COMMUNICATIONS ALLIANCE LTD

NATIONAL BROADBAND NETWORK REFERENCE ARCHITECTURE

HIGH LEVEL ARCHITECTURE OPTIONS FOR THE NBN

RELEASE 1

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National Broadband Network Reference Architecture
High Level Architecture Options for the NBN

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1 SCOPE

1.1 Introduction

The Communications Alliance NBN Reference Model working group developed the set of high level NBN network architecture options in this document.

1.2 Relationship with other Communications Alliance NBN Working Groups

The work of the NBN Reference Model working group is related to activities within other NBN Project working groups in Communications Alliance. The general relationships can be seen in Figure 1.

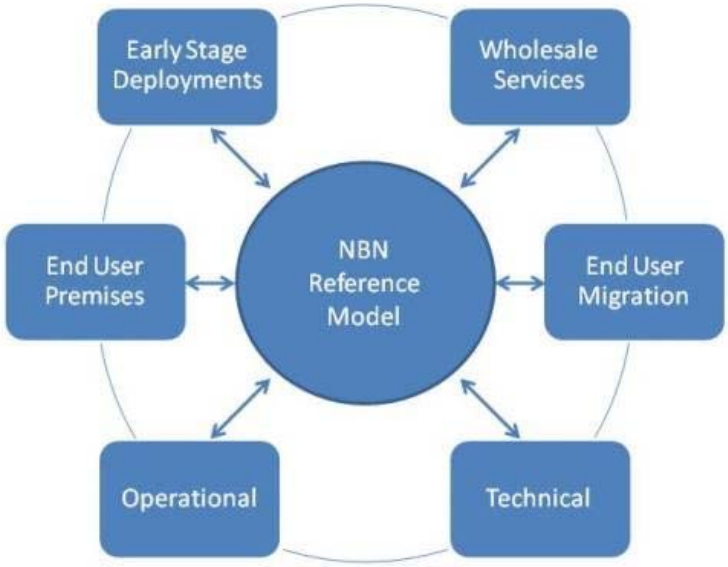

FIGURE 1
Communications Alliance NBN Project Working Group Structure

The NBN Reference Model working group is one of seven working groups established by Communications Alliance to address industry requirements for the National Broadband Network (NBN). The other six working groups address:

- **Wholesale Services** - The Wholesale Services working group is developing high level service definitions relevant to the National Broadband Network (NBN) that will be required in an NBN framework and supplied by NBN Co, FTTP greenfields carriers and other broadband access providers.

- **Early Stage Deployments** - The Early Stage Deployments working group is developing a definition of "Greenfields" for Fibre To The Premises (FTTP) developments, plus information to guide stakeholders such as planning authorities, approvals bodies, premises owners and constructors that draws upon industry best practices.

- **End User Premises** - The End User Premises Project Team is developing advice on NBN installation practices for end-user premises, guidelines on in-premises distribution and suggested procedures for testing and provisioning

services. The types of end-user premises include business, residential (including multi-dwelling), government, educational, infrastructure and backhaul sites.

- **Technical** - The Technical Group identifies appropriate international and local standards and industry documents that can be used to realise the NBN Reference Model.
- **End User Migration** - The End User Migration working group is defining a 'migration' with respect to the NBN for the definition of processes for customer movement to, within and from the NBN.
- **Operational** – The Operational working group is proposing approaches to enable the best possible customer experience in provisioning, assurance and billing of NBN services.

1.3 Scope

This document defines:

- The end-to-end broadband network architecture framework, including domains and functions required to deliver a range of network services and application/content services to end users.
- A range of potential passive and active NBN wholesale interconnect scenarios. This will be a key input to other Communications Alliance NBN work stream activities, in particular the wholesale services stream. In developing these options there has been some regard to overseas experience where different FTTH wholesale open access models are being adopted by different countries.
- Terminology and definitions for different industry participants, taking into account a range of possible roles providing Wholesale and Retail services.
- The relationship(s) between:
    - the CPE (such as the ONT and RG(s));
    - Retail Service Provider(s) and;
    - Wholesale Service Provider(s).

This document does not address:

- Aspects of the NBN reference architecture that are specific to:
    - voice services; and
    - video services.
- The evolution of existing broadband networks to implement the NBN;
- The interworking of the NBN with existing broadband networks;
- Commercial views on how the reference architecture and the business entities in it are mapped to existing and newly constituted business entities; and

- The competition model between the entities that implement or use the NBN.

It is expected that the latter four points above will be addressed by the NBN implementation study.

NOTES:

1. This document presents a range of scenarios and options that Communications Alliance working groups have identified with the purpose of facilitating broader NBN discussion and decision making for NBNs. It does not represent the preferred position of Communications Alliance, its individual members, or the communications industry.

2. While the scenarios presented in this paper are technically feasible, any agreed set of scenarios will require tradeoffs between technical and operational complexity versus requirements for maximum flexibility in support of functional and service requirements. These issues will need further analysis as part of more detailed Communications Alliance work stream activities.

2 BROADBAND NETWORK ARCHITECTURE VISION

The next generation broadband network will enable a wide range of network services and application/content services to be delivered to end users via FTTP, terrestrial Wireless and Satellite access. Figure 2 shows the end-to-end architecture vision which identifies the different functional and service domains applicable to the provision of Next Generation Broadband Services. The retail network service providers and application/content service providers are those that provide services to end users and have a direct customer relationship with the end users. Wholesale service providers do not have this relationship.

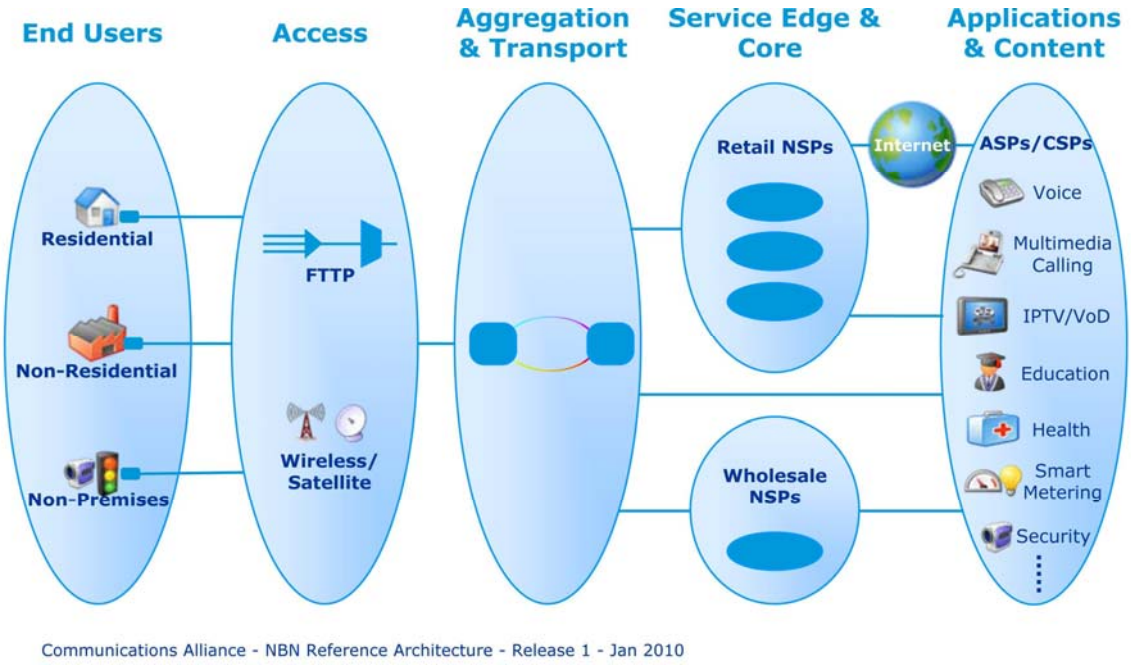

Figure 2
Broadband Network Architecture Vision

3 BROADBAND NETWORK REFERENCE ARCHITECTURE – FTTP ACCESS

3.1 Introduction

This section describes the end-to-end network architecture for Fibre to the Premises (FTTP) access.

FTTP will be the the primary form of access to the NBN.

Figure 3 shows the end-to-end broadband network reference architecture for FTTP access, segregated into a number of functional domains. This architecture is based on the reference architecture defined by the Broadband Forum[1] but has been adapted for the specific purposes of this exercise. In particular, the terminology used in this document is not fully aligned with that used by the Broadband Forum. It should be noted that the terminology used in this document will be reviewed and may change in future releases.

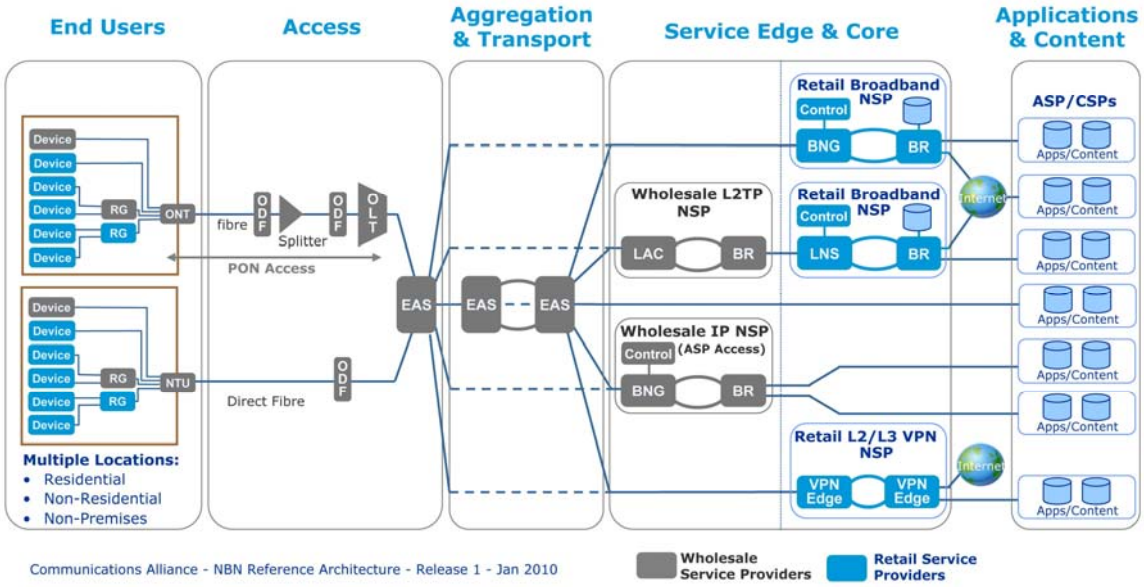

Figure 3
Broadband Network Reference Architecture - FTTP Access

3.2 Key Network Domains and Functions

The following sections describe the key network functions in each of the network domains.

3.2.1 End User Domain

End users will be located in residential and non-residential premises and also in non-premises based locations such as public road infrastructure (traffic control systems, street lights, surveillance cameras, etc.).

[1] International forum for developing broadband network specifications.
See www.broadband-forum.org

The key functions required in the end user domain are:

- **Optical Network Termination (ONT)/Network Termination Unit (NTU)** devices which terminate the optical network and provide a range of end user interfaces. This device could be located indoors or outdoors.
- **Routing Gateways (RG)** which provide a layer 3 (IP) gateway function between end devices and the network. They include functions for:
  IP routing, IP address allocation to end devices, Quality of Service (QoS), Network Address Translation (NAT), firewall, management, Domain Name Server (DNS) and network authentication.
  A Retail NSP may include additional capabilities on the RG not listed above.
- **Premises (Home) Networks** which provide connectivity between RGs and end devices.
- **End devices** which can be application specific (e.g. set top boxes, phones, videophones) or can be more general in nature (e.g. personal computers).

It should be noted that some end devices do not necessarily need a RG function and can be connected directly to the NTU. This document does not define or limit the types and number of ports on devices.

It should also be noted that there are multiple architecture options to support multiple service providers delivering services to the premises and what options are applied will determine the overall level of technical complexity. This document does not show all of the possible architecture options. The wholesale RG shown in Figure 3 represents only one of the end user architecture options.

3.2.2 Access Domain

The functions of the Access Domain include to:

- provide connectivity from the end user premises to the network; and
- allow IP multicast replication.

The Access Domain consists of both passive and active components.

- The passive components include:
  - Optical Fibre;
  - Optical Splitters;
  - Optical Distribution Frames (ODF); and
  - pit and pipe enclosures.
- The active components include:
  - Optical Network Termination (ONT) equipment; and
  - Optical Line Termination (OLT) equipment.
- Ethernet Aggregation Switches (EAS) which aggregate multiple OLTs at a local exchange site.

3.2.3 Aggregation and Transport Domain

The functions of the aggregation and transport domain include:

- to aggregate a large number of access connections onto a relatively small number of physical interfaces and transport these connections from local, distributed locations to centralised locations such as major regional and metropolitan centres with regional, state or national scope.
- allow IP multicast replication.

Multiple levels of aggregation are possible (e.g. local, regional, state, national) with potential for multiple service providers to operate in this domain. It should be noted that service providers may potentially provide transport-only services without any aggregation.

The current and future trend for providing aggregation and transport networks is to use Ethernet based aggregation and transport technology. As shown in Figure 3, Ethernet Aggregation Switches (EAS) provide the aggregation function.

3.2.4 Service Edge and Core Domain

The main function of this domain is to provide layer 3 (e.g. IP) connectivity between end devices, application/content services and the public Internet. It can also provide layer 2 Ethernet VPN and/or layer 3 IP VPN connectivity between end devices, application/content services and the public Internet.

In the case of providing broadband IP services, there are two main approaches for delivering end user logical connections into the IP service layer:

The predominant approach in use today involves aggregation of Point-to-Point Protocol (PPP) end user connections into Layer 2 Tunnelling Protocol (L2TP) tunnels for delivery into the IP network service layer. While this approach is adequate for providing best effort services, the emergence of IP based applications requiring more stringent Quality of Service (QoS) has lead to the development of an alternative "QoS enabled broadband" approach. This alternative approach enables the provision of end-to-end QoS capabilities at the IP service layer by providing direct Ethernet connectivity between the Routing Gateway (RG) at the end user premises and the Broadband Network Gateway (BNG) within the IP service layer.

The key functions of the BNG are to:

- Provide the first point of IP routing for end user traffic.
- Enforce subscriber level Quality of Service (QoS) and policy decisions.
- Allow IP multicast replication.

The key functions of the BNG control plane are:

- Authentication of RGs and association of RGs with subscribed service profiles.
- IP Address allocation to RGs.
- Management of QoS policies on the BNG and the RG.

It is generally accepted that QoS enabled broadband is likely to be the dominant approach in the future, however, given the large installed base of L2TP based services, it is likely that both approaches will need to be supported in the proposed NBN timeframe.

Within the Service Edge and Core domain, there are a number of different wholesale and retail roles that can be defined:

- Retail Broadband NSP
- Wholesale L2TP Network Service Provider (NSP)
- Wholesale IP NSP
- Retail L2/L3 VPN NSP

These roles are further defined in section 3.4.

3.2.5 Application and Content Domain

This domain provides application and content services to end users such as web-based application content, IP Telephony, IP Video, Smart metering, education, health, etc.

Today, the predominant means of connectivity between this domain and end users is via the public Internet (also known as "Over The Top"). Other connectivity models are possible to support applications requiring different capabilities to those available via the Internet. Examples include smart metering of home appliances, delivery of high quality video services, etc. The connectivity options listed below are further defined in section 3.4.

- Over The Top (via public Internet).
- Connect via Retail NSPs.
- Connect via a Broadband Access Provider (Wholesale Layer 2 Ethernet service).
- Connect via a Wholesale IP NSP.

Each of these connectivity options are different and will involve a tradeoff in technical and operational complexity between the end user network, NSPs and ASPs.

3.3 Wholesale Point of Interconnect and Service Boundary Point Scenarios

Within the context of the end-to-end Broadband Network Reference Architecture described in section 3.2, there are a range of potential Wholesale Points Of Interconnect (POI) and corresponding Service Boundary Points (SBP). These POI and SBP scenarios can be defined by the service functionality available at the interface, their physical location and the amount of aggregation they provide.

The possible locations within the logical network hierarchy of the Wholesale POI and SBP are shown in Figure 4. They are not intended to represent physical locations, rather they represent logical points in the network hierarchy which can be used to further define applicable service constructs. Each POI has a corresponding SBP. The numbering of the POI and SBP scenarios indicates the allowable POI and SBP pairings.

The service functionality of each scenario is summarised in Table 1 below.

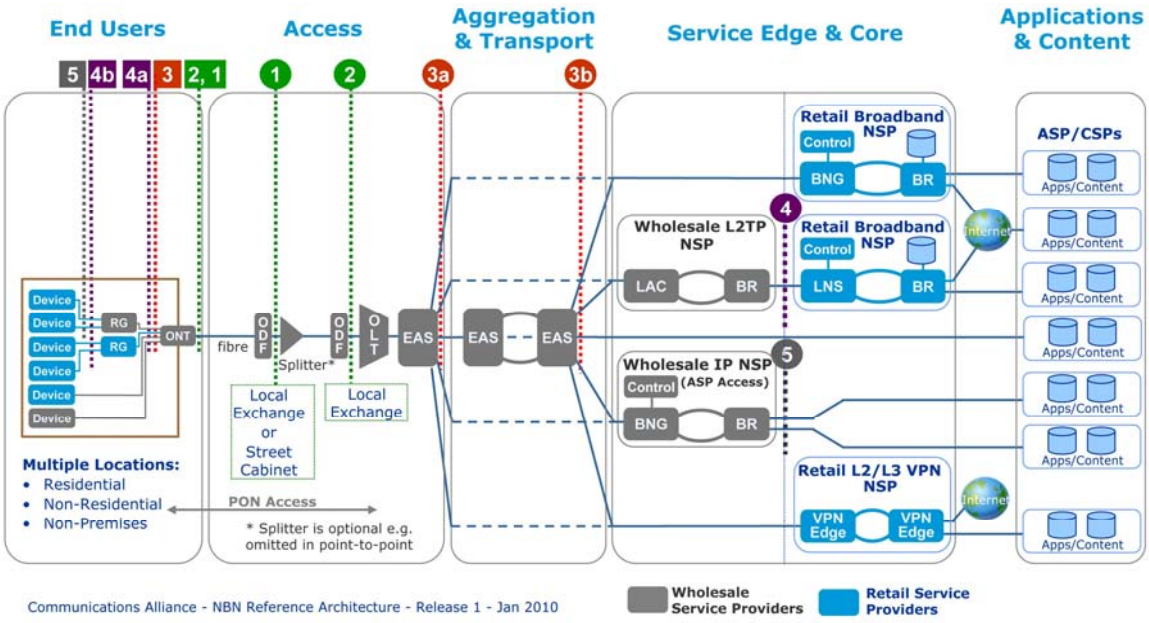

Figure 4

Wholesale Point of Interconnect and Service Boundary Point Scenarios - FTTP Access

Table 1
Wholesale POI and SBP Scenarios

POI Scenario	POI Type	Service Functionality	POI Physical Location(s)	SBP Physical Location(s)
1	Layer 1 - Passive Direct Dark Fibre	Single or multiple direct (pt-to-pt) dark fibres to the end user premises.	• Local Exchange • Street Cabinet	• Optical connector at the: • Street Pit (footpath/nature strip) • Outdoor Connection Device (OCD) • Indoor Wall Plate • Basement ODF
2	Layer 1- Passive Dark PON	Single or multiple dark PON fibres to the end user premises	• Local Exchange	• Optical connector at the: • Street Pit (footpath/nature strip) • Outdoor Connection Device (OCD) • Indoor Wall Plate • Basement ODF
3	Layer2 – Ethernet	Layer 2 Ethernet service to the end user premises. Service could be untagged Ethernet or support IEEE 802.1Q VLAN tagged interfaces. Equivalent to Broadband Forum TR-156 "A10 – NSP L2 (Eth)" interface	3a) Local Exchange 3b) Regional, State and/or National Aggregation POI Note : There may be circumstances where there are multiple instances of the 3b) POI (ie. Regional, State and National) involving multiple service providers. As a result a readers should not infer that POI Scenario 3 implies a strictly two layer hierarchy.	• Ethernet port on the end user facing side of the NTU (internal, external or basement)
4	Layer 2 – Wholesale L2TP	PPP connections to the end users delivered over L2TP tunnels. Equivalent to Broadband Forum TR-156 "A10 – NSP L2TP" interface	• Regional, State or National Aggregation POI	4a) Ethernet port on the end user facing side of the NTU (internal, external or basement) 4b) Ethernet Port on the end user facing side of the RG (PPPoE pass through)

POI Scenario	POI Type	Service Functionality	POI Physical Location(s)	SBP Physical Location(s)
5	Layer 3 - Wholesale IP	IP Layer connectivity to end user devices Equivalent to Broadband Forum TR-156 "A10 – ASP IP" interface	• Regional, State or National Aggregation POI	• Ethernet port on the end user facing side of the RG

3.4 Roles and Relationships between Different Industry Players

Within the context of the end-to-end Broadband Network Reference Architecture described in Figure 3, there is scope for a number of different industry roles to exist. Figure 5 and Table 2 summarise the different possible roles and the potential relationships between Wholesale and Retail providers. Note that each of the provider roles in Table 2 may be fulfilled by one or more entities.

It should be noted that it is possible for a single provider to perform multiple roles (retail and wholesale). For example, in the wholesale POI scenarios 1 and 2 (passive fibre infrastructure) the roles of Broadband Access Provider, Aggregation Transport Provider and Retail Broadband NSP could be performed by a single, integrated wholesale-retail service provider.

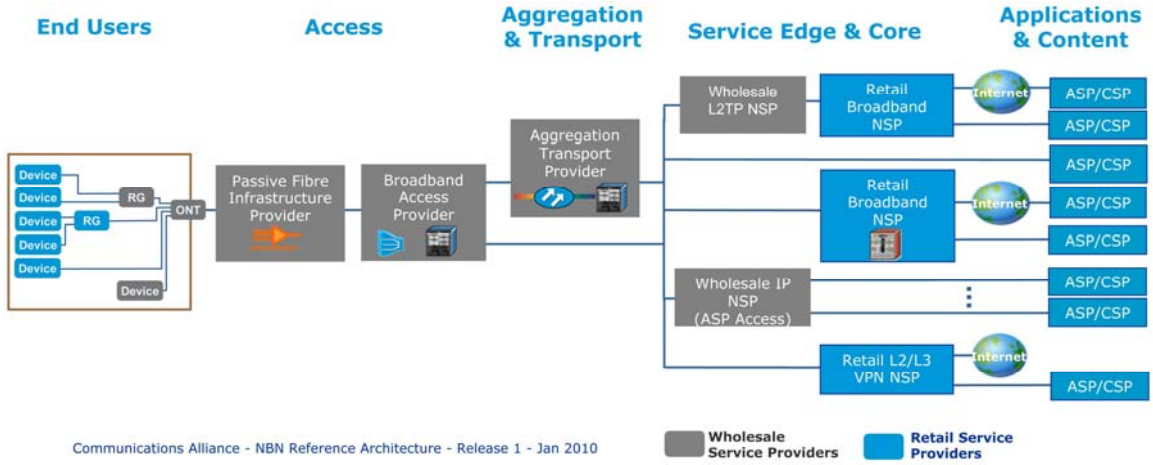

Figure 5
Summary of Industry Roles and Wholesale-Retail Scope

Table 2
Industry Roles and Wholesale-Retail Scope

Provider	Role
Passive Fibre Infrastructure Provider	• Provides passive optical fibre infrastructure (including fibre, splitters, ODFs etc.) in a dark fibre (i.e. point-to-point) and/or dark Passive Optical Network (PON) configuration from each end user premises to a Fibre Concentration Point
Broadband Access Provider	• Provides L2 Ethernet services from end users to Network Service Providers or directly to Application/Content Service Providers • Provides first level of aggregation of multiple OLTs at a local exchange site onto a single physical link to avoid the need to provide individual connections to each OLT for FTTP access. • Provides and operates PON OLT and end user ONT for FTTP access.
Aggregation Transport Provider	• Provides transport of traffic from local Points of Presence to central locations • Provides aggregation of end user connections onto a small number of physical links • Multiple providers can fulfil this role • This role is optional in the sense that NSPs can connect directly to the Broadband Access Provider
Retail Broadband Network Service Provider	• Provides IP network connectivity services to end users. e.g. o Broadband Internet access o Connectivity to ASP/CSPs o Authentication of RGs and association of RGs with subscribed service profiles o IP Address allocation to RGs o Management of QoS policies on the BNG and the RG • There are many retail NSPs
Wholesale L2TP Network Service Provider	• Aggregates end user (PPP) connections into L2TP tunnels for delivery to Network Service Providers. • Only supports best effort services • No IP Addressing, RG Auth, QoS
Wholesale IP Network Service Provider	• Provides IP connectivity between end users and ASP/CSPs (IP Addressing, RG Authentication, QoS Mgmt) • Acts as a service provider with national and/or regional scope to enable simpler connectivity for ASPs. This avoids the need for ASPs to connect to multiple NSPs to reach the entire NBN customer base.
Retail L2/L3 VPN Service Provider	• Provides Layer 2 Ethernet VPN and/or Layer 3 IP VPN connectivity services to end users. A range of value added services can also be provided. e.g.: o Firewalled Internet access o Hosted application/content services
Application / Content Service Provider (ASP/CoSP)	• Provides application and content services to end users • 4 options to reach end users are: a) Over The Top (via public Internet); b) Connect via Retail NSPs; c) Connect via Broadband Access Provider (Wholesale Layer 2 Ethernet service); and d) Connect via a Wholesale IP NSP. • Both ASP and CSP are terms used in the industry and are sometimes used interchangeably

3.5 Relationship between CPE and Retail/Wholesale providers

As described in section 3.4, a range of different industry players will provide wholesale and retail services in the NBN environment. This section describes the relationship between the various types of CPE required to deliver broadband IP services and the wholesale and retail service providers of these services.

The relationships summarised in Figure 6 show the different service layers and how they map to the wholesale and retail service domains.

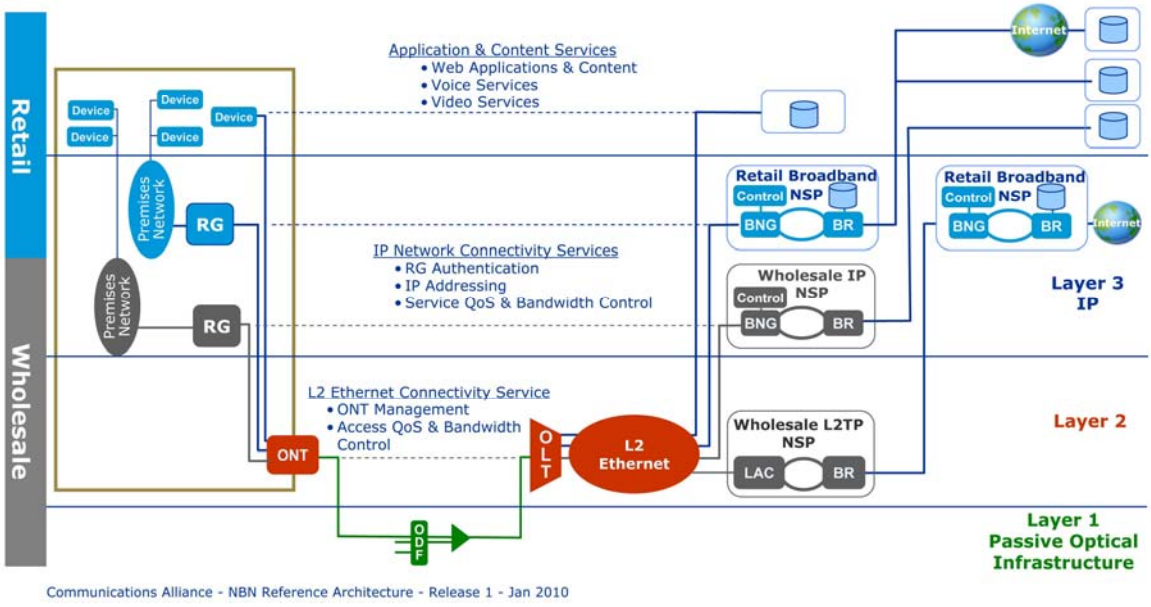

Figure 6
CPE Service Relationships

The key relationships are as follows:

- **Customer ONT and Network OLT managed by the same provider.** The layer 2 Ethernet service is provided via the end user ONT and network OLT. To ensure device compatibility and the integrity of the service, the ONT and OLT are tightly coupled and are therefore managed by a single wholesale broadband access provider.

- **Each Retail Broadband NSP manages their own RG.** A retail broadband NSP will provide services at layer 3. In order to allow management of authentication, IP addressing and service QoS and bandwidth profiles on the RG, a Retail Broadband NSP will need to manage its own RG. It is also likely that premises (home) network(s) will be setup and managed by the retail broadband NSP(s).

- **Wholesale RG managed by a Wholesale IP NSP.** Layer 3 can optionally include a wholesale IP service as described in section 3.4. For similar reasons to the Retail NSP case described above, the Wholesale IP service provider will need to manage its own RG. This implies that there may be a requirement for multiple RGs at the end user premises to support both Retail NSP and Wholesale IP NSP to deliver services into the premises. The impacts of supporting multiple RGs and multiple premises (home) networks at the end user premises or the potential for

delivering all services through a single retail NSP RG and premises (home) network needs further consideration.

- **End devices may or may not be managed as part of the application service**. The application layer provides application and content services to end users such as voice and video services and web based applications and content. The end devices used to access these services may or may not be provided and managed as part of the service being provided, depending on the application.

4 BROADBAND NETWORK REFERENCE ARCHITECTURE – WIRELESS/SATELLITE ACCESS

4.1 Introduction

This section describes two alternative architectures for providing broadband services over terrestrial wireless access or satellite access, namely at Layer 2 or Layer 3.

The choice of architecture depends ,in part, on the capabilities provided by the terrestrial wireless/satellite access network.

Currently, terrestrial wireless and satellite access networks typically provide layer 3 IP connectivity to end users.

While layer 3 IP connectivity is appropriate for providing retail access services, the prefered industry approach for providing wholesale access services is to use layer 2 access connectivity.

The use of layer 2 access connectivity aligns with the approach for FTTP access. However, layer 2 connectivity solutions require development from terrestrial wireless and satellite vendors.

4.2 Option 1: Layer 2 Ethernet Access

The end-to-end network architecture for layer 2 access connectivity can be segregated into a number of functional domains as shown in Figure 7.

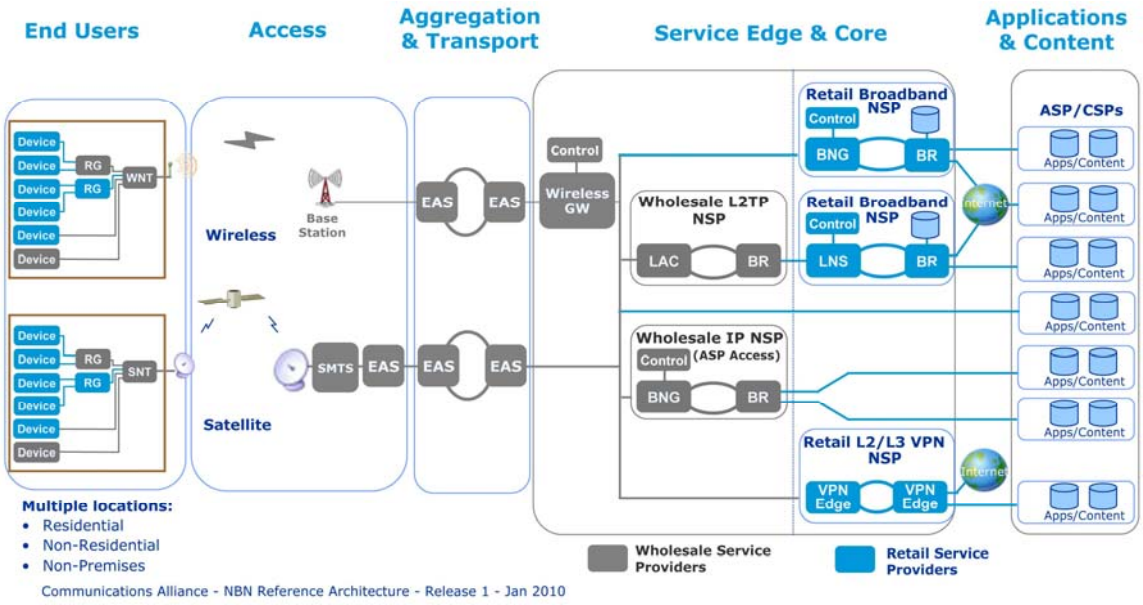

Figure 7

Network Reference Architecture – Terrestrial Wireless/Satellite Layer 2 Ethernet

4.2.1 Key Network Domains and Functions

The following sections describe the key network functions in each of the network domains.

4.2.1.1 End User Domain

End users will be located in residential and non-residential premises and also in non-premises based locations such as public road infrastructure (e.g. traffic control systems, street lights, etc.).

The key functional components required in the end user domain are:

- **Outdoor Antenna and Transceiver** to provide access to the air interface.
- **terrestrial Wireless/Satellite Network Terminal (WNT/SNT)** provides RF modem functions to access the air interface. This function also provides the layer 2 Ethernet interface to the RG or directly to end devices. It should be noted that this function is typically integrated with the RG function into a single device in today's layer 3 based deployments. However, any future development of layer 2 services on satellite/terrestrial wireless technologies may bring about the separation of these functions into distinct devices.
- **Routing Gateways (RG)** which provide a layer 3 (IP) gateway function between end devices and the network. They include functions for: IP routing, IP address allocation to end devices, QoS, Network Address Translation (NAT), firewall, management, Domain Name Server (DNS) and network authentication. A Retail NSP may include additional capabilities on the RG not listed above.
- **Premises (Home) Networks** which provide connectivity between end devices and RGs.
- **End devices** which can be application specific (e.g. set top boxes, phones, videophones) or more general in nature (e.g. PCs).

It should be noted that there are multiple architecture options to support multiple service providers delivering services to the premises and what options are applied will determine the overall level of technical complexity. This document does not show all of the possible architecture options. The wholesale RG shown in Figure 7 represents only one of the end user architecture options.

4.2.1.2 Access Domain

The function of the access domain is to provide connectivity from the end user premises into the network.

For terrestrial wireless access, standards define protocols and procedures to control access to the air interface, which operates between the WNT and the Wireless Base Station. These terrestrial wireless specific functions allow controlled access to the shared radio frequency (RF) resources and establishment of radio channels with associated QoS.

Terrestrial wireless standards support both fixed and mobile configurations. Which particular standard is deployed will determine characteristics of the wholesale service. The reference architecture is agnostic in the choice of standard.

For satellite access, the satellite transmission systems are proprietary, requiring a single vendor for the SNT and the Satellite Modem Termination System (SMTS). The layer 2 Ethernet service is provided between the SNT on the end user premises and the SMTS. The SMTSs are located at Satellite Earth Stations which are typically deployed at a small number of locations around the country.

Satellite Earth Stations and terrestrial wireless base stations may be in very remote locations and therefore will require transport services to more centralised locations. There could also be multiple STMSs at a Satellite Earth Station or a terrestrial wireless base station. This may drive the need to provide a level of aggregation at this location.

It should be noted that due to the delays inherent to satellite based connectivity, satellite tansmission systems are required to support higher layer protocol acceleration techniques (e.g. TCP acceleration). These techniques should be supported regardless of whether the satellite system is providing a service at layer 2 or layer 3.

4.2.1.3 Aggregation and Transport Domain

For terrestrial wireless access, the Aggregation and Transport domain provides Ethernet transmission from distributed terrestrial wireless base stations, which may be located in remote areas, back to centrally located Wireless Gateways. It should be noted that there may be specific requirements placed on the Ethernet aggregation and transport network to support terrestrial wireless access (e.g. support for QoS and synchronisation over Ethernet).

For satellite access, the Aggregation and Transport domain provides Ethernet transmission from Satellite Earth Stations, which may be located in remote areas, back to more centralised locations.

4.2.1.4 Service Edge and Core Domain

For terrestrial wireless access, standards define protocols and procedures to manage user connections across the terrestrial wireless domain between the Wireless Gateway and the WNT. The layer 2 Ethernet service leverages these wireless protocols and is provided between the WNT on the end user premises and the Wireless Gateway. The Wireless Gateways are typically located in centralised locations in metropolitan areas.

For satellite access, the satellite transmission system between the Satellite Modem Transmission System (SMTS) and the SNT is proprietary. The layer 2 Ethernet service is provided between the SNT and the SMTS. The SMTSs are located at Satellite Earth Stations which are typically deployed at a small number of locations around the country. It should be noted that these Earth Stations may be in very remote locations and will therefore require transport services to more centralised locations.

The NSP functions in this domain have the same functionality and access the Ethernet service in the same way as the FTTP case described in section 3.2.4. In addition to these functions, support for QoS over terrestrial wireless access will require control plane interaction between the terrestrial wireless gateway and the wholesale/retail NSP due to the dynamic nature of radio bearer establishment/teardown.

4.2.1.5 Application and Content Domain

See section 3.2.5.

4.2.2 Wholesale Point of Interconnect and Service Boundary Point Scenarios

Within the context of the end-to-end Broadband Network Reference Architecture described in section 4.2.1, there are a range of potential Wholesale POIs and corresponding Service Boundary Points (SBP). These Wholesale POI and SBP scenarios can be defined by the service functionality available at the interface, their location and the amount of aggregation they provide.

The possible locations in the network hierarchy of the Wholesale POI and corresponding SBP scenarios are shown in Figure 8. Each POI scenario has a corresponding SBP scenario. The numbering of the POI and SBP scenarios indicates the allowable POI and SBP pairings. The service functionality of each scenario is summarised in Table 3.

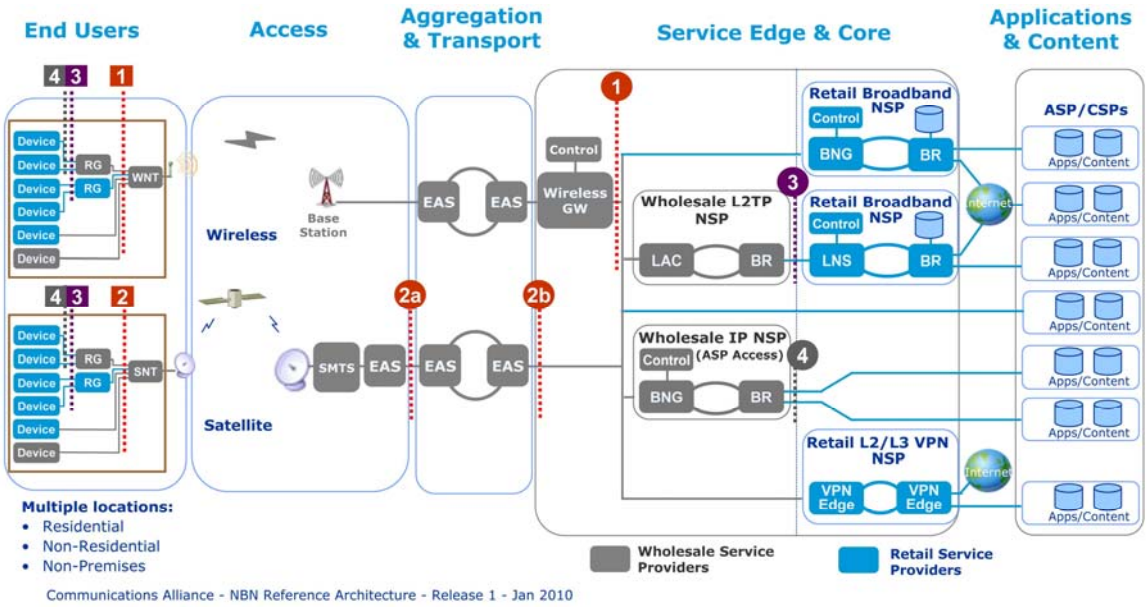

Figure 8

Wholesale Point of Interconnect and Service Boundary Point Scenarios – Terrestrial Wireless/Satellite Layer 2 Ethernet Access

Table 3

Wholesale POI and SBP Scenarios for Terrestrial Wireless/Satellite Layer 2 Ethernet Access

POI Scenario	POI Type	Service Functionality	POI Physical Location	SBP Physical Location
1	Terrestrial Wireless Layer 2 Ethernet	Wholesale Layer 2 Ethernet service to the end user premises.	• Aggregation and transport provided by the terrestrial wireless network to a regional, state or national location.	• Ethernet port on the end user facing side of the WNT.
2	Satellite Layer 2 Ethernet	Wholesale Layer 2 Ethernet service to the end user premises.	2a) Satellite Earth Station 2b) Regional, State or National Aggregation POI	• Ethernet port on the end user facing side of the SNT.
3	Wholesale L2TP	PPP connections to the end users delivered over L2TP tunnels.	• Regional, State or National Aggregation POI	• Ethernet port on the end user facing side of the RG
4	Wholesale Layer 3 IP	IP Layer connectivity to end user devices	• Regional, State or National Aggregation POI	• Ethernet port on the end user facing side of the RG

4.3 Option 2: Terrestrial Wireless/Satellite Layer 3 IP Access

The following sections describe the key network functions in each of the network domains for layer 3 IP access connectivity.

4.3.1 Key Network Domains and Functions

The end-to-end network architecture can be segregated into a number of functional domains as shown in Figure 9. The following sections will describe the key network functions in each of these domains.

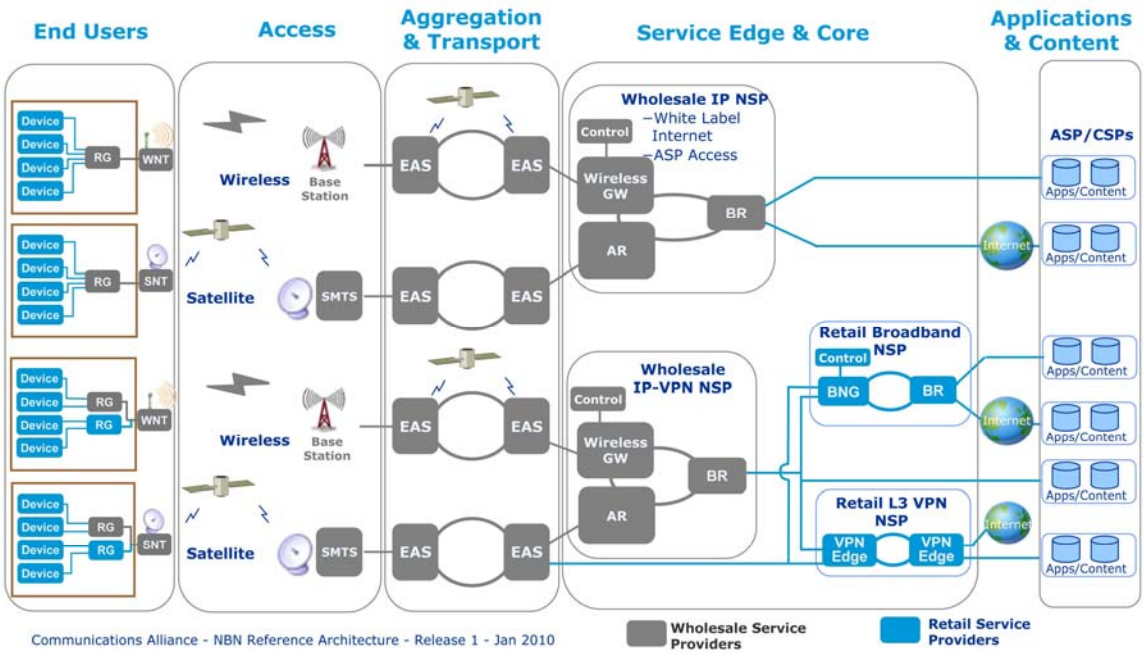

Figure 9

Broadband Network Reference Architecture – Terrestrial Wireless/Satellite IP Access

4.3.1.1 End User Domain

End users will be located in residential and non-residential premises and also in non-premises based locations such as public road infrastructure (traffic control systems, street lights, etc.).

The key functional components required in the end user domain are:

- **Outdoor Antenna** and Transceiver to provide access to the air interface.
- **Routing Gateways (RG**) which provides a layer 3 (IP) gateway function between end devices and the network. They include functions for: IP routing, IP address allocation to end devices, QoS, Network Address Translation (NAT), firewall, management, Domain Name Server (DNS) and network authentication. The RG also provides RF modem functions to access the air interface. A Retail NSP may include additional capabilities on the RG not listed above.
- **Premises (Home) Networks** which provide connectivity between end devices and RGs.
- **End devices** which can be application specific (e.g. Set Top Boxes, Phones) or more general in nature (e.g. PCs).

It should be noted that there are multiple architecture options to support multiple service providers delivering services to the premises and what options are applied will determine the overall level of technical complexity. This document does not show all of the possible architecture options. The wholesale RG shown in Figure 9 represents only one of the end user architecture options.

4.3.1.2 Access Domain

The function of the access domain is to provide connectivity from the end user premises into the network.

For terrestrial wireless access, standards define protocols and procedures to control access to the air interface, which operates between the RG (RF modem) and the Wireless Base Station. These wireless specific functions allow controlled access to the shared radio frequency (RF) resources and establishment of radio channels with associated QoS.

For satellite access, the satellite transmission systems are proprietary, requiring a single vendor for the RG and the Satellite Modem Termination System (SMTS). The SMTSs are located at Satellite Earth Stations which are typically deployed at a small number of locations around the country.

It should be noted that Satellite Earth Stations and terrestrial wireless base stations may be in very remote locations and will therefore require transport services to more centralised locations.

4.3.1.3 Aggregation and Transport Domain

For terrestrial wireless access, the Aggregation and Transport domain provides Ethernet transmission from distributed terrestrial wireless base stations, which may be located in remote areas, back to centrally located Wireless Gateways. It should be noted that there may be specific requirements placed on the Ethernet aggregation and transport network to support terrestrial wireless access (e.g. support for QoS and synchronisation over Ethernet).

For satellite access, the Aggregation and Transport domain provides Ethernet transmission from Satellite Earth Stations, which may be located in remote areas, back to more centralised locations.

The current and future trend for providing aggregation and transport networks is to use Ethernet based aggregation and transport technology.

4.3.1.4 Service Edge and Core Domain

Terrestrial Wireless/Satellite IP access can support two access models:

- The standard approach is to provide Wholesale IP access. In this case, the Wholesale IP network provides all of the Network Service Provider (NSP) network functions and retail services are provided via a resale model (so called White Label NSP). This scenario also supports direct access to the Wholesale IP service by ASP/CSPs.

- The alternative approach is for the terrestrial wireless/satellite network to provide Wholesale IP-VPN access. This allows retail broadband NSPs to provide some network functionality. In this case, the terrestrial wireless network provides IP-VPN connectivity between each retail broadband NSP to the end users. The retail broadband NSP provides a similar set of subscriber management functions as described in section 3.2.4. This approach also supports retail layer 3 VPN NSPs. While this approach is not specified in standards, it is supported by some wireless equipment vendors. Support by satellite vendors may require development.

It should be noted that Wholesale IP or IP-VPN Access implies a single national/ regional wholesale provider per terrestrial wireless/satellite access network.

4.3.1.5 Application and Content Domain

See section 3.2.5.

4.3.2 Wholesale Point of Interconnect and Service Boundary Point Scenarios

Within the context of the end-to-end Broadband Network Reference Architecture described in section 4.3.1, there are a range of potential Wholesale POIs and corresponding SBPs. These Wholesale POI and SBP scenarios can be defined by the service functionality available at the interface, their location and the amount of aggregation they provide.

The possible locations in the network hierarchy of the Wholesale POIs and corresponding SBPs are shown in Figure 10. Each POI has a corresponding SBP. The numbering of the POI and SBP scenarios indicates the allowable POI and SBP pairings. The service functionality of each scenario is summarised in Table 4.

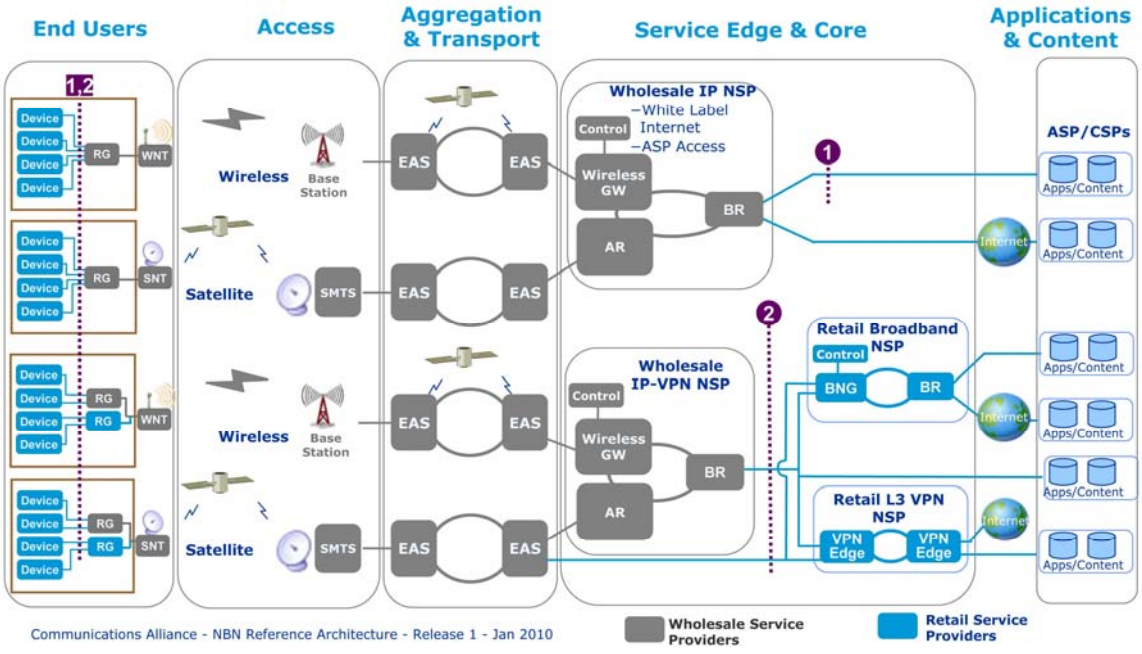

Figure 10

Point of Interconnect and Service Boundary Point Scenarios – Terrestrial Wireless/Satellite IP Access

Table 4

Wholesale POI and SBP Scenarios for Terrestrial Wireless IP Access

POI Scenario	POI Type	Service Functionality	POI Location	SBP Location
1	Wholesale Layer 3 IP	IP Layer connectivity to end user devices	Regional, State or National Aggregation POI	Ethernet port on the end user side of the RG
2	Wholesale Layer 3 IP-VPN	IP Layer connectivity to end user devices.	Regional, State or National Aggregation POI	Ethernet port on the end user side of the RG

5 FURTHER CONSIDERATIONS

Each document produced as part of the Communications Alliance NBN project has a section dedicated to the specific issues listed below. The purpose of these sections is to prompt the contributors, participants and persons commenting on the documents to identify issues or considerations relevant to the section. These sections are completed based on information available at the time of writing and may change over time.

5.1 Sustainability

The sustainability of the Broadband Network Reference Architecture options listed in this document have not yet been assessed.

However, contributors and persons commenting on this document are encouraged to advise of any issues regarding the sustainability of the options at the earliest possible opportunity.

5.2 Robustness

The robustness of the Broadband Network Reference Architecture options listed in this document have not yet been assessed.

However, contributors and persons commenting on this document are encouraged to advise of any issues regarding the robustness of the options at the earliest possible opportunity.

5.3 Security

The security of the Broadband Network Reference Architecture options listed in this document have not yet been assessed.

However, contributors and persons commenting on this document are encouraged to advise of any issues regarding the security of the options at the earliest possible opportunity.

5.4 IPv6

The compatibility of the Broadband Network Reference Architecture options listed in this document have not yet been assessed in light of IPv6.

However, contributors and persons commenting on this document are encouraged to advise of any issues regarding IPv6 at the earliest possible opportunity.

5.5 Future Proofness

The future proofness of the Broadband Network Reference Architecture options listed in this document have not yet been assessed.

However, contributors and persons commenting on this document are encouraged to advise of any issues regarding future proofness of the options at the earliest possible opportunity.

6 DEFINITIONS AND ABBREVIATIONS

6.1 List of terms

A current list of terms and their definitions is available at:
https://commswiki.dgit.biz/index.php/Agreed_Term_Definitions

NOTE: At the time of publication of this release the relevant wiki page was being finalized for public availability.

6.2 Definitions and Abbreviations

Refer to Table 5 for a list of definitions and associated abbreviations used in the Guideline.

TABLE 5

Abbreviations and Definitions for Terms

Term	Abbreviation (where relevant)	Definition	Comments / References
Carriage Service Provider	CSP	a person who supplies a carriage service to the public using licenced network units.	Section 87 of the *Telecommunications Act 1997*.
Content Service Provider	CoSP	a person who uses a listed carriage service to supply a content service to the public.	Section 97 of the *Telecommunications Act 1997*.
Service Provider	SP	as a stand alone term "Service Provider" is defined in section 86 of the Telecommunications Act 1997 as: "(a) a carriage service provider; or (b) a content service provider."	There are legislative consequences for "service providers." As far as possible the term should be avoided as a stand-alone term.
Wholesale Service Acquirer	WSA	An entity that consumes a wholesale service from a BAP, BBP o BIP.	

6.3 Other Abbreviations

Other abbreviations used in the Guideline and their meaning are:

ASP	Application Service Provider
AR	Access Router
CSP	Content Service Provider
BNG	Broadband Network Gateway
BR	Border Router
DNS	Domain Name Service
EAS	Ethernet Aggregation Switch
FTTP	Fibre to the Premises
IPv6	Internet Protocol version 6
L2	Layer 2
L2TP	Layer 2 Tunnelling Protocol
LAC	L2TP Access Concentrator
LNS	L2TP Network Server
NAT	Network Address Translation
NBN	National Broadband Network
NSP	Network Service Provider
NTU	Network Termination Unit
ODF	Optical Distribution Frame
ONT	Optical Network Termination
OLT	Optical Line Termination
POI	Point of Interconnect
PON	Passive Optical Network
PPP	Point to Point Protocol
PPPoE	Point to Point Protocol over Ethernet
QOS	Quality of Service
RG	Routing Gateway
RSP	Retail Service Provider

SBP	Service Boundary Point
SMTS	Satellite Modem Termination System
SNT	Satellite Network Terminal
VLAN	Virtual Local Area Network
VPN	Virtual Private Network
WNT	Wireless Network Terminal

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