Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Connect America Fund	)	WC Docket No. 10-90
A National Broadband Plan for Our Future	)	GN Docket No. 09-51
High-Cost Universal Service Support	)	WC Docket No. 05-337
	)	

COMMENTS of ADTRAN, Inc.

ADTRAN, Inc. ("ADTRAN") respectfully submits the following comments in response to the Commission's Notice of Inquiry and Notice of Proposed Rulemaking,[1] which seeks comment on, among other items, whether the Commission should use a model to help determine universal service support levels in areas where there is no private sector business case to provide broadband and voice services. These comments are limited primarily to technical issues associated with the use of the OBI technical model, as discussed in Section II.B.1 of the NOI/NPRM.

ADTRAN recognizes the necessity for the use of a well designed model as a tool to help establish support levels, set reserve prices, or for other purposes associated with the implementation of the Connect America Fund ("CAF"). Further, subject to the issues noted below, we believe that the OBI technical model provides a good basis for such a tool. However, there exist issues that must be addressed, both with the OBI technical model specifically and with the use of a model in general. These issues are summarized as:

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[1] *Connect America Fund, A National Broadband Plan for Our Future, High-Cost Universal Service Support*, 25 FCC Rcd 6657 (2010) (hereafter cited as NOI/NPRM).

- The OBI technical model, as documented in OBI Technical Paper No. 1,[2] includes several material assumptions that are unsupported, in conflict with generally accepted industry data, and/or internally inconsistent. These issues must be resolved before the model can be used in support of the CAF objectives. ADTRAN has previously provided comments[3] on these issues:

  1. The estimate of 160 kbps for Busy Hour Offered Load (BHOL) used for network dimensioning throughout the model underestimates BHOL by a factor of almost three.

  2. The capacity estimate of 650 fixed users per cell used for FWA modeling is unrealistically high. This is true even if the current input parameters from the model (including 160 kbps for BHOL) are used to generate the estimate.

  3. The model assumes paired 20 MHz channels in the 700 MHz band for its baseline analysis. This is at odds with the actual allocation of that band, which is split into blocks of 12 MHz or less.

- No predictive model can substitute for the appropriate verification of performance. Any ongoing support and/or retention of funds awarded in connection with CAF should be contingent on verification of actual network performance meeting the requirements of the award. After all, the myriad benefits of broadband identified in the National Broadband Plan – including telehealth, distant learning, smart grids and

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[2] Federal Communications Commission, "The Broadband Availability Gap: OBI Technical Paper No. 1," April 19 2010.

[3] *See*, ADTRAN ex parte filing, "GN Docket No. 09-51 -- OBI Technical Paper 1," May 28, 2010; ADTRAN ex parte filing, "GN Docket No. 09-51 -- OBI Technical Paper 1," June 16, 2010.

civic participation – can only be realized if Americans have access to actual broadband capabilities; it is not enough that a model predicts that they should.

We discuss the above topics in more detail below.

Issues with the OBI technical model

OBI Technical Paper No. 1 provides valuable and transparent documentation of the technical model used to generate the Broadband Availability Gap. The technical model itself is detailed, thorough, and well designed in most areas. ADTRAN views the issues documented below, while very important, as exceptions rather than indications of a fundamentally flawed model.

1. The value for Busy Hour Offered Load (BHOL) used to dimension networks throughout the model is severely underestimated.

The most serious issue with the model regards the assumption that networks can be dimensioned at an average BHOL of only 160 kbps per subscriber for the year 2015. This assumption is in direct conflict with both industry data showing current and projected traffic trends, and with figures in the OBI Technical Paper itself.

Two highly regarded sources for Internet traffic data are the Cisco Visual Networking Index[4] and the University of Minnesota Internet Traffic Studies (MINTS) project,[5] which are consistent with each other in regard to monthly Internet traffic in the United States as of year end 2009. Per-household data derived from the June 2010 release of Cisco's VNI estimates the Busy Hour Carried Load (which can be lower but

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[4] Cisco, "Cisco Visual Networking Index – Forecast and Methodology, 2009-2014," June 2 2010, http://cisco.biz/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-481360_ns827_Networking_Solutions_White_Paper.html, last accessed on June 23 2010.

[5] http://www.dtc.umn.edu/mints/home.php, last accessed on June 23 2010.

not higher than BHOL) at 436 kbps in 2014 (see Attachment 1). Extrapolating the same data to 2015 generates a projected BHOL of 510 to 645 kbps.

The majority of the difference between the OBI estimate and the range provided above comes from the way the OBI figure is artificially truncated, as described in the Technical Paper. Summarizing the description which begins on page 111, the authors estimate the BHOL for year 2009 at 111 kbps and estimate that, without "reasonable network management techniques," it will grow to about 444 kbps in year 2015. Then, while briefly discussing examples of reasonable network management techniques, they note that about 65% of the traffic is due to 10% of the heaviest users and state "… if we were to ***exclude the capacity demand of these heaviest users*** [emphasis added], the BHOL of the remaining users would be far lower." The model then does exactly that – it excludes the heaviest 10% of users from the BHOL estimate to arrive at a year 2015 figure of 160 kbps.

There are several fundamental issues with this approach to arbitrarily truncating the offered load:

- Obviously, excluding the heaviest users is incompatible with the goal of providing broadband available to all. A more palatable interpretation of the mathematical manipulation performed is that the average for the top 10% of users is reduced to the same value as that for the bottom 90% of users. In reality, even if usage could be ideally truncated to a defined level – a goal which is impossible in a practical deployment – the usage for each of the top 10% of users would be equal to the maximum value associated with the 90th percentile user, which is much higher than the average for the bottom 90% of

users. While the resulting reduction in load cannot be calculated without knowing its distribution, it is significantly less than the 65% cited in the paper.

- Again assuming that usage could be ideally truncated to a defined level – which, again, is not possible in a practical deployment – the load from the heaviest 10% of users would form an impulse at the top end of the distribution which would have a disproportionate effect on the network capacity required to meet performance objectives compared to the average load.

- "Offered load," which is defined as the traffic that users try to place on the network, is not affected by network management techniques. Network management techniques only affect "carried load" – that is, the amount and distribution of the traffic that the network carries. In other words, network management only affects what users get, not what they want (unless of course, the heaviest users are actually excluded from the pool!).

  This is important for two reasons. First, since offered load cannot be measured directly using network traffic monitors, traffic estimates such as Cisco's VNI (as well as the estimate in Exhibit 4-BQ of the Technical Paper) are actually estimates of carried load. By definition, offered load can be higher but not lower than carried load.

  Second, one of the characteristics of a non-congested network is that total offered and carried loads are relatively close to each other. In ADTRAN's internal simulations, total offered and carried loads remain within about 10% of each other in non-congested scenarios. A network in which carried load is only 35% of offered load is severely congested and would not support the

minimum broadband performance goals defined in the National Broadband Plan.

- Finally, in a paper which relies heavily on endnote citations in nearly all other instances, ADTRAN observes that there are no references providing support or rationale for this truncation. No industry or academic data is cited indicating how such an extreme limit on either offered or carried load would be accomplished, or even that it might be possible. This important parameter, which affects required network capacities for all last mile technologies as well as second and middle mile capacities, seems to have been slashed by two thirds based on no more than a speculative and artificial mathematical manipulation.

In discussions on this topic,[6] FCC personnel have noted that the growth rate for users in the 4 Mbps service tier addressed by the OBI technical model cannot be expected to be as high as that for the broadband population as a whole, because the overall growth rate considers both growth within tiers and migration from lower to higher service tiers. ADTRAN agrees, but notes that the non-truncated projection of 444 kbps in 2015 described in the Technical Paper (in Exhibit 4-BS) is already specific to the 4 Mbps service tier. We consider 444 kbps to be a more reasonable projection of carried load for the 4 Mbps service tier in the year 2015 (although probably somewhat understated). Applying the above observation about the approximate equivalence of offered and carried loads in non-congested networks, and taking into account the model's sensitivities, we consider it an acceptable estimate of offered load as well.

[6] *See*, ADTRAN ex parte filing, "GN Docket No. 09-51 -- OBI Technical Paper 1," June 16 2010.

2. The capacity estimate of 650 fixed users per cell used for FWA modeling is unrealistically high.

The maximum number of fixed subscribers served by a FWA cell in the model is estimated at 650, assuming 2x 20 MHz channels.[7] Even using *arguendo* the value of 160 kbps for BHOL, it is not clear how this number of fixed subscribers was calculated. The model assumes that fixed broadband access will account for 33% of the devices on the wireless network (two mobile users for each fixed user) and generate 73% of the traffic in the areas of interest by the year 2015.[8] Optimizing capacity in the cell for the increased spectral efficiency of fixed directional antennas and for the proportion of traffic generated, the fixed users in a sector would share 30.4 Mbps on average – however, 160 kbps x 217 users (1/3 of 650, allowing for three sectors per cell) results in an average load of 34.7 Mbps, or 114% average utilization. This is clearly not a feasible scenario.

Based on ADTRAN simulations and on discussions with the FCC,[9] it seems probable that the estimate of 650 fixed users was arrived at assuming a 100% fixed user population on the wireless network, rather than the ratio cited above of two mobile users for each fixed user. This assumption results in 70% average utilization, as well as performance (based on ADTRAN's simulations) consistent with the FCC's minimum requirement of 4 Mbps service. If this is the case, the assumption used is inconsistent

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[7] OBI Technical Paper No. 1, p. 61.

[8] OBI Technical Paper No. 1, pp. 53-54. The percentage figures apply to areas in which FWA provides the only means of mass broadband access. In areas with other options for broadband access, the percentage of FWA users and traffic relative to the mobile percentages would presumably be lower.

[9] *See*, ADTRAN ex parte filing, "GN Docket No. 09-51 -- OBI Technical Paper 1," June 16 2010.

both with expected 4G deployments and with the rest of the technical model, which allocates cost for wireless networks based on fixed users generating only 73% of the traffic. Any future use of the model must estimate wireless capacity using the appropriate mix of both fixed and wireless users on the network.

3. The model assumes paired 20 MHz channels in the 700 MHz band for its baseline analysis, which is inconsistent with the actual allocation of spectrum in the band.

The OBI model assumes paired 20 MHz channels (40 MHz total) in the 700 MHz band for the baseline analysis. This is at odds with the actual current allocation of that band – due to its legacy as a series of 6 MHz broadcast TV channels, the band has been auctioned off in blocks from 6 to 12 MHz wide. Within those blocks, the maximum usable channel width is 10 MHz.

As noted in the Technical Paper in Exhibit 4-Q, smaller channel widths are less efficient for providing broadband service. In order for the model to reflect the FCC's own spectral allocations, it must estimate wireless capacity using channel bandwidths consistent with those allocations.

The issues addressed above have varying effects on different network access technologies. The value of BHOL affects network capacity requirements for all types of access networks. The second and third issues are specific to FWA. The cumulative effect of these three issues on FWA capacity is significant – if capacity is estimated using BHOL at 444 kbps, the FCC's recommended mix of fixed and mobile users, and 10 MHz paired channels, then the capacity of a wireless cell (normalized to 40 MHz total spectrum) is approximately 100 to 120 fixed users, less than one-fifth of the 650 value in the Technical Paper.

While the OBI technical model may be relatively insensitive to changes in FWA capacity – Exhibit 4-Z shows little sensitivity to small capacity changes, and in the FCC's webcast presentation on May 6, the presenters noted that cell capacity could be cut by a factor of four with minimal impact on the FWA availability gap – the issues above need to be corrected for both purely technical and perceptual reasons. From a technical standpoint, correcting the model may highlight localized issues that are not reflected in the overall availability gap. From a perceptual standpoint, it is vital that the model be seen to be as accurate and technology-neutral as possible. Even if the changes identified have little or no bearing on numerical results, they should be implemented to preclude any possible perception of bias.

Use of a model together with verification of performance

Although ADTRAN supports the use of a model in support of CAF objectives, the model cannot be used as a substitute for a commitment to provide network performance meeting the requirements associated with CAF awards. The CAF process should award subsidies on a schedule and with requirements that make funding dependent on actual network performance, rather than performance predicted by a model, no matter how well designed, transparent, or thoroughly reviewed the model might be.

There are at several reasons to base payments on actual rather than predicted performance. First, assuming the Commission uses a bidding process to determine who will receive CAF subsidies, the understanding that funding will be dependent on actual results will encourage bidders to carefully check model assumptions against their internal projections (in many cases confirmed by actual experience), which should result in more carefully considered bids.

Second, tying awards to performance places the responsibility for appropriate network design, monitoring and upgrading over time on the award recipient. This fosters an evolutionary approach in which changes to the growth rate relative to initial predictions, for example, are detected early and accommodated via updates to the network growth plan. No model, no matter how well designed, can anticipate growth requirements well enough to serve as a substitute for ongoing measurements.

Third, tying awards to performance acknowledges local variability in offered load. Most models, including the OBI technical model, deal with overall populations. Access networks, on the other hand, need to address the needs of localized populations that may consist of no more than a few dozen users served by a specific access node. The localized averages for these populations will vary significantly around national or regional averages and localized monitoring is required to make sure they have sufficient network capacity to meet the performance requirements.

Finally, tying awards to performance removes some of the controversy that is sure to accompany any predictive model. No model will satisfy all stakeholders – however, if its use in the bidding process is superseded by performance measurement after deployment, any potential advantage to be gained from model bias is minimized or eliminated in the long term. Stakeholders can then work towards consensus based on technical merit, focusing on accuracy in model parameters rather than temporary advantage.

Summary

The use of a forward looking model will be valuable in implementing the objectives of the Connect America Fund. The OBI Technical Model, in particular, if corrected as discussed above can further those objectives both through its design and through the transparency with

which it is documented. However, specific issues with the OBI model must be addressed in order for it to reflect current spectral allocations, expected deployment models, and accurate projections of future demand. Further, the use of any model must be combined with requirements based on actual performance to best serve the objectives driving creation of the CAF, because actual performance – not just predictions – is what counts for consumers.

Respectfully submitted,

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Attachment 1
Busy Hour Consumer Internet Traffic Projections

Abstract

ADTRAN has previously published data projecting mean busy hour traffic per household for consumer Internet traffic for the next several years. The data is derived from aggregated data published in the Cisco Visual Networking Index (VNI) combined with other sources.

Cisco updates the VNI yearly, with the latest update released earlier this month. This memo updates the mean busy hour traffic values to correspond to the latest Cisco data. We also make some minor methodology changes to improve the derivation of the per-household traffic data, and compare the results with previous projections.

1 Busy hour traffic projections

1.1 Cisco VNI source data

The Cisco Visual Network Index [1] provides data showing global and regional traffic per month, broken down by industry segment. We use the North American consumer Internet traffic from that report, which is provided per application class. The data from the Cisco VNI is shown in Table 1.

Table 1 – North American consumer Internet traffic by application class

By Sub-Segment (PB per month)	2009	2010	2011	2012	2013	2014	CAGR 2009–2014
Web, email, data	634	809	996	1,221	1,454	1,645	21%
Peer to peer	664	796	958	1,155	1,396	1,691	21%
Gaming	10	13	18	24	30	35	28%
Video communications	6	11	18	24	34	50	53%
VoIP	19	21	22	22	22	21	2%
Internet video to PC	892	1574	2,639	3,301	3,873	4,375	37%
Internet video to TV	54	128	365	749	1,288	1,833	102%
Totals	2279	3351	5015	6495	8096	9652	33%

The data in Table 1 is a total for the North America region, including the US and Canada (Mexico and other countries are included in the Latin America region). The populations of the US and Canada in 2009 are estimated at 307.0 million [2] and 33.9 million [3] people, respectively. Using these populations as a ratio we estimate the US consumer Internet traffic by application class in Table 2

As a check on the data, the total monthly US Internet traffic for year-end 2009, as reported by the Minnesota Internet Traffic Studies (MINTS) [4], was from 1,800 to 2,700 Petabytes. This is in line with our estimate of 2052 Petabytes per month for US consumer traffic.

Table 2 – United States consumer Internet traffic by application class

By Sub-Segment (PB per month)	2009	2010	2011	2012	2013	2014	CAGR 2009–2014
Web, email, data	571	728	897	1099	1309	1481	21%
Peer to peer	598	717	863	1040	1257	1523	21%
Gaming	9	12	16	22	27	32	28%
Video communications	5	10	16	22	31	45	53%
VoIP	17	19	20	20	20	19	2%
Internet video to PC	803	1417	2376	2972	3488	3940	37%
Internet video to TV	49	115	329	674	1160	1651	102%
Totals	2052	3018	4517	5850	7291	8690	33%

1.2 Per-household traffic estimates

The figures in Table 2 are monthly totals for US consumer Internet traffic. To convert these totals to per-household figures, we need to estimate the number of households over which to average the data. The total number of occupied households in the US is projected by generating a linear curve fit for American Housing Survey data from 1997 to 2007 [5]. Broadband penetration for US households is projected by fitting a Bass diffusion model [6] to historical data from 2000 to 2009 from the Pew Internet and American Life Project [7].

We take the traffic data in Table 2 and divide each value by the total number of broadband households estimated for each year. The results are then converted from Petabytes per month to kilobits per second. The household totals estimated and the resulting per-household traffic values are shown in Table 3.

Table 3 – Internet traffic long term mean traffic per household

Estimated broadband adoption	2009	2010	2011	2012	2013	2014
No. of households (million)	113.0	114.1	115.1	116.2	117.3	118.3
Broadband adoption rate	62%	65%	67%	68%	69%	69%
No. of broadband households (million)	70.0	73.6	76.7	78.9	80.6	81.9
Traffic by Sub-Segment (kbps per household)						
Web, email, data	25.2	30.5	36.1	43.0	50.1	55.8
Peer to peer	26.3	30.1	34.7	40.7	48.1	57.4
Gaming	0.40	0.49	0.65	0.85	1.03	1.19
Video communications	0.24	0.42	0.65	0.85	1.17	1.70
VoIP	0.75	0.79	0.80	0.77	0.76	0.71
Internet video to PC	35.4	59.4	95.7	116.3	133.6	148.4
Internet video to TV	2.14	4.83	13.2	26.4	44.4	62.2
Totals	90.4	126.6	181.8	228.8	279.3	327.4

The data in Table 3 includes both upstream and downstream traffic averaged over a month. As is well documented [8, 9, 10], traffic volume exhibits a diurnal pattern reflecting user activity cycles. While business activity peaks during normal weekday office hours, consumer activity peaks during evening hours, with much less variation between weekdays and weekends. A diurnal pattern with similar peak times of day applies to different categories of traffic, although different application classes exhibit different excursions from the mean [8].

We use data from [8] to estimate upstream and downstream volumes during daily busy hour periods. Modeling the diurnal excursions from the mean as approximately symmetric,[10] the corresponding mean loads during busy hour can be estimated as

$$P = M\left(1 + \frac{r-1}{r+1}\right), \tag{1}$$

where: P = the mean load during busy hour,
M = the long term mean load, and
r = the diurnal max/min traffic ratio.

The Gerber study [8] also provides upstream vs. downstream traffic ratios for traffic from different application classes. These values are incorporated for the year 2009 data in Table 4.

Table 4 – Traffic during busy hour, 2009

Application class	Web	P2P	Video to PC	Video to TV	Other (1)	Total
Long term mean *M* (kbps)	25.2	26.3	35.4	2.14	1.39	90.4
Diurnal max/min *r* (2)	5	2	5	5	4	
Busy hour mean (kbps)	41.9	35.1	59.0	3.6	2.22	141.8
Down/up ratio (3)	8	1	8	8	1	
% downstream	89%	50%	89%	89%	50%	
Downstream (busy hour)	37.3	17.6	52.4	3.2	1.1	111.6
Upstream (busy hour)	4.7	17.6	6.6	0.4	1.1	30.3

Notes on Table 4:

1. The Other class includes the gaming, video communications, and VoIP sub-segments.
2. [8] states that the maximum to minimum diurnal load ratio is about 2 for P2P traffic and about 5 for Web browsing traffic. For this analysis, the Web browsing ratio is applied to interactive categories and the P2P ratio is applied to categories in which files can be scheduled for off-peak download. While all the sub-segments in the Other class are interactive, VoIP and video calling may be somewhat more distributed in time so the ratio applied is reduced slightly.
3. Downstream/upstream ratios in [8] are approximately 8 for client/server applications that primarily download data, and approximately 1 for symmetric applications. For this analysis, all video traffic is assumed to follow the client/server model. Increased adoption of P2P video (*e.g.*, Joost) could push upstream rates higher.

[10] This assumption of symmetry probably results in underestimation of the peak period means. The diurnal patterns for consumer traffic in [8] look approximately symmetric, but those in [10] look like they exhibit positive skewness, which would make the peak period volumes somewhat higher than those calculated here.

Table 4 shows how values for mean traffic during daily busy hours are derived. Totals for the same parameters are provided in Table 5 for the years covered by the current Cisco forecast. The same data is shown graphically, and broken out by application class, in Figure 1 and Figure 2.

Table 5 – Mean busy hour traffic per household

Direction	2009	2010	2011	2012	2013	2014	CAGR 2009-2014
Down (kbps per household)	112	162	240	304	372	436	31.3%
Up (kbps per household)	30	39	52	64	77	91	24.5%

At this point, we need to step back and list a few caveats regarding the above numbers.

- The extrapolation of future broadband adoption in this analysis may deviate significantly from the assumptions made by Cisco when generating their total volume forecasts. Differences in those extrapolations could have a significant impact on the per-household CAGR values.
- The forecast data from Cisco may not reflect actual future trends, considering the volatile history of the Internet [11]. While some characteristics of the Internet are relatively invariant, such as diurnal patterns and traffic self-similarity, other characteristics can change almost literally overnight. Rapid adoption of new applications, protocols or technologies could render the forecast obsolete, even in the relatively limited span that this forecast covers.

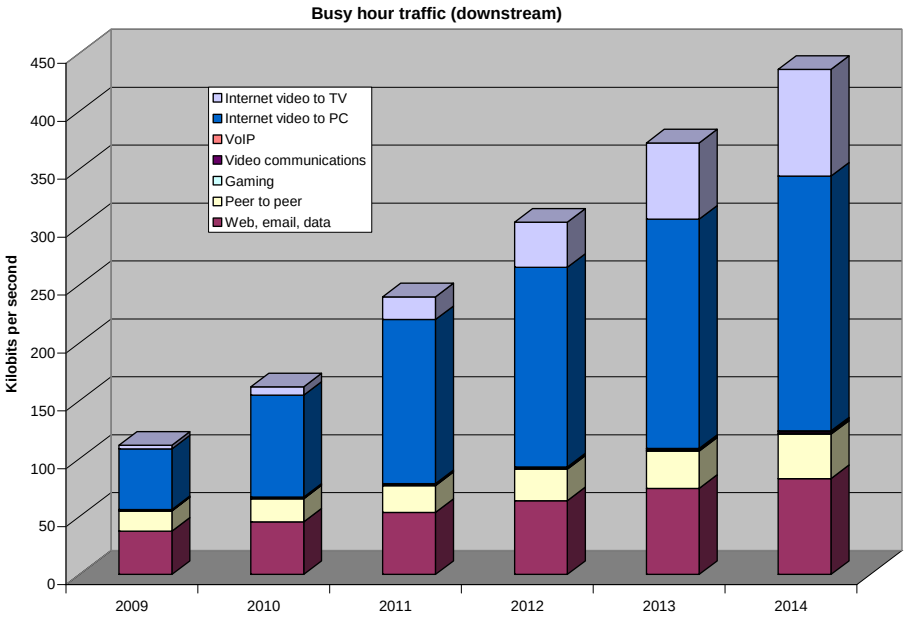

Figure 1 – Mean busy hour traffic per household (downstream)

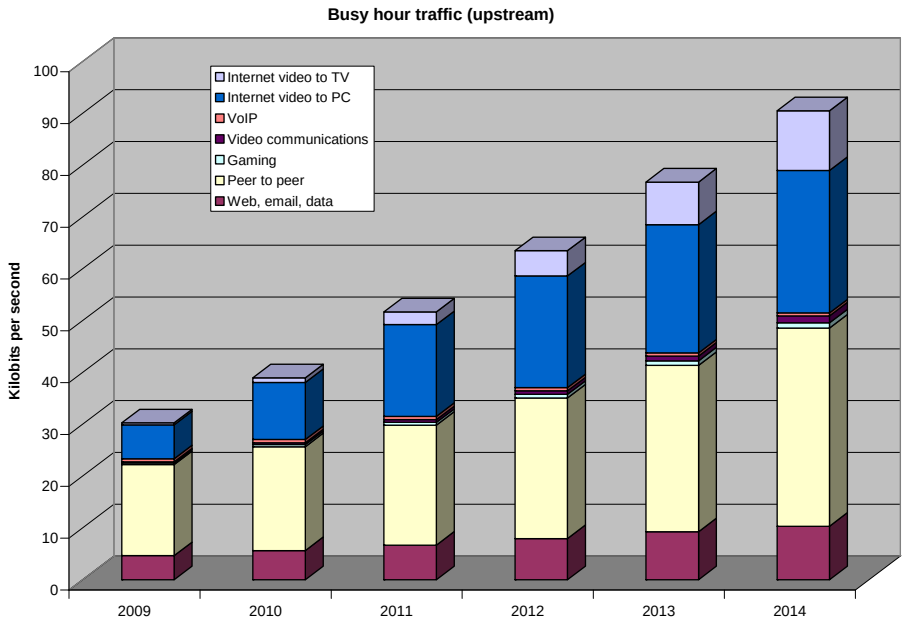

Figure 2 – Mean busy hour traffic per household (upstream)

1.3 Projections past 2014

The National Broadband Plan (NBP) [12] contains goals for consumer broadband performance out to the year 2020. If we are to assess network requirements against the NBP goals, we need to project expected traffic demands out through the same time frame. A projection this far into the future is by definition speculative, so rather than trying to predict an exact value we will use a range of values projected from the busy hour traffic derived in the above section.

Table 6 shows the year-over year growth rates for the busy hour traffic in Table 5. The overall Compound Annual Growth Rates (CAGRs) for years 2009-2014 are 31% and 25% for the downstream and upstream directions, respectively. However, the year over year numbers show a trend with the highest increases in 2010 and 2011, followed by slower growth, and the 2013-2014 increase is only 17% and 18% in the downstream and upstream directions. We'll do projections based on the highest and lowest year-over-year values as well as the 5 year CAGR in the hopes of bracketing the actual figure. The results are shown in Table 7.

Table 6 – Year-over-year growth for busy hour traffic

Direction	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	CAGR 2009-2014
Down	45.1%	48.1%	26.9%	22.5%	17.0%	31.3%
Up	28.6%	32.7%	22.8%	20.9%	17.9%	24.5%

Since Table 6 shows a trend in which year-over-year growth rates decrease over time, it may be tempting to just extrapolate the results past 2014 using the lowest growth rates (for the 2013-2014 period in both directions). Several factors support a more conservative approach, however. First, the traffic figures projected for years further into the future are by nature less reliable than near term values, so basing long term growth on CAGR values predicted three or four years in

advance is inadvisable. Second, the Cisco data may be conservative. While they have estimated global Internet traffic growth rates of about 40% in the 2008 and 2009 updates to the VNI [13, 14], MINTS has estimated volume-weighted annual growth rate from 2002 to 2009 at about 67% [15], and Cisco has tended to revise their data upwards with new updates to the VNI (see Section 3 Appendix).

Table 7 – Mean busy hour traffic projections to Year 2020

Direction	Estimate	CAGR	Mean busy hour traffic (kbps)					
			2015	2016	2017	2018	2019	2020
Down	High	48.1%	645	956	1,415	2,094	3,101	4,591
	Mid	31.3%	573	752	988	1,297	1,703	2,237
	Low	17.0%	510	597	699	818	957	1,120
Up	High	32.7%	120	159	211	280	372	494
	Mid	24.5%	113	140	175	217	270	337
	Low	17.9%	107	126	148	175	206	243

2 References

[1] Cisco, "Cisco Visual Networking Index – Forecast and Methodology, 2009-2014," June 2 2010, http://cisco.biz/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-481360_ns827_Networking_Solutions_White_Paper.html last accessed on June 23 2010.

[2] U.S. Census Bureau, Population Division, "Table 1: Annual Estimates of the Resident Population for the United States, Regions, states, and Puerto Rico: April 1, 2000 to July 1, 2009 (NST-EST2009-01)," December 2009, http://www.census.gov/popest/states/NST-ann-est.html, last accessed on June 23 2010.

[3] Statistics Canada, http://www.statcan.gc.ca/daily-quotidien/100325/dq100325a-eng.htm, last accessed on June 23 2010.

[4] http://www.dtc.umn.edu/mints/home.php, last accessed on June 23 2010.

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[12] Federal Communications Commission, "Connecting America: The National Broadband Plan," March 16, 2010.

[13] Cisco, "Cisco Visual Networking Index – Forecast and Methodology, 2007-2012," June 16 2008.

[14] Cisco, "Cisco Visual Networking Index – Forecast and Methodology, 2008-2013," June 9 2009.

[15] http://www.dtc.umn.edu/mints/2002-2009/analysis-2002-2009.html, last accessed on June 23 2010.

[16] ADTRAN ex parte filing, "Defining Broadband Speeds: Deriving Required Capacity in Access Networks," January 25 2010.

3 Appendix – Comparison to projections based on 2009 data

The data in this memo updates projections that were previously published by ADTRAN [16]. This appendix addresses the relative differences between the old and new projections and the sources of those differences. Differences are due both to changes in the source data and to changes in ADTRAN's internal methodology.

3.1 Differences in Cisco source data

Figure 3 shows North American consumer Internet traffic data from the 2008, 2009 and 2010 issues of the Cisco VNI. Since each issue covers a span of five years, there are several years of overlap that can be compared directly. The figure shows that growth rates were revised sharply upward between the 2008 and 2009 issues of the VNI. The data is much more consistent between the 2009 and 2010 issues, but the new values are on the order of 10% higher than last year's values.

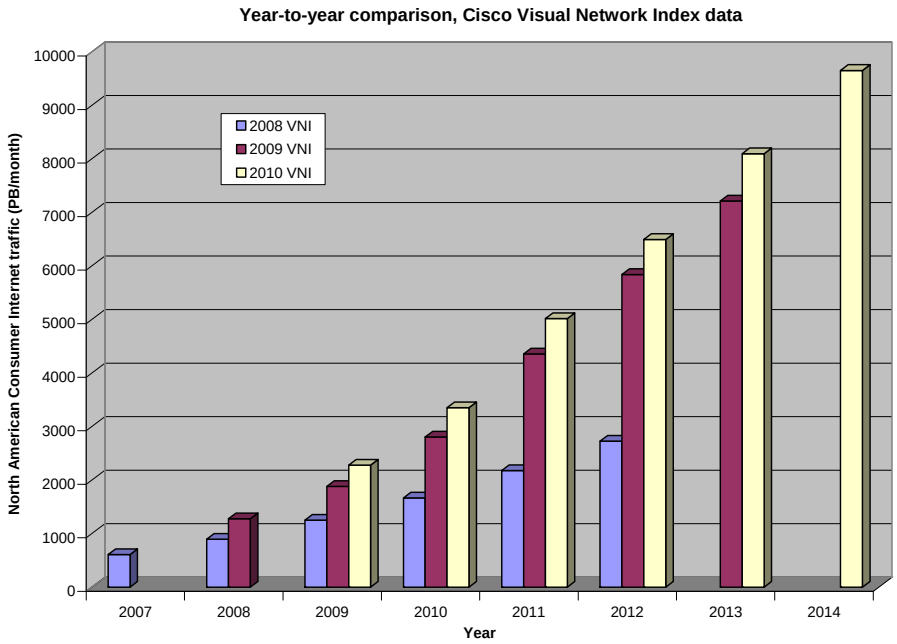

Figure 3 – Year to year comparison of Cisco source data

3.2 Differences in ADTRAN methodology

The following changes were made to the methodology used by ADTRAN to derive per household busy hour traffic from the Cisco figures:

- We are now using the relative populations of the US and Canada to estimate US-only consumer Internet traffic as an input to the per-household derivation. Older estimates used North American traffic, which included both US and Canada and inflated the per-household results by about 10%.
- The estimates for the numbers of occupied households in previous versions were derived by taking population estimates and dividing by the average number of people per

household from the 2000 census. The new estimates are generated by a linear curve fit to occupied household data from the bi-yearly American Housing Surveys done by the U.S. Census Bureau.

- Previous projections for broadband adoption extrapolated the current value at a linear 3% increase per year. The new projections are based on a Bass diffusion model fit to historical data.
- The previous model for diurnal variation estimated the max/min traffic ratio for Video-to-TV traffic at 2:1, based on the assumption that much of this traffic would be downloaded in advance during non-peak hours. The ratio has been adjusted to 5:1 to reflect expected increases in broadband rates and the prevalence of on-demand viewing.

3.3 Differences in results

Figure 4 shows the differences between the latest results (2010 data) and previously published results (2009 data) for mean busy hour traffic. Despite the adjustment to account for US-only traffic, the new values for downstream busy hour traffic are 10% to 20% higher than previous projections. Upstream traffic is slightly lower than previous projections.

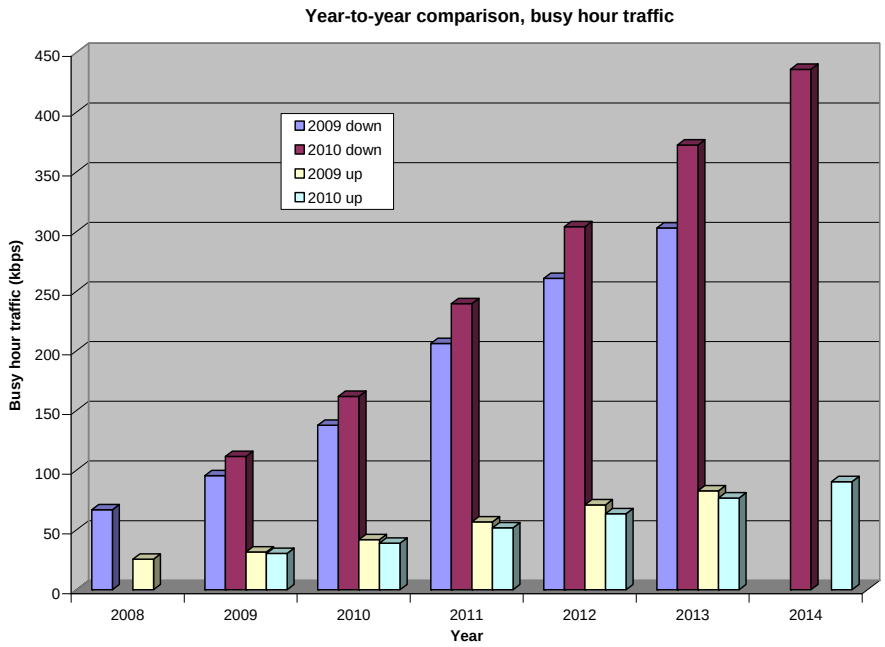

Figure 4 – Year to year comparison of busy hour traffic results