NBN Co Network Design Rules

provided to the ACCC in support of NBN Co's Special Access Undertaking in respect of the NBN Access Service

19 December 2011

NBN Co Limited (ACN 136 533 741) and NBN Tasmania Limited (ACN 138 338 271)

Network Design Rules

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1 Introduction

This document provides an overview of the current physical network architecture and high level design of NBN Co's network and network components. It describes the high level solution that has been developed by NBN Co to achieve its objectives of delivering fibre to the premises to 93% homes and businesses, and satellite and wireless services to the remaining 7%.

This document is provided with NBN Co's Special Access Undertaking in respect of the NBN Access Service ('the SAU'), and is the document referred to in the SAU as the Network Design Rules.

This version of the Network Design Rules addresses the fibre GPON, TD-LTE Wireless, Transport and Aggregation network domains. An indicative view of the Satellite Access network design is also provided. It is intended that the final satellite network designs, along with other aspects of the NBN Co network will be provided to the ACCC as soon as they are available.

2 Purpose

This document is intended to be read together with NBN Co's Special Access Undertaking (SAU). These Network Design Rules will be provided to the ACCC as part of its assessment of the reasonableness of NBN Co's SAU. NBN Co's objective is to provide certainty with respect to the capital expenditure it may recover in relation to the design of the NBN, but also to provide an appropriate degree of flexibility.

If the SAU is accepted, these Network Design Rules will provide a baseline design for the NBN Co fibre, satellite and wireless networks in respect of which NBN Co may incur capital expenditure and recover it over time through the Long Term Revenue Constraint Methodology, provided that NBN Co also meets the Prudent Cost Condition, as specified in the SAU, in respect of that capital expenditure.

The process for varying or enhancing NBN Co's network design which is beyond the scope of these Network Design Rules is separately set out in the SAU (Schedule 8). On completion of the process for variation or enhancement of the network design, NBN Co will be required to update these Network Design Rules accordingly. These Network Design Rules will also be reviewed in accordance with the conditions specified in the SAU.

3   Network Design

3.1   High Level Design Overview

The NBN Co network has been divided into domains to allow for communication of the overall solution.

The target high level architecture is shown in Figure 1. This view includes the IT platforms, which are out of scope for this High Level Design, but must be interfaced to, to achieve a complete working solution. The target high level architecture will not be achieved for a number of years, and will be implemented in steps determined by the services introduced.

A first step towards the target architecture is captured in

Figure 2. These are domains introduced to support the NBN Co Fibre Access Service Ethernet Bitstream (Data) service, the NBN Co Wireless Access Service Ethernet Bitstream (Data) service, the NBN Co Fibre Access Service Multicast service and the NBN Co Fibre Access Service Analogue Telephony (Voice) service. The Satellite Access Service will be delivered in the future, and the supporting Satellite Access domain network design is still under development.

The high level domains and their functions are as follows:

- Network: Key function is the carriage of customer traffic

  - Access: Various technology solutions to allow end users to be connected to the NBN Co network. The expected long term technology domains are Fibre (GPON), Wireless (LTE) and Satellite.

  - Transport: Provides transparent connectivity between network elements

  - Aggregation: Takes many interfaces from network elements and aggregates them for presentation on fewer interfaces back into network elements and vice versa. Also provides the point of interconnect for access seekers, the customers of NBN Co services

- Data Communications Network: networks that do not carry the Access Seeker to/from End User traffic. These networks carry OA&M related traffic and signalling traffic.

- Network Management: Systems that support the network carrying the customer service traffic. Functions include element management, time information, Authentication, Authorisation and Accounting (AAA) for access to network elements and connectivity between the equipment providing Network Management functions and the Network Elements themselves

- Control: those required to operate in real time (or very near real time) to support the establishment of an end user connection through to the Access Seeker

- Lawful Interception: support the delivery of replicated customer traffic to Law Enforcement Agencies as legally required by the Telecommunications (Interception and Access) Act 1979.

- IT Platforms: Platforms supporting systems required for providing a customer portal, order acceptance, enforcement of business rules (e.g. number of active data services per NTD), activation, fulfilment, assurance and billing. Also includes systems required to interact with Element Management systems to operate the network carrying the customer traffic.
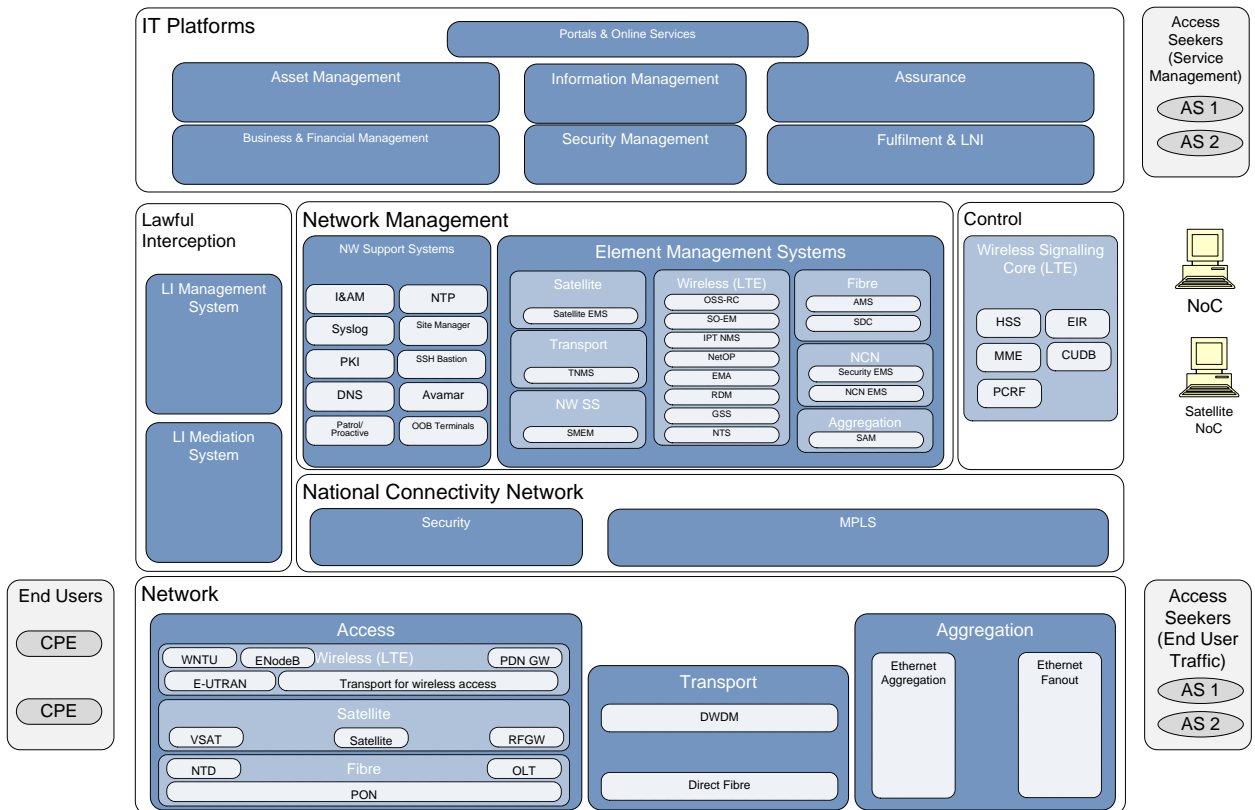
Figure 1   Target High Level Architecture Context Diagram
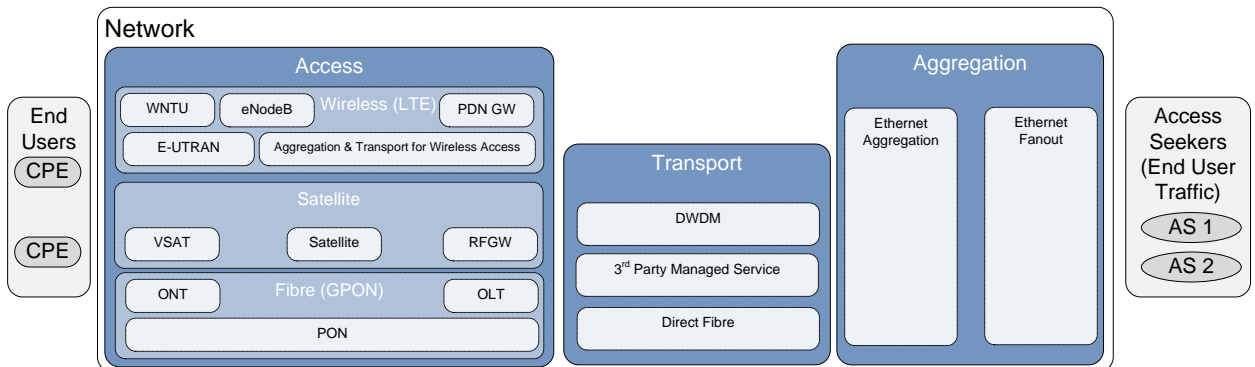
Figure 2   Focus of this Document

The NBN Co physical network architecture is designed to provide the required connectivity for NBN Co services whilst allowing for the required level of availability and resiliency in an efficient manner.

Each domain has a set of physical network elements that deliver the functionality and interfaces to support the NBN Co services.

3.2   GPON Access Domain

The GPON access domain solution consists of the following components:

- GPON NTD (ONT) - The Optical Network Terminal located at the end-user premises uses GPON technology to extend optical cable from an OLT shelf. It delivers UNI-V and UNI-D capabilities to a premise.

- PON - provides optical pathways between the GPON NTD and OLT

- OLT - The Optical Line Terminal provides FAN Site processing, switching, and control functions. The OLT aggregates GPON networks into a number of network-facing 10Gbps links.

3.2.1.   GPON NTD (ONT)

The GPON NTD terminates the incoming physical fibre at the end-user premises and provides one or more User to Network Interfaces (UNI). A number of GPON NTD varieties will be used to suit different circumstances, end-user types and interface quantities. The variants included are Indoor and Outdoor Single Dwelling GPON NTDs. Both have the following:

- 1 x GPON fibre interface

- 2 x UNI-Voice interfaces

- 4 x UNI-Data interfaces

- Support for standard power supply or Uninterruptable Power Supply (UPS)

Indoor GPON NTD variants may be semi-permanently mounted to a surface (e.g. a wall) or placed untethered on a flat surface (e.g. desk). Outdoor GPON NTD variants will be permanently fixed to a surface (e.g. exterior wall).

There are two basic types of power supply available for each GPON NTD variant; standard AC to DC power supply or Uninterruptable Power Supply. The standard AC to DC power supply accepts ~240 VAC input and provides 12 VDC towards the GPON NTD via a specialised cable with captive connectors (indoor GPON NTD) or screw terminals (outdoor GPON NTD), it provides no protection against AC mains failure.

The Uninterruptable Power Supply (UPS) also accepts ~240 VAC input but includes a battery facility for providing 12 VDC towards the GPON NTD even during an AC mains failure event, until the battery falls below the minimum energy capacity. DC power is fed to the GPON NTD via a specialised cable with captive connectors (indoor GPON NTD) or screw terminals (outdoor GPON NTD), the cable also

allows for simple power related alarms to be forwarded from the UPS unit to the GPON NTD. The UPS can be installed with or without a battery, allowing an Access Seeker or end-user to provide a battery at a later date, and perform maintenance of the battery facility without requiring NBN Co involvement. When there is no battery installed, the UPS operates like a regular AC to DC power supply. Both the AC to DC power supply and UPS must be installed indoors. When installed with an Outdoor GPON NTD, the power cabling must extend within the premises to the power supply or UPS.

3.2.2.   PON

The NBN Co Passive Optical Network is required to provide connectivity in the form of a Fibre to the Premises (FTTP) network for 93% of Australian premises.

The passive network component of a fixed network build comprises a significant part of the overall FTTP deployment. It is disruptive and expensive to augment or modify so it is important that the architecture, planning, design, and installation accommodates the long term needs and future growth and capacity. It is NBN Co's aspiration that these facilities will be suitable not only for the NBN's initial technology choice, but for fixed access technologies developed in the future, whatever they may be.

In order to provide a functional and operational network a high degree of uniformity of the passive infrastructure is desirable. Uniformity of design and construction facilitates education and training, the availability of competent staff, and economies of scale and efficiencies in the supply industry in general. Regionalised or localised variations in design or construction practices will be minimised where practical as these differences may disadvantage the affected communities due to the increased costs and complexity of managing variations in technical and operational processes.

The NBN Co Passive Fibre Network includes the Distribution Fibre Network (DFN), the Local Fibre Network (LFN) and Premises Fibre Networks (PFN). The DFN and LFN are connected with a Fibre Distribution Hub. PFNs provide the connectivity from the LFN to the Fibre Wall Outlet (FWO).

The common denominator of this network is the actual physical fibre strands. NBN Co has selected ribbon fibre technologies due to the benefits of using ribbon and the high level cost and labour savings associated with the use of this technology.

3.2.2.1. *Fibre*

Ribbon fibre technology significantly increases the fibre cable core counts available, and also provides significant time savings when joining fibres via fusion splicing when compared to stranded or single fibre. Ribbon fibre cables are available with fibre counts ranging between 12 and 864 fibres, and these are virtually identical in size and handling characteristics to similarly constructed single fibre cables.
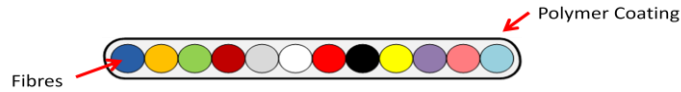
Figure 3   Ribbon Fibre

The cables match the core counts required (144, 288, 432, 576, and 864) and the 12 fibre matrix suits the modularity of the Factory Installed Termination Systems (FITS). The FIT System is a pre-connectorised system which pre-terminates fibres in the Local Fibre Network onto multi-fibre connectors in groups of 12 and multi-ports are then connected into these as required.
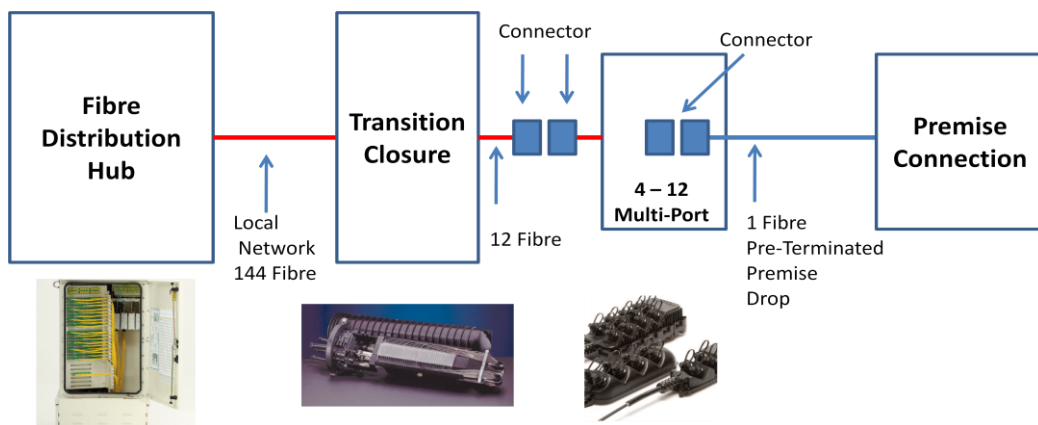
Figure 4   Connector and Multi-port Connections

The following table provides a summary view of what fibre types and connectors are used where in the network:

Network	Fibre Type	Connectors	Standards Reference (see Table 2 below)
DFN	Ribbon	• Splice	All Fibre Optic Cable
LFN	Ribbon	• Splice: FDH (72) Tail to factory installed patch panel • Connector: FDH Patching = SC/APC • Splice: FDH Tail (e.g. 576) to Multiport Tail (12) • Connector: Multiport tail = 12 fibre tether optical connector (proprietary format) • Connector: Multiport Single Customer Connection = single fibre optical connector (proprietary format)	All Fibre Optic Cable
LFN	Ribbon – Aerial	• Splice: FDH Tail (e.g. 576) to Aerial Cable • Splice: Aerial Cable to Multiport Tail (12) • Connector: Multiport tail = 12 fibre tether optical connector (proprietary format) • Connector: Multiport Single Customer Connection = single fibre optical connector (proprietary format)	All Fibre Optic Cable
PFN – SDU	Single Fibre Drop	• Splice: Single Fibre Fusion Splice to PCD & FWO	All Fibre Optic Cable + • Fibre Optic Single Drop Cable • Multiport Feeder Cable
PFN – MDU	Ribbon	• Splice: Internal FDH,FDT tail ,FWO • Connector: Internal FDH,FDT,FWO,NTD = SC/APC • Connector: FDT,FCD = MPO/APC	All Fibre Optic Cable + • Fibre Optic Aerial Cable
PFN – MDU	Single Fibre Drop	• Splice: Single Fibre Fusion Splice to PCD	All Fibre Optic Cable + • Fibre Optic Single Drop Cable

Table 1 Summary of fibre & connector types used in the network

Standards Reference Code	Title / Description
All Fibre Optic Cable	
ITU-T G.652	Characteristics of a Single Mode Optical Fibre and Cable, Table 4 G.652-G.652D attributes.
GR-20-CORE	Generic Requirements for Optical Fibre and Optical Fibre Cable
IEC 60793	Optical Fibres
IEC 60794	Optical Fibre Cables
AS1049	Telecommunication Cables-Insulation, sheath, and jacket
Fibre Optic Aerial Cable	
IEEE 1222	Standard for All Dielectric Self Supporting Aerial Fibre Optic Cable
GR-3152	Generic Requirements of Hardened Multi-Fibre Optical Connectors.
GR-3122	Generic Requirements for a Factory Installed Termination System.
GR-771	Generic Requirements for Fibre Optic Splice Closures
Fibre Optic Single Drop Cable	
ITU-T G.657	Characteristics of a Bending Loss Insensitive Single Mode Optical Fibre and Cable, Table A2
GR-3120	Generic Requirements of Hardened Fibre Connectors.
Multiport Feeder Cable	
GR-3152	Generic Requirements of Hardened Multi-Fibre Optical Connectors.
Multiport	
GR-771	Generic Requirements for Fibre Optic Splice Closures
GR-3152	Generic Requirements for Hardened Multi-Fibre Connectors
GR-3120	Generic Requirements for Hardened Fibre Connectors.
MPO / APC	
GR1435	Generic Requirements for Multi Fibre Optical Connectors

Table 2 Fibre Standards Reference Code

3.2.2.2. Distribution Fibre Network

The Distribution Fibre Network (DFN) provides the underground fibre pathways between the FAN sites and the Fibre Distribution Hubs (FDH). The DFN is generally installed in a loop topology starting from a FAN site and finishing at the same site, with FDHs connecting into it along its length. The DFN cables are typically higher fibre counts, with fibre core counts needed between 288 to 864 fibres. The DFN is also notionally allocated an A and B direction to assist in the identification of upstream connections at the FDH, where the A indicates a clockwise direction and B an anticlockwise direction.

The FDHs are street side externally rated cabinets which are used to house the Gigabit Passive Optical Network (GPON) splitters used to facilitate connectivity between the DFN and the Local Fibre Network (LFN). The FDH also provides the ability to provide direct connectivity between the DFN and LFN.

The DFN is also required to provide diverse pathways for point to point services from FDHs where required.

The DFN fibre links cable into the FDH is provided by a single cable and has both A and B directions within the same cable sheath.

DFN Diversity

The FTTP network has been extensively modelled for availability percentages and expected downtime due to faults and this modelling has recognized that the DFN has a significant input into the availability calculations. This is the direct effect of the high fibre counts and distances required for the DFN.

The availability target indicates that a link distance of 4500 metres can be applied to a single connection pathway between the FAN and the farthest FDH or to a spur off the DFN without the need to provide diversity. For practical purposes this distance is reduced to 4000 metres to account for unforeseen alterations to the network in the construction phase and to provide flexibility for future maintenance.

This calculation allows the DFN to be installed in topologies other than fully diverse.

The default position for the DFN is to provide connection diversity to each FDH for the provision of diverse services and to provide the capability for a quicker Mean Time to Repair (MTTR). The quicker MTTR is achieved through the use of the diverse path available at the FDH to move affected services to the other "side" of the DFN effectively bypassing the affected cable link.
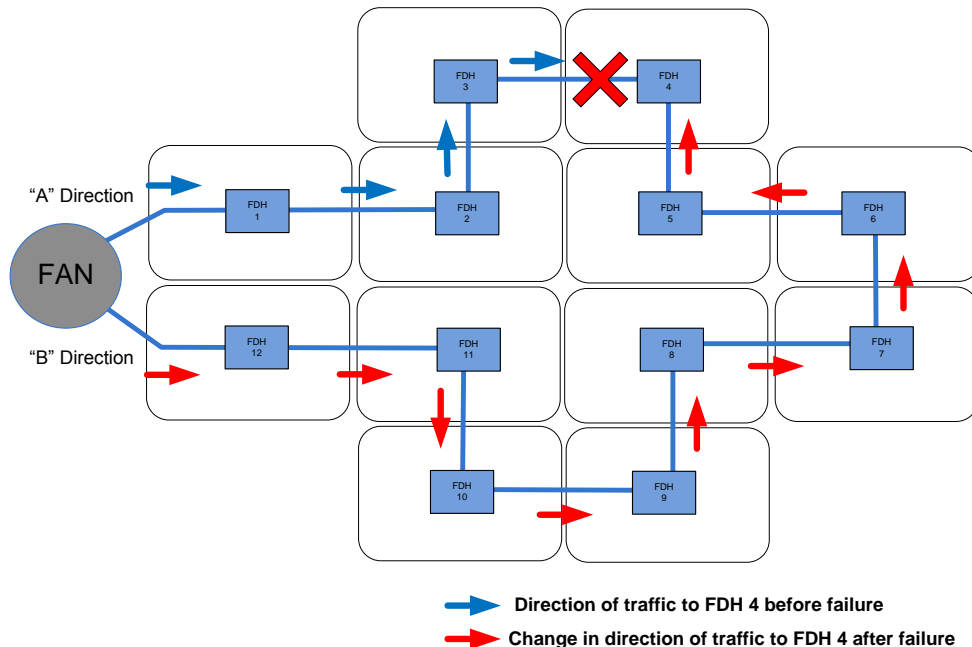
Figure 5   Traffic paths available when failure occurs

The second position is for a collapsible loop (referred to as a return spur) to be installed from the main diverse DFN, up to 4000 metres, with a maximum of 2 FDHs connected into the return spur.

This topology does not permit service restoration patching for the two connected FDHs when the return spur is interrupted but does allow for restoration patching for the remainder of the DFN.

Direction of traffic to FDH 4 before failure

Change in direction of traffic to FDH 4 after failure
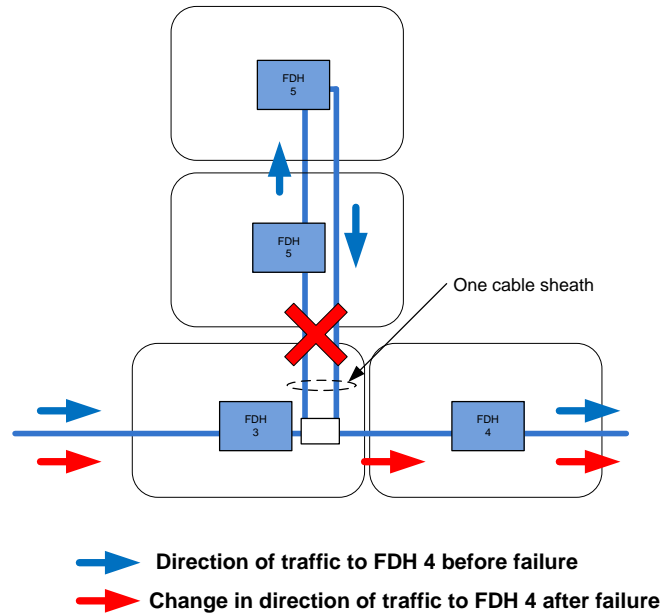
Figure 6   Traffic paths available when failure occurs on return spur

The third and least optimum deployment is for a spur in which only one pathway (either A or B and referred to as a single spur) is presented to the FDHs. This topology will only be used within temporary conditions, such as Greenfield developments in which the development is out of synch with the DFN build. The proviso to this option is that the DFN must be amalgamated into the DFN as either a fully diverse DFN or return spur to meet the distance and FDH counts.

DFN Connectivity

The DFN is preferably installed underground, and by exemption aerially and is designed in a ring topology starting and finishing at the same FAN site. This effectively divides the DFN cable ring into an 'A' and a 'B' side.

The DFN provides connectivity to the Fibre Distribution Hubs (FDH) located within the FSAM modules and provides two diverse fibre pathways back into the FAN site for each FDH (refer to Figure 5).

Any individual DFN ring cable will be separated from any other portion of the same ring by the most practically achievable distance. Multiple cables from different DFN ring cables can share the same duct-line, as well as sharing duct-lines with TFN and LFN cables.

Fibre Distribution Hubs are connected to the DFN ring cables and each FDH is allocated fibres in both A and B directions towards the FAN site. This ring allocation provides a diverse pathway for end-user connectivity and allows for temporary service restoration when required. In the event of a serious

service impacting event (e.g. Cable cut etc.,) the services that are connected to the affected side can be manually re-patched at the FDH and FAN site to the diverse pathway.

Therefore the DFN network must be capable of servicing these connections in both directions of the DFN within the optical constraints.

Whilst the DFN provides diversity from each FDH this diversity is not transferred into the LFN (the LFN is a star topology) and therefore the DFN should also be designed to align with potential users of point to point services (e.g. Banks, schools, universities, business parks) to allow the LFN to provide the diverse links.

3.2.2.3. *Fibre Distribution Hub*

The Fibre Distribution Hub (FDH) is an aggregation and connection point between the Distribution Fibre Network (DFN) and the Local Fibre Network (LFN). The FDH is available in 432, 576, and 864 LFN variants however the 576 will be the preferred choice.

The FDH is an environmentally secure passive device installed on street frontages and serves as a centralized splitter location. The splitter modules housed within the FDH provide a one-to-many relationship between the in-coming DFN fibres and the out-going LFN fibres. In keeping with the requirements of the GPON equipment the splitters used are a 1:32 passive split.

The standard and most common connectivity type will be a PON connection between an end-user and the output leg of a splitter module.

The splitter module is in a 1:32 planar configuration and these modules are pre-terminated with 1 X DFN SC/APC fibre lead and 32 X LFN SC/APC fibre leads and these connect into the network via the patch panel array within the FDH.
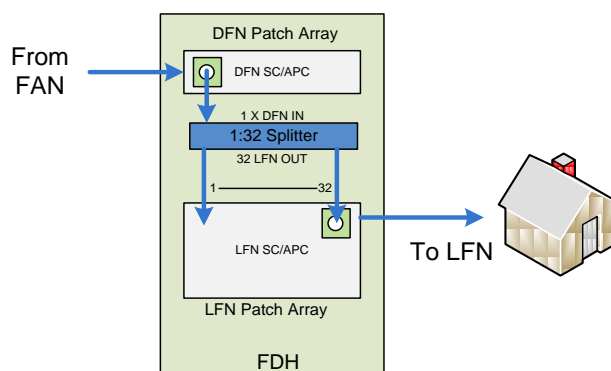

Figure 7   FDH PON Connection

3.2.2.4. Local Fibre Network

The Local Fibre Network (LFN) is installed from the FDH to the end-user premises in a star topology with no inherent capacity for diversity. Diversity is achieved by extending the LFN from any other FDH, dependant on the status of the other FDH's location in separate geographic pathways.

LFN cables are typically smaller fibre count cables, ranging between 72 and 288 fibre counts, and are installed in the aerial corridor and underground pathways typically alongside property boundary street frontages. The LFN cables are presented at the FDH on a connector array to facilitate connection to the upstream DFN either via a PON splitter or direct connection.

For an underground deployment the individual LFN cables are extended from the FDH into the Local Fibre Network to multiple centralized splice closures (AJL) where the cables are joined into smaller fibre count "tether" cables via splicing. The tether cable is factory terminated on one end only with an environmentally hardened multi-fibre connector and is installed between the AJL and local fibre pits where they provide a connection point for the factory terminated Multi-Ports (MPT). Service fibre drops to end user premises are connected into the MPTs as required.

For aerial deployment the LFN is a factory installed termination system (FITS) that utilizes factory installed splice closures, referred to as overmoulds, to present the multi-fibre connector at each required location. The MPTs are then connected in a similar manner as the underground method.

Single Dwelling Unit and Non Addressable Allocations

Each SDU is allocated one fibre in the LFN between the MPT and the FDH. This fibre is utilized for the service connection. A second fibre is allocated to the same Multiport location that the SDU will connect to and although allocated is available for any use at the MPT for any non-addressable connections, extra connections per SDU etc.

Non Addressable locations can be identified as locations without a physical address e.g. power transformers, traffic light controllers etc.

Extra fibres shall be allocated to provide future capacity. In total the effective allocation on average is three fibres per premises.

Multi- Dwelling Unit Allocations

The fibre allocations within MDUs are based on using the external FDH as the centralized splitter location and to use these splitters and the fibres in the LFN to facilitate connections. Therefore internal splitters within MDUs are used when there are above 110 connections required and the FDH is then connected into the DFN. Splitters connected to the LFN should only be used for network augmentation when the LFN is at, or near, full capacity.

MDUs are classified into the following categories:

Classification	Actual Premises Count
Very Small	2 - 10
Small	10-30
Medium	30-60
Large	60-110
FDA	110+

Table 3   MDU Classifications

Fibre allocations for MDUs are based on an assumption that the lower number in the actual premises count will generally be horizontal or "garden" MDUs (e.g. a set of detached dwellings grouped around a central driveway) and may also be semi-detached housing. This classification would also apply to semi-detached MDUs within a community, for example a rest-home or similar. For this example the same fibre allocation applied to SDU (3 fibres) will be applied.

For the range of MDUs from Small to Large, if contained within the same building or in close vicinity, a ratio of 1.5 fibres per residential dwelling is used. This can be applied as having 1 fibre for initial connection and the remaining fibres available for use for building services or future non-addressable locations.

For FDA sized MDUs the fibre allocation is consistent with the 1.5 fibres per residential premise however the FDH requires connection to the DFN.

For commercial buildings an allocation of 6 fibres per floor shall be applied and the LF Network should be designed so as to be able to provide any diverse connection requirements.

Classification	Actual Premises Count	Fibre Allocations
Very Small	2 – 10	2 per SDU
Small	10-30	1.5 per SDU
Medium	30-60	1.5 per SDU
Large	60-110	1.5 per SDU
FDA	110+	1.5 per SDU
Commercial	Per Floor	6 per floor

Table 4   MDU Fibre Allocation:

Extra fibres shall be allocated as required for any specific connections (in building services, lift phones etc.,) or for future capacity.

3.2.2.5. PON Planning Hierarchy

For planning, design, and construction purposes the network is divided into hierarchical modules and network entities.

These modules are used to provide the planning constructs needed to provide connectivity between the individual End-Users premise through to the Access Seeker (AS) Point of Interconnection (POI)

The first identifiable connection point is an end-user premise. These are defined as physical address points. Each individual dwelling unit is required to have a unique service location, and is identified as an end-user. If the end-user premise is situated in a Multi-Dwelling unit environment then these are treated as individual connections.

The first module is the Fibre Distribution Area (FDA) which is comprised of an average of 200 end-users. The FDA is the catchment area of a Fibre Distribution Hub (FDH) which provides a passive optical aggregation point for the LFN into the DFN.
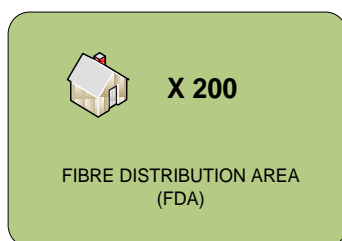
Figure 8   Fibre Distribution Area

The second module is the combination of a maximum of 16 FDAs to create a Fibre Serving Area Module (FSAM). An FSAM with the maximum of 16 FDAs will, as a result, have an average catchment of 3200 end-users.
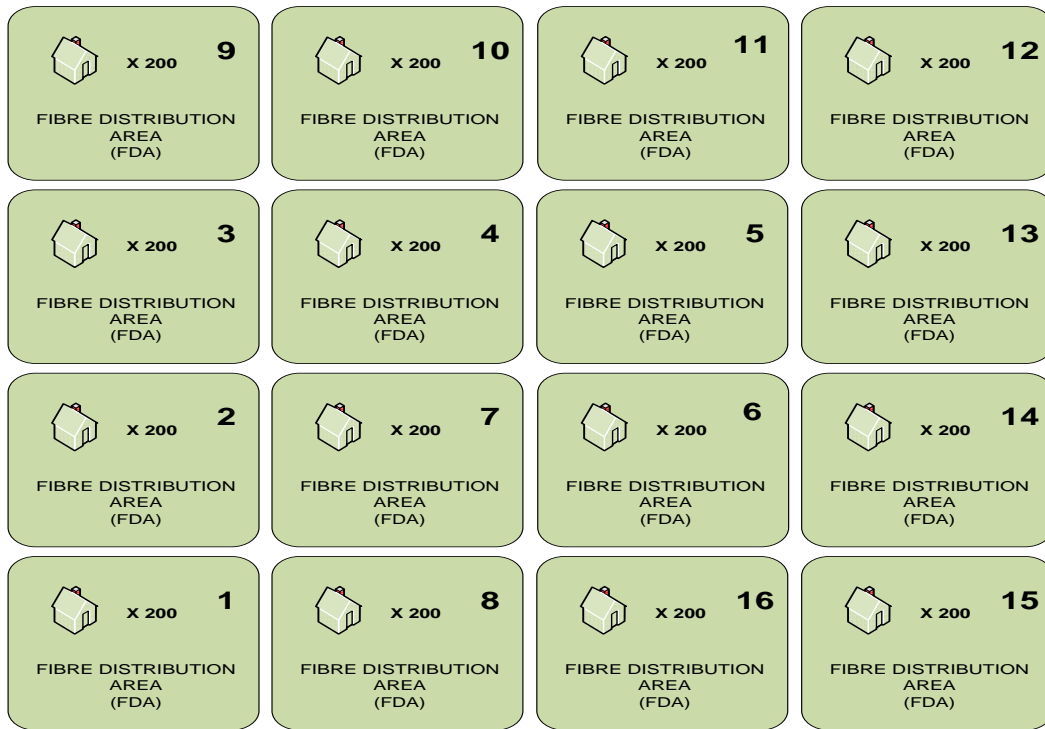
Figure 9   Fibre Serving Area Module Example

The modular size of the FSAM is dependent on the geography of the area to be served and can be constructed with any number of FDHs.

The maximum design shall allow for the grouping of 16 FDAs onto a single DFN cable. This grouping can contain between 13 and 16 FDAs and for this the DFN requires two loops, an inner and an outer loop, and these are used to provide connectivity of a maximum of 16 FDHs. The inner loop as shown in figure 6 is used for FDHs 1-8 and the outer loop for 9-16. The cable links between FDA 3 back to the FAN and FDA 8 back to the FAN is a 576 fibre cable split evenly across the two rings at the splice closures located in FDA 3 and FDA 8.
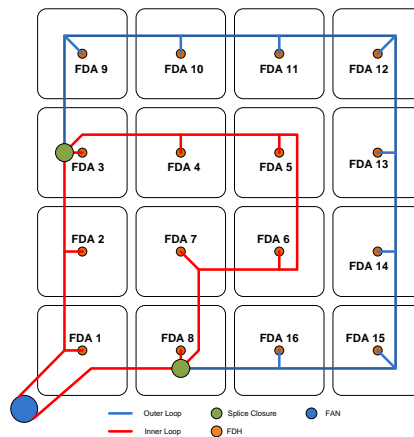
Figure 10   16 X FSAM Distribution Cable Connectivity

For an FSAM containing 12 FSAMs or less the DFN is a single ring with the same size cable sheath installed between FDAs back to the FAN.
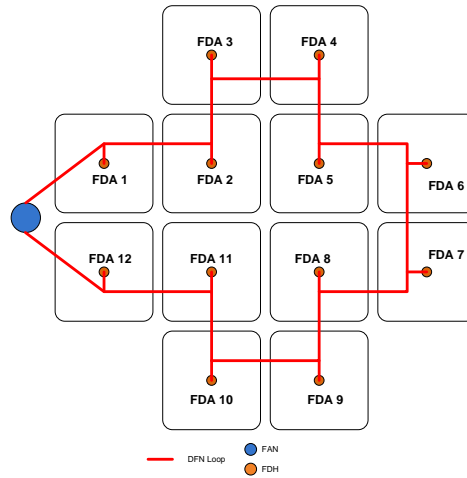
Figure 11   12 X FSAM Distribution Cable Connectivity

The DFN cable size also alters dependant on the number of FDHs within the FSAM:

Number of FDAs per FSAM	DFN Cable Size
1	288
2	288
3	288
4	288
5	288
6	288
7	288
8	288
9	432
10	432
11	432
12	432
13	576 (Two loops of 288)
14	576 (Two loops of 288)
15	576 (Two loops of 288)
16	576 (Two loops of 288)

Table 5   12 FDH FSAM Fibre Requirements per FDH
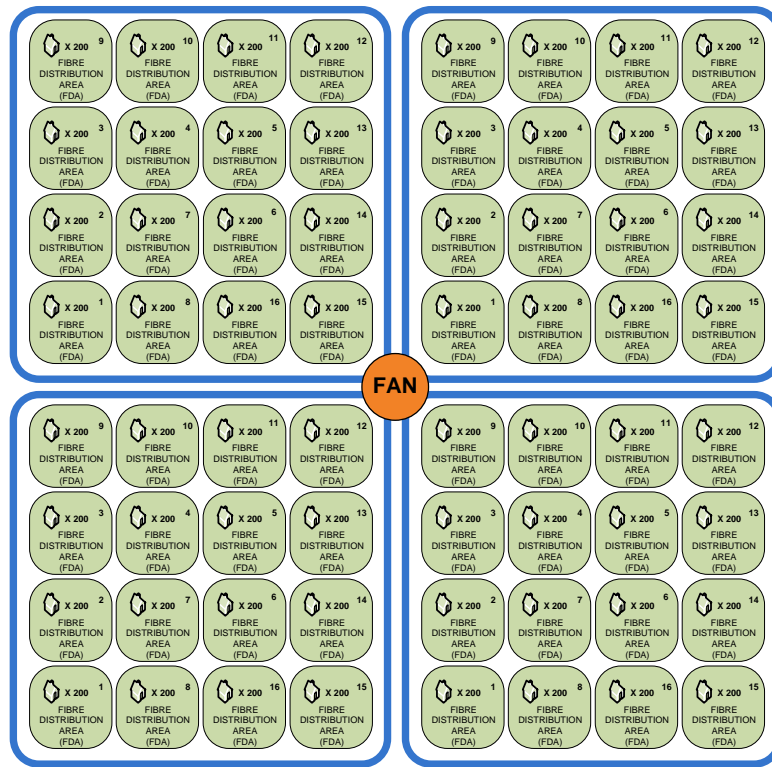
Figure 12   Fibre Serving Area (FSA)

The third module is the Fibre Serving Area (FSA) and is the combination of a number of FSAM modules located centrally around a Fibre Access Node.

The Fibre Serving Area is (FSA) linked to a Fibre Access Node (FAN) and is comprised of multiple FSAMs linked into the FAN via the DFN cables.

The placement of the FAN site in relation to the FSAMs is derived by identifying as central a location as practical.

The FSA is increased by adding FSAM modules as required. The optical return path for the DFN needs to be identified and monitored during the planning and design phase per FSAM to keep the DFN ring within the optical constraints.

3.2.2.6.   Optical Budget

The optical budget allocation provides the most significant design constraint of the DFN and LFN Network. The combination of fibre strand attenuation, splice losses, passive optical splitters, connectors, and operating headroom provide an optical limitation on the distance between the Optical Line Terminals (OLT) located in FAN sites and the GPON NTD located at end-user premises. This is further constrained by the requirements of the Distribution Fibre Network to provide a diverse path for any FDH within the optical budget constraints.

The limitations are based on the optical equipment transmit and receive parameters which are set via the optical devices as referenced in the Gigabit Passive Optical Network (GPON) standard ITU-T

G.984, and this equates to a maximum permissible optical loss of 28dB or a permissible distance of 15,000 meters, whichever is less, between the OLT and GPON NTD. This optical loss is calculated for the worst case combination of OLT and GPON NTD connection within an FDA and is applied to both the A and B direction. The average optical losses used for detailed design optical budget calculations are listed in table 1.

Event	Optical Loss
Single Fibre Strands (DFN and LFN)	0.34dB/km @ 1310nm , 0.22dB/km @ 1550nm
Fusion Splice	0.10dB
Mated SC/APC Connector	0.30 dB
1:32 Passive Optical Splitter (without connectors)	16.7 dB
Mated 12 Fibre Multi-Fibre Connector Environmentally Hardened	0.60 dB
Mated SC/APC Connector Environmentally Hardened	0.50 dB

Table 6   Maximum Optical Loss

The calculation of the optical loss is performed with the following equation:

(DFN Distance (in km) x 0.35dB) + (DFN planned splices x 0.10dB) + (FDH Optical Splitter Loss) + (2 X mated connector (at FDH)) + (LFN Distance (in km) x 0.35) + (LFN splices x 0.10dB) + (multi-fibre connector loss) + (mated environmentally hardened SC/APC connector) + (2 x mated SC/APC connectors).

3.2.3.   OLT

The GPON Optical Line Terminator function terminates multiple individual Gigabit Passive Optical Network (GPON) connections, each with a number of ONTs attached. The GPON Optical Line Termination (OLT) supports up to 128 GPON interfaces per shelf, with each GPON interface extending to one or more Fibre Serving Areas for connectivity to end-users. GPON interfaces are arranged in groups of 8 per Line Terminating card (LT).

The GPON OLT system supports dual Network Termination (NT) cards for control and forwarding redundancy, and 4 x 10 Gigabit Ethernet (SFP+) network uplinks per NT for network connectivity. The system is fed by -48VDC power, and power module/feed redundancy is incorporated into the shelf.

The OLT is located in Fibre Access Node (FAN) sites. To support Greenfields sites where a FAN site has not yet been established a cabinetised OLT solution is deployed, known as a Temporary FAN (TFAN).

3.3 Point to point Fibre Access Domain

There is no defined solution for point to point based customer services, but fibre has been deployed to support this in the future.

3.3.1. Fibre

The fibre selected is designed to support both GPON and point to point services. Refer to GPON DFN section.

3.3.2. Distribution Fibre Network

The DFN is designed to support both GPON and point to point services. Refer to GPON DFN section.

3.3.3. Fibre Distribution Hub

Point to Point connections use a different patching array than GPON services, with the FDH patching directly between the LFN and DFN. This links an individual end-user directly to a DFN fibre.
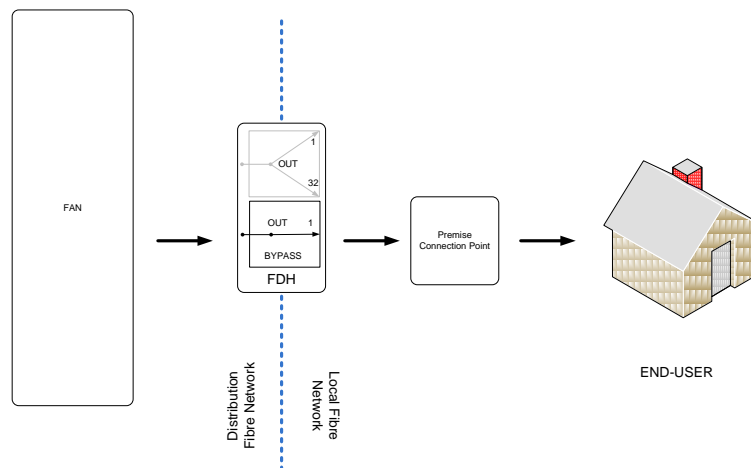

Figure 13   Point to Point Connection using DFN

3.3.4. Local Fibre Network

The LFN is designed to support both GPON and point to point services. Refer to GPON LFN section.

3.4 TD-LTE Wireless Access Domain

The Wireless Access domain solution consists of the following components:

- Wireless Network Terminating Device (WNTD) - The Wireless Network Terminal located at the end-user premises uses TD-LTE technology to connect back to the eNodeB. It delivers UNI-D capabilities to a premise.

- Radio Spectrum – NBN Co has radio spectrum to support the TD-LTE radio technology in line with the 3GPP specification

- eNodeB – provides the radio access interface for the WNTDs

- Aggregation and Transport for Wireless –

  o Microwave equipment is used to backhaul and where appropriate, aggregate traffic from eNodeBs back to a FAN site
  o FAN Aggregation switch may be used in a FAN site to further aggregate traffic from eNodeBs before entering the Transport solution
  o Transport - provides the carriage between the FAN site and a further aggregation switch located in the POI site. Common infrastructure used for all connectivity between FAN and POI sites
  o POI Aggregation Switch is used in the POI site to aggregate the traffic from the FANs before entering the PDN-GW. This is common infrastructure that provides the Aggregation Domain EAS/ECS functions as well.

- The PDN-GW - provides policy and admission control for the WNTDs. It also provides the interface to the Aggregation Domain for the aggregated Wireless Access traffic.
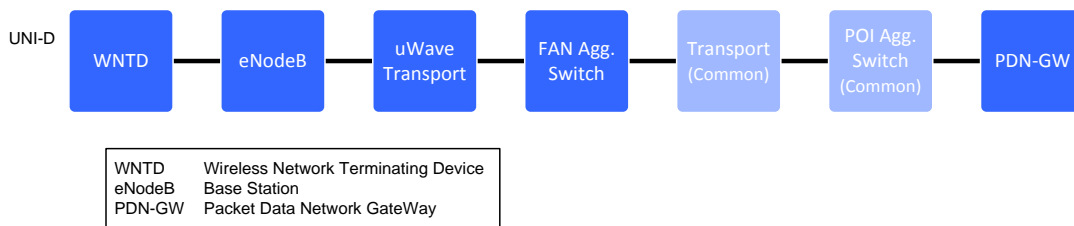

Figure 14   High level interconnection block diagram of Wireless Access

3.4.1. Wireless NTD (WNTD)

The WNTD terminates the incoming radio signal at the end-user premises and provides one or more User to Network Interfaces (UNI).

The WNTD consists of the following two physical components: an Indoor Unit (IDU) and an Outdoor Unit (ODU), connected together with a Cat 5 cable.

The ODU key components include:

- Cross-polar panel antenna
- LTE TRx and modem
- Interface to the IDU

The IDU key components include:

- 4 UNI-D ports,
- Switch
- Interface to the ODU

A standard AC power supply is used to power the IDU and through that the ODU.

3.4.2. Radio Spectrum

NBN Co will use its holdings in the 2.3 GHz spectrum band in its deployment of Wireless Access Services in the 2015 timeframe.

The NBN Co spectrum holding in the 2.3 GHz band is defined by the ACMA in:

http://web.acma.gov.au/pls/radcom/client_search.client_lookup?pCLIENT_NO=1104329

http://web.acma.gov.au/pls/radcom/client_search.client_lookup?pCLIENT_NO=8129031

Generally the spectrum held by NBN Co Limited was purchased in the spectrum auction while the spectrum held by NBN Co Spectrum Pty Ltd was purchased from AUSTAR.

A licence number in the table links to the licence details, including a Licence Image. The Licence Image defines, among other technical requirements, the exact geographic area covered by the licence.

3.4.3. eNodeB (Base Station)

Each eNodeB has three sectors and is sited according to a site specific radio coverage plan to provide optimised coverage. Each sector supports a maximum of 60 end users, with an approximate CIR for the eNodeB of 100Mbps. Some sites have existing sheltered accommodation available, while other sites will have none. Where none is available an environmentally protected housing will be provided to house the equipment.

The eNodeB provides the Air (Radio) Interface which connects the eNodeB to the WNTD, and a backhaul Interface which connects the eNodeB to the Microwave Backhaul equipment. The eNodeB comprises a number of interconnected modules:

- 3 RF Antennae
- GPS Antenna
- Remote Radio Unit
- Digital Baseband Unit
- Power Supply
- Battery Backup

3.4.4. Aggregation and Transport for Wireless

3.4.4.1. Microwave Transport Equipment

Microwave Transport equipment is used where an eNodeB site does not have access to direct fibre tail to connect to a FAN site. Microwave Transport equipment is housed in the eNodeB cabinet. The Microwave Antenna is mounted on the radio tower where the eNodeB RF Antennas are mounted.

Microwave Transport equipment is also used to connect an eNodeB spur using a Microwave End Terminal to a Microwave Hub Site.

A Microwave Hub Site is located with an eNodeB. The Microwave Transport equipment at a hub site will communicate with up to four Microwave End Terminals, and provide an aggregate point for connectivity with another Microwave End Terminal located as close as possible to a FAN site. The maximum bandwidth achievable is 900Mbps, allowing for the aggregation of up to 8 eNodeBs.

Microwave Hub sites can be connected to other Microwave Hub sites, as long the final Hub to end terminal bandwidth does not exceed an aggregate of eight eNodeBs.

The exact number of eNodeB spurs that are connected back to a Microwave Hub, and the location of the Microwave End Terminal to connect to the FAN site is heavily dependent on local geography and end user distribution.

Example deployment scenarios are shown in the diagram below:
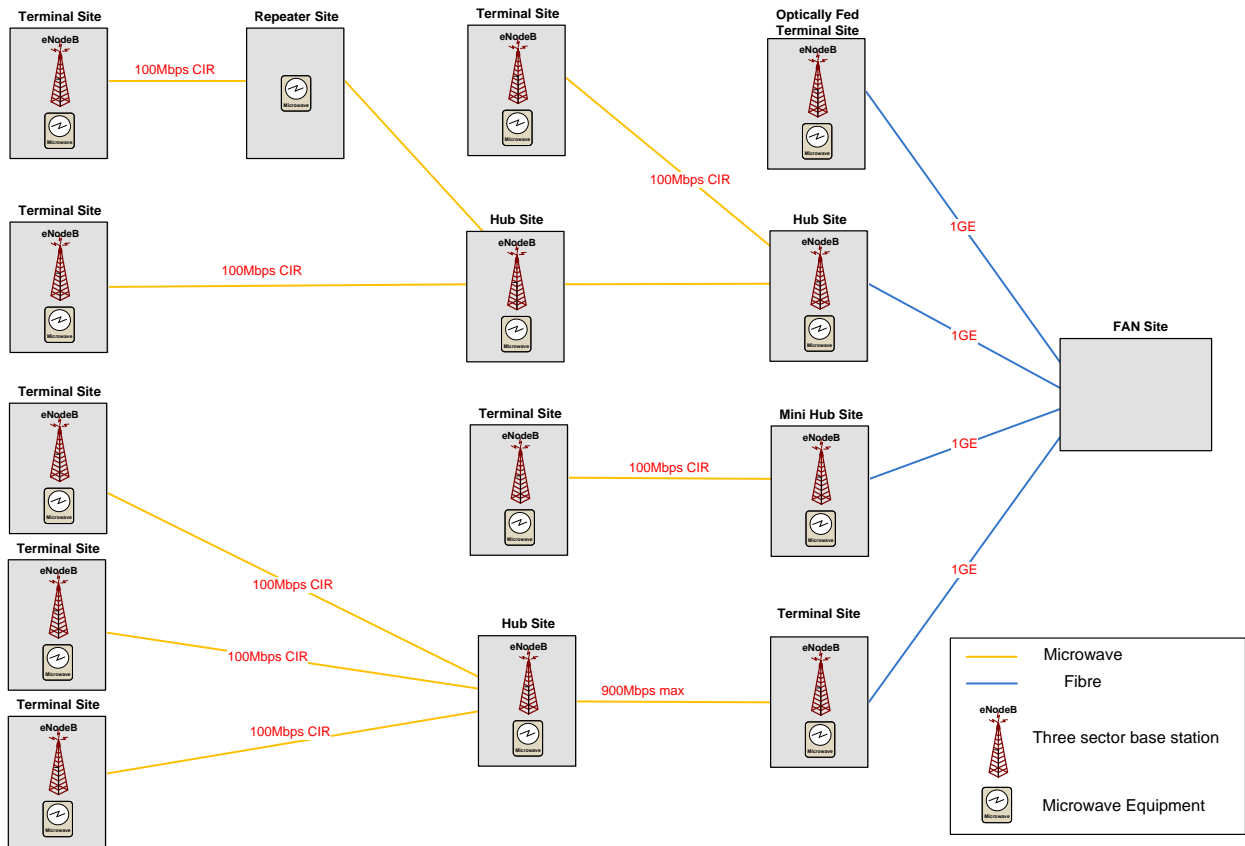
Figure 15 Microwave Transport Design

3.4.4.2. Fibre Transport Equipment

Where an eNodeB site has access to a direct fibre tail to connect to a FAN site a switch function is housed in the eNodeB cabinet to enable connectivity from the eNodeB to the fibre. The CIR of just over 100Mbps is applied for consistency with eNodeBs connected via Microwave Transport.

3.4.4.3. FAN Aggregation Switch

The FAN Aggregation Switch may be deployed on its own or in pairs for resiliency. They are located in FAN sites where aggregation for up to 18 Microwave Hub sites, eNodeBs that are connected directly to the FAN site via a direct fibre tail, and/or where traffic shaping is required to integrate to the Transport Domain.

3.4.4.4. Transport

Transport from the FAN to the POI is provided by either 3rd party backhaul or NBN Co's DWDM solution. Refer to the Transport Domain section for further information.

3.4.4.5. POI Aggregation Switch

The POI Aggregation Switch is deployed in pairs in POI sites to aggregate the Wireless Access traffic from FAN sites. The switches are shared infrastructure, providing both this function and the function of the Ethernet Access Switch (EAS) of the Aggregation Domain.

3.4.5.   Packet Data Network Gateway (PDN-GW)

The PDN-GW supports up to 25000 WNTDs. It is provided as a pair for resiliency, each with its own internal resiliency of controller, traffic and line cards.

The PDN-GW has 2 4 x 10 Gigabit Ethernet (SFP+) interfaces to the Aggregation Domain for resilient network connectivity, and 2 4 x 10 Gigabit Ethernet (SFP+) interfaces to the POI Aggregation Switch pair for resilient network connectivity. The system is fed by -48VDC power, and power module/feed redundancy is incorporated into the shelf.

3.4.6.   Wireless Access Planning Hierarchy

For planning, design, and construction purposes the network is divided into hierarchical modules and network entities.

These modules are used to provide the planning constructs needed to provide connectivity between the individual End-Users premise through to the Access Seeker (AS) Point of Interconnection (POI)

The first identifiable connection point is an end-user premises. These are defined as physical address points. Each individual dwelling unit is required to have a unique service location, and is identified as an end-user.

The first module is the Base Station Sub-cluster Module. Three sector eNodeBs provide adjacent or overlapping coverage and are grouped in clusters of up to eight sites.

The maximum number of active dwellings in a sector is 60 dwellings (this may vary depending on the exact positions and radio conditions of the served dwellings.

The three sectors of an eNodeB (maximum of 180 end users) typically provide an aggregated CIR throughout of approximately 100 Mbps. This determines the Microwave Transport backhaul capacity required.

The maximum bandwidth achievable for the Microwave hub back to a FAN site is 900Mbps, allowing for the aggregation of up to 8 eNodeBs, with a maximum of 1440 end users.
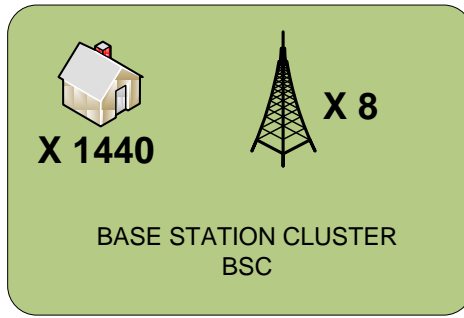
Figure 16   Base Station Sub-Cluster

The second module is the Wireless Serving Area Module. All Base Station Clusters connected to a common FAN site are grouped into a Wireless Serving Area Module. The largest WSAM will have up to 24 Base Station Clusters connecting to a FAN.
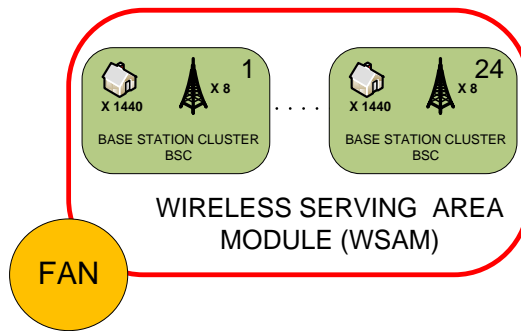
Figure 17   Wireless Serving Area Module

The third module is the Wireless Serving Area (WSA). All the Wireless Serving Area Modules connected to a common POI (the location of the PDN-GWs) are grouped into a Wireless Serving Area. The maximum number of WSAMs in a WSA is determined by the number of FANs that connect back to the POI. For the purposes of wireless dimensioning, the size of a WSA is based on the maximum number of end users, rather than the maximum number of WSAMs, with a maximum of 25000 end users in a WSA.

3.5 Satellite Access

The Satellite Access solution is currently under development. This section provides an indicative network design based on the requirements NBN Co has used during the on-going procurement process. The final design adopted as a result of this process may differ in some details to that described in this section. However, any such changes will be as a result of a competitive tender process that will identify the best value for money approach that can be delivered consistent with the overall indicative network design.

The Satellite Access domain solution consists of the following components:

- Satellite NTD (Very Small Aperture Terminals or VSATs) - The Satellite Network Terminal located at the end-user premises communicates over the satellite RF links back to the VSAT baseband sub-system. It delivers UNI-D capabilities to a subscriber premises.
- Satellite – two, multi-spot beam, geostationary, "bent-pipe", telecommunications satellites to connect VSATs to the VSAT Baseband sub-system. Located in orbital slots overlooking Australia and operating in the Ka-band RF spectrum.
- RFGW – RF Gateway Facility supporting the RF, VSAT Baseband and Service Control Sub-Systems.
- RF Sub-System – Earth station RF antennas, transmission and reception equipment to provide trunk links to and from the satellites.
- VSAT Baseband Sub-System – subscriber service termination equipment to manage and carry user traffic to and from Satellite subscribers.
- Service Control – Satellite specific user application and traffic management equipment to enhance the user experience due to the long latencies incurred over geostationary satellite links.
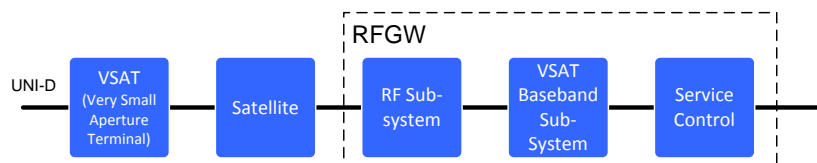
Figure 18   High level interconnection block diagram of Satellite Access

3.5.1. Satellite NTD (Very Small Aperture Terminal (VSAT))

The VSAT is located in the user premise and provides the User to Network Interfaces (UNI-D) and connects to the NBN Co network via the satellite over Ka-band RF spectrum.

The VSAT consists of the following two physical components: an Indoor Unit (IDU) and an Outdoor Unit (ODU), connected together with a coaxial cable.

The ODU key components include:

- Parabolic satellite terminal antenna
- Ka-Band VSAT transceiver
- Interface to the IDU

The IDU key components include:

- 4 UNI-D ports,
- Switch
- Embedded Transparent Performance Enhancing Proxy (TPEP) software client
- Interface to the ODU

A standard AC power supply is used to power the IDU and through that the ODU.

3.5.2. Satellite

3.5.2.1. Systems Engineering Design

NBN Co is building two, multi-spot beam, geostationary, "bent-pipe", Ka-band, telecommunications satellites for the Satellite Access Solution with the following characteristics:

- Two satellites to enable service redundancy and load balancing of users.
- Multi-spot beam design to enable the system capacity to support 3% of the Australian population and the optimum broadband user experience from the amount of RF spectrum available.
- Geostationary locations to enable full coverage of the Australian mainland and territories with the least number of satellites and at the lowest possible VSAT costs.
- "bent-pipe" design, meaning the satellite is only an RF transceiver for network to user traffic and user to network traffic, providing support for broadband services to 3% of the Australian population with minimum mass of the spacecraft.
- Ka-band operation to achieve the user experience speeds and the required system capacity from 2 satellites.

The "satellite - user" spot beams are designed to achieve the system capacity requirements for the last 3% of population, by re-using the Ka frequency band as efficiently as possible. This is achieved through the combination of:

- Optimized placement of user spot beams
- Frequency re-use and polarity re-use of the Ka-band spectrum
- Highly directional satellite and VSAT antennas to minimize interference
- Optimized RF filter designs to achieve the highest order modulation techniques over satellite links.
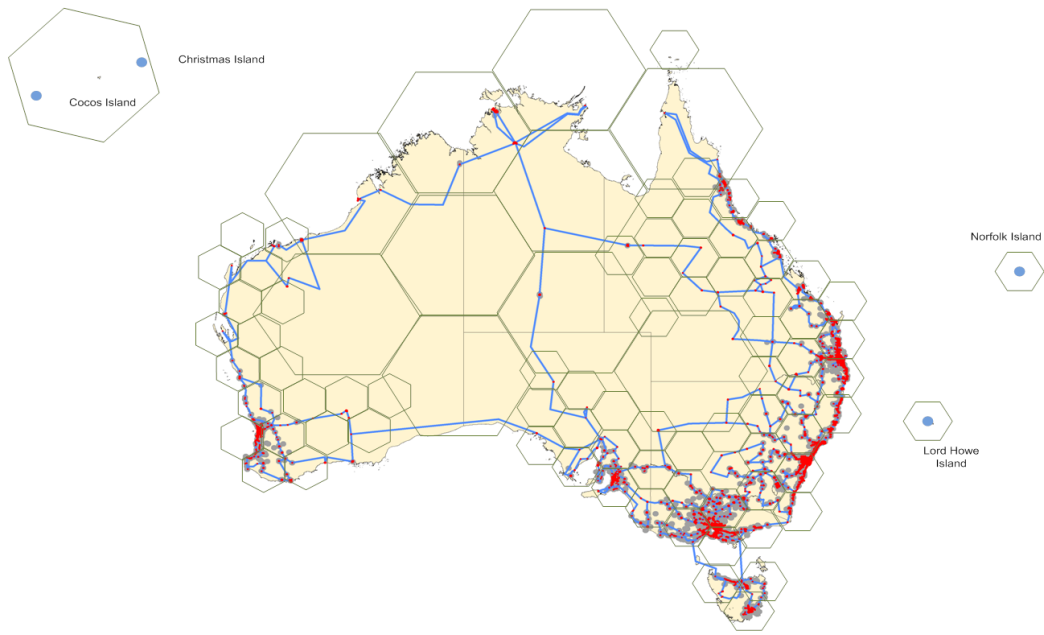
Figure 19   Preliminary Design of User Spot Beams

The "RF Gateway - satellite" links are designed to carry the satellite traffic to the RF Gateways (RFGWs), which contain the RF Subsystem, VSAT baseboard subsystem and Service Control system. Approximately 10-15 RFGW's will be needed to carry the aggregated traffic load. To achieve the optimum RFGW trunk link performance, the following design criteria are optimised:

[c-i-c]

Using this criteria the shortlist of possible RF Gateway regions are shown in the figure below.

[c-i-c]

Figure 20   Shortlisted RF Gateway Regions

3.5.2.2.   RF Spectrum and Orbital Slots

NBN Co will use the Ka-band radio spectrum through a combination of using class licensed bands as well as privately negotiated spectrum licenses with current license holders.

Description	Frequency Range
RFGW to Satellite Uplink	**[c-i-c]**
Satellite to VSAT Downlink	**[c-i-c]**
VSAT to Satellite Uplink	**[c-i-c]**
Satellite to RFGW Downlink	**[c-i-c]**
RF Auto Tracking Downlink	**[c-i-c]**
Uplink Power Control	**[c-i-c]**

Table 7   Preliminary RF Spectrum Plan

The NBN Co satellites are designed to operate at the orbital slots of **[c-i-c]**. NBN Co is currently going through the ITU domestic and international orbital slot coordination process.

3.5.3. RF Sub-System

In each RF Gateway, the RF Sub-System transmits and receives RF signals with the satellites, and connects to the VSAT baseband Sub-system. The RF Sub-system comprises of the following major components;

- **[c-i-c]** earth to satellite antennae on controllable mounting platforms
- RF amplification, filtering, conditioning and receiving equipment operating at Ka-band.
- Power Supplies
- Monitoring and Control systems.

3.5.4. VSAT Baseband Sub-System

The VSAT baseband system located in the RFGWs and is the termination system for VSAT traffic and management signals. It is composed of the following components;

- Modulation and Demodulation equipment
- Air Resource Management equipment
- Traffic forwarding equipment

The dimensioning of each RFGW's VSAT Baseband sub-system will be based on the aggregate number of end-user services being terminated at the site, the most efficient RF channel packing of the available Ka-band spectrum, the highest order modulation code points possible for transmission and reception to and from the satellite from the specific RFGW location and the highest N to 1 equipment redundancy ratio supported by the VSAT Baseband sub-system supplier.

3.5.5. Service Control

The Service Control system is designed to enhance the user experience by intelligently accelerating and spoofing user traffic to counteract the latency effects of the very long distances encountered between earth to satellite, then satellite to earth RF links. Multiple Transparent Performance Enhancing Proxy (TPEP) techniques are being used in the Satellite Access solution design;

- Traffic payload and header compression and suppression
- TCP traffic acceleration
- Web traffic acceleration
- Traffic caching and pre-fetching

The TPEP system is implemented in servers located in the NBN Co RFGW as well as embedded software in the VSATs. No software or configuration is required by the Access Seeker or the user to enable the TPEP functionality.

3.6   Transport Domain

3.6.1.   Dense Wavelength Division Multiplexing (DWDM)

The NBN Co Dense Wavelength Division Multiplexing (DWDM) fibre optic transport network is made up of a number of DWDM Nodes (DNs) situated mainly at Point of Interconnect (POI) and Fibre Access Node (FAN) sites, all interconnected by Optical Multiplex Section (OMS) links. A DN may also be used within a link for amplification.

The DWDM network will predominantly provide physical connectivity and transit backhaul capacity between POI and FAN sites. The network will also provide connectivity to centralised depots, data centres and delivery points for the specific transport services that require them.

The following diagram shows the basic connectivity scenarios for the DWDM network. Each DN has a metric called "degree of connectivity", which is the number of fibre interfaces it has, and therefore the number of other DNs it can connect to. The DN at POI 1, for instance, has a degree if two: it connects to the DNs at two FAN sites. The DN at FAN 7 has a degree of one.
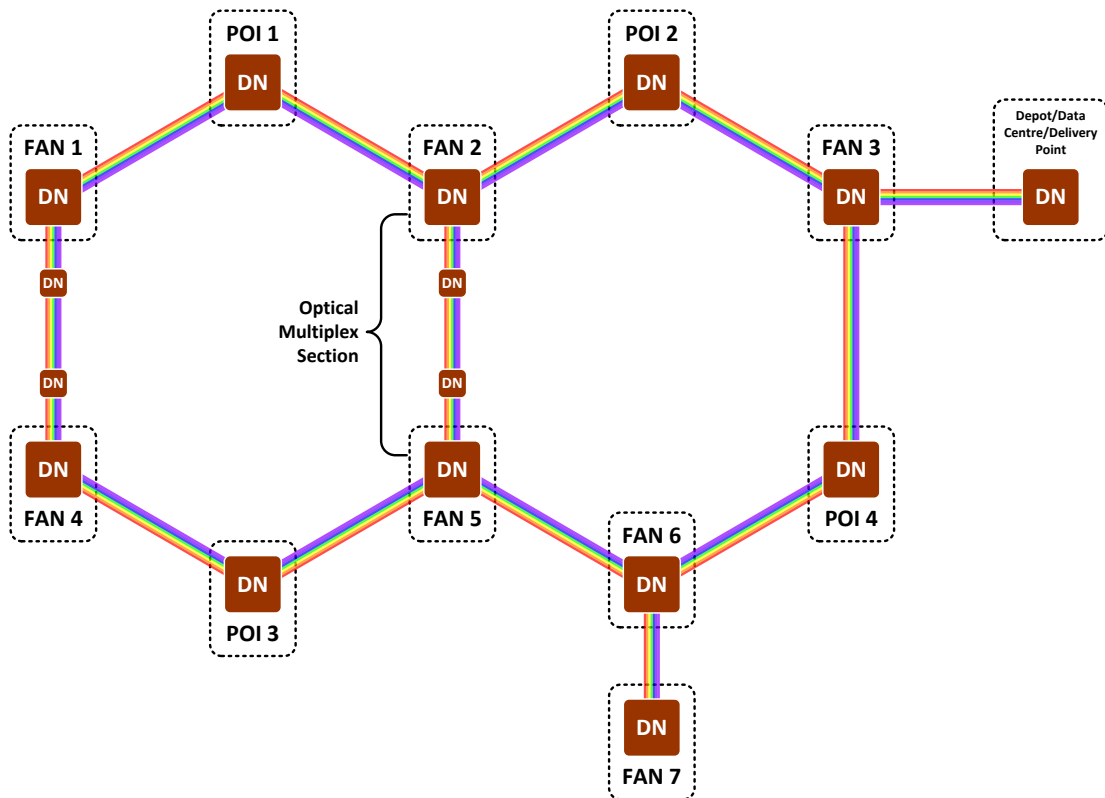

Figure 21   Basic DWDM physical connectivity scenarios

There are two types of DWDM Nodes: Reconfigurable Optical Add-Drop Multiplexers (ROADMs) and Optical Line Repeaters (OLRs). Each of these two types of DN comprises:

- Baseline elements: elements that have a fixed quantity per degree and do not expand with traffic growth unless that growth involves an increase in degrees. Such elements include amplifiers, add/drop filters and wavelength selective switches.
- Growth elements: these are elements within a degree that can be added to as growth requires. Such elements include channel cards, controller and chassis.

3.6.1.1. Reconfigurable Optical Add-Drop Multiplexers (ROADMs)

Reconfigurable Optical Add-Drop Multiplexers (ROADMs): these are one- (or more) degree nodes that can provide the following functions:

- Extract data from a wavelength on any of its degrees for presentation to a client interface
- Inject data from the client interface into a wavelength for transport on any of its degrees
- Transit wavelengths between degrees

The standard ROADM variant used allows transmission up to 96 wavelengths, each wavelength in effect a channel of 40Gbps initially, rising to 100Gbps in future network releases. Standard ROADMs will be used at both POI and FAN sites.

A smaller, compact ROADM variant, for use where space is an issue, supports up to 8 wavelengths. The standard and compact ROADMs can be used together: although the compact ROADM only supports 8 wavelengths, those wavelengths can be any of the 96 produced by the standard ROADM. Compact ROADMs will be used only at FAN sites that require a maximum of two degrees and a maximum of 8 channels.

There is also a Long Span ROADM that is used to allow un-regenerated OMS links across Bass Strait. The Long Span ROADM allows up to 40 wavelengths (channels).

3.6.1.2. Optical Line Repeaters (OLRs)

Optical Line Repeaters (OLRs): these are two-degree wavelength-pass-through nodes that provide optical amplification only. OLRs may be required when transmission fibre distances between adjacent ROADMs exceeds the optical reach of the equipment.

3.6.1.3. DWDM Network Topologies

There are four network topologies that can be deployed. In most cases the overlapping physical ring topology will be used as the majority of dark fibre is being sourced from Telstra and only a single pair is being provided on most routes.

Standalone Physical Rings:

Each physical ring utilises one fibre pair. Wavelength routing and count within one ring has no dependencies on the physical attributes or traffic requirements on any other ring. If there are any DNs common between rings, they will require a degree of more than two. Any inter-ring wavelength connectivity will be performed via the wavelength selective switches within the common DNs.
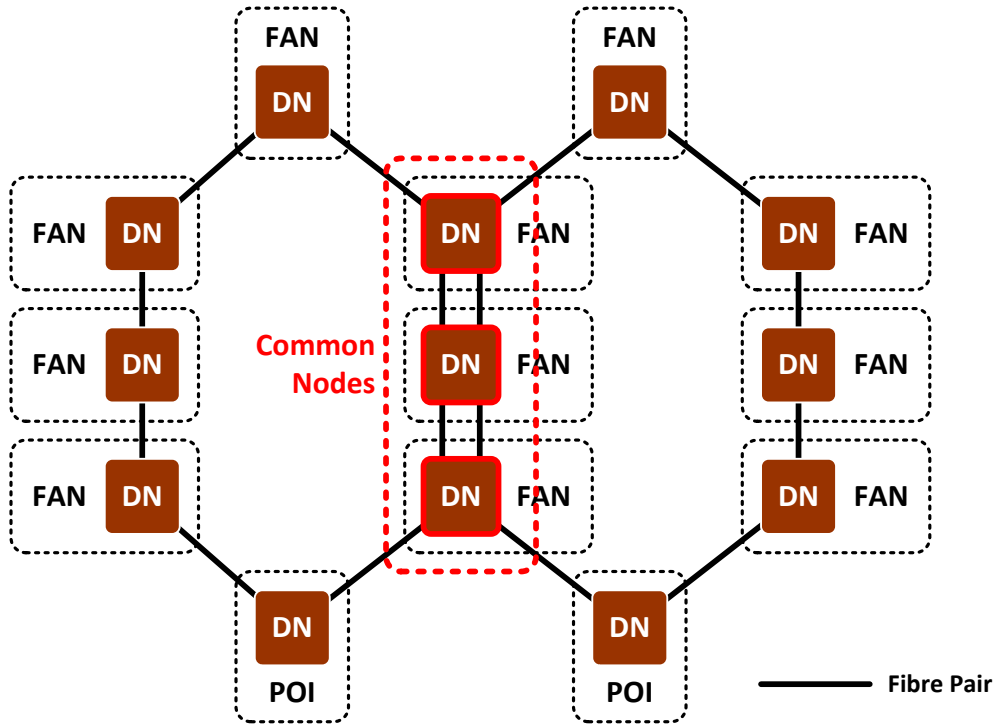
Figure 22   Standalone physical rings

The rings provide the 1+1 redundancy required between any two points in the network: if one link should fail, any node past the breach can be reached by routing in the other direction using a different wavelength. The re-routing can be achieved through either 1+1 Client Protection, where the client network recognises the break and uses a second connection for traffic continuity, or 1+1 Service Protection, where the DWDM network itself provides the rerouting capability.
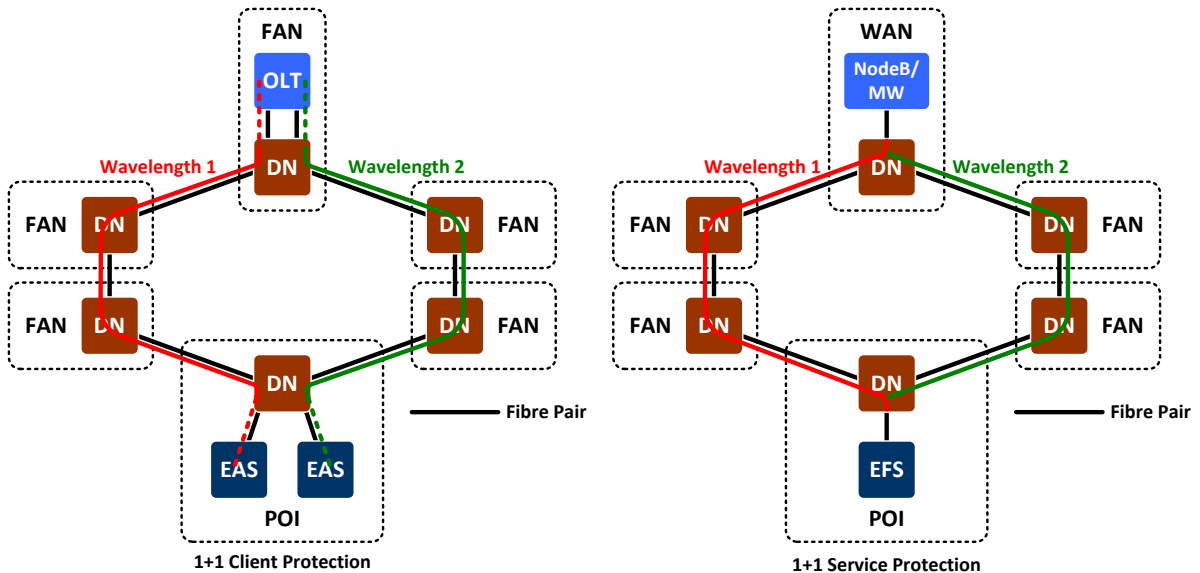

Figure 23   Examples of redundancy in the DWDM network (using 1+1 Client Protection and 1+1 Service Protection)

Overlapping Physical Rings:

This is the preferred topology where there are adjacent DWDM rings with shared physical routes. In this scenario physical rings can share common fibre pairs. This means that wavelength routing and counts within the shared links have dependencies on the physical attributes and traffic requirements of both rings. Like the standalone deployment option, some DNs will require degrees of more than two degrees. And again inter-ring wavelength connectivity will be performed via the wavelength selective switches within the common DNs.
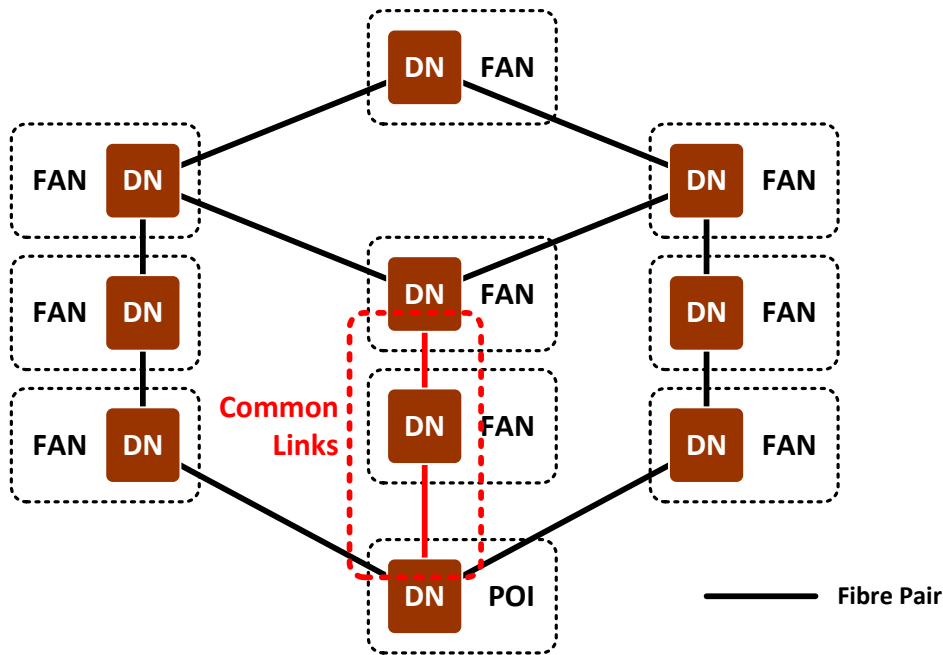

Figure 24 Overlapping physical rings

Point-to-Point Spur Links:

These will be used to extend ring or POI connectivity to one or more isolated FAN sites. There is a preference to use two fibre pairs within a spur link to introduce diversity, but some spur links may be limited to one fibre pair. Standard and compact ROADMs can both be used as the far DN in spur links, but the DN that connects the spur to the ring must have at least three degrees, and therefore must be a standard ROADM. OLR nodes may be required within the spur link when transmission fibre distances between adjacent ROADM nodes exceed the optical reach.
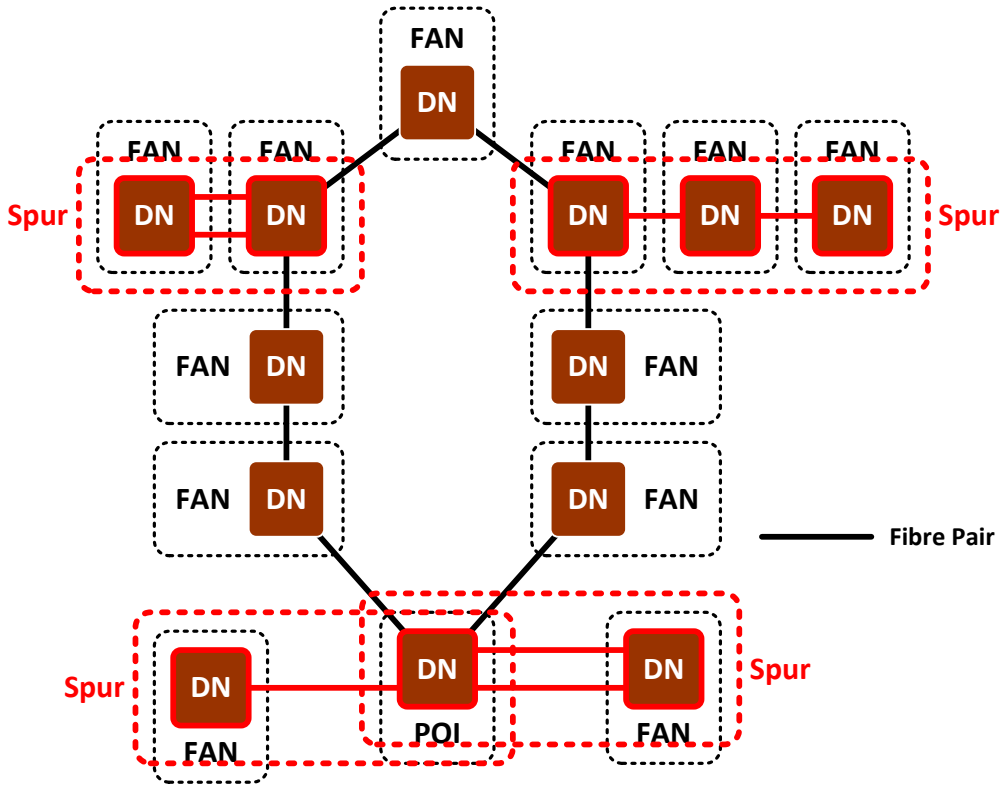
Figure 25 Point-to-point spur links

Point-to-Point Standalone Links:

Used only in the Bass Strait deployment, two point-to-point standalone links are deployed between the Long Span ROADM nodes.
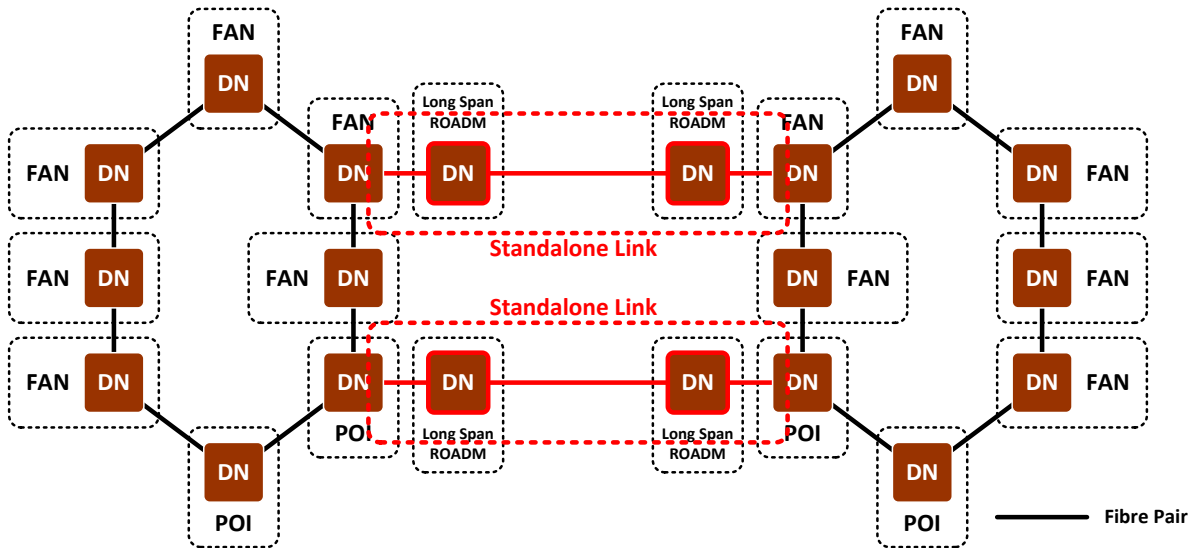

Figure 26 Point-to-point standalone links

3.6.2.   *Managed Services Transmission*

Managed Services are required to supplement the direct fibre and DWDM transport solutions during the roll-out of the transit network. They may be used to provide a complete end-to-end solution or form part of a transport service in combination with DWDM and/or direct fibre.

Managed services are supported for the following connectivity scenarios:

- Fibre access transit (OLT to ECS/EAS)
- Greenfields fibre access transit (OLT to ECS/EAS)
- Wireless access transit (eNodeB or microwave transport to ECS/EFS)

Fibre Access Transit:

Transport is required between FAN and POI sites for the Fibre Access Service. The basic transport using Managed Services is a pair of fully redundant (1+1) point-to-point Ethernet services running at subrate, 1Gbps or 10Gbps speeds.

Figure 27   Fibre access transit

Greenfields Fibre Access Transit:

Transport is required between FAN and POI sites, much as with the standard fibre access transit. A single unprotected managed service will be deployed.

Figure 28   Unprotected Greenfields fibre access transit

Wireless Access Transit:

Wireless access transit is required between FAN and POI sites. As with the fibre access transit, the basic transport using Managed Services is a pair of fully redundant (1+1) point-to-point Ethernet services running at subrate, 1Gbps or 10Gbps speeds.
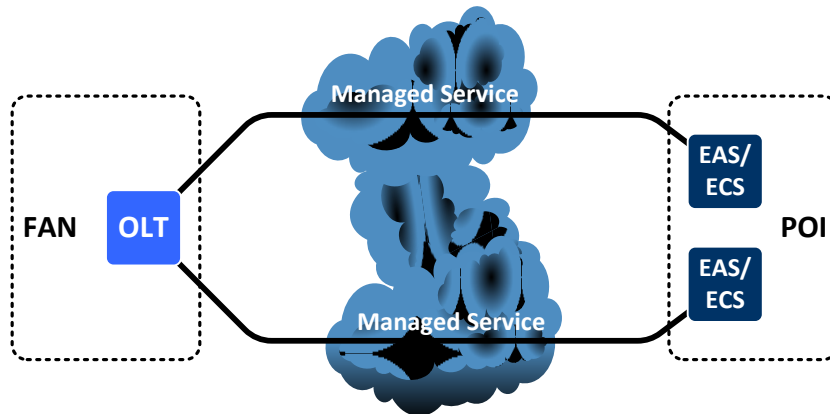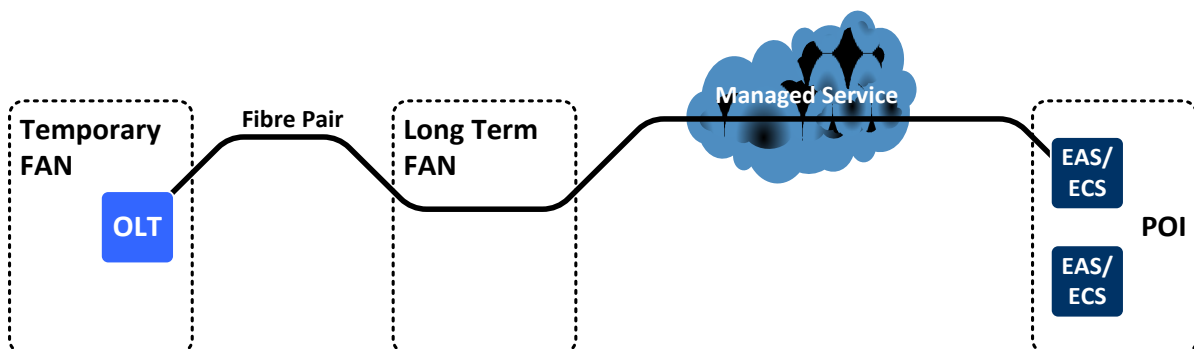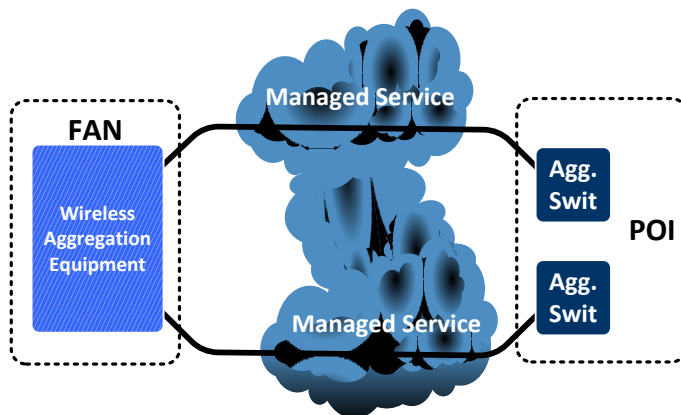
Figure 29   Wireless access transit

3.6.3.   *Direct Fibre*

Direct fibre is the underlying building block of the Transport network domain. The following connectivity scenarios are either fully or partially supported by direct fibre:

- Fibre Access Transit
- Greenfields Fibre Access Transit
- Wireless Transit

Fibre Access Transit:

Direct Fibre for fibre access transit is limited by the interfaces supported on the OLT. The OLT only supports 10GBase-LR interfaces today, which limits direct fibre reach for fibre access to 10km. This is being upgraded to support 10Gbase-ER interfaces in 2012, extending the reach to 40km.

The following direct fibre transit scenarios are supported for fibre access transit:

- Direct fibre for both paths from the OLT back to the POI. This can be used when both fibre paths are ≤10km today, or ≤40km from mid-2012.
- Direct fibre on the short path from the OLT to the POI and direct fibre on the long path from the OLT to the nearest DWDM node. This can be used when the short path is ≤10km (≤40km from mid-2012) and the path to the nearest DWDM node is ≤10km (≤70km from mid-2012, as both the OLT and the DWDM nodes will support 10Gbase-ZR).

Greenfields Fibre Access Transit:

Direct fibre is used between the OLTs housed in temporary FAN sites and the Managed Services interface (see Figure 27and Figure 28). Both 1000Base-LX and 1000Base-ZX interfaces are supported allowing for fibre distances of up to 70km to be supported.

Wireless Access Transit:

Direct fibre is supported between the Wireless Access network eNodeBs and Microwave Transport and the local FAN site. 1000Base-LZ and 1000Base-ZX interfaces are supported allowing for fibre distances of up to 70km to be supported.

3.7 Aggregation Domain

The Aggregation Domain performs fanout and aggregation of media between the Access Seekers and the Access Domain for both the Fibre and Wireless Access Services. Aggregation Domain network elements are exclusively deployed in Points of Interconnect sites (POIs).

For the Fibre Access Service, the majority of metropolitan Fibre Access Node (FAN) sites will also be POI sites, where Access Seekers can connect their network equipment into the NBN Co – via the External Network-to-Network Interface (E-NNI) – to service all end-users hosted off the FANs associated with that POI.

In regional areas where end-user densities are lower, it will be more common for FAN sites and POI sites to be in separate physical locations.

For the Wireless Access service, the Aggregation Domain connects locally at the POI to the Wireless Access Domain.

The Aggregation Domain network elements are:

- The Ethernet Aggregation Switch (EAS)
- The Ethernet Fanout Switch (EFS)
- The Ethernet Combined Switch (ECS)

3.7.1. Ethernet Aggregation Switch (EAS)

This platform is used to aggregate a number of Access Domain network interfaces and provide traffic forwarding towards other Aggregation Domain network elements such as the EFS, or another EAS. To support Access Domain network interface resiliency, EAS are deployed in pairs.

The EAS node is connected to its paired EAS node and to the EFS nodes using N × 10Gbps direct fibre links, where N is 1 to 5.
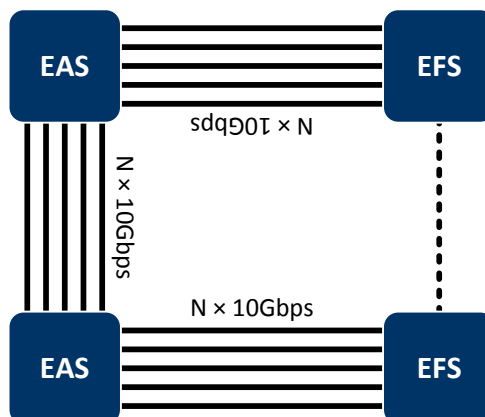

Figure 30   Aggregation Domain interfaces on the EAS

The EAS offers redundant connectivity to the access domains via 1Gbps, 10Gbps or sub-rate bit rates. The links can use any of the Transport Domain solutions for connectivity to remote locations

(e.g. FAN sites), or direct fibre for any local connections within the POI (e.g. the PDN-GW for wireless access).

3.7.2. Ethernet Fanout Switch (EFS)

This platform is used to aggregate a number of Access Seeker interfaces (on the External Network-Network Interface, E-NNI) and fan out the traffic towards other Aggregation Domain network elements such as the Ethernet Aggregation Switch, or another EFS. To support E-NNI redundancy, EFS are deployed in pairs.

The EFS node is connected to its paired EFS node and to the EAS nodes using N × 10Gbps direct fibre links, where N is 1 to 5.
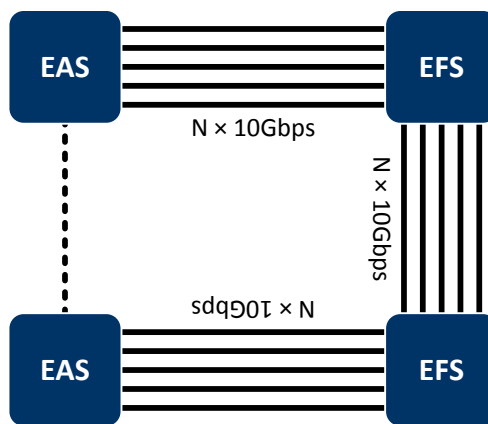

Figure 31   Aggregation Domain interfaces on the EFS

Depending on Access Seeker (AS) demand, EFS nodes may be equipped with a combination of 1Gbps, 10Gbps and 100Gbps (available for future use) Ethernet interfaces. The following connectivity models are supported for the AS E-NNI on the EFS nodes, referred to as the "E-NNI Mode":

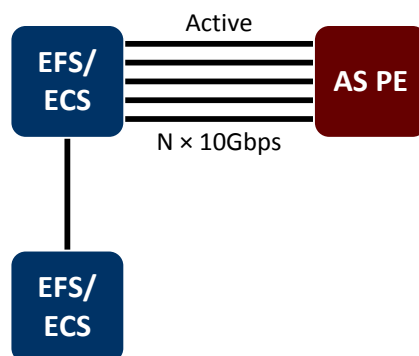- E-NNI Mode A: provides an N × 1Gbps or N × 10Gbps uplink to a single EFS node, where N is between 1 and 5 links.

Figure 32   E-NNI Mode A connection model from an Access Seeker Provider Edge (AS PE)

- E-NNI Mode B: provides an N × 1Gbps or N × 10Gbps dual uplink with 1+1 protection to an EFS pair.
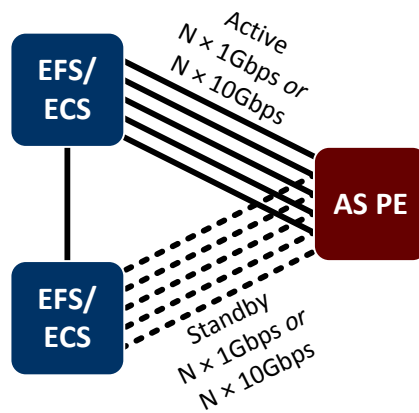

Figure 33   E-NNI Mode B connection model from a single AS PE
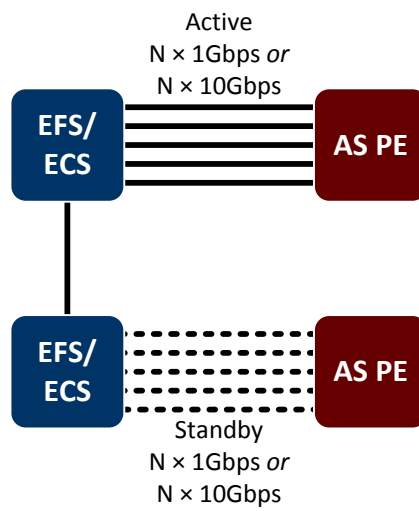

Figure 34   E-NNI Mode B connection model from two AS PEs

3.7.3. Ethernet Combined Switch (ECS)

This platform takes the functions of the EAS and EFS and combines them into the one physical box. It is used in the smaller POIs.

The ECS node is connected to its paired ECS using N × 10Gbps direct fibre links, where N is 1 to 5.

Figure 35 Aggregation Domain interfaces on the ECS

Like the EAS, the ECS offers redundant connectivity to the access domains via 1Gbps, 10Gbps or sub-rate bit rates. The links can use any of the Transport Domain solutions for connectivity to remote locations (e.g. FAN sites), or direct fibre for any local connections within the POI (e.g. the PDN-GW for wireless access).

The ECS has the same interfaces to Access Seekers as those on the EFS. See the section above on EFS Access Seeker interfaces.

3.7.4. Aggregation Domain and POI Architecture

To support E-NNI redundancy, a POI site will contain one pair of EFSs or ECSs. The EFSs attach downstream to the EASs, which aggregate connectivity across all Access Domain nodes associated with the POI site. The ECSs combine the functionality of the EFSs and EASs.

There are two physical architecture types for Points of Interconnect sites, based on whether the EAS/EFS is used, or the ECS:

- **Two Tier:** this architecture type uses at least two pairs of nodes, an EAS pair (which can grow to four EAS pairs, depending on the size of the POI site) and an EFS pair.
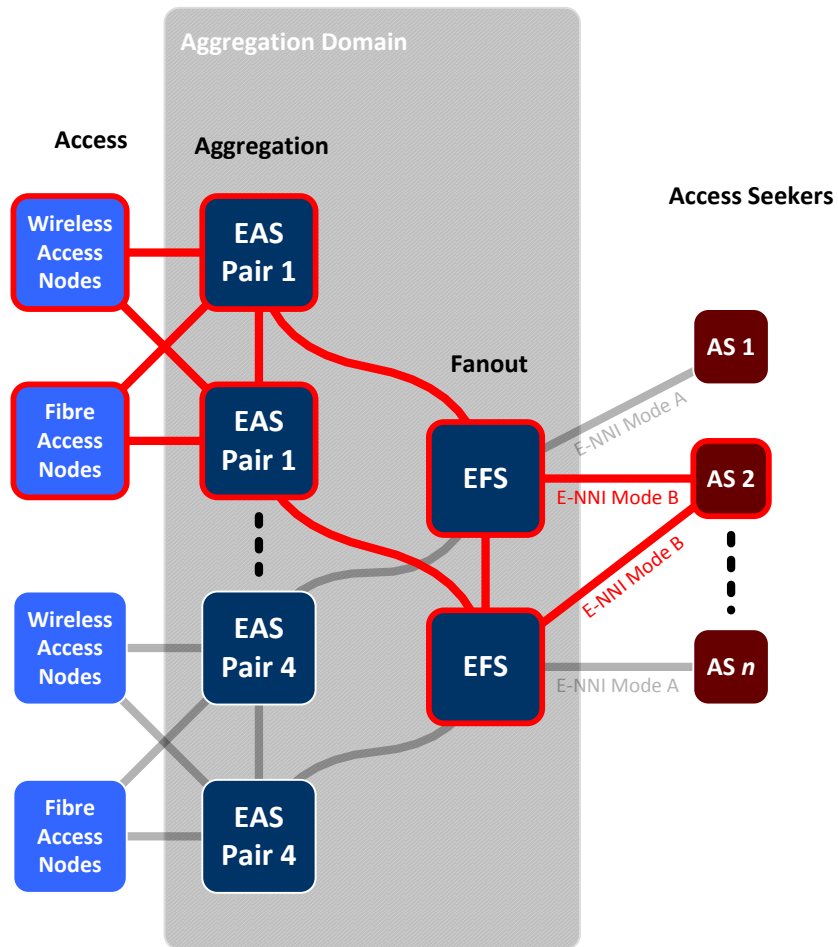
Figure 36   Two tier aggregation architecture

- **One Tier:** this uses a pair of Ethernet Combined Switches (ECSs), which is a single platform that combines the EAS and EFS functions.

Figure 37   One tier aggregation architecture

Whether the one tier or two tier architecture is used depends on the size of the Customer Serving Area (CSA).

A CSA is comprised of a number of access service areas: Fibre Serving Areas (FSAs; each served by an OLT) and Wireless Serving Areas (WSAs; each served by a pair of PDN-GWs).

4 Appendix - Definitions

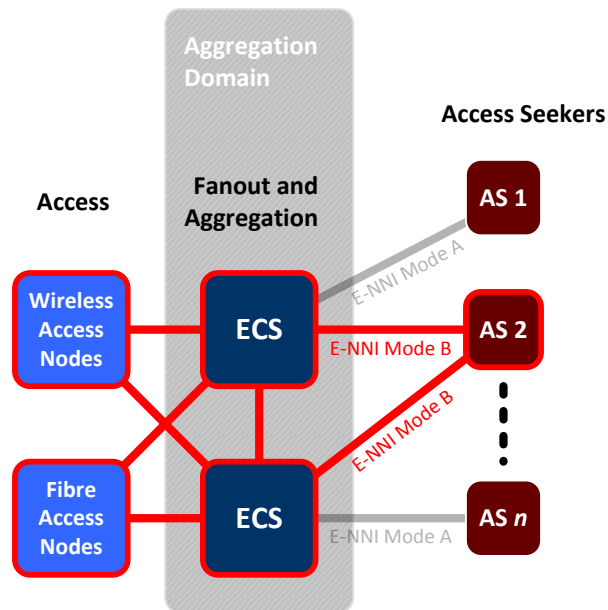| Acronym /Term	Definition
AS	Access Seeker
CIR	Committed Information Rate
DCN	Data Communications Network
DFN	Distribution Fibre Network
DN	DWDM Node
DWDM	Dense Wavelength Division Multiplexing
EAS	Ethernet Aggregation Switch
ECS	Ethernet Combined Switch
EFS	Ethernet Fanout Switch
eNodeB	Evolved Node B Base Station
FAN	Fibre Access Node
FCD	Fibre Collector Distributor
FDA	Fibre Distribution Area
FDH	Fibre Distribution Hub
FDT	Fibre Distribution Terminal
FSA	Fibre Serving Area
FSAM	Fibre Serving Area Module
FTTP	Fibre to-the Premises
FWO	Fibre Wall Outlet
Gbps	Gigabits Per Second
GNAF	Geocoded National Address File
IDU	Indoor Unit
LFN	Local Fibre Network
LTE	Long Term Evolution
Mbps	Megabits Per Second
MPO/APC	Multi-fibre Push On/Angled Physical Contact
MR	Management Router
NBN	National Broadband Network
NFAS	NBN Fibre Access Service
NMS	Network Management System
NTD	Network Terminating Device
NTU	Network Termination Unit
ODF	Optical Distribution Frame
ODN	Optical Distribution Network
ODU	Outdoor Unit
OLR	Optical Line Repeater
OLT	Optical Line Termination
OMS	Optical Multiplex Section
ONT	Optical Network Termination. The GPON NTD.
PCD	Premises Connection Device
PCP	Premises Connection Point
PCP	Priority Code Point
PDN-GW	Packet Data Network Gateway
PFN	Premises Fibre Network

POI	Point of Interconnect
PON	Passive Optical Network
ROADM	Reconfigurable Optical Add-Drop Multiplexer
RF	Radio Frequency
RFGW	Radio Frequency Gateway
SC/APC	Standard Connector/Angled Physical Contact
SP	Service Provider
TPEP	Transparent Performance Enhancing Proxy
UNI	User to Network Interface
UNI-D	User to Network Interface – Data
UNI-V	User to Network Interface - Voice
VSAT	Very Small Aperture Terminal
WSP	Wholesale Service Provider
Access Seeker	A Customer of NBN Co, providing one or more public telecommunications services whose provision consists wholly or partly in the transmission and routing of signals on a telecommunications network. Access Seekers may be Retail or Wholesale Service Providers.
End User	A 'User' or 'End User' is the person/persons who subscribe to telecommunications services provided by Retail Service Providers
Fibre to the Premises	Provision of Optical Fibre connections to homes and businesses
Optical Distribution Network	In the PON context, a tree of optical fibres in the access network, supplemented with power or wavelength splitters, filters or other passive optical devices.
Point of Interconnect	Designated point with the NBN Co network for Access Seeker connection.
Optical Network Termination	A single subscriber device that terminates any one of the distributed (leaf) endpoints of an ODN, implements a PON protocol, and adapts PON PDUs to the subscriber service interfaces.
Retail Service Provider	Retail Service Providers are Access Seekers who purchase the Ethernet Bitstream service from NBN Co and on-sell the service to their own customers (End Users).
Wholesale Service Provider	Wholesale Service Providers are Access Seekers who purchase the Ethernet Bitstream service from NBN Co and on-sell the service to other Service Providers.
Wholesale Telephony Access Service	A wholesale telephony access service offered by NBN Co that is a combination of an ATA function in the ONT, associated analogue ATA port(s), and logical connectivity to a Point of Interconnect.

Table 8   Acronyms, Terms and Definitions