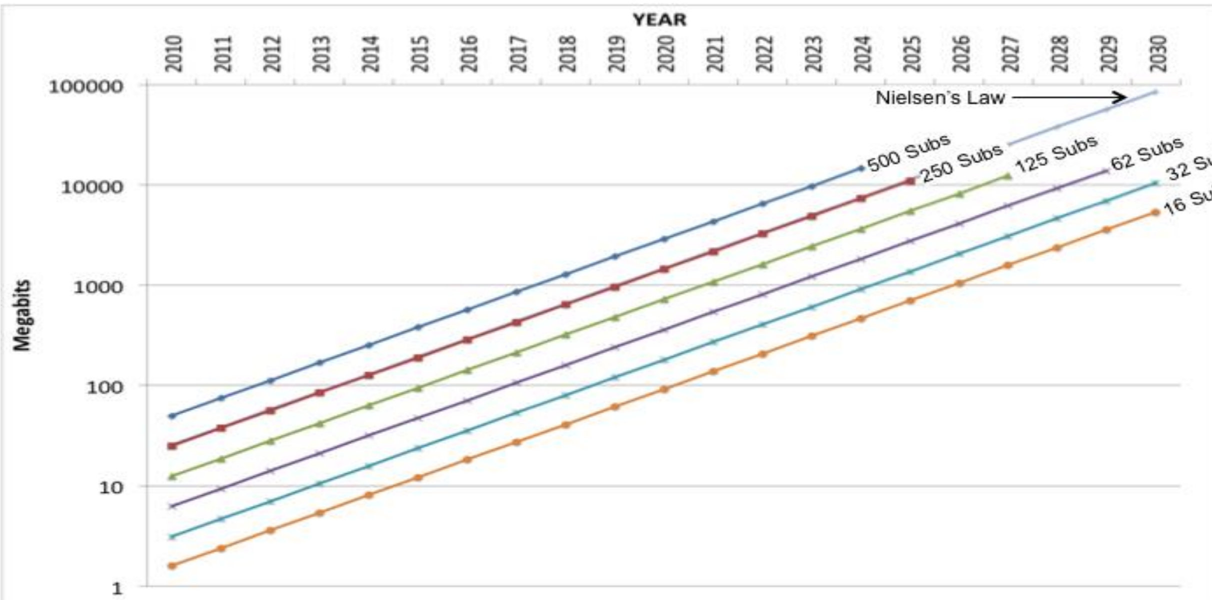


Figure 13: Nielsen's Law with Traffic per Service Group Estimates 2010 to 2030

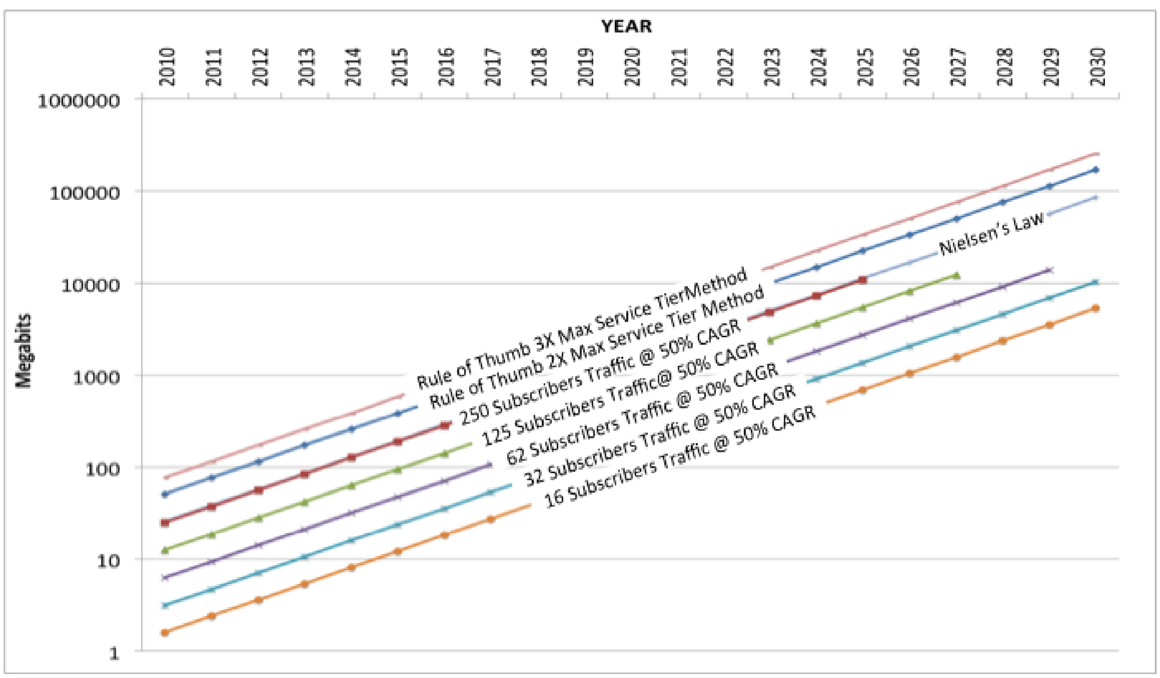


Figure 14: The Rule of Thumb Method and Traffic per Service Group 2010 to 2030

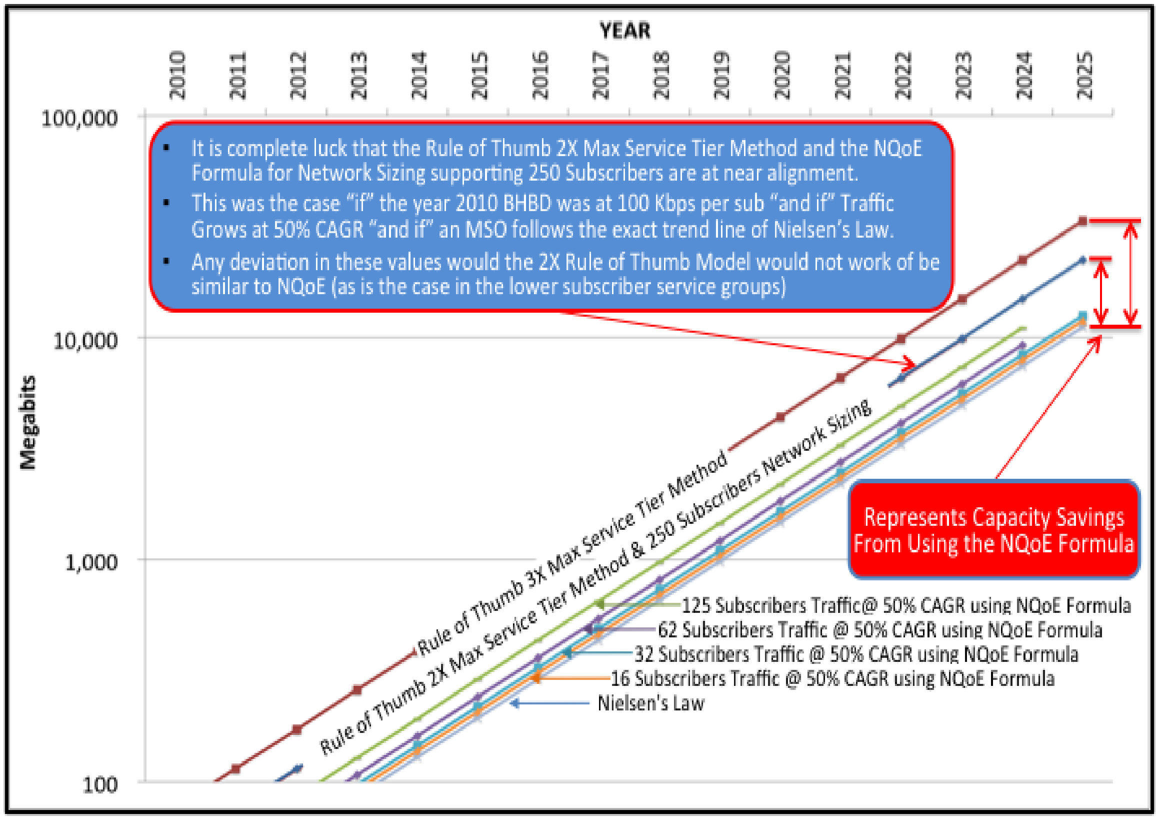


Figure 15: Rule of Thumb Method Compared to the NQoE Formula

The HFC downstream capacity assumptions will use several reference points; these include 192 MHz, 384 MHz, 576 MHz, 768 MHz and 960 MHz of usable DOCSIS downstream spectrum. These assume High-Speed Internet Max Service Tier and Traffic continues at a 50% CAGR. It again should be stated that these are predictions for the next decade or more, it is uncertain if growth for either or both will continue at this pace, see figure 16.

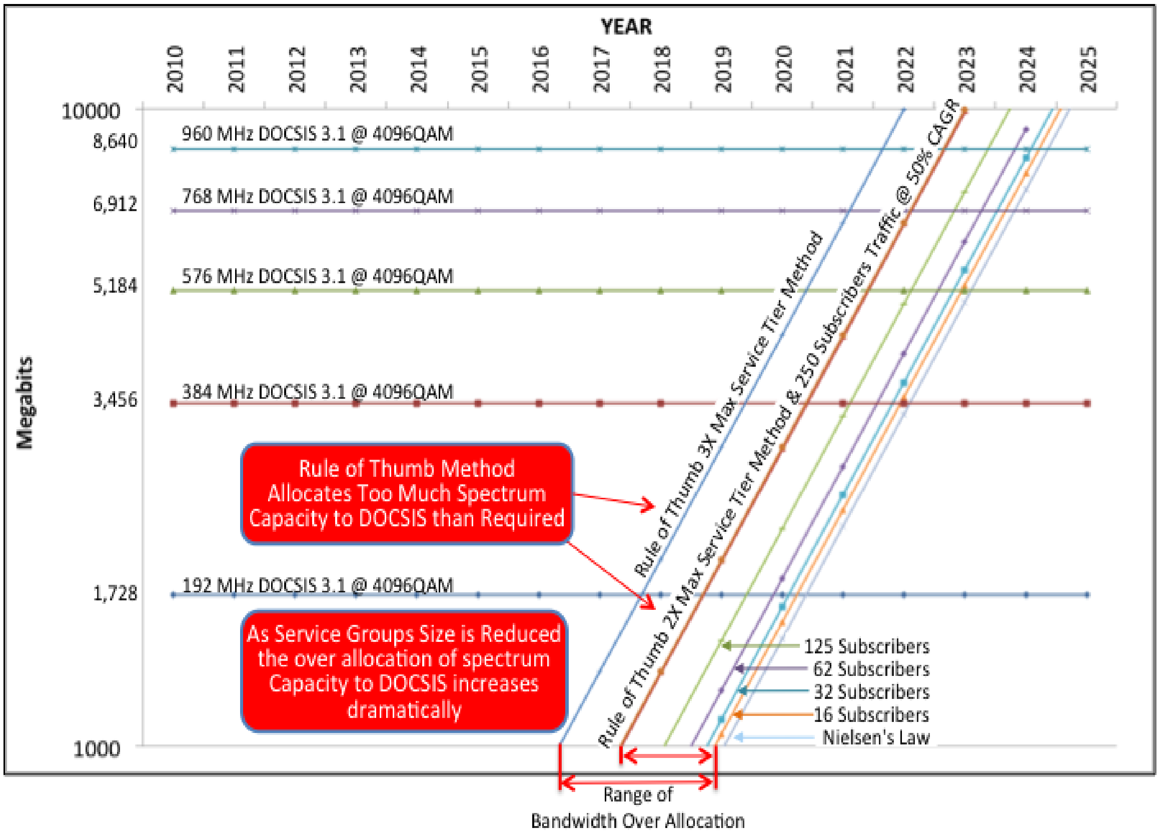


Figure 16: DOCSIS 3.1 Capacity with Rule of Thumb Method and NQoE Formula

Figure 16 uses the NQoE Formula, the combination of Service Tier plus Traffic per Service Group as well as other factors to estimate network capacity needs. The horizontal lines represent spectrum allocation and modulation to determine the network capacity. In figure 16, the red boxes illustrate that the rule of the thumb methods may allocate too much capacity as service group size is reduced. Additionally, since this does not take into account traffic or service group size among other factors, the NQoE Formula may more accurately forecast network capacity requirements.

CONCLUSIONS

Operators will need to track these key drivers and levers that force network change, like Nielsen's Law of Max Services Tier Growth Rate and also Traffic Growth Rates for proper network planning. In terms of targeting a single video service delivery network, this would likely reach the same network capacity, yet other costs need to be considered. The main conclusion is that the migration to a single network for video delivery will likely extend the life of the HFC network and perhaps the service group levels. The figure above illustrates that a typical node and customer take rate could be served if we allocated capacity and spectrum to a single video delivery network. If there were two video delivery networks, MPEG TS and DOCSIS, the allocation of capacity would likely be higher since it may be hard to predict which network a customer would use in a given evening. The use of the Network Quality of Experience (NQoE) Formula will help service providers of all types and technologies size their network more accurately.

Conclusion Summaries:

- Drivers for Traffic Engineering and Capacity Planning:
  - Nielsen's Law will dominate network capacity allocation
  - We must understand the Traffic Composition like OTT video
- Unicast video delivery method may actually extend the life of the network:
  - OTT utilizes unicast video over DOCSIS
  - MSO allocating capacity for unicast and broadcast is over MPEG TS
  - MSOs are really support two video delivery networks
  - The challenge is traffic engineering because which one will the customer use
  - Planning Video Capacity for two networks is costly and a long terms guessing game
  - Which network will the customer use for video (DOCSIS or MPEG) tomorrow, month, year, etc. from now?
  - Eventually migration to full spectrum DOCSIS creates one service delivery network to manage
  - Advanced Video CPEs accommodate consumers TV choices while preserving capacity
- We need a new Traffic Engineering and Capacity Planning formula:
  - NQoE Formula (Network Quality of Experience) Formula for Capacity Planning
  - Achieves Max Service Tier even during busy periods
  - Allocates appropriate amount of network resources

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