Wholesale InterConnect & Symmetric Ethernet Services (SES) Products Technical Manual

Version 1.1.1
Effective from: April 2020

Contents

Document Control

Revision history

Version	Date	Status	Revision initials: Revision details
1.0	Apr 2020	Active	Published version
1.1	Apr 2020	Active	Published version
1.1.1	Apr 2020	Active	Published version

Associated documents

Title	Location
InterConnect & SES Reference Offer InterConnect & SES Product Process Manual InterConnect & SES Service Level Agreement	All available online at https://nbi.ie/industry/service-provider/ or from your NBI Account Manager

The products in this document relate to the set of Wholesale InterConnect and Symmetric Ethernet Services SES Products outlined in the Project Agreement between National Broadband Ireland (NBI) and the Department of Communications, Climate Action and Environment (DCCAE) as signed on 19th November 2019.

Glossary of terms

AF:	Assured Forwarding
API:	Application Programming Interface
BE:	Best Effort
CIR:	Committed Information Rate
Co-Lo:	Co-Location
CPE:	Customer Premises Equipment
EF:	Expedited Forwarding
E-NNI:	External - Network to Network Interface
FTTH:	Fibre to the Home
IBH:	In-building Handover
ISH:	In-Span Handover
LAG:	Link Aggregation
LER:	(MPLS) Label Edge Router
MPLS:	Multi-Protocol Label Switching
NBI:	National Broadband Ireland
NTU:	Network Termination Unit
ODP:	Optical Distribution Point
OLT:	Optical Line Terminal
PE:	Provider Edge node
PoH:	Point of Handover
PoP:	Point of Presence
SES:	Symmetric Ethernet Services
SP:	Service Provider (also known as RSP – Retail Service Provider)
UNI:	User Network Interface
VLAN:	Virtual Local Area Network
VPLS:	Virtual Private LAN Service
VUA:	Virtual Unbundled Access
XGS-PON:	10Gb Symmetric Passive Optical Network

1 Introduction

The purpose of this document is to provide a technical description of the InterConnect & Symmetric Ethernet Services (SES) products in order to assist Service Providers in the design and development of their own product offerings.

Please note that this is a working document and therefore subject to regular updates as new products and product enhancements are introduced, which will be updated and referenced in the version control table of this document.

This InterConnect & Symmetric Ethernet Services (SES) Product Technical Manual provides a detailed description of the products that will be made available to Service Providers.

This Technical Manual refers to and should be read in conjunction with Schedule 1 and Schedule 2 in the published InterConnect & Symmetric Ethernet Services (SES) Reference Offer, which is published on the NBI website or can be obtained via the NBI Service Provider Account Manager.

Any Service Provider specific technology mentioned in this document is current as at the date of issue and is for guidance purposes only. NBI reserves the right to adapt the technology used to deliver the products at any time through the change management process subject to the notification and timelines agreed for this product set.

2 Product Overview

This section provides a high-level overview of the InterConnect & Symmetric Ethernet Services (SES) products available to Service Providers.

2.1 InterConnect Product

The InterConnect product enables Service Providers to handover Bitstream, VUA & SES traffic over the same InterConnect. The traffic can be aggregated together for handover at a specific PoH.
The InterConnect product is available in three variants:

- Third Party Premises (TPP) Handover, also called Customer Sited Handover (CSH)
- In-Building Handover (IBH)
- In-Span Handover (ISH)

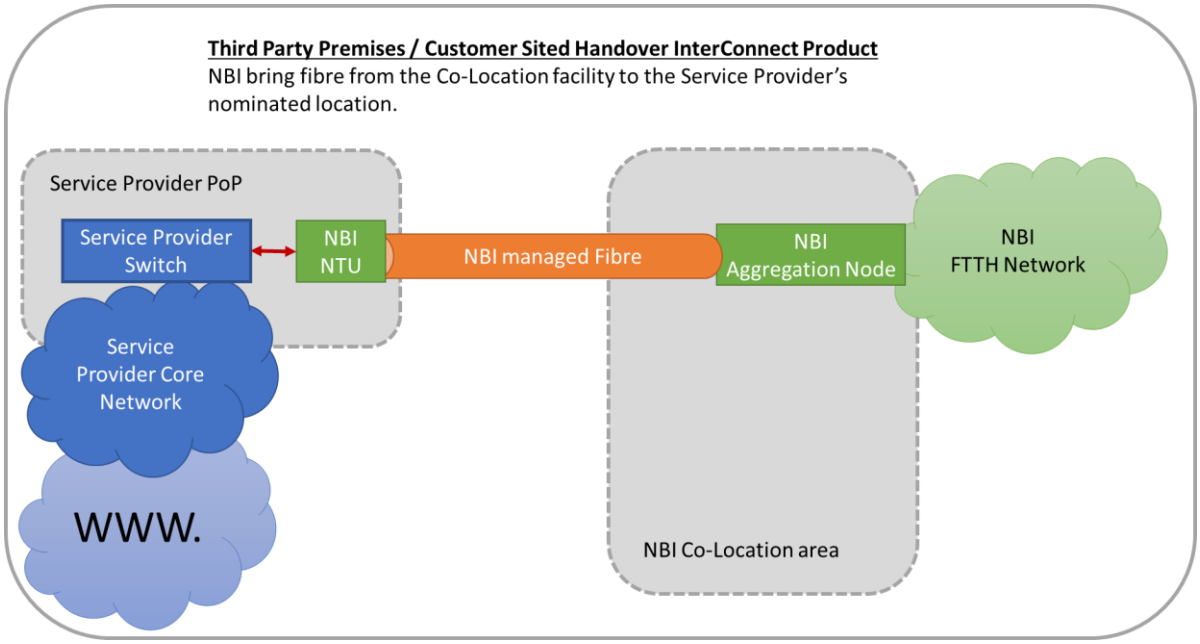

Figure 1: TPP/CSH Overview

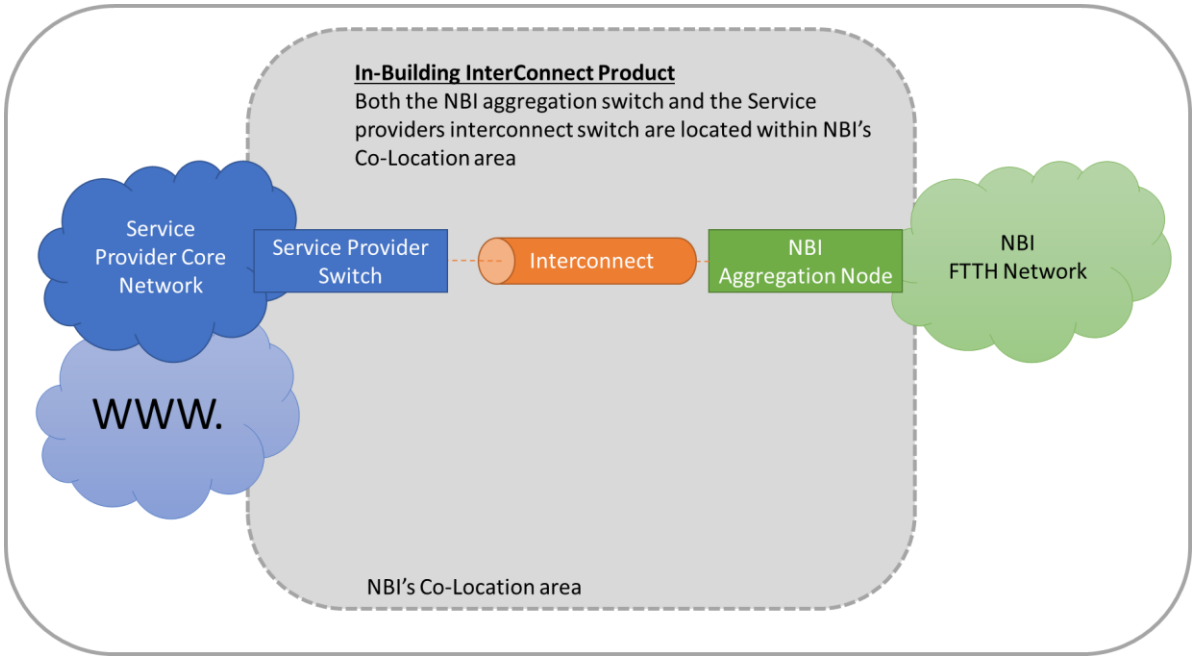

Figure 2: IBH Overview

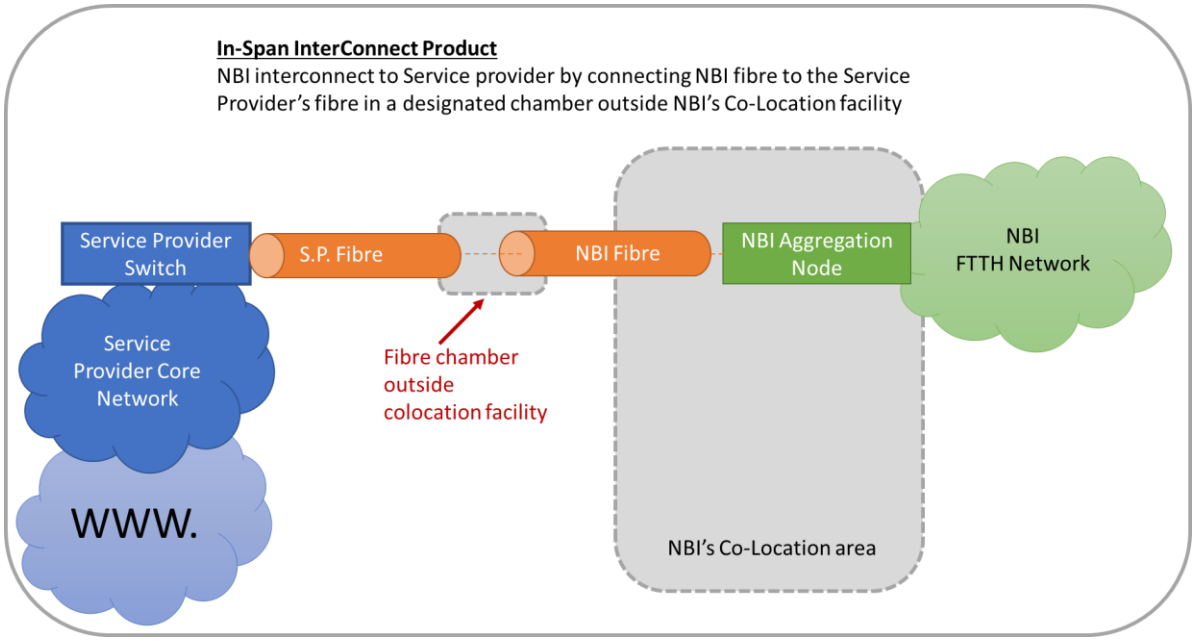

Figure 3: ISH Overview

Each handover order is composed of two components:

1. The physical interconnection demarcation point (Cable from the Router/Node to the handover point NTU port):

   IBH: the NTU is the Service Provider's ODF

   CSH: the NTU is the NBI provided Nokia NTU

   ISH: the NTU is the ODF in the chamber

2. The Logical InterConnect providing the service which has bandwidth assigned and managed

Both the physical and logical components have separate and unique Identifier Codes with an identifying prefix to ensure easier recognition of the circuit type to assist with reporting and fault handling. These Identifier Codes are used on all Bitstream, VUA and SES orders.
NBI is responsible for the provision, repair and maintenance of the InterConnect from the NBI aggregation node to the physical interconnection demarcation point as described in point 1 above.

Service Providers are responsible for connectivity between the PoH and the Service Provider equipment, and any end-to-end testing of their service. Service Providers must ensure that a suitable environment is provided, at their own expense, with adequate space, power, environmental conditions and general facilities available to allow NBI to deliver the InterConnect service for CSH (TPP) and IBH InterConnects.

Where the product required it the Service Provider must enable access to the handover location for NBI to install and support the service; e.g. a Service Provider rack space so NBI can install a patch panel for IBH Handover.

2.2 Symmetric Ethernet Services (SES) Product

The Symmetric Ethernet Service product is a Fibre to the Home (FTTH) product suitable for providing a means of mitigating the delivering of services that may be sensitive to delay and packet loss to Business and Enterprise customers.

SES enables Service Providers to combine their own transport network with the NBI access network in order to deliver advanced high-speed services to End Users. SES provides a Layer 2 Ethernet VLAN-transparent service with Class of Service (CoS) options.

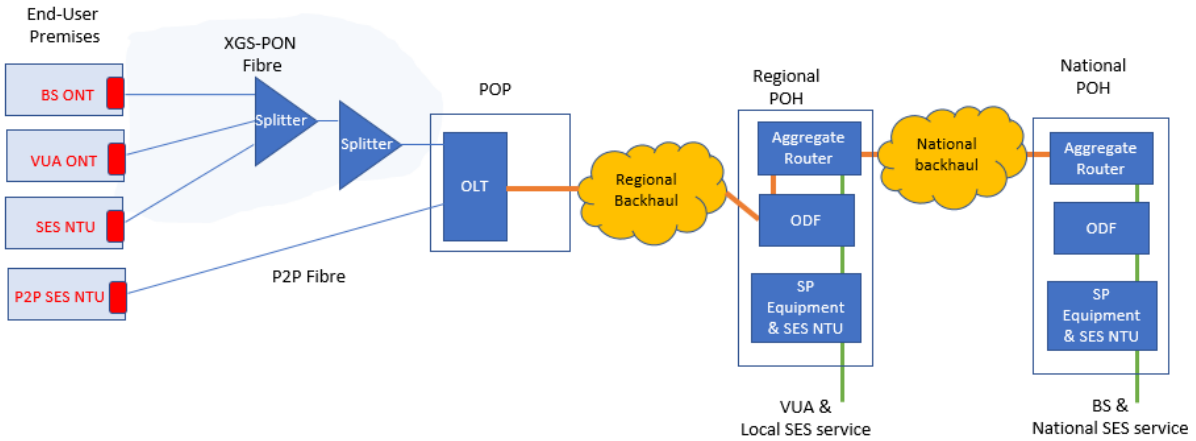

Figure 4: SES Product Overview

As shown in the diagram above, SES is delivered locally by either a XGS-PON fibre or point to point network to the Co-Location PoH-interconnection and onwards nationally with backhaul transporting the traffic to a carrier InterConnect point.

SES is available in various bandwidths to suit most business needs.

The table below details the various speeds for XGS-PON and point-to-point (p2p) fibre:

Table 1: SES Product Set
Product
200 Mbit/s
500 Mbit/s
1Gbit/s
5Gbit/s

Both the physical and logical components have separate and unique Identifier Codes with an identifying prefix to ensure easier recognition of the circuit type to assist with reporting and fault handling. These Identifier Codes are used on all Bitstream, VUA and SES orders.

3 Network Solution Overview

This section provides a high-level technical overview of how InterConnect and SES services are supported and interact on the NBI network.

3.1 SES (UNI) to InterConnect (NNI) Traffic Flow

The traffic flow in the UNI to the NNI direction is managed as follows:

1. End User traffic is input to the NBI network at a physical port (UNI) on an NBI managed NTU installed at the End User site. The UNI port is configured as an 802.1Q trunk.
   The SES product is a Transparent LAN InterConnect (TLI) service so the traffic can be tagged or untagged. The End User can present double tagged frames. (QinQ). These C-VLAN tag(s) are carried transparently across the NBI network.

2. The NTU supports one UNI port per SES Logical connection.
   An S-VLAN tag is added to the End User traffic at the NBI NTU UNI.

3. CoS is applied to the End User traffic associated with the S-VLAN and the traffic is mapped to the appropriate Forwarding Class within the NBI network.
   If traffic is going across the National Backhaul, the S-VLAN tag is removed.

4. The traffic is passed to the Service Provider handover site NTU.
   If traffic is going over National Backhaul, an S-VLAN tag is added to the End User traffic.

5. The S-VLAN on the network-facing port is mapped to the port of the NTU at the Service Provider handover site. The NNI port is configured as an 802.1ad port.
   The S-VLAN ID identifies End User traffic associated with an individual SES logical connection.
   If the Service Provider has more than one InterConnect it should specify which InterConnect is associated with which SES logical connection.

3.2 InterConnect (NNI) to SES (UNI) Traffic Flow

The following describes how Service Provider traffic is treated in the NNI to UNI direction:

1. Service Provider traffic is presented to the NBI network at a physical port (NNI) of the Service Provider handover site NTU (an ODF or Nokia NTU). The NNI port is configured as an 802.1ad port.
   The Service Provider must add an S-VLAN tag to their traffic prior to presentation at the NNI.
   The S-VLAN tag is associated with the destination SES connection.

2. The CoS profile is applied to the traffic associated with the SVLAN and the Service Provider traffic is mapped to the appropriate Forwarding Class within the NBI network.
   If traffic is going across the National Backhaul, the S-VLAN tag is removed.

3. If traffic has gone across the National Backhaul, a S-VLAN tag is added.

4. The S-VLAN tag is removed from the Service Provider traffic on the NBI NTU.

5. Service Provider traffic is presented to the End User at the UNI port on the NBI NTU.

3.3 SES Connection Scenarios

A SES circuit with the InterConnect in the same PoH can have its logical connection configured as an uncontended connection. The NBI Node is a nonblocking device and so the Service Provider may inventory manage the InterConnect to ensure that it is not overbooked.

Conversely, the Service Provider may inventory manage the InterConnect which may result in the InterConnect being overbooked, i.e. the sum of the SES bandwidths exceed the bandwidth on the InterConnect

In this scenario CoS may be required on the SES and the required level of circuit-based class of service should be specified by a Service Provider.

3.4 VLAN Tagging Model (QinQ) for SES Products

This section summarises the VLAN tagging model used for SES products across the National network.

C-VLAN
The Service Provider can use the full C-VLAN ID range (i.e.1-4096) to tag their End User traffic. The C-VLAN IDs are carried transparently across the NBI network.

S-VLAN
The default is for NBI to assign the S-VLAN ID presented at the NNI. The assigned S-VLAN IDs will be in the range 100-4000. However, the Service Provider can also specify the S-VLAN ID presented at the NNI. If the Service Provider chooses to specify their own S-VLAN ID, the Service Provider will be responsible for specifying all S-VLAN IDs within the range 100-4000 on that NNI.

The Service Provider must ensure that the S-VLAN 802.1p markings are also mapped to the C-VLAN (or vice-versa) prior to presentation at the NNI (EF to EF, AF to AF etc.)

4 Service Parameters for InterConnect & SES Products

This section summarises the service parameters associated with the SES and InterConnect products:

Table 2: SES and InterConnect Service Parameters	
Parameter	Value
MAC Address learning	off
Max Frame Size	9000 bytes
Max no. of S-VLANs per NNI	3900
Max no. of C-VLANs per UNI	4096
C-VLAN ID Preservation	Yes
C-VLAN CoS Preservation	Yes
Multicast traffic limit	No limit
Broadcast traffic limit	No limit
Unknown Unicast traffic limit	No limit

The following table is to be confirmed:

Table 3: Layer 2 Control Protocol Processing	
Parameter	Value
Spanning Tree Protocol (STP), Rapid Spanning Tree Protocol (RSTP) Multiple Spanning Tree Protocol(MSTP)	Tunnelled
PAUSE (802.3x)	Discarded
Link Aggregation Control Protocol (LACP)	Tunnelled
Marker Protocol	Tunnelled
Authentication (802.1x)	Tunnelled
All LANs Bridge Management Group Block of Protocols	Tunnelled
Generic Attribute Registration Protocol (GARP) Block of Protocols	Tunnelled
Cisco Discovery Protocol (CDP)	Tunnelled
Cisco VLAN Trunking Protocol (VTP)	Tunnelled

5 SES Bandwidth Profile

The SES bandwidth options for physical access are shown in the following table.

The bandwidth values listed include the Ethernet frame overhead, preamble, and interframe gap.

The bandwidth/throughput on the SES connection is not dependent on frame size.

For Traffic Based CoS, the % values of traffic mapped to the EF and AF queues is used for the calculation of the upper limits.

Table 4: SES Bandwidth Options
200Mbit/s
500Mbit/s
1Gbit/s
5Gbit/s

6 Class of Service (CoS)

This section describes the basic Class of Service (CoS) design for the products. It is broken down into the CoS design on the SES connections and the CoS design on the InterConnect connections.

There are three forwarding classes, or network queues, used within the NBI network for products:

- Expedited Forwarding (EF) class
- Assured Forwarding (AF) class
- Best Effort (BE) class (or standard class (STD))

Expedited Forwarding is serviced before the Assured Forwarding class and is intended to be used for real-time delay-sensitive traffic. There is a committed information rate (CIR) associated with the Expedited Forwarding class. End user traffic which exceeds the configured CIR will be dropped on ingress to the NBI network.

Assured Forwarding is serviced before the Standard Forwarding class and is intended for business applications which require priority access to available bandwidth over standard applications. There is a committed information rate (CIR) and peak information rate (PIR) associated with the Assured Forwarding class. The Assured Forwarding class provides the ability to classify ingress traffic as either in-profile or out-of-profile based upon the traffic arrival rate.

A queue is considered in the in-profile state if the rate at which the queue is being serviced is less than its configured CIR. A queue is considered out-of-profile if the rate at which the queue is being serviced is greater than its CIR, but less than its PIR. After the profile state of the packet is determined at network ingress, the profile state of the packet influences the packets queuing priority and drop preference.

Standard Forwarding is used for carrying all remaining traffic. This remaining traffic generally uses protocols capable of maintaining some form of connectivity during congestion.

The End User traffic is mapped to the appropriate forwarding class on ingress to the NBI network for BS, VUA, SES and InterConnect connections.

6.1 Traffic-based CoS

With traffic-based CoS the End User marks the 802.1p bits in their Ethernet frame headers on network ingress. End user traffic is mapped to a forwarding class on ingress to the NBI network based on the 802.1p markings.

For SES, the CoS is purchased as:

Table 5: SES XGS-PON CoS Service Offerings				
XGS-PON Product	0% EF	10% EF	20% EF	50% EF

Table 6: SES P2P CoS Service Offerings	
Point to Point (p2p) Product	100% EF

For Bitstream and VUA, the CoS is purchased as:

Table 7: Bitstream & VUA CoS Service Offerings				
	EF Downstream	AF Downstream	EF Upstream	AF Upstream
Consumer Option	1 Mbit/s	0	1 Mbit/s	0
Business Option 1	10 Mbit/s	20 Mbit/s	10 Mbit/s	20 Mbit/s
Business Option 2	20 Mbit/s	40 Mbit/s	20 Mbit/s	40 Mbit/s

6.2 InterConnect CoS Model

This section describes the CoS model for the InterConnect associated with the products. The InterConnect CoS model is shown in the following diagram:

6.3 Mapping UNI to NNI CoS Markings

This section describes mapping of CoS markings across the NBI network. End User C-VLAN 802.1p markings will never be remarked and will always be tunnelled across the network.

6.4 UNI to NNI Traffic Flows

Classification on ingress to the NBI network is based on the End User C-VLAN 802.1p markings. Traffic is forwarded to the Forwarding Class based upon ingress policy (i.e. the EF and AF bandwidths if specified). C-VLAN 802.1p markings mapping is as follows:

Table 8: Ingress Mapping of CoS Markings	
C-Vlan 802.1p marking	Forwarding Class
4	EF
2	AF
0	SE

Traffic with 802.1p markings other than 0,2,4 will be dropped.

On egress of the NBI network, the markings are mapped to the S-VLAN 802.1p markings on the NNI as per the following table:

Table 9: Egress Mapping of CoS Markings	
Forwarding Class	S-Vlan 802.1p marking
EF	4
AF	2
SE	0

The original End User C-VLAN 802.1p markings are tunnelled across the NBI network and are presented to the Service Provider at the NNI within the C-VLAN ID header.

6.5 NNI to UNI Traffic Flows

The Service Provider must ensure that the S-VLAN 802.1p markings are also mapped to the C-VLAN (or vice-versa) prior to presentation at the NNI.

Classification on ingress to the NBI network is based on the Service Provider S-VLAN 802.1p markings. Traffic is forwarded to the core Forwarding Class based upon the ingress policy specified for the SES connection (i.e. the EF and AF bandwidths if specified). The mapping of the S-VLAN 802.1p markings to the core Forwarding Classes is as follows:

S-VLAN 802.1p Marking Forwarding Class:

Table 10: Ingress Mapping of CoS Markings

S-Vlan 802.1p marking	Forwarding Class
4	EF
2	AF
0	SE

On egress of the NBI network, the classification is based on the MPLS EXP bits markings associated with the different core Forwarding Classes. The MPLS EXP bits markings are mapped to the S-VLAN 802.1p markings on egress of the NBI network.

The S-VLAN tag is stripped off prior to presentation to the customer on the UNI and the original End User/Service Provider CVLAN 802.1p markings are presented on the UNI.

6.6 Capacity Management

Capacity management to be defined

6.7 Planning Ratios

Planning ratios are to be defined.
However, the following planning ratios are expected to be used for capacity management purposes in the NBI Network:

Table 11: Planning Ratios

Traffic Type	Planning Ratio
EF	1:1
AF In Profile	1:1
AF Out of Profile	5:1
STD	5:1

7 Interface Specifications

This section details the interface specifications for InterConnect and SES products.

7.1 SES NTU

An SES connection requires the installation of an NBI NTU at the nominated PoH to the Service Provider. The NTU is detailed below.

Figure 5: Nokia NTU Model 7210 SAS-DXP

Table 12: SES NTU Accommodation Requirements	
Specification	Description
NTU Model	Nokia 7210
Power Supply options	One feed. External AC or DC power supply
Power Consumption	AC input: 100 V to 240 V, 50 Hz to 60 Hz DC input: -36 V DC to -72 V DC
Dimensions	• Height: 4.3 cm (1.69 in) 1RU • Width: 26.0 cm (10.23 in) • Depth: 23.5 cm (9.25 in)
Weight	DC Unit: 2.2 kg (4.9lb) AC Unit: 2.0 kg (4.5lb)

The following table details the UNI specification for the SES product:

Table 13: SES UNI Interface Specification	
Specification	Description
NTU Model	Nokia 7210
UNI Physical Interface options	10/100/1000BaseT (Default)
UNI Physical interface presentation	RJ45 for 10/100/1000 Base-T (Default)
Optical Wavelength	1000BaseSX SFP
Optical Power Budget 1000	BaseSX SFP
Auto negotiation support	Yes
Full Duplex Support	Yes
Autosensing Enabled	Yes
UNI Port Setting Options	10Gbps full duplex
Ether Type Support	0x8100
Link Loss Forwarding (LLF) Support	Y

7.2 Multi-Service SES NTU

SES is currently limited to a single UNI port on the NBI managed NTU installed at the End User site.

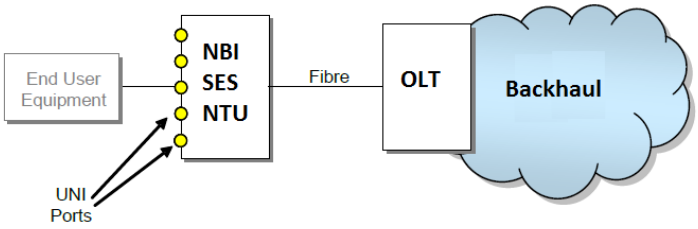

Figure 6: SES Multiple UNI Ports

One SES logical connection per UNI is supported. Port kept spare for if Link Aggregation (LAG) is required on the network connection.

7.3 InterConnect Customer Sited Handover (CSH)

The InterConnect CSH option involves the installation of an NBI NTU.

Figure 7: Nokia NTU Model 7210 SAS-DXP

Table 14: CSH NTU Accommodation Requirements	
Specification	Description
NTU Model	Nokia 7210
Power Supply options	One feed. External AC or DC power supply
Power Consumption	AC input: 100 V to 240 V, 50 Hz to 60 Hz DC input: -36 V DC to -72 V DC
Dimensions Weight	• Height: 4.3 cm (1.69 in) 1RU • Width: 26.0 cm (10.23 in) • Depth: 23.5 cm (9.25 in) DC Unit: 2.2 kg (4.9lb) AC Unit: 2.0 kg (4.5lb)

The following table details the UNI specification for the SES product:

Table 15: CSH NTU Specification	
Specification	Description
NTU Model	Nokia 7210
UNI Physical Interface options	10/100/1000BaseT (Default)
UNI Physical interface presentation	RJ45 for 10/100/1000 Base-T (Default)
Optical Wavelength	1000BaseSX SFP
Optical Power Budget 1000	BaseSX SFP (input/output: min & max)
Auto negotiation support	Yes
Full Duplex Support	Yes
Autosensing Enabled	Yes
UNI Port Setting Options	10Gbps full duplex
Ether Type Support	0x8100
Link Loss Forwarding (LLF) Support	Yes

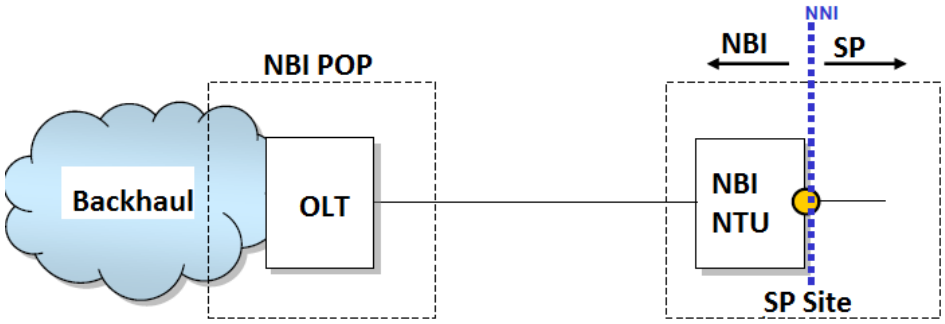

Figure 8: InterConnect Customer Sited Handover (CSH)

7.4 InterConnect In-Span Handover (ISH)

For the ISH option, the NBI fibre joins the Service Provider's fibre at a transition point outside the PoH exchange.

The actual PoH is the point at which the Service Provider's optical fibres join to the NBI fibres. It is housed in a U/G manhole located within 100 Metres outside the boundary of the NBI PoH exchange. The Service Provider must provide a suitable mini-ODF type closure at the UG chamber in which NBI terminates its optical fibres on one side of the mini-ODF and the Service Provider terminates its fibres on the other side.

The maximum distance of the ISH is determined by the available optical power budget measured at the NBI ODF to the Service Provider PoH ODF:

- Minimum Receive Level at the PoH is -19 dBm at start of life to ensure minimum of -22 dBm at end of life, after aging and repair of systems measured at the NBI ODF

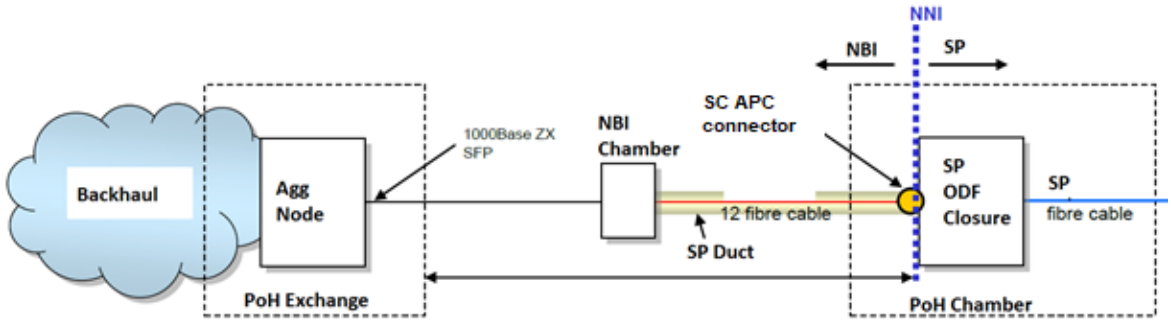

Figure 9: InterConnect In Span Handover (ISH)

Table 16: ISH Interface Specification	
Specification	Description
NNI Physical interface presentation	Single Mode Fibre SC APC connector
Optical Wavelength 1550 nm	1550 nm
Optical Power Budget	10 Gbit/s Access ER XFP Input Power (dBm) Min: -13 Max: -1 Output Power (dBm) Min: -7 Max: +4
Auto negotiation support	no
Full Duplex Support	yes
Autosensing Enabled	yes
NNI Port Setting Options	10000BaseER/ZR Port
	Auto Negotiate (Default)
	10G Full Duplex
EtherType Support	S-VLAN
	0x88A8 (Default)
	C-VLAN
	0x8100
Link Loss Forwarding (LLF) Support	The tunnelling of End User/Service Provider LLF L2CP traffic is supported on the NBI network. By default all L2CP traffic is marked as 802.1p 7 and will get mapped to the STD Forwarding Class on ingress to the NBI network.

7.5 InterConnect In-Building Handover (IBH)

For an In-Building Handover, a fibre cable is installed between the Service Provider Co-Location footprint and an NBI optical distribution frame (ODF) in the same NBI exchange as the serving NBI node.

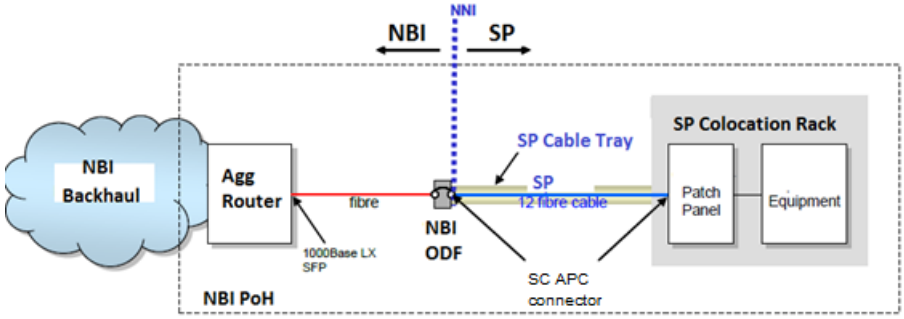

Figure 10: InterConnect In-Building Handover (IBH)

Table 17: IBH Interface Specification	
Specification	Description
NNI Physical interface presentation	Single Mode Fibre SC APC connector
Optical Wavelength 1550 nm	1550 nm
Optical Power Budget	10 Gbps Access ER XFP Input Power (dBm) Min: -10.2 Max: + 0.5 Output Power (dBm) Min: - 12.2 Max: + 0.5
Auto negotiation support	no
Full Duplex Support	yes
Autosensing Enabled	yes
NNI Port Setting Options	1000M Full Duplex
	Auto Negotiate (Default)
	10G Full Duplex
EtherType Support	S-VLAN
	0x88A8 (Default)
	C-VLAN
	0x8100
Link Loss Forwarding (LLF) Support	The tunnelling of end user/Operator LLF L2CP traffic is supported on the NBI network. By default all L2CP traffic is marked as 802.1p 7 and will get mapped to the STD Forwarding Class on ingress to the NBI network.

NBI will provide an optical signal at -10.2 dBm minimum at a Service Provider optical patch panel. The Service Provider shall provide to NBI an optical signal at -12.4dBm minimum at a Service Provider optical patch panel.

Note that a 2dB margin is used in the above figures to account for losses associated with connectors, ODF, etc. between the Nokia NTU port and the NNI.

8 Configuration of Loopbacks on SES Connections

A Service Provider can request a loopback to be configured on an NBI SES connection. The loopback is configured by NBI on the end-user facing port (UNI) on the NBI NTU deployed at the end-user site.

The Service Provider should use one of the following methods to submit a request for a loopback to be configured:

- The Service Provider can request a loopback to be configured via the Portal by selecting 'Configuration of Loopback on SES Circuit' on the fault reporting screen and referencing the SES Circuit ID

- The Service Provider can log a request for a loopback to be configured by calling the Support Centre. The Service Provider must request a 'Configuration of Loopback on SES Circuit' and reference the SES Circuit ID

The Service Provider must submit an additional request to have the loopback removed using the contact options outlined above (the SES Circuit ID must be referenced in all cases). The length of time that a loopback is applied should not exceed 24 hours.

9 Fibre Access & Resilience

9.1 SES Fibre Access

There are two main models for fibre access in connecting the End User ONT and NTU to the network. These are shown in the diagram below.

1. XGS-PON SES by default is connected to the OLT by a passive shared fibre network following the XGS-PON model. This incorporates primary and secondary splitters with up to 32 End User sharing a fibre (Ration 32:1).

2. Higher speed SES is available as point to point from the End User Premises to the OLT.

SES connections (XGS-PON and P2P) from the OLT to the Aggregation Router is by P2P fibre or by DWDM, depending in which POP the OLT is located.

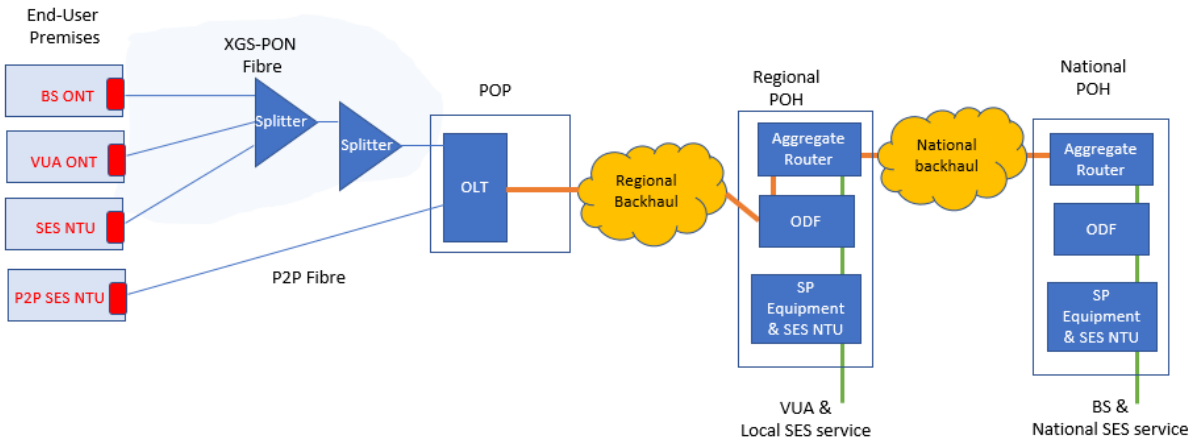

Figure 11: Fibre Access to Aggregation Models

9.2 InterConnect Resilience

IBH & ISH

Standard Protection through Path Diversity on IBH and ISH is achieved using Link Aggregation 802.3ad over dual fibre paths.

Link Aggregation Groups (LAG) and Link Aggregation Control Protocol (LACP) are methods to provide more than one link between two nodes. They automate its configuration and maintenance, respectively.

LAG increases link reliability so that with multiple links between two devices, if one fails the other link(s) keep carrying the information and the traffic on the failed link is also transferred to them. This way communication between them is maintained. LAG also enables traffic load-balancing so that traffic is evenly distributed.

LACP also enables multiple ports/links to work together between two nodes. LACP enabled ports can automatically configure themselves into trunk groups, without manual configuration/intervention.

If there are more links (between two devices) than what is supported by the vendor for LACP, the additional links are placed in stand-by mode and activated automatically when a link fails.

LAG and LACP can be enabled on ISH and IBH InterConnects to provide the Service Provider with protection on the NNI interfaces by grouping two InterConnects into a LAG. Both primary and LAG will be built off different slots on the same aggregation node for slot and port protection.

In a LAG scenario; the second 10Gbit/s InterConnect will be recorded as an LMC (LAG Member Cable). The 1 Gbit/s or 10 Gbit/s InterConnects, which are members of the LAG, will be configured in active/active mode. Only Single Chassis mode LAG is supported on NBI equipment.

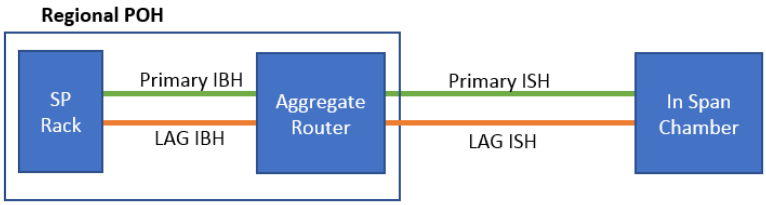

Figure 12: IBH & ISH Resilience Overview

Full failover capability, will no loss of traffic, can only be assured if the max. bandwidth is 10 Gbit/s. Hence if one of the LAG ports fails, the remaining link has capacity to carry all traffic, with minimal service interruption in the switchover.

CSH

Protection is provided for CSH using route disjoint paths where available. These are a working path and protection path use different physical routes in all sections of the network between the demarcation points of the InterConnect product.

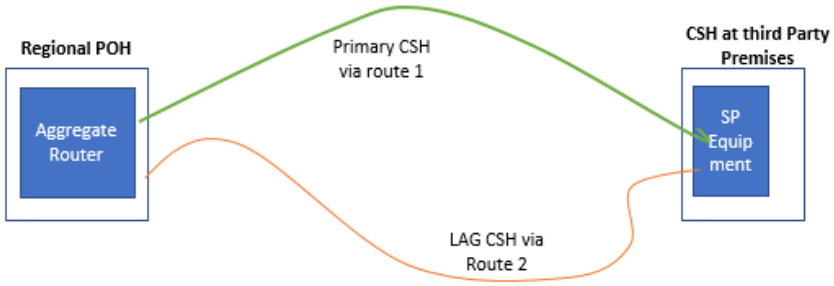

Figure 13: CSH Resilience Overview