A Business Case Comparison of the IP NGN Carrier Ethernet Design to the Centralized BRAS Design for Triple Play Broadband Access Networks

Network Strategy Partners, LLC

MANAGEMENT CONSULTANTS TO THE NETWORKING INDUSTRY

www.nspllc.com

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Executive Summary

Today incumbent service providers are facing serious challenges. Cable companies and other new competitors are entering the telephone business while incumbent telecom service providers are entering the video business. They are responding by developing new integrated services such as IP-TV and VoIP that are, in turn, challenging the fundamental structure of traditional broadband networks.

Triple play services have dramatically increased bandwidth requirements in broadband networks and have driven a strong migration in the access network from the legacy ATM networks to next generation metro Ethernet. This paper compares the business case for two alternative designs for delivering broadband services over the next generation metro Ethernet:

1. *The Centralized BRAS Design*
2. *The IP NGN Carrier Ethernet Design*

The *Centralized BRAS Design* is an extension of the current legacy ATM design. In many legacy Broadband access networks, DSLAM's use ATM PVC's to backhaul traffic to Broadband Remote Access Servers (BRAS). The BRAS manages AAA (authentication, authorization, and accounting) for both wholesale and retail broadband subscribers. In the Centralized BRAS Design all traffic including video is backhauled over the Layer 2 metro Ethernet network to a centralized BRAS in a regional POP. Services are controlled and provisioned at the BRAS.

The *IP NGN Carrier Ethernet Design* is an intermediate step towards fully distributed service intelligence. Video traffic is carried by the Layer 3 access network and VoIP and high speed Internet are backhauled to the BRAS. The metro Ethernet network is an L2/L3 network with full QoS capabilities for VoIP, Video, and Data as well as full multicast capabilities for broadcast video. This approach is based on the fundamental concept that the old centralized design is no longer appropriate for triple play traffic and that it is necessary to distribute intelligence to the network edge.

The key financial results are presented in Figure 1. From these results the cost advantage of the *IP NGN Carrier Ethernet over the Centralized Design* is clear. The higher capital and operating expenses of the *Centralized BRAS Design* lead to 1.5 times higher TCO then that of the *IP NGN Carrier Ethernet Design*. The Net Present Value (NPV) and Return on Investment (ROI) are key financial metrics used in evaluating the business case for capital investments. The *IP NGN Carrier Ethernet Design* has both a higher NPV and ROI than the *Centralized Design*.

Key Financial Results

Five Year Total	IP NGN Carrier Ethernet	Centralized	Cost Advantage
Psuedo Revenue	$ 88,222,185	$ 88,222,185	
Capital Cost	$ 9,913,800	$ 23,279,750	2.3
Network Operations Expenses	$ 27,319,721	$ 30,839,612	1.1
Total Cost Of Ownership (TCO)	$ 37,233,521	$ 54,119,362	1.5
Cash Flow From Operations	$ 50,988,664	$ 34,102,823	
Net Present Value (NPV)	$ 42,176,403	$ 27,359,156	
Return On Investment	514%	146%	

Figure 1

The primary driver for this difference in cost is that the *Centralized BRAS Design* requires all video to be carried directly through the BRAS. The capital expenses of the centralized design is significantly higher than the CapEx of the *IP NGN Carrier Ethernet Design* because of the high cost per port of the BRAS. Operations expenses of the centralized design are slightly higher due to extra cost associated with more CapEx, more switches and routers to manage, and greater environmental expenses. It also should be noted that all service management of video for both alternatives is centralized in the video headend. There is no real operational advantage, therefore, to centralizing video service delivery in the BRAS.

The conclusion of this paper is that the older *Centralized BRAS Design* is no longer appropriate for today's triple play networks. Instead, a model that distributes intelligence to the edge is the right business choice.

Introduction

The following subsections of this paper provide relevant background information in order to set the stage for this business case analysis. These subsections give an overview of the legacy network and the business drivers that are propelling service providers to build new network architectures.

Legacy Broadband Network Overview

The predominant legacy broadband networks consist of:

- ATM DSLAM's aggregating ADSL
- ATM Access Networks backhauling ATM PVC's to a Regional POP
- Broadband Remote Access Servers (BRAS) terminating ATM PVC's are providing IP Services

This design is depicted in Figure 2. Three factors have shaped the state of the Broadband network design as it stands today:

- Incumbent Service Providers in some countries were not allowed to leverage intelligent L3 IP services in their access networks due to government regulation
- The wide scale availability and relative scalability of ATM networks motivated Service Providers to backhaul broadband connections from DSLAM's in CO's to Regional POP's on L2 ATM PVC's
- Their experiences with dial-up networks lead Service Providers to standardize on PPP to enforce AAA (authentication, authorization, and accounting) for both wholesale and retail broadband subscribers.

While legacy networks were effective at providing first generation broadband service, the business drivers associated with triple play have created technical requirements that can not be adequately addressed by legacy networks. These business drivers and technical requirements are discussed in the following section.

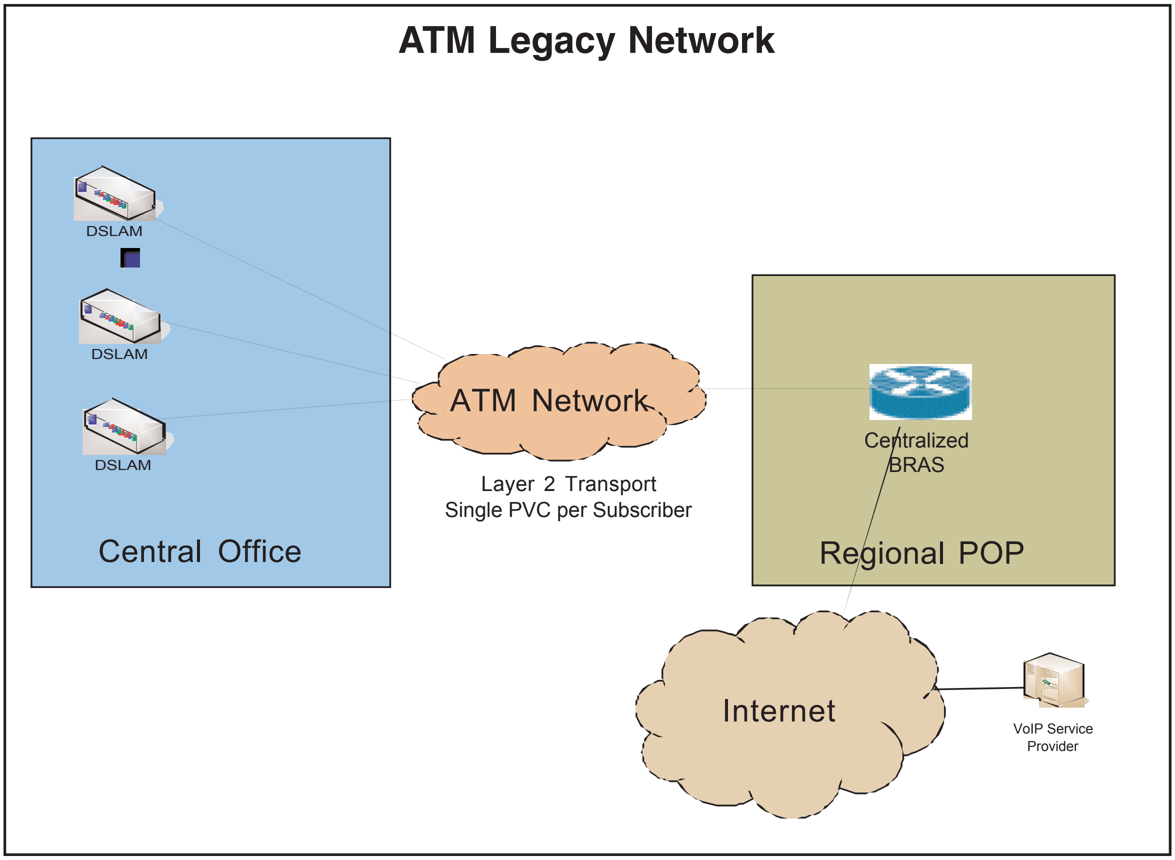

FIGURE 2

Business Drivers for Multiservice Design over Ethernet

Competition from Cable TV and other emerging service providers in basic services such as voice and high speed Internet has driven many incumbent service providers into the triple play market. In addition, shrinking margins from the basic voice and Internet business has created more urgency to develop new value added services that will increase revenues and profits and reduce churn. New service offerings include:

- Broadcast Video (Standard and High Definition)
- Video-on-Demand
- DVR
- VoIP

These new services are driving fundamental changes in the access and core network designs including:

- A clear migration away from ATM to an IP/MPLS access and core network.
- Metro Ethernet is replacing SONET in the access network to flexibly and cost effectively scale the network to support increased video traffic.
- IP End-to-End networks are providing the flexibility to support complex combinations of wholesale and retail triple play services with multiple content providers and end customers.

While everyone agrees that these changes are necessary and are taking place, there is not yet universal agreement on the best access network design to implement. The rest of this paper describes two alternative designs and presents a detailed business case model examining both alternatives. The design alternatives and the assumptions used in the business case model are presented in the following sections.

Design Alternatives

This paper presents the results of a business case model that analyzes two reference design alternatives for next generation broadband networks:

1. The *Centralized BRAS Design*
2. The *IP NGN Carrier Ethernet Design*

Both of the reference designs are described in the following subsections. The purpose of the reference design is to provide a baseline that is used in the business model to compare the capital and operations expenses of the various approaches.

Centralized BRAS Design

The Centralized BRAS design is an extension of the legacy network to the metro Ethernet network. This design uses the same basic principal of the legacy network: backhaul all traffic to a BRAS for IP service processing. This reference design is depicted in Figure 3.

The centralized design has the following key characteristics:

- All traffic including video passes through the BRAS which is the service control point
- Voice and data traffic are backhauled from the DSLAM or OLT to the BRAS over a metro Ethernet network
- 10 GigE interfaces are used on the BRAS
- Multicast traffic for broadcast video is transmitted from the BRAS over L2 multicast VLANs to all DSLAM's
- QoS in the metro Ethernet transport network is provided by 802.1p

In this reference design all services are controlled by the BRAS. IP packets are passed across the metro Ethernet using VLAN's.

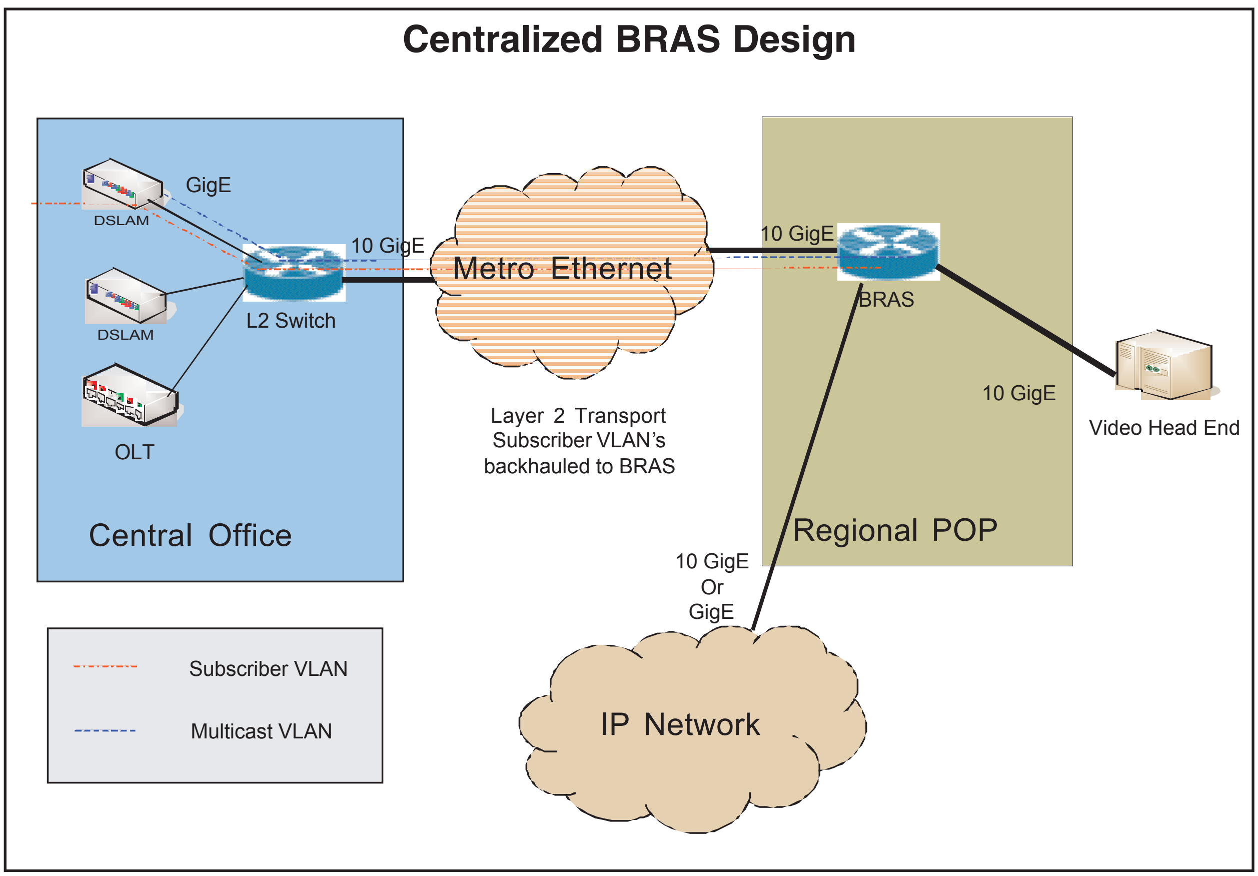

FIGURE 3

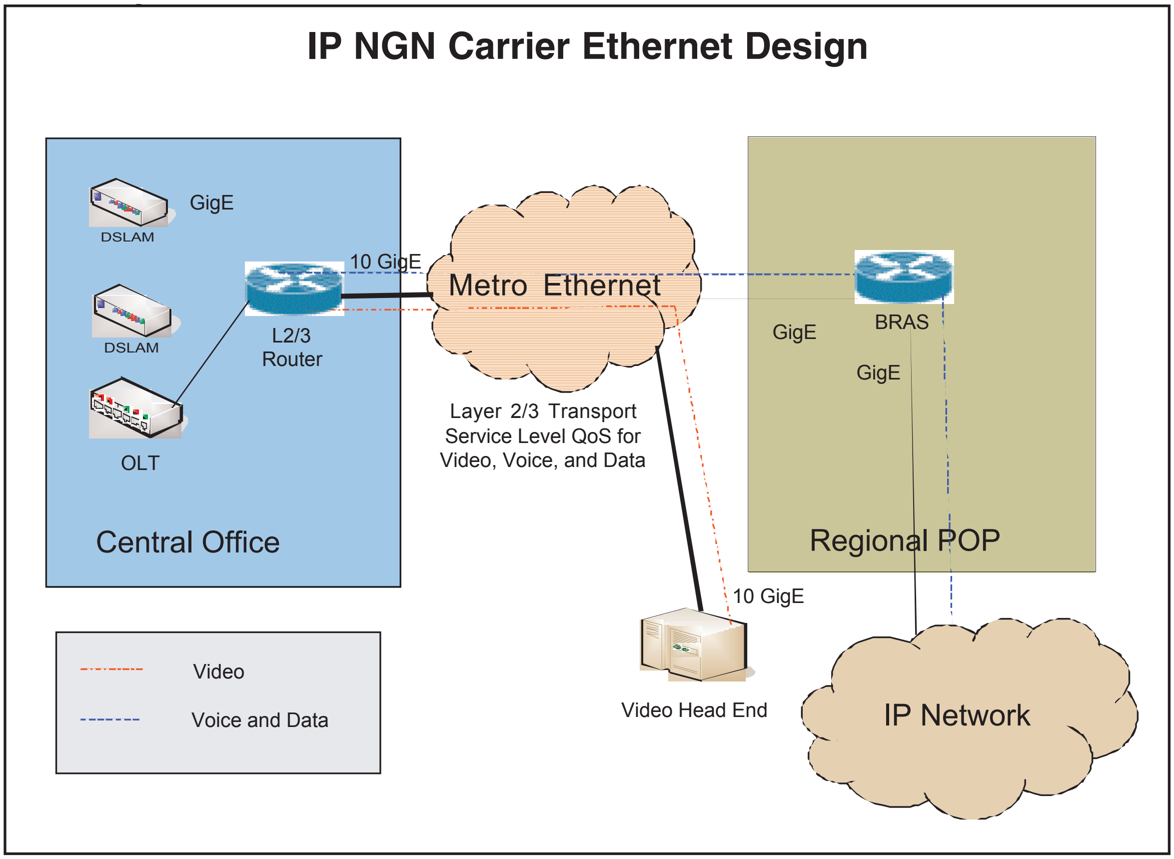

FIGURE 4

The IP NGN Carrier Ethernet Design

The IP NGN Carrier Ethernet Design used in the business case model is depicted in Figure 4. This approach utilizes metro Ethernet Layer 2/3 routers for transport. Video services are not transported through the BRAS, instead video is transported directly to the Video Head End over the Layer 2/3 metro Ethernet network.

Central Offices host DSLAM's and/or OLT's for terminating DSL and/or PON broadband access circuits. The DSLAM and OLT's connect to the metro Ethernet routers via GigE. The routers use 10 GigE to backhaul traffic across the metro Ethernet transport network to a Regional CO. In the Regional CO video traffic is routed directly from the Head End to the metro Ethernet routers in the CO. Voice and Data Traffic are backhauled over VLANS's to the BRAS where services and access to the IP network is controlled.

Some of the key characteristics of this design are:

- Video is routed directly from the Head End to the DSLAM's over the L3 metro Ethernet network
- 10 GigE interfaces are used on the L2/L3 routers for metro Ethernet transport
- GigE interfaces are used on the BRAS for VoIP and Internet service
- IP multicast routing is used across the Layer 2/3 metro Ethernet transport for delivery of broadcast video services
- QoS is implemented for each service (voice, video, and data) across the metro Ethernet transport
- Ethernet OAM is used to manage L2/L3 transport
- SSM (source specific multicast) prevents unauthorized access to content and helps to prevent denial of service attacks
- Dynamic multicast based on anycast technology provides fault tolerance when a multicast path is out of service in a network
- Service Exchange Frame Work[1] provides subscriber control for customization and policy control of the network layers
- Service Control Engine provides control for video service delivery

[1] Service Exchange Frame Work and Service Control Engine are Cisco nomenclature.

Business Case Assumptions

In order to compare the two approaches described above, a business case model has been developed. The assumptions used in this model are presented in the following subsections.

Service Profile Assumptions

One of the key drivers of the business model is the service profile. The service profile drives the revenue and traffic forecasts. The traffic forecast in turn drives capital and operating expenses.

The service price assumptions are presented in Figure 5 and the estimates for service penetration rates are depicted in Figure 6.

In this model we assume that the service provider's Central Offices (CO's) pass a fixed number of homes. The service penetration rates in Figure 6 are estimates of service penetration rates for those homes passed by CO's. The service penetration estimates are then used to calculate the number of subscribers for each service, the service revenues, and the traffic generated by each service.

Service Pricing

Services	Service Pricing ($/month)
Basic Broadcast TV	$ 18
Standard Broadcast TV	$ 45
Silver Broadcast TV	$ 60
Gold Broadcast TV	$ 87
Platinum Broadcast TV	$ 100
DVR	$ 10
VoD	$ 20
HDTV	$ 5
Extra Set-top box	$ 2
Internet Gaming	$ 10
Video Chat	$ 10
VoIP	$ 25
High Speed Internet	$ 30

Figure 5

Aggregate Service Penetration Rates

Service	Year 1	Year 2	Year 3	Year 4	Year 5
Broadcast SDTV	3%	5%	7%	10%	16%
Broadcast HDTV	1%	2%	3%	4%	5%
VoD	3%	5%	7%	10%	15%
VoIP	3%	5%	7%	10%	15%
High Speed Internet	27%	29%	31%	32%	34%

Figure 6

Revenue Assumptions

Using the service pricing and penetration assumptions stated above, the revenues for the service provider are calculated and presented in Figure 7. These are the total revenues generated for triple play services. However, in this business case analysis we are only considering a subset of the capital and operations expenses associated with the business. There are many other aspects of the network infrastructure (sales and marketing, and G & A) that contribute to the business expenses. Therefore, we have allocated 7% of the business revenue to the business case for the Metro Ethernet and BRAS infrastructure. The resulting revenue which is 7% of the total revenue is referred to as Pseudo Revenue and is used to estimate cash flows and Net Present Value of the investment. The value of 7% is based on Network Strategy Partners' extensive experience working with service providers and vendors.

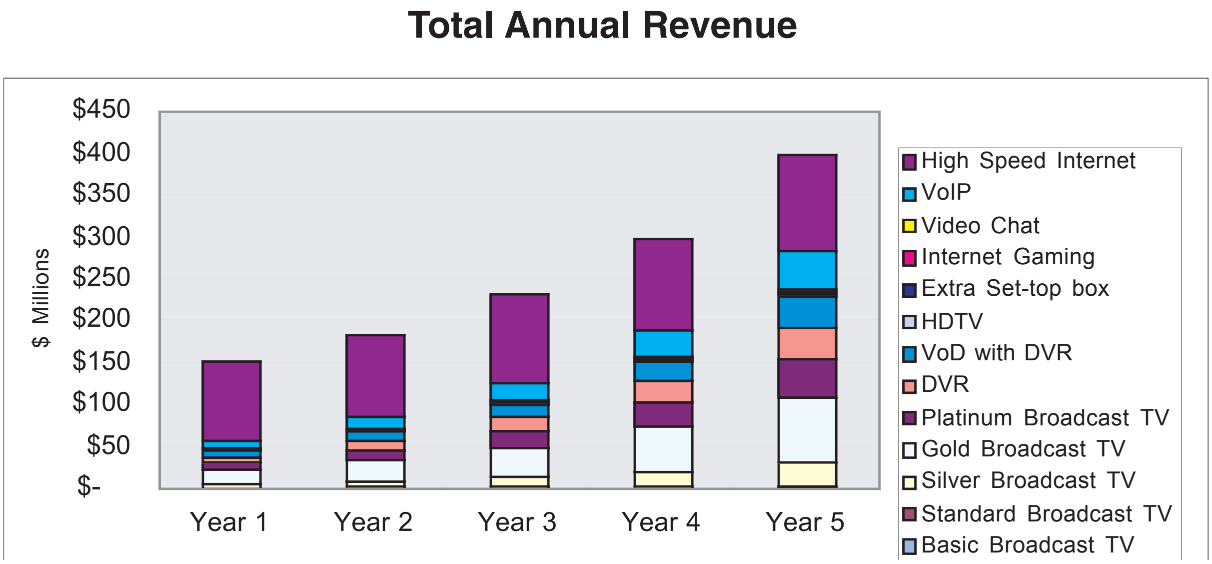

FIGURE 7

Network Design Assumptions

Several key network design assumptions used in the reference model are combined with the service profile as additional input to the business model. These assumptions are presented in Figure 8.

Network Design Assumptions

Network Assumptions	Parameter
Number of CO's in Network	100
Number of Regional POP's in Network	10
Number of homes passed per CO	10,000
Number of subscribers per DSLAM	250
Number of subscribers per OLT	300
Percentage of DSLAM's in Network	80%
Percentage of OLT's in Network	20%

Video Assumptions	Parameter
Average number of TV's per household	3
Average number of HDTV's per household	2
Average Number of Channels of SDTV	225
Average Number of Channels of HDTV	25

FIGURE 8

The assumptions are separated into two categories:

- Network Assumptions
- Video Assumptions

These values are used to calculated network traffic, capital expenses, and operations expenses.

Business Case Results

Given the reference designs and the assumptions stated above, we have used a business case model to calculate network traffic, network configurations, pseudo revenues, capital, and operating expenses associated with these designs. The business case model calculates these results over a 5 year period and compares the financial performance of the two designs.

The results show a clear advantage of the *IP NGN Carrier Ethernet Design* over the *Centralized BRAS Design*. This is primarily due to the fact that the capital equipment costs associated with the *Centralized BRAS Design* are much higher than those capital costs associated with the *IP NGN Carrier Ethernet Design*.

Network Traffic Forecast

One of the key drivers of transport, capital, and operations costs in the network is the magnitude of network traffic. Using the assumptions specified above, our model forecasts access traffic over a five-year period for both of the designs considered in this paper.

The biggest driver of network traffic is video. Video consists of:

- SDTV Broadcast
- HDTV Broadcast
- SDTV VoD
- HDTV VoD

Broadcast TV is well suited to multicast because there are sets of channels that are always on and are watched by a large number of subscribers. VoD by definition is watched by independent subscribers on an on-demand basis and therefore uses unicast transport.

The results of this analysis are presented in Figure 9 and Figure 10.

The network traffic forecast is a key component of the business model because it is used to calculate equipment configurations that have impact on both capital and operating expenses. The traffic forecast also is used to calculate metro Ethernet transport expenses that are a significant component of operating expenses.

Capacity from all Regional POP's to all CO's in Region (Mbps)

Service	Year 1	Year 2	Year 3	Year 4	Year 5
Broadcast SDTV	9,450	9,450	9,450	9,450	9,450
Broadcast HDTV	4,550	4,550	4,550	4,550	4,550
VoD	63,000	94,500	141,750	212,625	318,938
Internet Gaming	3,000	3,600	4,320	5,184	6,221
Video Chat	23	27	32	39	47
VoIP	240	360	540	810	1,215
High Speed Internet	16,406	17,227	18,088	18,992	19,942
Total	96,669	129,714	178,730	251,650	360,362

FIGURE 9

Network Traffic Forecast

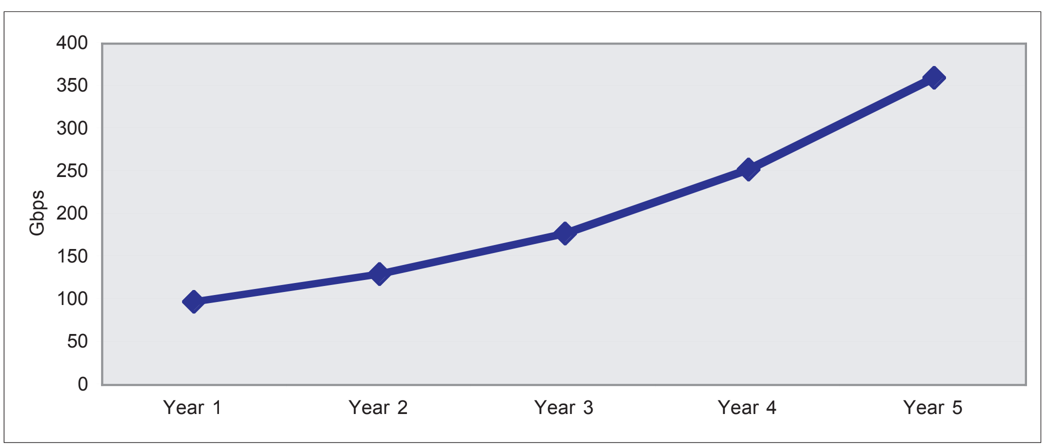

FIGURE 10

Key Financial Results

Five Year Total	IP NGN Carrier Ethernet	Centralized	Cost Advantage
Psuedo Revenue	$ 88,222,185	$ 88,222,185	
Capital Cost	$ 9,913,800	$ 23,279,750	2.3
Network Operations Expenses	$ 27,319,721	$ 30,839,612	1.1
Total Cost Of Ownership (TCO)	$ 37,233,521	$ 54,119,362	1.5
Cash Flow From Operations	$ 50,988,664	$ 34,102,823	
Net Present Value (NPV)	$ 42,176,403	$ 27,359,156	
Return On Investment	514%	146%	

Figure 11

Financial Comparison of IP NGN Carrier Ethernet Design with Centralized BRAS Design

Figure 11 presents the key financial results. The cost advantage of the *IP NGN Carrier Ethernet Design* over the *Centralized* design is clear from these results. The higher capital and operating expenses of the *Centralized BRAS Design* lead to 1.5 times higher TCO then that of the *IP NGN Carrier Ethernet Design*. The Net Present Value (NPV) and Return on Investment (ROI) are key financial metrics used in evaluating the business case for capital investments. The *IP NGN Carrier Ethernet Design* has both a higher NPV and ROI then the *Centralized Design*.

The primary driver for this difference in cost is that the *Centralized BRAS Design* requires all video to be carried directly through the BRAS. The capital expense of the centralized design is significantly higher than the CapEx of the *IP NGN Carrier Ethernet Design* because of the high cost per port of the BRAS. Operations expenses of the Centralized Design are slightly higher due to extra cost associated with more CapEx, more switches and routers to manage, and greater environmental expenses. It should also be noted that all service management of video for both alternatives is centralized in the video headend. There is no real operational advantage, therefore, to centralizing video service delivery in the BRAS.

The results of this analysis are highly dependent on the reference network model and input assumptions described earlier. It should be noted that the video penetration rates were assumed to be a modest 16%. In the case of higher video penetration rates *the business case becomes increasingly stronger for the IP NGN Carrier Ethernet Design.*

The detailed results of the 5-year financial comparison are presented in Figure 12.

Detailed Financial Statements

Five-Year Cumulative Totals	IP NGN Carrier Ethernet	Centralized
Pseudo Revenue		
Basic Broadcast TV	$ 29,909	$ 29,909
Standard Broadcast TV	$ 373,866	$ 373,866
Silver Broadcast TV	$ 4,984,875	$ 4,984,875
Gold Broadcast TV	$ 14,456,138	$ 14,456,138
Platinum Broadcast TV	$ 8,308,125	$ 8,308,125
DVR	$ 6,646,500	$ 6,646,500
VoD with DVR	$ 6,646,500	$ 6,646,500
HDTV	$ 643,601	$ 643,601
Extra Set-top box	$ 514,881	$ 514,881
Internet Gaming	$ 750,113	$ 750,113
Video Chat	$ 7,501	$ 7,501
VoIP	$ 8,308,125	$ 8,308,125
High Speed Internet	$ 36,552,051	$ 36,552,051
Psuedo Revenue	$ 88,222,185	$ 88,222,185
Capital Cost		
Metro Ethernet L2/L3 Router	$ 8,724,300	$ 7,982,000
Distributed Voice and Data BRAS	$ 1,189,500	$ -
Centralized Voice, Data , Video BRAS	$ -	$ 15,297,750
Capital Cost	$ 9,913,800	$ 23,279,750
Operations Expenses		
Engineering, Facilities, and Installation (EF&I)	$ 991,380	$ 2,327,975
Capacity Management	$ 1,386,356	$ 1,388,953
Network Upgrades & Patches	$ 799,341	$ 760,167
Network Care	$ 5,120,776	$ 5,031,472
Testing and Certification Operations	$ 499,588	$ 499,588
Testing and Certification Capital	$ 198,276	$ 465,595
Training	$ 1,608,970	$ 1,608,970
Network Management Equipment and Software	$ 673,361	$ 1,108,201
Network Transport Costs	$ 8,250,158	$ 8,250,158
Service Contracts	$ 1,487,070	$ 2,727,075
Sparing Costs	$ 198,276	$ 465,595
Floor Space Cost	$ 427,326	$ 434,302
Power Cost	$ 1,287,720	$ 1,308,744
Cooling Cost	$ 4,391,125	$ 4,462,817
Expenses	$ 27,319,721	$ 30,839,612
TCO	$ 37,233,521	$ 54,119,362
Pseudo Cash Flow	$ 50,988,664	$ 34,102,823
ROI ([Revenue-Expenses]/Capital)	514%	146%
NPV	$ 42,176,403	$ 27,359,156

Figure 12

Each of the areas in this table is explained in the following paragraphs.

Revenue In this analysis revenues are computed from the service profile using the pseudo revenue approach discussed earlier. The Pseudo Revenues are assumed to be 7% of the total service revenues. This is the percentage of revenue that can be applied to the operating costs of this part of the overall Service Provider business. This 7% value is based on Network Strategy Partners' consulting experience and data.

Capital Cost Capital expenses are based on the equipment configurations required to support the networks specified in the reference network design. One of the key drivers of the configurations is the five-year traffic forecast. After the configurations are created, capital expenses are calculated using Average Selling Prices (ASP's) of network equipment.

Operations Expenses Operations Expenses are calculated using a Network Strategy Partners model developed over many years in conjunction with service providers and equipment vendors. The categories of operations expenses are defined in Figure 13.

Operations Expense

Operations Expense	Definition
Engineering, Facilities, and Installation (EF&I)	This is the cost of engineering, facilities, and installation of network equipment.
Capacity Management	Capacity management is the engineering function of planning and provisioning additional network capacity.
Network Upgrades & Patches	This includes both hardware and software upgrades to the network.
Network Care	This includes network provisioning, surveillance, monitoring, data collection, maintenance, and fault isolation.
Testing and Certification Operations	Testing and certification is needed for all new hardware and software releases that go into the production network.
Testing and Certification Capital	This is capital equipment required for the test lab.
Training	Training expenses are required initially and also on an on-going basis.
Network Management Equipment and Software	This is all the hardware and software required to manage the network.
Network Transport Costs	These are the costs associated with the transport network. The calculations of these costs are described in detail in the early section on traffic forecasting.
Service Contracts	These are vendor service contracts required for on-going support of network equipment.
Sparing Costs	These costs are associated with line card spares.
Floor Space Cost	These costs are associated with the floor space cost/square meter in the CO.
Power Cost	This is the electric utility bill to power equipment.
Cooling Cost	This is the cost of the HVAC system to cool equipment.

Figure 13

The following charts in Figure 14 through Figure 17 present discounted cash flows, total cost of ownership (TCO), capital expenses, and operation expenses over the five-year interval. In all cases the financial performance of the *IP NGN Carrier Ethernet Design* is superior to the *Centralized BRAS Design.*

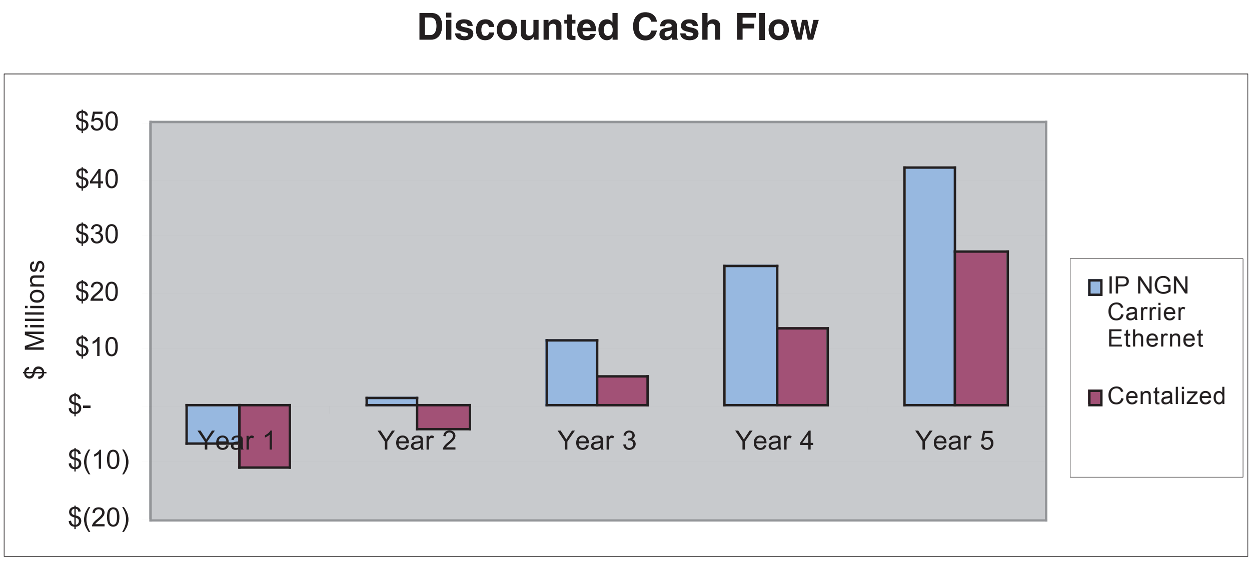

Figure 14

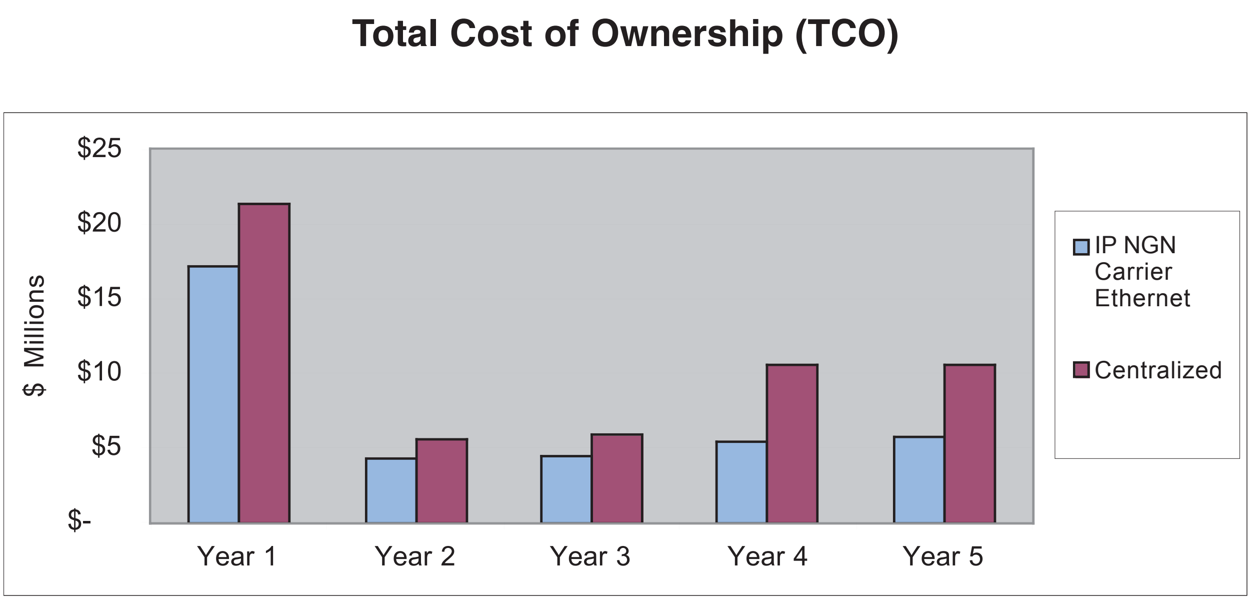

Figure 15

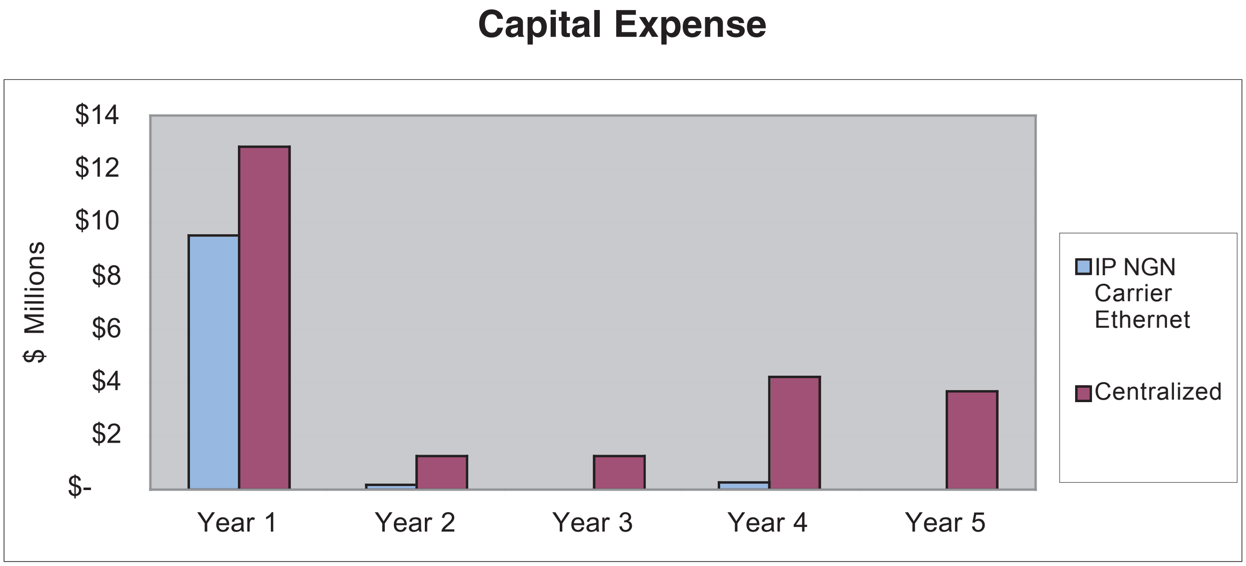

FIGURE 16

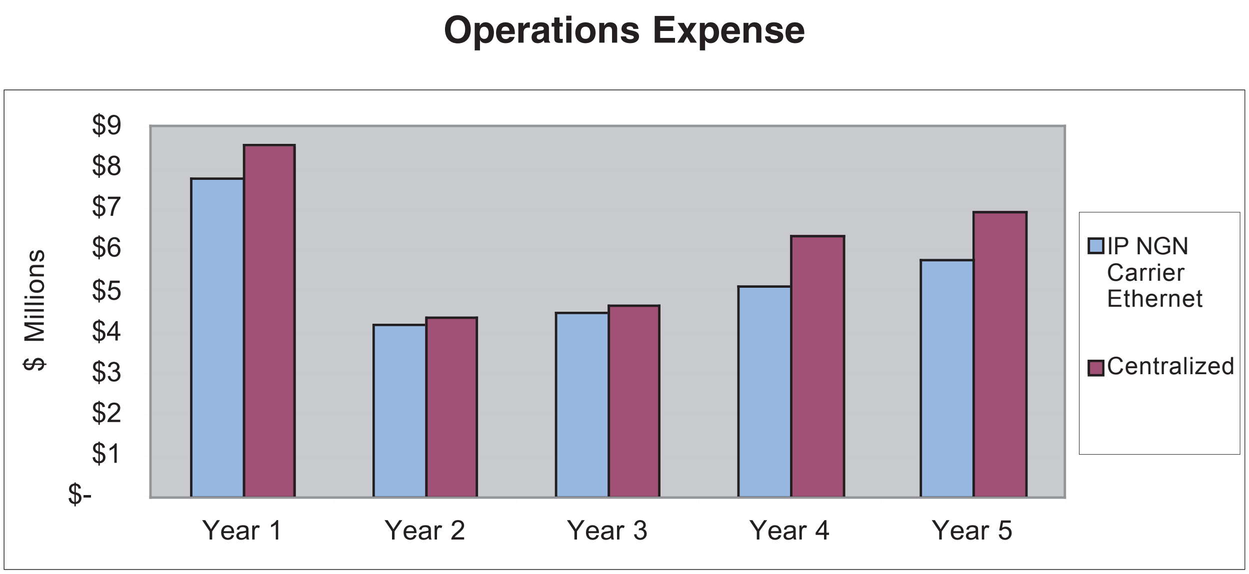

FIGURE 17

Conclusion

This paper demonstrates that the legacy Centralized BRAS design using Layer 2 backhaul to terminate traffic in a regional POP is not the right design to support triple play services. In the example presented in this whitepaper, the total cost of ownership of the *Centralized Design* is over 1.5 times that of the *IP NGN Carrier Ethernet Design*. In order to effectively manage traffic and service delivery the right approach is to distribute network intelligence and QoS control to the edge.