November 2011

Rev. 3/29/2012 – added Addendum "Preliminary Analysis of the Broadcast Overlay Business Opportunity" - Pricing the Broadcast Overlay Service

THE ECONOMIC VALUE OF BROADCAST INNOVATION – IMPACT ON THE U.S. TREASURY

Why Broadcast Innovation is the most practical path to create consumer and taxpayer value from mobile IP services

Business Analytix

A Report based on the Techno-economic Analysis prepared by Business Analytix, Inc., Bordentown, NJ 08505| +1.609.291.7160

Prepared for: Sinclair Broadcast Group

"The Plan" as Advanced by

~ Advanced Television Broadcasting Alliance ~

Advanced Television Broadcasting Alliance

Table of Contents

Executive Summary

Every day, more and more Americans begin to use smartphones, tablets, and wireless modems to access new mobile applications and services that are proliferating at an astounding pace. Some have argued that without a fundamental shift of spectrum from broadcasters to commercial wireless operators the nation will soon face a massive "mobile traffic jam" and that auctioning broadcast spectrum will deliver a revenue windfall to the U.S. Treasury.

But the opposite is true. The best way to meet the projected explosive growth in mobile data is to allow broadcasters to use point-to-multipoint "Broadcast Overlay" technology to provide the most efficient possible delivery of high bandwidth data to mobile users. Simply allocating more spectrum to commercial wireless operators would do very little to address projected massive capacity shortfalls and would do even less to address Federal budget deficits. Commercial mobile networks based on "cellular" one-to-one architectures are not designed to efficiently carry the portion of mobile data traffic that is likely to grow the fastest. The U.S. Treasury would receive far less revenue from one-time auctions of reclaimed broadcast spectrum than it would from recurring ancillary service fees, if broadcasters are permitted to serve the segment of traffic that commercial mobile networks are inherently weak at delivering; viz, one-to-many/ point-to-multipoint IP traffic.

This paper – the first of its kind – quantifies the superiority of a mobile-friendly Broadcast Overlay service to address growing demand for mobile data. It also projects the impact on revenues to the U.S. Treasury from ancillary service fees on broadcasters that provide Overlay services. We show:

- The demands of a mobile data ecosystem will be too diverse to be served only by cellular networks and commercial wireless operators. Different kinds of mobile data traffic require different networks and different service models. A Broadcast Overlay service that is technically compatible with commercial wireless networks would allow users to consume more data at a lower cost with a higher quality of service.

- Even doubling the amount of spectrum available to commercial wireless operators using cellular architectures would do little to meet projected demand, which is expected to soar almost seventyfold by 2026.

- Under traditional commercial mobile service models, users can not afford to consume the amount of data on which spectrum shortage predictions are based. High costs and mobile data usage caps will severely temper demand for high bandwidth services through cellular systems.

- Reallocating and auctioning television broadcast spectrum would throttle innovation, permanently institutionalize today's policy choices, and limit the development of a more varied and robust wireless ecosystem.

- Estimated one-time auction net receipts of less than $20 billion for re-allocated broadcast spectrum would shortchange taxpayers. We project that Broadcast Overlay ancillary service fees would yield a net present value of more than $60 billion over a 15 year forecast period, and would continue to pay billions (>$200 billion total) in dividends to the U.S. Treasury in perpetuity.

THE ECONOMIC VALUE OF BROADCAST INNOVATION: IMPACT ON THE U.S. TREASURY

I. Overview

We are in the midst of a massive explosion in global IP traffic even as we witness ever faster proliferation of a culture in which mobile computing and communications are becoming the norm. Cisco's June 2011 Visual Network Index (VNI) update confirmed that the world is entering "the Zettabyte Era" with annual IP traffic poised to touch 966 Exabytes (EB) in 2015 (Cisco Systems) . The relentless pace of innovation -- in Internet cloud technology and in the devices and applications that people use to access the cloud -- is driving this remarkable growth in traffic. And among all forms of IP traffic, the fastest growth and the greatest innovation are in mobile traffic – especially, mobile video traffic.

Policymakers are rightly asking what steps the government should take to accommodate that growth in traffic and foster the virtuous cycle of innovation in an environment of strained Federal budgets. Many argue that the best policy is to reclaim spectrum allocated to television broadcasting and auction it for commercial wireless service. This approach would bring "new" wireless spectrum to the commercial wireless operators that carry essentially all mobile data traffic today, and, some argue, will help alleviate a looming spectrum crisis. Many expect that "incentive auctions" of broadcast spectrum will also generate meaningful net proceeds for the U.S. Treasury even after reclamation and transition costs are paid out of the auction proceeds.

A linear increase in the supply of spectrum cannot solve a geometric increase in demand for mobile data

But reclamation and auction is an imperfect solution for several reasons, including these:

- A linear increase in the supply of spectrum cannot solve a geometric increase in demand for mobile data. The projected growth in mobile data traffic is so great that re-allocation of television spectrum would provide only temporary and barely discernible relief. Although the National Broadband Plan targeted 120 MHz of television spectrum for re-allocation, today reclamation of 84 MHz is widely viewed as optimistic. 84 MHz would increase the amount of spectrum available for mobile broadband by roughly 15%. Yet mobile data traffic will grow by more than 2100% by 2015. Plainly, spectrum re-allocations alone will do little to avert a mobile traffic jam.[1]

- When reclaiming and auctioning spectrum the government must directly or indirectly bear substantial transition costs. This greatly shrinks the proceeds to the U.S. Treasury.

- The auction value – a one-time payment to the U.S. Treasury for an asset that has perpetual value – is far less than the value of a perpetual annuity accruing to the U.S. Treasury arising directly from ancillary service fees paid by broadcasters for data delivered via a Broadcast Overlay.

- Licensing by auction imposes practical limits on the licensee's business model and, of course, on the types of services that are made available with the auctioned spectrum. If the government subjects all licensees to the same business constraints imposed by auction, the unavoidable side

[1] In contrast, more than 200 MHz of spectrum already available for mobile broadband are unused or underused. This failure to deploy spectrum that is already available suggests that lack of spectrum is not the primary factor in projections of a looming spectrum shortage.

effects include throttling of innovation, permanent institutionalization of today's policy choices, and limitations on the development of a more varied and robust wireless ecosystem.

- Reclamation and auction would require most, if not all, broadcast stations to change their technical facilities. Those direct costs must be paid out of auction proceeds, and many other indirect costs must be borne by the public and by broadcasters, including loss of service. With a Broadcast Overlay, the government would not absorb transition costs and broadcast service would be substantially improved.

This paper evaluates how alternative spectrum policies can enable a much richer suite of mobile services, spur even greater innovation and competition, and provide far larger returns to the U.S. Treasury and to all Americans. We specifically address one alternative for re-development of portions of the television broadcast band – a Broadcast Overlay service –and compare the benefits of that approach to the legacy approach of reclamation and auction.

A "One Size" Spectrum Policy Would Stifle Innovation

The rush to reclaim and auction more spectrum for commercial mobile wireless service is driven by massive growth in data traffic on existing mobile networks, coupled with intense pressure to address enormous federal budget deficits. But the growth in mobile data demand cannot be met simply by deploying more spectrum within mobile broadband networks. Worse, a policy of addressing all growth in mobile data by a single architecture and a single business model would continue to burden the nation with a homogenous mobile communications system, even as mobile traffic becomes more diverse.

Policymakers should encourage and enable a wide range of approaches to foster the nascent but critical mobile data sector. Large markets – and by all accounts the market for mobile data will become very large – are not well served by one-size-fits-all solutions. For example, the transportation sector provides widely varied infrastructure and services, each optimized for different types of traffic. Even transportation sub-sectors, such as shipping, are diversified to more efficiently handle different types of traffic. Almost anything, including barrels of oil, can be transported in standard shipping containers. But crude oil is carried far more efficiently in tankers.

Large sectors of the economy are not well served by one-size-fits-all solutions

Spectrum policy likewise should consider what types of mobile traffic must be accommodated in the future and whether a homogenous approach to carrying that mobile traffic would best serve the country.[2] It makes no more sense for all mobile data to be pumped through commercial cellular networks than it does to ship crude oil on container ships.

As mobile data traffic grows, the composition of that traffic is changing greatly. The mobile sector to date has successfully expanded to meet growing demand, first for mobile voice and then for two-way mobile data, by upgrading technology and deploying additional spectrum.[3] The cellular architecture of

[2] The benefits of a more heterogeneous approach are already evident: commercial mobile wireless carriers that once criticized unlicensed WiFi service as inferior and inefficient are now among the largest suppliers of WiFi devices. By 2015 in the United States carriers will offload almost a third of their traffic to the fixed network using WiFi and femtocells. *Cisco*, *supra*.

[3] It has done this in substantial part by relying on WiFi offload, an acknowledgement that traffic should be carried in the most efficient way.

commercial mobile operators is well-suited to voice, web browsing, email, and other common mobile applications, almost all of which are native "point-to-point" services.[4] Although each new user puts additional load on the network, the data traffic for these services is relatively modest, and incremental capacity can be built to accommodate growing demand. In spite of the rapid growth in penetration of "smart" mobile devices, these point-to-point services account for only a portion of the projected growth in demand for mobile data.

It is widely acknowledged that the largest driver behind mobile data traffic growth is video services. Three factors make video traffic qualitatively and quantitatively different from traditional mobile traffic such as voice, email and web surfing.

- Video consumes vastly more bandwidth than other services per session. Assuming limited resources, a single five minute video stream provided to a single user could displace more than an hour of web surfing or several hours of voice calls.

- While every phone call and every web session is unique to the user, only a small percentage of video consumed in a given period of time is unique to the user. Although some video streams (for example, video calls or YouTube videos) are user-specific, most video consumed in any given period of time is consumed not by five or ten, but by thousands or millions of users.[5] Serving individual streams to each of those users is enormously wasteful of spectrum.

- The bandwidth demands of video service increase dramatically as screen size increases. An email consumes the same bandwidth whether rendered on a smartphone, a tablet or a laptop. But video is different: quadrupling screen size requires a sixteen-fold increase in data to maintain equivalent perceived video quality.[6]

Given the explosive growth in IP traffic, especially in the mobile environment, it is imperative to carefully analyze the trends and patterns of this traffic as well as study segmentation of the traffic, before one assesses optimal solutions to meet the challenges posed by the growing demand for mobile data (Table 1).

This report and techno-economic model discuss a market-oriented approach to meet growing demand for mobile data, keeping in perspective the dual objectives of the Federal Government: (a) to maximize the public gain by creating a frictionless communications ecosystem that will boost the economy; and (b) to maximize the U.S. Treasury revenue in the short term as well as in the long term. We have focused on analyzing the probable patterns in mobile traffic in coming years and examining the

---

4 We refer to these traffic types as "native" point to point because the data transmitted is useful to only one user or device per link, and each unit of data is addressed and available to only one device in the service area. Therefore, every time a point-to-point service is used, additional load is placed on the network. In contrast, each unit of data provided by "point-to-multipoint" services is addressed to many or even all devices within the service area. Broadcast television and radio and satellite television and radio are typical point-to-multipoint services. A single bit transmitted by one of the services can be used by an unlimited number of receivers. Additional users place no additional load on the network. Thus, an unlimited number of users can be served with the same amount of spectrum that would be required to serve a single user in a point-to-point system.

5 Even though on demand streaming video services such as YouTube, Netflix and Hulu have been available for years, video transmitted using point-to-multipoint "broadcast" systems still accounts for 80% (Nielsen Company, *The Cross-Platform Report*) (2011) (available at http://bit.ly/Cross_Platform) to 90% (Erlandsson, A., *TV and Video Consumer Trend Report* (Ericsson, 2011) (available at http://bit.ly/TV_Trends) of viewing.

6 Consumption of video on mobile devices with larger screen sizes will drive enormous increases in mobile data traffic. Cisco projects that mobile-connected tablets will generate as much traffic in 2015 as the entire global mobile network in 2010. Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2010–2015, February 1, 2011 (available at http://bit.ly/rwxJNO)

potential value of innovation in broadcast technology and services against the backdrop of these two policy objectives.

TABLE 1

Data Traffic and Growth Patterns: USA

I. Traffic Volume (EB/Year)

	2010	2011	2012	2013	2014	2015
1. Total Data Traffic	62.982	89.523	116.802	145.044	169.632	200.466
2. Mobile Traffic	0.741	1.744	3.612	6.451	10.205	15.583
Mobile Traffic %	*1%*	*2%*	*3%*	*4%*	*6%*	*8%*

** USA Traffic assumed to be 75% of the North American traffic*

II. Traffic Source (%)

	2010	*2011*	*2012*	*2013*	*2014*	*2015*
1. Fixed Internet	*74%*	*74%*	*73%*	*73%*	*73%*	*74%*
2. Managed IP	*25%*	*24%*	*24%*	*23%*	*21%*	*18%*
3. Mobile data	*1%*	*2%*	*3%*	*4%*	*6%*	*8%*

Source: Cisco VNI, 2011

Trends in Mobile Data Traffic

Demand for mobile video and other data-intensive "downstream" services is the real driver behind the exponential growth of mobile IP traffic. According to Cisco:

> **Two-thirds of the world's mobile data traffic will be video by 2015**. Mobile video will more than double every year between 2010 and 2015. Mobile video has the highest growth rate of any application category measured within the Cisco VNI forecast at this time.[7]

In addition, networks will carry a surprising amount of "passive" mobile data traffic consisting of software updates and application enhancements. According to Cisco, "[p]assive networking (consisting largely of background streaming and downloading) has the potential to rival active Internet use as a traffic driver".[8] Cisco also reports that 10 out of the top-50 data sites were associated with software updates and downloads.[9]

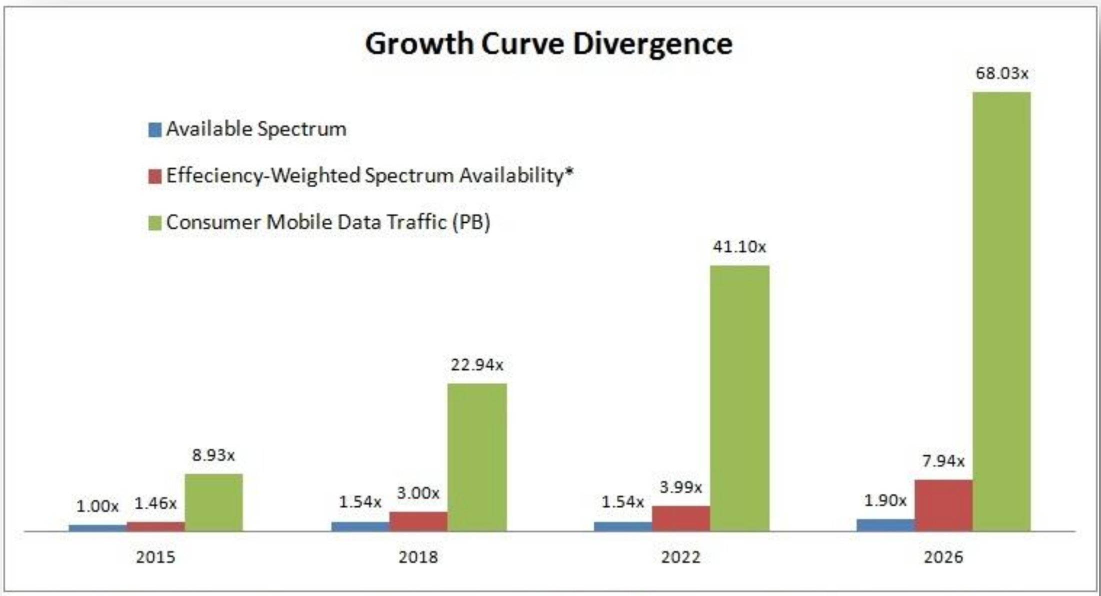
Commercial mobile networks are optimized for low data rate services like voice, text, email and web surfing – but these account for only a fraction of the projected growth in demand for mobile data

Growing dominance of video and passive networking (including background streaming and downloading) create mounting downstream traffic, which is growing much faster than the upstream traffic. Upstream data as a percent of the total data declined from 31% in 2007 to 23% in 2010.[10]

7 *Id.* (emphasis in original)
8 *Cisco Visual Networking Index: Usage. Rep. San Jose, CA: CISCO Systems, 2010. Print.*
9 *Id.*
10 *Id.*

With the combined IP traffic of mobile video and passive networking comprising a vast majority of total IP traffic, it is clear that any solution to a perceived mobile bandwidth crunch must include a far more efficient means of delivering these services than can be achieved by the point-to-point architecture of commercial mobile wireless systems. As we have noted, even today those services must rely on WiFi offloading to manage growing data traffic.

Simply using the right architecture for the right traffic will do far more to alleviate mobile traffic jams than any amount of re-purposed spectrum



Sources: US Wireless Services- coping with the Spectrum Crunch by Deutsche Bank Securities, Cisco Visual Networking Index-Global Mobile Data Traffic Forecast Update, 2010–2015, Business Analytix

FIGURE 1

It is equally clear that allocating more spectrum to commercial mobile wireless service alone will not solve the projected capacity shortfall. As the Growth Curve Divergence chart (Figure 1) shows, even if the total available spectrum is nearly doubled, and even if improvements in technology multiply the capacity of that spectrum fourfold, the eightfold increase in supply over next 15 years would be dwarfed by the growth in demand: consumer mobile data traffic alone is projected to increase almost seventy-fold by 2026.

From a systems perspective, when the quantity of traffic grows exponentially, and when the traffic is not uniform in character, the logical solution is send "point-to-point" traffic over infrastructure that is optimized for that type of traffic, and to send multicast traffic –for which the underlying data-stream is common to hundreds, thousands or millions of users – by a service that is optimized to deliver that kind of traffic. As we will show below, a large percentage of the traffic that is projected to create a mobile traffic jam will do so only because mobile broadband systems are ill-suited to handle distribution of point-to-multipoint traffic. Most of the growth in data – video and software downloads – can be catered to with a higher quality of service and with vastly greater efficiency by a broadcast (or point-to-multipoint) architecture that allows data to be transmitted once and used by thousands or millions.

Not all of the projected growth in mobile data can be met by one-to-many/point-to-multipoint systems, but a very large portion of the growth can be. Remarkable efficiency gains achieved by doing so would decrease in traffic load on mobile wireless networks significantly. Simply using the right architecture for the right traffic will do far more to alleviate mobile traffic jams than any amount of re-purposed spectrum. And, as we will explain below, this approach can also deliver far larger proceeds to the U.S. Treasury, simply by enabling broadcasters to deploy ancillary services so that their signals are easily received on mobile devices.

Flexible (Collaborative) Use of Broadcast Spectrum

Today, broadcasters are permitted to use a portion of their signals to provide ancillary data services, and are required to pay a percentage of the revenue they derive from those ancillary services to the U.S. Treasury.[11] But the revenues generated to date have been inconsequential because FCC technical rules prohibit broadcasters from deploying new technologies in response to changing market conditions. While demand for mobile services grows at a breakneck pace, technical rules adopted 15 years ago mean that only a small portion of the vast capacity of digital television service (and spectrum) is accessible by mobile devices.

Elimination of these outdated and counterproductive regulatory restrictions would enable broadcasters to provide enhanced ancillary services supporting the point-to-multipoint data, voice, and video applications that constitute the great majority of projected new traffic, even while making the core free-to-air broadcast services more robust and useable. This study and the accompanying techno-economic model conclude that, as an alternative to re-allocating and auctioning broadcast spectrum for mobile broadband services, permitting broadcasters to deploy new technologies in response to changing market conditions would:

- *Dramatically lower the cost of mobile broadband service for consumers*
- *Greatly improve mobile broadband service quality for video and other point-to-multipoint services as well as for point-to-point services*
- *Ensure the continuance of a vital, economically strong and competitive free-to-air television service*
- *Greatly reduce the amount of "new" spectrum required for mobile broadband services*
- *Eliminate the need for the government to absorb the cost of transitioning broadcast spectrum for broadband use*
- *Yield a far greater contribution to the U.S. Treasury than net auction proceeds*

Preserving spectrum for broadcast use, but making broadcast services easily accessible by mobile devices, will also prevent another looming crisis that has been overlooked in all projections of future mobile demand: the cost crisis. Projections of a looming spectrum crisis assume that users will begin to consume large amounts of video requiring vast amounts of data capacity – far more capacity than the average smartphone user consumes today. The cost of a gigabyte of mobile data delivered over a point-to-point mobile broadband network today is between $70 and $80.[12] Projections of a looming spectrum crisis assume that consumers will begin to use many more gigabytes per month, but they do

---

[11] 47 U.S.C. §336.
[12] NielsenWire - Don Kellogg, Senior Manager. (2011, June 17). *Average U.S. Smartphone Data Usage Up 89% as Cost per MB Goes Down 46%.* Retrieved October 25, 2011, from Telecom Research & Insights, NielsenWire: http://blog.nielsen.com/nielsenwire/online_mobile/average-u-s-smartphone-data-usage-up-89-as-cost-per-mb-goes-down-46/

not address the consumer affordability aspect nor do they explain the effect of price in moderating that demand. It is apparent that consumers will hit increasingly prevalent data usage caps long before they consume the amount of video and other data-rich services that are assumed in projections of a looming spectrum crisis.

Consumers will not use mobile video and other rich data services at the levels projected unless mobile data rates fall precipitously

Policymakers should be cognizant of the interplay between usage and cost of bandwidth. At present, wireless operators do not differentiate between video and data traffic. Consumers are billed at the same per-gigabyte rate for video as well as other data (and some providers have limited or prohibited video streaming on some rate plans). However, as the ratio of video consumption increases, consumer will find these per-gigabyte rates unaffordable. Consumers will not use mobile video and other rich data services at the levels projected unless mobile data rates fall precipitously. The approach studied in this paper would provide a far lower cost solution for delivering mobile video to consumers by using ancillary data capacity. It would also ensure that free, over-the-air broadcasts too would be easily compatible with mobile devices, now and in the future.

The Methodology of This Study: The Three-Step Analytical Approach

This paper forecasts a number of variables affecting mobile data traffic and pricing until 2026. We followed a three-step analytical approach, briefly described here.

Step 1: Estimation of Point-to-Multipoint Consumer Mobile IP Traffic in the US

We begin by estimating the volume of projected IP traffic that is "native" point-to-multipoint based on certain assumptions.

We project total mobile IP traffic by utilizing the Cisco VNI forecast for the period 2010-2015[13] and thereafter by applying the intrinsic acceleration/ deceleration rates (indicative of the slower/faster pace of growth in future traffic) to project the traffic forecast up to 2026.

While a large portion of IP traffic can be more efficiently delivered by broadcast/multicast system than by point-to-point or "unicast" means, we acknowledge that other traffic is either ill-suited or unsuitable for broadcast/multicast delivery. To err on the side of conservative assumptions, our analysis assumes that only two types of mobile video traffic are suitable for broadcast transport: (1) mobile video traffic and (2) the point-to-multipoint "downstream" IP data traffic including software downloads and application updates. We further assumed that only a portion of each of these types of traffic is suitable for broadcast delivery.

Our projections assume that even by 2026, less than one third of total consumer mobile traffic will be appropriate for delivery by a point-to-multipoint transmission system, even though there is far greater potential. We subjected the techno-economic model to an even slower ramp in point-to-multipoint video to test the ultimate conclusions.

A clear assessment of the market, including existing and projected usage patterns, is essential to meaningful projections useful for guiding policy decisions. Today it is not uncommon to hear sweeping "intuitive" judgments about critical trends that are, in most cases, based on personal experiences

[13] The Cisco VNI forecast does not extend beyond 2015.

and/or local observations and not grounded in firm data. We prefer to base our judgments on current data and widely accepted projections.

Step 2: Estimation of the Value of Point-to-Multipoint Services

The techno-economic model bases the growth in value of point-to-multipoint services provided by broadcasters on the following factors:

- adoption of the Broadcast Overlay services by the broadcasters in terms of population covered
- demand for the point-to-multipoint Broadcast Overlay services in the areas covered
- supply of the bandwidth capacity by participating broadcasters to support such point-to-multipoint demand

Broadcast, as a point-to-multipoint transport, when applied to the appropriate traffic, has the impact of multiplying downstream data capacity many times over, since the same "stream" reaches multitudes of users who can receive the broadcast signal. In theory, a Broadcast Overlay can cater all such services that are better carried over a point-to-multipoint stream to 100% of the devices within the coverage area. However, actual utilization at any given point-in-time is likely to be limited only to the 'active' devices in the range. Hence, we have applied a low (2% to 5%) utilization rate to limit the economic benefit to that arising only from the streams or bytes that would be actually used to replace the "unicast" bytes.

Step 3: Estimation of the U.S. Treasury Share of the Ancillary Service Revenue

In order to compute the potential revenue from the point-to-multipoint Broadcast Overlay services, we have assumed that the price of bits delivered by a more efficient broadcast service will be substantially lower than the price of bits provided though cellular mobile broadband networks.[14] Though such price impact is likely to occur gradually as the Broadcast Overlay point-to-multipoint services proliferate, for the purpose of our study and the techno-economic model, we have considered a price reduction of 75% in the first year of service (2014) in addition to annual reductions of 5%.

We then computed the potential ancillary revenue generated by Broadcast Overlay services. It is assumed that the broadcasters would share 5% of such ancillary revenue with the U.S. Treasury in accordance with present regulations. This U.S. Treasury revenue stream was then discounted at the 10-Year Treasury Bonds yield to compute the Present Value of the U.S. Treasury revenue. Separately, we also computed the economic value of the residual revenue that will occur beyond the forecast horizon of 2026 (till perpetuity) by capitalizing the 2026 revenue and discounting it to compute its present value.

Sources of Data

We have relied on, and extrapolated from, various widely-quoted sources such as:

1. OBI Technical Paper I - Federal Communications Commission
2. Cisco Visual Networking Index: Usage
3. Cisco Visual Networking Index: Forecast and Methodology, 2010–2015
4. The Cross-Platform Report by Nielsen
5. Entering the Zettabyte Era by Cisco Systems

[14] We have not assumed any cost to consumers from use of free, over-the-air broadcast television/video services on mobile devices. Our projections assume that broadcasters will receive revenue only for capacity used to provide ancillary and supplementary services. We note that the widespread availability of free broadcast services on mobile devices would materially reduce load on commercial mobile wireless networks and would provide a quality of service (especially video resolution and audio fidelity) that cannot feasibly or economically be matched by point-to-point networks.

6. TV and Video Consumer Trend Report 2011 by Ericsson
7. Mobile TV, Tuning in or Switching Off? Rep. Arthur D. Little, 2009
8. PC Mag Report 9/11/2011 (http://alturl.com/2kew2) on data usage cap benchmarking

Refer detailed Bibliography for the exhaustive listing of all citations.

Analysis in a Nutshell

Analysis in a Nutshell

The following (Table 2) summarizes the model computations of the techno-economic analysis:

TABLE 2

	2011		2015		2020		2026
Total Mobile Consumer Video IP traffic (PB)	721	...	7,254	...	28,685	...	55,949
Point-to-Multipoint Video Traffic (PB)	36		1,813		12,908		27,975
Total Mobile Consumer Data IP Traffic (PB)	351		2,774		16,108		38,889
Point-to-Multipoint Data Traffic (PB)	54		394		2,068		4,423
Total Point-to-Multipoint Traffic (PB)	90		2,207		14,977		32,398
Broadcast Overlay capacity providing Point-to-Multipoint services (PB)	-	...	1,405	...	11,988	...	25,933
Annual Ancillary Revenue from Broadcast Overlay Point-to-Multipoint service ($ millions)	-	...	$21,204	...	$139,992	...	$222,612
U.S. Treasury Revenue Share of Ancillary Revenue @5% ($ millions)	-	...	$1,060	...	$7,000	...	$11,131
Cumulative Present Value of U.S. Treasury Revenue ($ millions)	-	...	$1,502	...	$19,314	...	$62,141

In order to ensure the robustness of the techno-economic model, we ran the following additional scenarios:

a) What if the point-to-multipoint traffic grows at a slower than forecasted growth rate?
b) What if the adoption of the point-to-multipoint Broadcast Overlay technology is slower than anticipated?

Key Conclusions

Our study and accompanying techno-economic business model conclusions are:

Base Case:

1. U.S. Treasury would gain $62 billion in ancillary revenue share between 2014 and 2026 in the Present Value terms.
2. In addition, the Present Value of the U.S. Treasury's share of the Broadcast Overlay ancillary revenue, beyond the forecast horizon of 2026, would be $215 billion.

Worse Cases:

3. Even if we compute the U.S. Treasury's ancillary revenue share on the basis of a much lower point-to-multipoint IP traffic in proportion to the total IP traffic, the Present Value of the U.S. Treasury revenue share between 2014 and 2026 would amount to $46 billion.
4. Similarly, in spite of accounting for a slower proliferation of the Broadcast Overlay service over the forecast horizon, the Present Value of the U.S. Treasury revenue share will still be significant at $54 billion.

Thus, in all scenarios, enabling broadcasters, by removing today's technical and regulatory limitations, to provide enhanced ancillary services supporting point-to-multipoint applications, results in:

a) More efficient utilization of spectrum by matching the transport platform with the type of potential IP traffic (i.e. broadcast for point-to-multipoint and unicast for point-to-point).
b) Lower bandwidth prices as a direct result of better bandwidth availability and better economics arising from the higher bandwidth efficiency.
c) A vastly higher contribution to the U.S. Treasury

II. Emerging Wireless IP Traffic Patterns

Several trusted sources provide detailed analysis of global and national IP traffic in fixed as well as wireless eco-systems. All of these studies concur on certain key aspects of IP traffic such as the exponential growth in the mobile traffic, significant share of video in the overall mobile traffic, etc. Given below is a brief description of the emerging trends noticeable from these studies:

Burgeoning Global IP Traffic and its Impact on the Quality of Consumer Experience

Cisco's June 2011 Visual Network Index (VNI) study declared that the world is entering "the zettabyte era" with the annual IP traffic poised to touch 966 Exabyte (EB) in 2015 (Cisco Systems). Though, there are indications that the growth is marginally slowing down (global IP traffic grew eight-fold over past five years, whereas it is poised to grow five-fold over next five years), the sheer volume of the forecasted IP traffic raises concern about how network operators will cope up with it without compromising the user experience. Sandvine, a leading provider of intelligent broadband networks, points out that service providers are increasingly using rate-adaptive video-streams that "shift to lower bitrates and quality [in response to the network congestion], which impacts the subscriber experience" (Sandvine Intelligent Broadband Networks). Sandvine estimate that roughly 1/3rd of the total peak downstream video traffic falls in this category. [15]

Segmentation of Global IP Traffic

Mobile IP traffic accounts for 2% of total IP traffic in 2011. However, this is the segment of overall IP traffic that is growing most aggressively with the current annual growth rates exceeding 100% (see Table 3).

TABLE 3

IP Traffic, 2010-2015	2010	2011	2012	2013	2014	2015	CAGR 2010-2015	Growth Deceleration
By Type (PB per Month)								
Fixed Internet	14,955	20,650	27,434	35,879	46,290	59,354	32%	
Year-over-Year Growth		*38%*	*33%*	*31%*	*29%*	*28%*		-7%
Managed IP	4,989	6,839	9,014	11,352	13,189	14,848	24%	
Year-over-Year Growth		*37%*	*32%*	*26%*	*16%*	*13%*		-24%
Mobile data	237	546	1,163	2,198	3,806	6,254	92%	
Year-over-Year Growth		*130%*	*113%*	*89%*	*73%*	*64.32%*		-16%
By Segment (PB per Month)								
Consumer	16,221	23,130	31,592	42,063	54,270	70,045	34%	
Business	3,930	4,894	6,011	7,357	8,997	10,410	22%	
By Geography (PB per Month)								
North America	6,998	9,947	12,978	16,116	18,848	22,274	26%	
Year-over-Year Growth		*42%*	*30%*	*24%*	*17%*	*18.18%*		-19%
Total (PB per Month)								
Total IP traffic	**20,151**	**28,023**	**37,603**	**49,420**	**63,267**	**80,456**	32%	
		39%	*34%*	*31%*	*28%*	*27%*		-9%

Source: Cisco VNI, 2011, Business Analytix computation of Growth Deceleration

[15] *Sandvine Global Internet Phenomena Report*, Sandvine Incorporated ULC (2011) (available at http://bit.ly/Sandvine_GBT).

North America accounts for 35% of the global IP traffic.

Roughly, 80% of the total IP traffic in 2010 is generated by consumer segment. Cisco projections expect the share of the consumer IP traffic to go up significantly by 2015 to 87% (See Table 4).

TABLE 4

Traffic Share by End-User Segment as of Year End 2015 — Source: Cisco VNI, 2011

	Overall Traffic Share by End-user Segment		Overall Traffic Share as of Year End 2015		
	Consumer	Business	Consumer	Business	Total
Internet	76%	58%	66%	8%	74%
Managed IP	17%	29%	15%	4%	18%
Mobile data	7%	13%	6%	2%	8%
Total	100%	100%	87%	13%	100%

Global IP Traffic is Not Becoming Symmetric

We often hear sweeping judgments about the universal trends that attach exaggerated weight to some topical and highly visible developments around us. One example of such a misguided belief (probably arising from our personal exposure to many user-generated small video-clips on YouTube) is that the web is getting more synchronous. In other words, it is widely believed that the upstream traffic now accounts for as much as the downstream traffic. The facts, however, tell us a very different story (see Table 5).

TABLE 5

Upstream Residential Broadband Traffic in North America, 2007-2010

	2007	2008	2009	2010	
Upstream as a percentage of total traffic Source: VNI Usage, 2010	31%	24%	25%	23%	-9.5%

Table 5 shows that IP traffic not only continues to remain asymmetric, but in fact is getting increasingly asymmetric. This highlights the importance of managing the downstream data optimally in order to cater to the rising bandwidth needs without sacrificing the quality.

Focus of this Study – Consumer Mobile IP Traffic

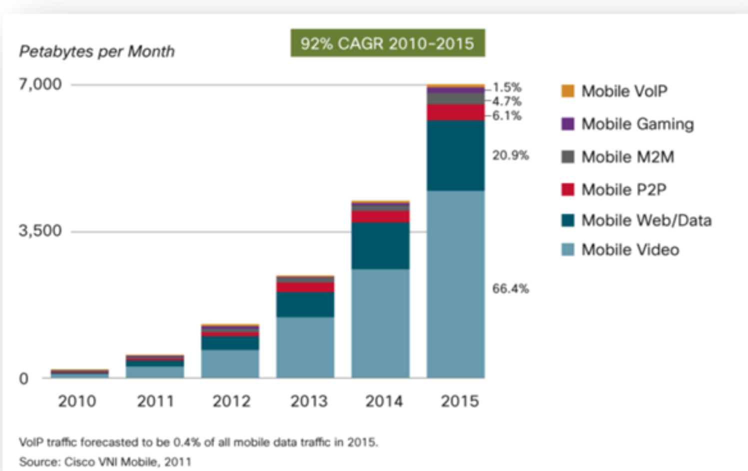
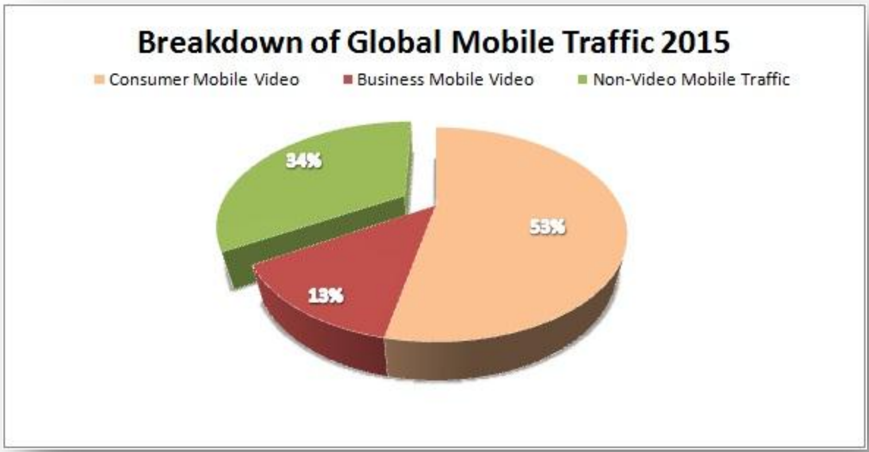


FIGURE 2

This study focuses specifically on mobile consumer IP traffic. It seeks to examine likely near-future challenges that may be faced by the wireless broadband eco-system in keeping the cost of the connectivity under control without compromising the quality of experience.

In the ensuing paragraphs, we will see how mobile IP traffic is growing at a geometric scale with mobile video taking a lion's share of it. This growth is easily seen in Figure 2.

FIGURE 3



We will also examine the leading indicators to estimate the proportion of mobile video and data traffic that is more optimally handled by the one-to-many (point-to-multipoint) transmission system rather than currently used one-to-one unicast systems. An illustration of future mobile traffic segmentation is represented in Figure 3 above.

Emerging Consumer Behavior

III. Emerging Consumer Behavior

While the growth in the aggregate IP traffic is relatively easy to project, how the behavior of an individual consumer might evolve over a period is a much more complicated parameter to predict. In recent years, innovative services (mostly video services) have emerged from nowhere to occupy significant portion of IP traffic. Even though a few of these trends may have surprised a layman, analysts tracking user behavior during last decade were not surprised. Let us look at the consumer behavior today with a similar objective of predicting it for coming decade. How will the consumers use connectivity in coming 5-10-15 years and what challenges would these emerging user behavior trends create for the network operators?

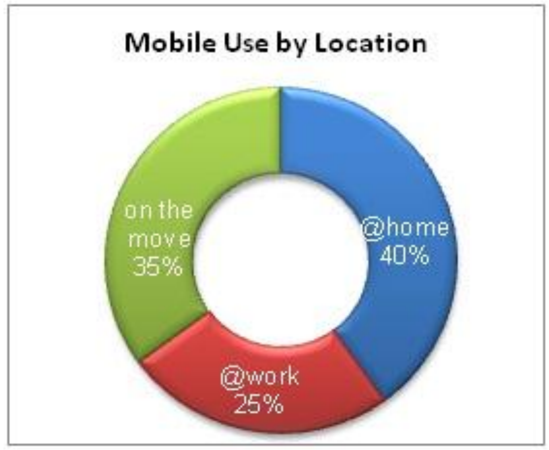


FIGURE 4

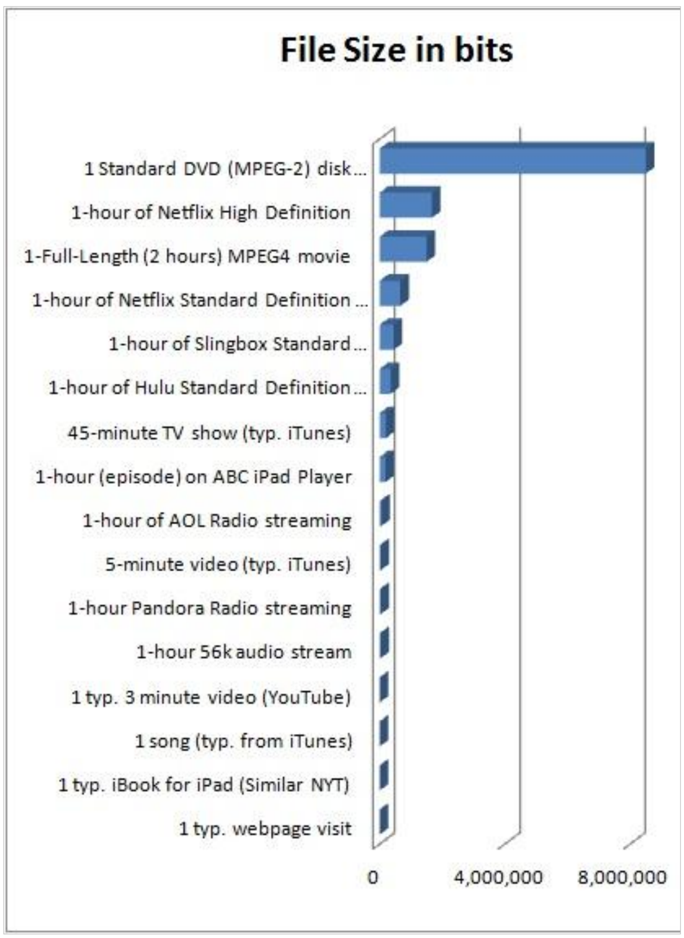


FIGURE 5

Is Mobile … mobile?

Consumer behavior often depends on the location where a consumer uses a communication device. It is but natural that consumers would have greater inclination to be led by their "fixed" environment behavior if they are using a "mobile" device at a "fixed" location. Cisco reports that 65% of use of the "mobile" devices is, in fact, done in a fixed environment (see Figure 4). More notably, almost 40% of all mobile use occurs when the consumer at his or her home.[16]

[16] *Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2010–2015*. Rep. San Jose, CA: Cisco Systems (2011) (available at http://alturl.com/774gr).

Video, Video, and Video

Dr. Carl Sagan, renowned American astronomer, writer, and scientist once said that "All of the books in the world contain no more information than is broadcast as video in a single large American city in a single year. Not all bits have equal value." This remains true in the mobile environment as well. In addition to the superior sensory pay-off offered by video to the consumer that drives higher appetite for video consumption, another factor drives the weight of "video" over an IP network … the size of a typical video file (see Figure 5). Given these factors, it is not surprising that consumer mobile video traffic is forecasted to take up almost half of total consumer mobile IP traffic by 2015 (see Figure 6).

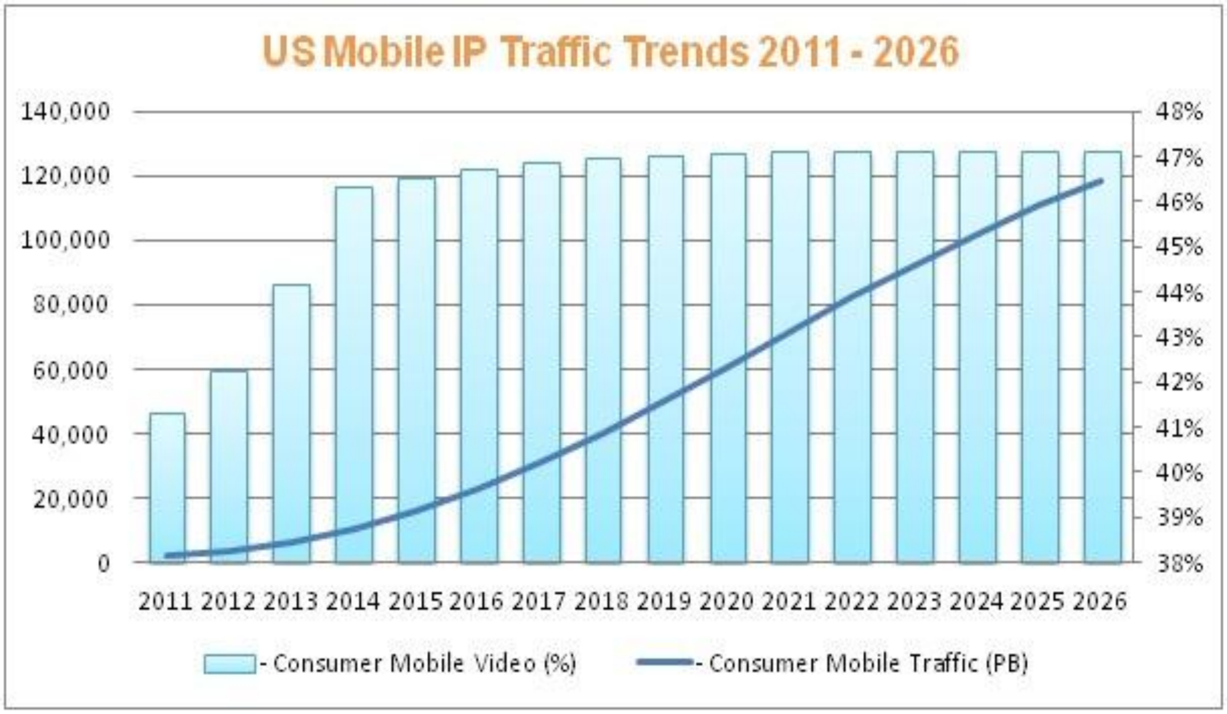


FIGURE 6

IV. Live TV and Mobile Broadband Data Traffic

The emergence of video streaming services such as Netflix and Hulu suggest to some that existing patterns of video consumption are changing. Recent studies do not support the perception of fundamental changes. Nielsen reports, "more than a third of the TV/Internet population is not streaming, whereas less than one percent are not watching [live] TV".[17] A closer look at how consumers watch their video content reveals an interesting picture (Table 6):

Cross Platform Consumer Preferences: How People Watch Video

	Fixed			Mobile				
	Q1 11	%	Growth '11		Q1 11	%	Growth '11	
TV In Home	158:47:00		0.20%	On Phone	4:20:00		20%	
DVR Plyaback	10:46:00		12.20%					
Point-to-Multipoint	**169:33:00**	**97%**		**Point-to-Multipoint**			**??**	
Time-Shifted TV								
Video on Internet	4:33:00		34.50%					
Point-to-Point	**4:33:00**	**3%**		**Point-to-Point**			**??**	
	174:06:00				4:20:00			178:26:00

Source: The Cross-Platform Report; Quarter 1, 2011 - The Nielsen Company

TABLE 6

Commuters in Japan watching Mobile TV

As one can observe from above Table 6; one-to-many (point-to-multipoint) mode of transmission accounts for 97% of video usage in the fixed environment (home, work, etc). More than 90% of US television households pay to receive "real-time" or synchronous television provided over one-to-many platforms such as cable or satellite.

Ericsson's ConsumerLab, in a report released this year,[18] corroborates this conclusion. It says that though on-demand TV is growing, people who claim that broadcast TV is dead or dying are exaggerating. Ericsson found that 84 out of every 100 consumers polled worldwide watched scheduled broadcast TV and 45 out of every 100 consumers watched recorded broadcast TV. In comparison, only 33 out of every 100 consumers polled watched streamed on-demand TV shows and 25 out of every 100 consumers watched streamed on-demand movies.[19]

As shown above, on-demand streaming is not displacing use of linear television – consumption of both forms of video delivery is growing. But linear television still accounts for the vast majority of usage. Cisco's projections tell the same story. Cisco forecasts that "Live Internet TV", which would be most efficiently handled by a point-to-multipoint broadcast system rather than unicast, will generate IP Traffic of 3,412 PB per month by 2015. To put this in perspective, non-linear Internet video delivered to television screens via an Internet-enabled set-top

---

[17] Nielsen Company, *The Cross-Platform Report*) (2011) (available at http://bit.ly/Cross_Platform)
[18] Erlandsson, A., *TV and Video Consumer Trend Report* (Ericsson, 2011) (available at http://bit.ly/TV_Trends)
[19] *Id.*

box or equivalent device (e.g, Xbox 360), Internet-enabled TV or PC-to-TV connection, is forecast to be 5,911 PB over the same period.[20]

Mobile video is still in its nascent stage and no such breakdown is available for mobile video. However, given that 40% of mobile device usage is done at home, we expect that "fixed" environment video consumption behavior will be replicated when a user consumes video at home or at work using a mobile device. Experience in Japan and South Korea supports this hypothesis. [21] When linear TV is available in a mobile environment people tend to replicate their "fixed environment behavior" of watching linear TV. Both Japan and South Korea have reached about 20 million mobile TV subscribers each in less than 5 years since the launch of mobile broadcasts. The growth of mobile TV in the U.S. has been hindered due to regulatory as well as technological issues. The Arthur D. Little Report titled Mobile TV states, "While broadcast Mobile TV services might have disappointed many market players to date, it is clear, that when the context is right, Mobile TV does have a mass market appeal" (Taga)[22].

Of course, all viewers of "live" television (including sports and most newscasts) are watching at the same time, and delivery of individual unicast streams to each user become vastly more inefficient as the number of viewers increases. But a substantial portion of video that is not "live" is still consumed in "real time" as a scheduled broadcast (or is recorded as scheduled for later replay – in either case, the spectrum efficiency is equivalent).

Ancillary data capacity in broadcast signals can alleviate a substantial portion of the growth in mobile data traffic. But even the primary free-to-air broadcast service itself could also address much of the demand for mobile video if regulations permitted broadcasters to use transmission standards such as LTE that are more compatible with mobile service. As explained above, linear (or "real-time" or synchronous) television, when available, remains the most popular source of video programming.

Aggregate viewing statistics confirm that most video can be delivered more efficiently by broadcast systems, but that other video is best delivered by unicast. Debating which approach is superior sets up a false choice. Consumers are best served when multiple sources of video (and other high bandwidth data) are available, each providing efficient delivery of a portion of total data traffic. Given a choice, at any given time many users will choose scheduled, recorded or "pushed" broadcast programming, saving capacity on carrier networks for others that choose unicast programming or non-video services for which those networks are optimal. The potential offered by the development of a Broadcast Overlay technology, based on integration of broadcast standards with the widely-adopted LTE wireless standard, could provide the "right context" and unleash the growth of mobile TV in near future. [23]

Estimating One-to-Many/Point-to-Multipoint IP Traffic and Cost"

[20] *Cisco Visual Networking Index: Forecast and Methodology, 2010–2015*. Rep. San Jose, CA: Cisco Systems, 2011. Print. http://alturl.com/dudda

[21] Fitzpatrick, M. (n.d.). *The Guardian*. Retrieved 10 25, 2011, from http://www.guardian.co.uk/technology/2007/sep/27/guardianweeklytechnologysection.mobilephones

[22] Taga, K. C. (2009). *Mobile TV, Tuning in or Switching Off?* . Arthur D. Little. http://www.digitaltvnews.net/content/?p=7573

[23] Aitken, M. A. (October 2011). Broadcast Convergence - Bringing Efficiency to a New Platform. *Sinclair Broadcast Group*. Cockeysville, MD: Technical Paper presented at IEEE BTS .

V. Estimating One-to-Many/Point-to-Multipoint IP Traffic

The significance of one-to-many/point-to-multipoint applications in coming years, even in the wireless environment, is well established from data cited above. Other trends also indicate a substantial expansion of point-to-multipoint mobile IP traffic in near future.

- Tablets have emerged as very popular and seemingly ideal devices for personal television viewing. Available for less than 2 years, tablets already account for 2% of the total digital traffic in US (see Figure 7). In fact, in August 2011 iPads accounted for a higher share of traffic on the iOS platform (46.8 percent) than iPhones (42.6 percent), even though far more iPhones have been sold.[24]

  In spite of relatively miniscule availability of live TV content on tablets, in September 2011 as many tablet-users watched live television on their tablets as the on-demand video content – using grossly inefficient one-to-one IP streams

  In a survey conducted by comScore in September 2011, almost half of the polled consumers reported to having viewed an Internet-delivered live television program at least once in past month on their tablet and 16% of respondents reported having done so almost every day in past month. The percentage of viewers watching on-demand video or TV episodes on tablets was almost exactly same. These statistics are striking, because on-demand sources of Internet video (Hulu, Netflix, YouTube, etc.) are far more prevalent than sources of live Internet streamed television. And they are particularly striking, because the most popular television programming -- from the major broadcast networks -- is ***not*** available via live streaming, but much of it ***is*** available for on-demand Internet viewing. This again confirms other data showing a marked preference for live, real-time use of television programming even when on-demand alternatives are available.

  This also underscores a point that bears great emphasis: a Broadcast Overlay service that is technically compatible with commercial wireless networks would not just deliver a large portion of mobile broadband data more efficiently. It would also displace much of the demand for mobile broadband data altogether, because when consumers are watching television broadcasts on their devices they are not streaming video over the broadband network, and they are not even using Broadcast Overlay capacity. And, of course, when they are watching the core free over-the-air programming, they are not paying any data usage charges.

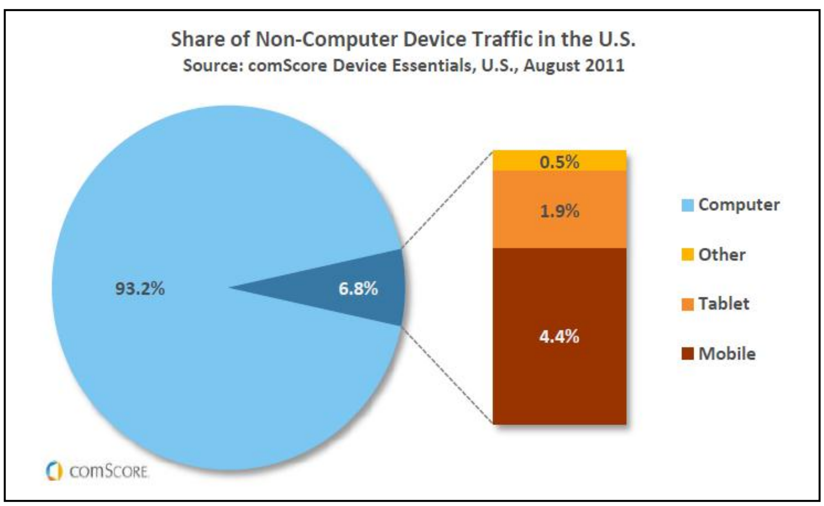


FIGURE 7

- Experience in Japan and South Korea shows the vast potential of Mobile TV if an appropriate ecosystem is fostered. ComScore MobiLense reported that 22% of mobile users in Japan watch TV and

[24] comScore, *Digital Omnivores: How Tablets, Smartphones and Connected Devices Are Changing U.S. Digital Media Consumption Habits* (October, 2011) (available at http://bit.ly/Digital_Omnivores (registration required)).

video and another 15.4% watch captured video over their mobile devices[25]. In spite of impediments such as proprietary technology standards, lack of regulatory push for a hybrid 3G streaming/broadcast Mobile TV service, and higher costs; there were 35 million broadcast mobile TV subscribers in Japan and South Korea[26].

- Considering that 40% of mobile use occurs when the consumer is at home, mobile users are likely to replicate their "fixed" behavior in consuming video. There are some very striking early signs. Observe the spike in tablet use between 8 PM-11 PM in Figure 8. In the real-time TV parlance this is the 'prime time'. Given that equal number of tablet users watch real time TV as the on-demand TV, this suggests a surge in potential point-to-multipoint traffic over mobile/nomadic devices during that time.

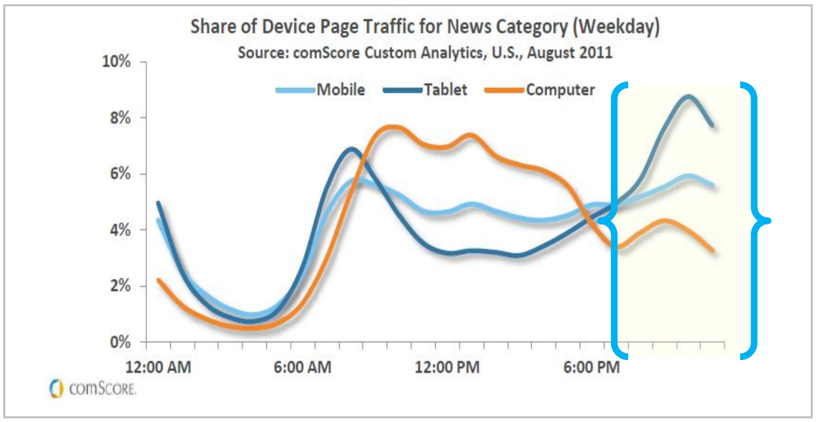


FIGURE 8

- There is a trend towards the app-store+ tablet-as-STB model of content delivery that will supplement or replace TV as a media to receive live TV along with time-shifted video content.[27] Players such as MobiTV are leading the charge to provide Live as well as on-demand TV programming on smart-phones and tablets. In June 2010, MobiTV surpassed 1 million app downloads on iPhone and soon after MobiTV, Inc. delivered over 100 million minutes of live and VOD World Cup coverage for ESPN Mobile TV. In August 2011, it launched AT&T U-verse Live TV on iPhone, iPod Touch and iPad (MobiTV - Company Timeline). These trends validate the demand for real-time video on mobile devices. But commercial mobile networks are ill-suited to deliver this kind of traffic, and this inherent inefficiency is the main cause of predicted spectrum shortages. As explained above, additional spectrum allocations cannot compensate for use of the wrong architecture to provide a core service, especially the most bandwidth-intensive core service.

- Apart from video, software downloads and application updates consume significant IP bandwidth. According to Cisco, Ten of the top 50 sites were associated with software updates and downloads (security and application enhancements) (Cisco Systems).

---

[25] comScore, Inc. (2011, February). *Mobile Year in Review 2010*. Retrieved October 25, 2011, from ComScore: http://bit.ly/tHiom8
[26] Taga, K. C. (2009). *Mobile TV, Tuning in or Switching Off?* . Arthur D. Little.
http://www.adl.com/reports.html?view=366
[27] Eden Zoller, J. D. (2011, May 19). *Mobile TV: the second coming*. Retrieved October 25, 2011, from Ovum.com: http://ovum.com/2011/05/19/mobile-tv-the-second-coming/

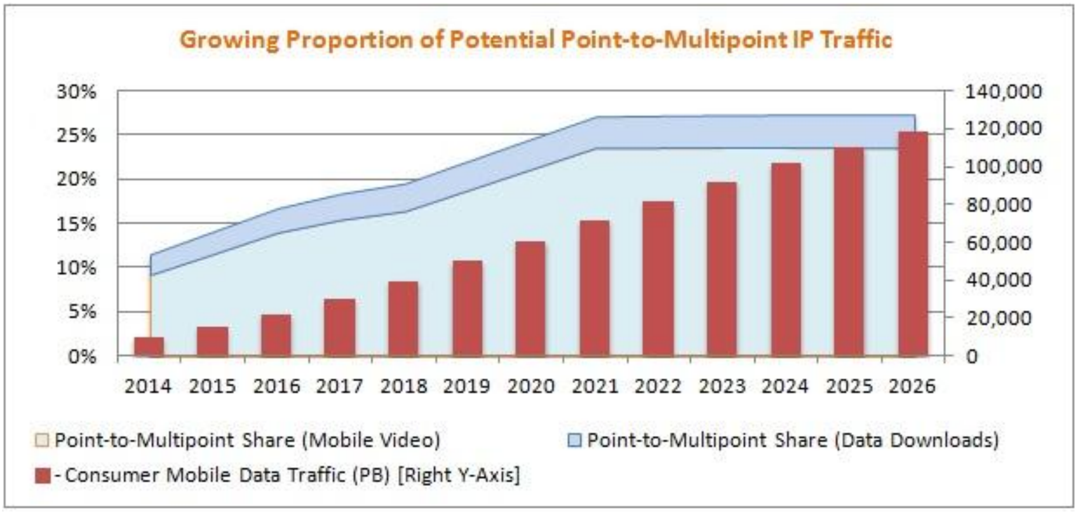


FIGURE 9

Keeping these key trends in perspective, we have forecasted a gradual yet significant rise in the proportion of point-to-multipoint as shown in Figure 9. However, in spite of a far greater potential for the growth of point-to-multipoint traffic, we preferred to err on a conservative side for our analysis and assumed that even at its peak, the point-to-multipoint traffic will be less than 1/3rd of the total consumer mobile IP traffic.

Impact of the Optimal Choice of Transmission Mode on Overall IP Traffic

VI. Impact of the Optimal Choice of Transmission Mode on Overall IP Traffic and Cost

Data (including video) can be distributed in either one-to-one/point-to-point (unicast) mode or one-to-many/point-to-multipoint (broadcast/multicast) mode. Certain types of data traffic are better suited for either of these transmission modes. Real-time video, which is watched by a critical mass of consumers in an operator's coverage area, instantly or soon after the transmission, is most efficiently distributed by a broadcast/multicast system.

As Cisco points out, live TV is currently distributed by means of a broadcast network, which is highly efficient in that it carries one stream to many viewers. Live TV over the Internet would carry a separate stream for each viewer[28]. AT&T estimates that a shift from multicast or broadcast to over-the-top unicast "would multiply the IP backbone traffic by more than an order of magnitude" [29]

In simple words, if a certain video or data stream has multitude of intended users in a given service area, that stream is more efficiently sent from the operator to the subscriber using a one-to-many/point-to-multipoint transmission system rather than sending multitude of individual one-to-one streams to each of the intended user. Replacing multiple unicast streams with one broadcast stream would result in better utilization of scarce spectrum as well as ensure a better quality of experience for the user. One noteworthy fact is that use of one-to-many/point-to-multipoint transmission will result in reduction in the per bit cost of the bandwidth (discussed in detail later). Reducing 'cost per used bit' would be critical from the perspective of the wireless operator, since average user's appetite for bandwidth is growing faster than his or her ability to pay for it.

The use of broadcast spectrum to cater to the point-to-multipoint traffic needs will also create a significant ancillary revenue stream that will result in a sustained and perpetual annuity for the U.S. Treasury.

Price of the Wireless Data

For economic goods or services to have value, it is not enough that it satisfies a human want or need. The other part of the value equation is scarcity: things have value when there isn't enough for everyone to have as much as they would like. For example, air is only valuable if there isn't enough for everyone to breathe; if there's plenty of air for everyone, it has no real economic value. By forcing us to decide who gets what, scarcity gives objects value.

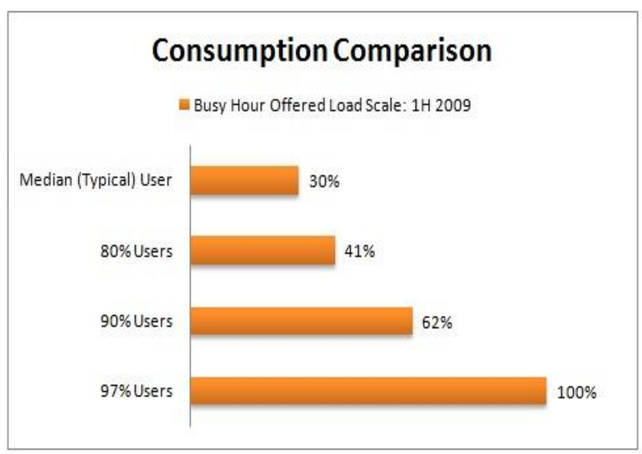


FIGURE 10

The supply of wireless data capacity is limited, and price is a key factor in determining how we utilize this scarce resource. We have estimated the price of mobile data based on the published price bands of leading wireless providers in US (and their respective usage limits) and the bandwidth consumption of a typical user as compared to the consumptions assumed by the usage ceilings. AT&T, for

[28] Cisco Systems, *Entering the Zettabyte Era* (2011) (available at http://bit.ly/Zettabyteera).

[29] Alexandre Gerber and Robert Doverspike, AT&T Labs Research; Traffic Types and Growth in Backbone Networks (available at http://www.research.att.com/export/sites/att_labs/techdocs/TD_100193.pdf).

example, has publically acknowledged that its usage caps are high enough to accommodate 98% of their users (AT&T).[30] Figure 10 shows how 'typical user' consumption may scale against the 97 percentile user, using the scale published by FCC (Federal Communications Commission). Thus, the actual 'price per used bit' for a typical user will be much higher than the price per bit implied by rate plan usage caps.

Our estimation of the bandwidth price per GB is around $70. In an independent report, Nielsen reported a price per MB of 8 cents (or $80 per GB) in the first quarter of 2011. [31]

Impact of an Optimal Solution for Point-to-Multipoint IP Traffic on Bandwidth Price

One of the factors that keep per Gigabyte bandwidth prices high is the use of one-to-one streams to carry one-to-many traffic. This approach multiplies the traffic and leads to increased $/Gigabyte due to (a) higher cost on account of economic inefficiencies – impacting the numerator, and (b) lower usage due to network congestion – impacting the denominator. A successful implementation of an optimal transport solution to carry one-to-many data without unnecessary duplication (multiple unicast streams all carrying the same data in the same service area) will result in bringing the 'cost/price per used bit' for such traffic down significantly. We have assumed that the one-to-many bytes, therefore, would be priced at 1/4th of the real price for mobile data delivered over point-to-point cellular networks. We have, in addition, assumed an annual reduction of 5% throughput the forecast period. See the chart below (Figure 11)

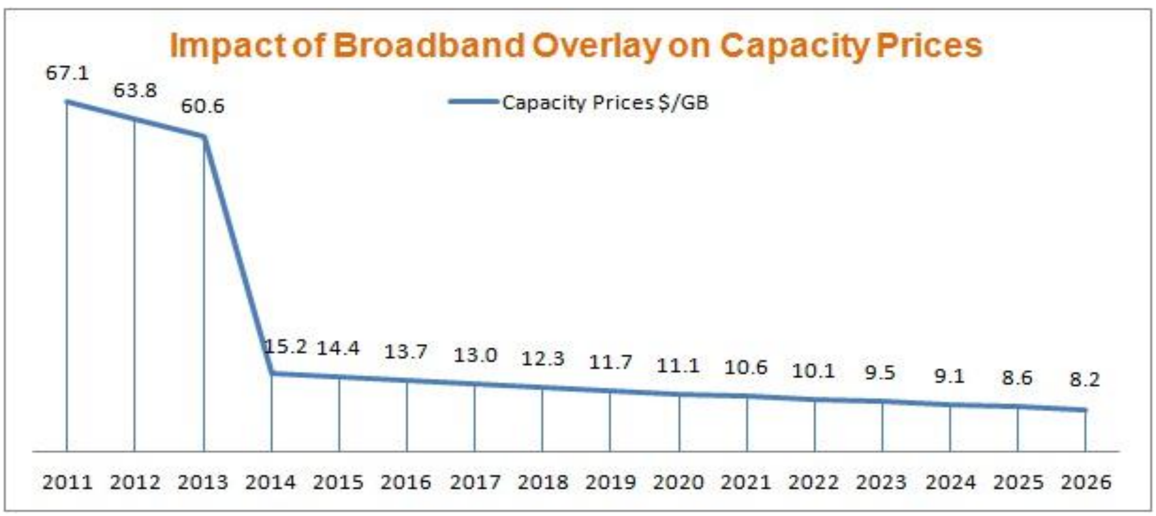


FIGURE 11

Supply Side of Point-to-Multipoint
Bandwidth: the Role of "Broadcast Overlay"

[30] AT&T, I. (2010, June 2). *AT&T- News*. Retrieved October 25, 2011, from http://www.att.com/gen/press-room?pid=17991&cdvn=news&newsarticleid=30854&mapcode=

[31] NielsenWire - Don Kellogg, Senior Manager, 2011 http://blog.nielsen.com/nielsenwire/online_mobile/average-u-s-smartphone-data-usage-up-89-as-cost-per-mb-goes-down-46/

VII. Supply Side of Point-to-Multipoint Bandwidth: the Role of "Broadcast Overlay"

Value resides at the intersection of the demand and supply. Hence, our assumptions regarding the supply of Broadcast Overlay data capacity need to be realistic to arrive at a reasonable estimate of the potential value of a Broadcast Overlay platform. Let us first understand the proposed technology solution of a Broadcast Overlay. A Broadcast Overlay is proposed as a technology that will provide a transport architecture optimally matched to the projected demand for one-to-many/point-to-multipoint IP traffic.

Broadcast Overlay – a Broad Overview

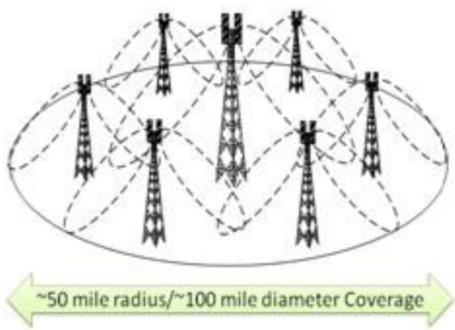


FIGURE 12

Broadcast Overlay is a technology solution that addresses the pain-point of carrying point-to-multipoint IP traffic in the most cost-efficient way, leveraging ancillary data capacity available in the transmission streams broadcasters provide for their primary broadcast service.[32] This solution assumes a distributed SFN (single frequency network) broadcast architecture with multiple towers (see Figure 12). This will be far more cost efficient than building hundreds of cell towers to cover the same area using wireless technologies.

However, the technology can be effective in transporting point-to-multipoint IP traffic in the most cost-effective way, if broadcasters and the wireless companies can work collaboratively to render shared services (see Figure 13).

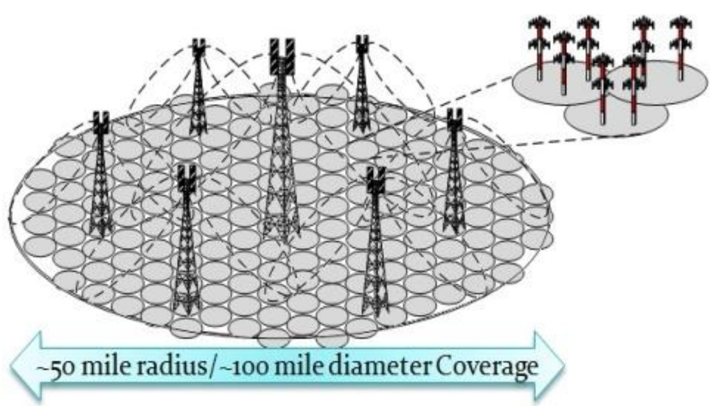


FIGURE 13

Broadcast Overlay infrastructure can contribute to a more efficient use of UHF spectrum while potentially creating huge value for the consumer, the operators, and the U.S. Treasury.

Assumptions regarding the roll-out

We have taken into account the lead time for the completion of the groundwork required to rollout Broadcast Overlay services and assumed a gradual roll-out. We have assumed a measured adoption of

[32] Aitken, M. A. (October 2011). Broadcast Convergence - Bringing Efficiency to a New Platform. *Sinclair Broadcast Group*. Cockeysville, MD: Technical Paper presented at IEEE BTS .

this technology starting from 2014 and expect 60% of broadcast stations to adopt this technology 7 years from today. The chart below (14) illustrates the assumed adoption curve:

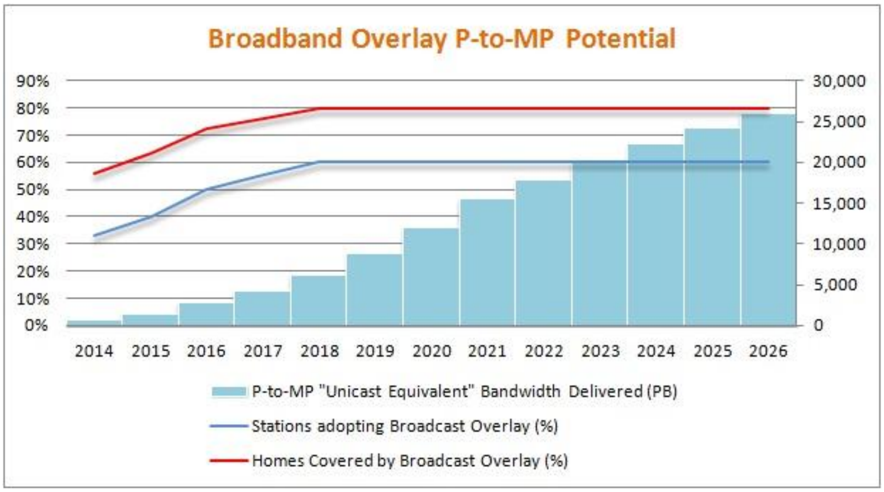


FIGURE 14

Unicast Equivalence of Broadcast Bits

When a one-to-one IP stream is created, it is usually in response to a specific need of the user. However, when a one-to-many IP stream is broadcasted, not all users in the coverage area are the intended users for the stream. We have, therefore, considered a 'utilization rate' to consider only 'unicast-equivalent' bits that are carried by the Broadcast Overlay system. This utilization rate is assumed to increase from 2% to 5% as the technology matures.

Broadcast Overlay Capacity Limitations

Broadcast Overlay is expected to generate roughly 3,000 GB/month capacity per station, 50% of this capacity is considered to be utilized to carry point-to-multipoint traffic.

VIII. The Economic Value of Broadcast Innovation from the Perspective of U.S. Treasury

After establishing (a) the demand potential for the Broadcast Overlay service, (b) the supply potential offered by rollout of Broadcast Overlay technology to carry point-to-multipoint IP traffic, and (c) the price per bit of one-to-many/point-to-multipoint bandwidth; we can forecast the revenue that can be generated by such a service.

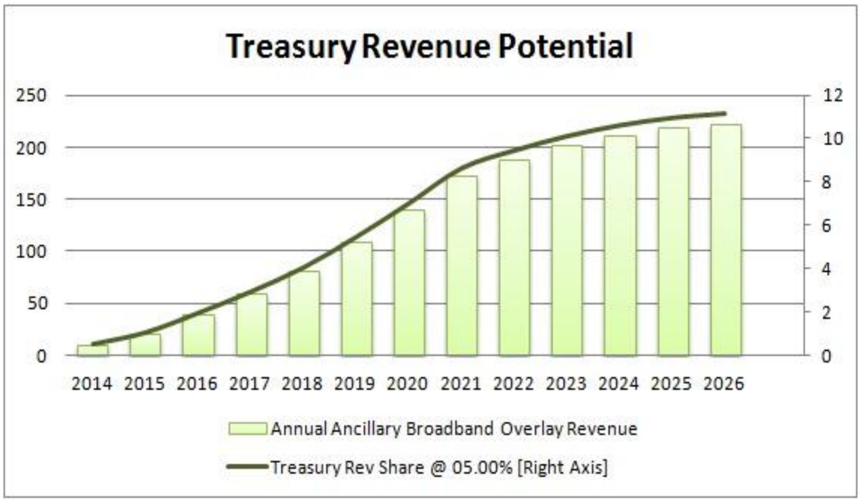


FIGURE 15

The chart above (Figure 15) shows the revenue S-curve between 2014 and 2026 arising from provisioning of the Broadcast Overlay service. The Broadcast Overlay revenue will be an ancillary use of the broadcast spectrum and it is assumed that the U.S. Treasury would be paid a 5% share of such ancillary revenue as per the present FCC rules.

Figure 16 (below) illustrates the potential cumulative revenue value to the U.S. Treasury.

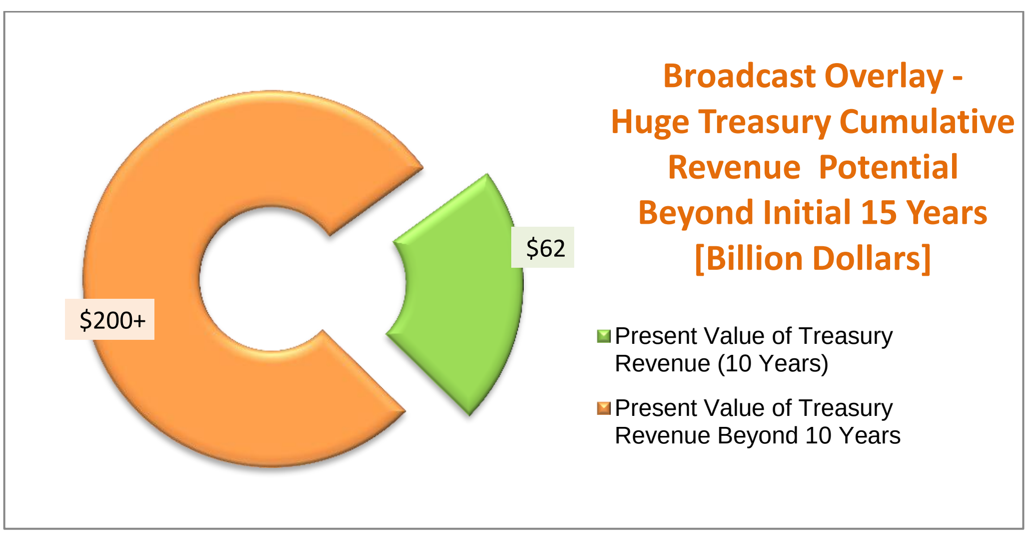


FIGURE 16

Conclusions

IX. Conclusions

If we build a 'bottoms-up' techno-economic model based on widely-accepted IP traffic data and make conservative estimates of the portion of that traffic that is more efficiently provided by a point-to-multipoint service, relying on experiences in other countries and trends visible from the latest consumer behavior data; it becomes abundantly clear that Broadcast Overlay technology will result in enormous value creation.

- Broadcast Overlay, as an optimal point-to-multipoint solution, would result in lower the 'cost per used bit'. This will mean lower bandwidth prices for the consumers

- By optimally utilizing the bandwidth, the Broadcast Overlay will result in improved quality of service. While unicast video streams must be greatly compressed to conserve bandwidth, broadcast programming (both the primary free-to-air programming as well as any video provided in the ancillary data stream) can be provided in extremely high resolution to all users.

- The Broadcast Overlay will generate substantial ancillary revenue for the broadcast industry and even though, this study is limited to the top-line analysis, such a service will be reasonably profitable for the investors.

- The Broadcast Overlay will result in an "annuity" for the U.S. Treasury (technically, till perpetuity). The projected annuity value is much greater than one-time proceeds from the auction of a portion of the broadcast spectrum.

The conclusions of our study and accompanying techno-economic analytical model (see Appendix I for a bird's eye-view of the model) are:

Base Case

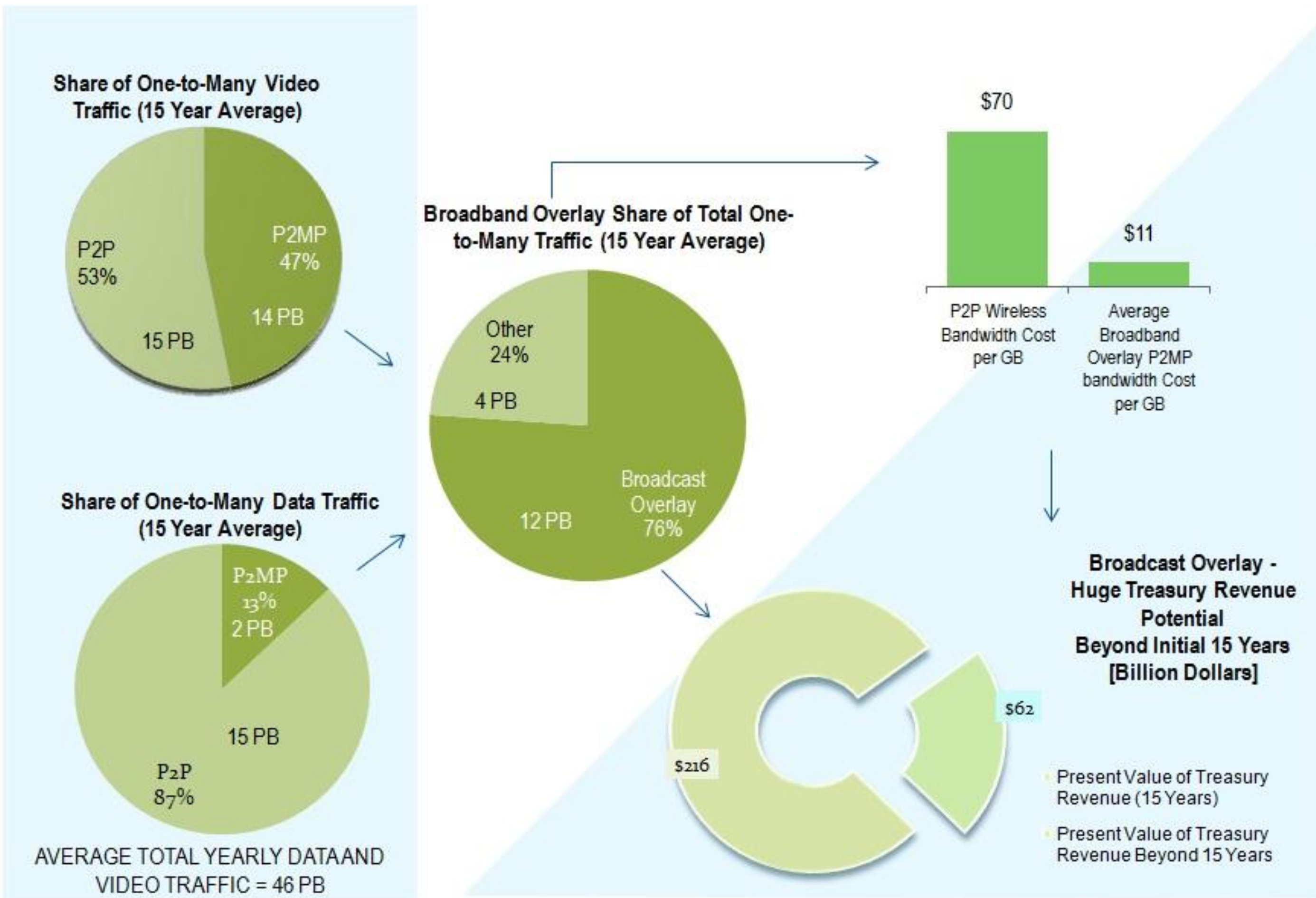
1. U.S. Treasury would gain $62 billion in ancillary revenue share between 2014 and 2026 in present value terms.
2. In addition, the present value of the U.S. Treasury's share of the Broadcast Overlay ancillary revenue, beyond the forecast horizon of 2026, would be $215 billion.

Worse Cases

3. Even if we compute the U.S. Treasury's ancillary revenue share on the basis of a much lower point-to-multipoint IP traffic proportion of the total IP traffic, the Present Value of the U.S. Treasury revenue share between 2014 and 2026 would amount to $46 billion.
4. Similarly, in spite of accounting for a slower proliferation of the Broadcast Overlay service over the forecast horizon, the present value of the U.S. Treasury revenue share will still be significant at $54 billion.

Appendix I: Bird's Eye-view of the Techno-Economic Analysis Treasury Bandwidth: the

X. Appendix I: Bird's Eye-view of the Techno-Economic Analysis



Bibliography

XI. Bibliography

NielsenWire - Don Kellogg, Senior Manager. (2011, June 17). *Average U.S. Smartphone Data Usage Up 89% as Cost per MB Goes Down 46%*. Retrieved October 25, 2011, from Telecom Research & Insights, NielsenWire: http://blog.nielsen.com/nielsenwire/online_mobile/average-u-s-smartphone-data-usage-up-89-as-cost-per-mb-goes-down-46/

Aitken, M. A. (October 2011). Broadcast Convergence - Bringing Efficiency to a New Platform. *Sinclair Broadcast Group*. Cockeysville, MD: Technical Paper presented at IEEE BTS .

Alexandre Gerber, R. D. *Traffic Types and Growth in Backbone Networks*. Florham Park, New Jersey : AT&T Labs - Research.

AT&T, I. (2010, June 2). *AT&T- News*. Retrieved October 25, 2011, from http://www.att.com/gen/press-room?pid=17991&cdvn=news&newsarticleid=30854&mapcode=

Carmela Aquino, S. R. (OCTOBER 2011). *Digital Omnivores-How Tablets, Smartphones and Connected Devices are Changing U.S. Digital Media Consumption Habits*. comScore, Inc.

Cisco Systems. (2011). *Cisco Visual Networking Index: Forecast and Methodology, 2010–2015*. San Jose, CA: Cisco Systems.

Cisco Systems. (2010). *Cisco Visual Networking Index: Usage*. San Jose, CA: CISCO Systems.

Cisco Systems. (2011). *Entering the Zettabyte Era*. San Jose, CA: Cisco Systems.

comScore, Inc. (2011, February). *Mobile Year in Review 2010*. Retrieved October 25, 2011, from ComScore: http://bit.ly/tHiom8

Eden Zoller, J. D. (2011, May 19). *Mobile TV: the second coming*. Retrieved October 25, 2011, from Ovum.com: http://ovum.com/2011/05/19/mobile-tv-the-second-coming/

Ericsson - Erlandsson, A. (2011). *TV and Video ConsumerTrend Report 2011*. Stockholm, Sweden: Ericsson Corporate Public & Media Relations.

Federal Communications Commission. (April 2010). *The Broadband Availability Gap*. Washington DC, USA: Federal Communications Commission.

Fitzpatrick, M. (n.d.). *The Guardian*. Retrieved 10 25, 2011, from http://www.guardian.co.uk/technology/2007/sep/27/guardianweeklytechnologysection.mobilephones

MobiTV - Company Timeline. (n.d.). Retrieved October 25, 2011, from http://www.mobitv.com/about-us/company-overview/company-timeline/

Nielsen Company. (Quarter 1, 2011). *The Cross-Platform Report*. Nielsen Company.

Sandvine Intelligent Broadband Networks. (Fall 2011). *Sandvine Global Internet Phenomena Report*. Waterloo, Ontario Canada: Sandvine Incorporated ULC.

Taga, K. C. (2009). *Mobile TV, Tuning in or Switching Off?* . Arthur D. Little.