WHOLESALE REFERENCE OFFER*

ETHERNET ACCESS SERVICES

PRODUCT SPECIFICATION

*Fibrus offer wholesale access in areas where public funding has been used to build the Network. Fibrus Networks is currently building the Network to achieve optimal performance and to support future Services. Fibrus Networks will inform you of product availability during the onboarding and ordering process.

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1. Introduction

This is the Reference Product Specification for Fibrus Ethernet Access Services as defined in the table below. The document defines a set of processes that encompasses Network Deployment, Order Handling, Wholesale Billing and Service Management. Fibrus provides an active Ethernet pure fibre broadband access service to homes and businesses in Northern Ireland providing ultrafast connectivity with downstream speeds from 50Mb/sup to 1000Mb/s and enables wholesale access in areas where public funding has been used.

This Product Specification is designed for use by Retail Service Providers (RSPs) who are Wholesale partners of Fibrus Networks (Fibrus). For information on how to become a Wholesale partner with Fibrus please see our guide *How to Become a Wholesale Customer* available at https://hyperfastni.com/wholesale-partners or https://hyperfastgb.com/wholesale-partners.

This document should be read in conjunction with the current Fibrus Networks Wholesale Services Framework Agreement, Wholesale Price List, Wholesale Access Service Level Agreement, Installation Services and Wholesale Access Order & Fulfilment documentation, which are available on the Fibrus website at https://hyperfastni.com/wholesale-partners or https://hyperfastgb.com/wholesale-partners.

Fibrus' approach is to enable wholesale customers to self-serve their customer requirements via direct digital access to the systems capable of high-volume transactions alongside dedicated relationship management to ensure their needs are met and to deal with specific requirements. The Operator Wholesale Gateway (OWG) is the ordering and fault management system for Fibrus wholesale products and services.

2. Wholesale Ethernet Access Services

2.1 Overview

Fibrus is a Northern Irish company providing full fibre connectivity to premises across Northern Ireland and specific locations in GB, offering high quality services to Retail Service

Providers (RSPs) who wish to avail of the benefits of Fibrus Networks' network.

Ethernet Products have been developed by Fibrus to provide RSPs with ultrafast services for 'last mile' reach into areas of Northern Ireland where Fibrus has built networks. The customer last mile services are delivered using GPON (or XGS PON) technology via full fibre active Ethernet Access Service. Connectivity from end customers is delivered back to Network to Network Interfaces (NNIs) at handover points in one of our designated handover locations.

Fibrus Ethernet Access Services provide a tunnelled Layer 2 service between the Fibrus Optical Network Termination (ONT) and the NNI connecting to the RSP network. Our Wholesale Ethernet Products provide the ability for RSPs to connect end customers via Layer2 Ethernet allowing appropriate control of network protocols and provides end to end connectivity between your end customer and our handover point in defined Data Centre locations. The RSP provides the Layer 3 service to the customer (IP address, routing, transit etc.), including appropriate Customer Premises Equipment (CPE).

2.2 Bandwidth Options

Fibrus offer both Asymmetrical and Symmetrical broadband products to RSPs. Asymmetrical services are offered in four bandwidth profiles as shown in the table below.

Code	***Wholesale Residential***	***Bandwidth Offering***
RFFL	Residential Full Fibre Lite	50 Mb/s downstream; 20 Mb/s upstream
RFFE	Residential Full Fibre Entry	100 Mb/s downstream; 30 Mb/s upstream
RFFM	Residential Full Fibre Median	300 Mb/s downstream; 100 Mb/s upstream
RFFB	Residential Full Fibre Best	1000 Mb/s downstream; 300 Mb/s upstream

Table 1: Fibrus Wholesale Residential Products

Fibrus symmetrical connectivity services are offered in six different bandwidth profiles and are shown in the table below.

Code	***Wholesale Business***	***Bandwidth Offering***
BFFE	Business Full Fibre Entry	100 Mb/s downstream; 100 Mb/s upstream
BFFE+	Business Full Fibre Entry Plus	200 Mb/s downstream; 200 Mb/s upstream
BFFP	Business Full Fibre Plus	300 Mb/s downstream; 300 Mb/s upstream
BFFS	Business Full Fibre Super	350 Mb/s downstream; 350 Mb/s upstream.
BFFS+	Business Full Fibre Super Plus	600 Mb/s downstream; 600 Mb/s upstream
BFFB	Business Full Fibre Best	1000 Mb/s downstream; 1000 Mb/s upstream

Table 2: Fibrus Wholesale Business Products

The SLAs for both our Asymmetrical and Symmetrical products are aligned to the Fibrus service levels defined in the Wholesale Access Service Level Agreement Specifications document (available at https://hyperfastni.com/wholesale-partners or https://hyperfastgb.com/wholesale-partners).

2.3 Ethernet Product Features

Fibrus Ethernet Access Service utilises a number of network and infrastructure layers to deliver the end-to-end service as shown in Figure 1 below.

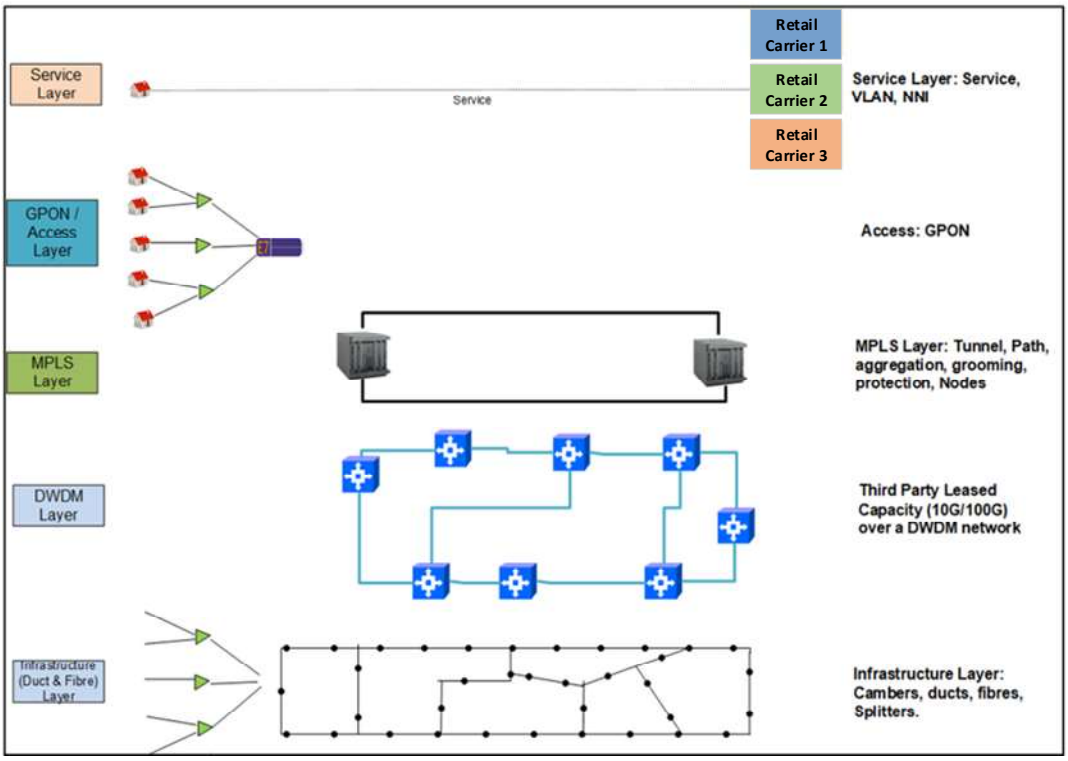

Figure 1 – Wholesale Ethernet infrastructure and service layers

- ***Passive Infrastructure Layer*** – Fibre, Ducts, Chambers and Splitters using Fibrus and Openreach PIA.
- ***Active Network Layer*** – GPON & XGSPON access network, resilient Dense Wave Division Multiplexing (DWDM) infrastructure and Next Generation Network (NGN) Multi-Protocol Label Switching (MPLS) network.
- ***Service Layer*** – provides the end-to-end logical service, to deliver connectivity from customer ONT to RSPs Interconnect handoff.

Each Ethernet virtual circuit (E LAN) provides a seamless end to end broadband access service between the service termination point in the end customer premises and the Network to Network Interface (NNI) at the defined handover point connecting to the Fibrus network. The service termination in the customer premises is the Optical Network Terminal (ONT) which acts as the demarcation point between Fibrus and the RSP responsibilities.

The Ethernet Product is based on NICC ND 1030 Access Line Standards and supports the following features:

- Layer 2 Ethernet access allowing RSPs to manage services at the IP layer and above

- Geographically diverse handover points available to support resilience and traffic management
- Fibrus managed backhaul to handover points assuring no network congestion
- Self service capability for Retail Service Providers via GUI or API
- Provision of service into the customer premises supporting RSP preference for end-customer service delivery e.g. in-home install, post-out, etc.

RSPs can manage their own Customer Premise Equipment (CPE) over the Fibrus network utilising a communication protocol e.g. TR69 Remote Device Protocol.

To utilise the Ethernet Product RSPs must have in place a working NNI connection between the Operator network and Fibrus Networks network.

2.4 Network to Network Interface (NNI)

Fibrus standard NNI product is the handover point between the Fibrus Networks' network and the RSP network. A NNI must be in place before Ethernet products can be ordered. As the NNI is a complex product please contact Fibrus at fibruswholesale@fibrus.com to order or amend your NNI product.

There are currently are currently two NNI products available to RSPs at 10Gb and 100Gb respectively.

2.4.1 Data Centre Handoff

Dependent on region, Fibrus will offer RSPs a NNI at our data centre locations in Belfast, Manchester and London. Further locations may be added, please ask your Fibrus Wholesale Relationship Manager for details.

Handover Locations:

- City Exchange: 62-78 Grosvenor Road, Belfast, BT12 5AP
- Telehouse North London: 14 Coriander Avenue, London E14 2AA
- Equinix MA5: Unit2, Agecroft Commerce Park, 4 Firedamp Way, Swinton, M27 8BX

Fibrus will support RSPs with the Cross-Connect process in the core WAN PoP in order to interconnect onto the Fibrus network and gain access to the A-end sites.
For the Data Centre connections, once the RSP has their equipment installed, the key steps in this process are:

- A Letter of Authority (LOA) is provided by Fibrus to the RSP to give the RSP access to the Fibrus co-location to install the physical interconnect Fibre cable.
- The RSP contracts the Data Centre to install a Fibre Cable between the Fibrus co-location point and the Network Services Supplier location
- Fibrus will provide a 10Gb/s or 100Gb/s port presented as a single mode LR optic.

2.4.2 Additional Handoff Locations – In Span Handoff

There are currently no additional Handoff locations listed. In Span Handoff locations may be available upon request, which can be made by the RSP via their Wholesale Relationship Manager.

2.4.3 Bandwidth Management and Oversubscription

Customer connections are built over the NNI links with a specified amount of bandwidth allocated to each connection. The total interface bandwidth can run in one of two models;

- Dedicated bandwidth
- Oversubscribed bandwidth.

In the dedicated bandwidth model, the total of all customer bandwidth allocations must not exceed the total interface bandwidth.

In the oversubscribed bandwidth model, the RSP can elect to have more customers using the connections, taking into account the actual utilisation of the circuit, rather than its potential utilisation.

Utilisation and oversubscription are managed by the RSP.

2.4.4 MTU

Ethernet circuits, should be ordered with an adequate MTU available. An MTU of 1600 is a minimum and a maximum MTU of 1960 is supported by Fibrus.

2.4.5 NNI Specifications

Fibrus' NNI specification for the physical and logical connectivity required over the NNI connections is shown below.

The RSP should order the NNI cross-connect at the appropriate Data Centre using the following details to locate the Fibrus cabinets. Once the NNI delivery date is known the RSP should contact their Wholesale Relationship Manager to arrange the commissioning and configuration of the NNI.

Type	**Description**
Type of interconnect	Layer 2 Ethernet link (with QinQ)
Interface Bandwidth	10G or 100G
Physical Interface	Single mode fibre.
Presentation	Data Centre Location: Meet Me Room. Fibrus ISH (In span Hand off): Fibrus will present in a fibre optic enclosure within an ISH chamber.
Optical Wavelength	1310nm
Optical power budget	Interface Type - 10GBASE-LR - 100GBASE-LR to be agreed as part of onboarding.
Fibre Specification	G652D
Full Duplex Support	Yes

NOTE: The only device to connect to the NNI must be the Partner QinQ termination device. Loop testing must NOT be performed on the Fibrus network, as this will disrupt services for other customers and result in Fibrus shutting down the RSP NNI.

2.5 Ethernet E-LAN

Fibrus offers a single Wholesale Ethernet service, E-LAN (based on E-VPN), presenting a Layer 2 connection from the customer site to the RSP via one of the NNI connection points. These circuits will be delivered as a QinQ packet (as defined in the VLAN section below) and RSPs will need to utilise this type of frame.

Fibrus provides RSPs with a point to multi-point 1:N architecture (as defined in NICC ND 1030). Fibrus presents an E-LAN on the NNI towards the RSP and all the RSP's ONTs reside within the E-LAN. Fibrus prevents direct communication between the RSPs ONTs. This means RSPs can securely host their customer ONTs within one E-LAN rather than use point to point connections.

2.5.1 E-LAN Identification

To segregate RSP traffic across the Core Network Fibrus utilise E-LAN Tagging (ethertypes 0x88a8 and 0x8100). Fibrus has built the network based on the standards of Ethernet Access Standard NICC ND 1030 and will provide a unique outer "S-Tag" for each RSP. All the RSP sites will be delivered under this S-Tag, however, an RSP may request a second S-Tag for client differentiation to enable them to host their customers on one of two E-LANs. The RSP can use inner "C-Tags" to segregate traffic across their network.

- The unique RSP S-Tag is to be presented at the NNI by the RSP for downstream packets, whilst Fibrus insert this near the end customer for upstream packets. The S-Tag identifies the RSP across the Fibrus core network.
- The C-Tag is inserted by the RSP and can identify both individual customer connections and segregate traffic at a site level, i.e. voice & data. The C-Tag is assigned by the RSP and is transparent to Fibrus.
- The C-Tag is carried transparently over the Fibrus network.
- An RSP can send packets without C-Tags (0x8100) if they wish.

A unique S-Tag will be allocated to each RSP from a pre-defined range by Fibrus. All customer traffic will be tagged with the unique S-Tag on entry to the Fibrus network. It will

be stripped from the traffic at handover at the customer ONT. At this point only Customer C-Tags are visible.

The figure below shows examples of S-Tag and C-Tag VLAN definition for a RSP taking NNI connections from Fibrus:

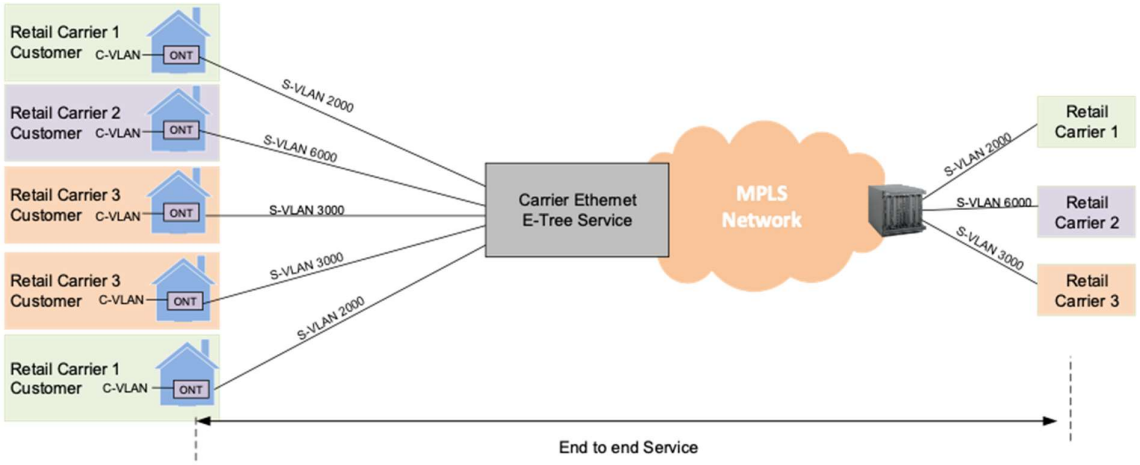

Figure 2 Ethernet Tags

2.6 Quality of Service

The Fibrus network can transport a multitude of applications, including voice, high-quality video and delay-sensitive data. Our access network is designed to enable predictable, measurable, and guaranteed services by managing bandwidth, delay, jitter and loss parameters.

Using advanced Class of Service options, Fibrus can support an RSPs, voice, video, and critical data applications which may be granted priority or preferential service levels set by the RSP over other best effort applications within the network.

2.6.1 Class of Service

RSPs can use the Priority Code Point (PCP) field on downstream traffic and prioritise upstream traffic from the CPE to the ONT by marking their traffic with PCP markings in the Customer VLAN.

It is recommended that PCP values 0, 1, 2, 3, 4 & 5 are used by RSPs to differential Data, Video and Voice applications on the network. PCP values 6 and 7 are supported and utilised for network control traffic.

Queue	P Bit	Description	Queuing Method
1	4,5,6,7	Voice, Video & Network Control Traffic	Priority
2	3	Critical Applications	Priority
3	1,2	Application Traffic	WFQ
4	0	Best Effort	WFQ

Table 3: Class of Service Queue Mapping

In the event of congestion within the Fibrus network, the markings will be used to identify which frames can be dropped first. Traffic is prioritised based on the p bit with higher values being served first.

1. Packets in queue 1 are serviced first (strict priority)
2. Followed by packets in queue 2 (strict priority)
3. Queues 3 and 4 are served via weighted fair queueing (WFQ)

The PCP field allows the RSP to influence which frames are dropped first under congestion, allowing loss sensitive applications such as voice and video to have greater prioritisation through the network. RSPs are expected to shape and mark their traffic in-line with the profile they have purchased.

Fibrus currently do not police traffic within these queues however reserve the right to implement traffic policing where it is deemed that a RSP is sending excessive traffic to higher priority queues. It remains the RSP's responsibility to shape traffic to be within the product specification.

2.7 End-customer Service Presentation

End-customer presentation will be the ONT (e.g. Nokia G-010G-Q ONT), a standards-based Full Service access (FSAN), ITU-T GPON Compliant modem. (For XGSPON, the equivalent ONT e.g. Nokia XS-010G-Q2.5G will be used.)

It is a 2.5 Gbps GPON small form factor service delivery terminal that delivers broadband connectivity to the subscriber. This high-performance terminal features one Gigabit Ethernet 1000Base-T interface.

The ONT terminates a GPON (or XGS PON) fibre optic link at the subscriber's premises and provides an industry-standard interface for the customer premises equipment. The ONT enables end customers to receive gigabit broadband data and IP video on a single fibre. The ONT establishes a strategic network termination point for the delivery and control of broadband services.

Figure 3 – For illustration an example ONT - Nokia G-010G-Q ONT

2.7.1 Customer Premises Equipment (CPE)

The ONT is the Fibrus demarcation point to our service.

The RSP will connect their managed CPE for their customer to the Gigabit Ethernet port. The RSP is responsible for sizing the CPE to the appropriate bandwidth to ensure the customer can avail of the full throughput of the access tail on a per site basis.

The RSP must provide a CPE in front of any hosts or devices on the site. To prevent MAC exhaustion Fibrus restricts the number of MAC addresses learnt per ONT to 8. A switch (not acting as a layer 3 gateway for local hosts) cannot be plugged directly into the ONT.

The RSP is responsible for management and monitoring of the customer CPE.

3. Fibrus Ethernet Access Service Ordering & Installation

The ordering and fulfilment process is detailed in the Wholesale Access Order & Fulfilment document and summarised below.

Fibrus has developed the Operator Wholesale Gateway (OWG) to provide functionality for Service Fulfilment and Service Assurance processes to RSPs.

Ethernet Access Services are available in designated locations as published and updated on the Fibrus wholesale partners website and is communicated to Fibrus Wholesale Partners in the Wholesale Ethernet Availability File.

3.1 Overview of Operator Wholesale Gateway (OWG)

The OWG is the interface for RSPs to place and manage all orders related to provision and amending service for Ethernet Access Services to end customers. RSPs can access the OWG via a Portal or defined API giving direct access to the same status and customer service information that is available to Fibrus.

This enables RSPs access to the vital information they require to manage effectively their customers. RSPs can access relevant order types; provide, cease, upgrade and downgrade services for their end customers. Management of access is provided by Fibrus' wholesale team and it is the RSPs responsibility to administer and assure appropriate use by their personnel.

3.2 Service Fulfilment Process

The Service Fulfilment process has five key elements for successful completion:

- Collate the mandatory required information to complete the order - RSP
- Enter the data into the OWG and select the required address / services - RSP
- Validate and accept the order - Fibrus
- Complete the validated order (including field or in-home work as required) - Fibrus
- Update the RSP on order status – Fibrus

3.3 Customer Premise Installation

On successful completion of the order entry and validation sub-processes, the appropriate network and service activations will be completed by Fibrus systems following which a field engineer will be dispatched to complete the connection (unless an in-situ connection already exists). Further information is available in the Installation Services documents available at https://hyperfastni.com/wholesale-partners or https://hyperfastgb.com/wholesale-partners).

To connect the end customer premise to the network, Fibrus need to bring a fibre optic cable from the Fibrus Distribution Point (DP) located closest to the property to the location in the property where the customer requires the Optical Network Termination (ONT) to be located. The ONT must be fixed to a wall inside the property, close to a power socket. Our fibre optic cable runs through a hole drilled in the wall, down into the ground or up to the eaves where it will then run back to connect to the network.

3.3.1 ONT Location

If the ONT is located away from the point of entry into the property, Fibrus will run internal cable to the point where the ONT is to be fixed. This cable will be up to 3m in length (unless the RSP has placed a special order which may incur additional cost).

Before commencing the installation, the technician will ask the customer representative (who must be authorised to make the decision and over 18 years of age) to agree the route of the fibre optic cable into the property. The technician will record the agreed plan for the installation on a form and ask the customer present to sign to confirm that they accept the route.

Please ensure that the route of the installation is within the boundaries of the property. If Fibrus are asked to install across a route which is not believed to have the necessary consents or permission, Fibrus will not be able to carry out the installation and there may be a cancellation charge to the wholesale partner for a failed installation.

There must be someone over the age of 18 at the property during the installation.

3.4 Escalation Process

Should an RSP wish to escalate a service order this can be done by contacting their Relationship Manager. Orders may only be escalated where they are beyond SLA parameters.

4. Ethernet Service Management

Fibrus operates to a principle of enabling RSPs to manage their customers directly. The OWG provides RSPs with direct access to monitor end customer service and network performance, initiate, track and close trouble tickets via the OWG Portal or defined API. As such, it is a fundamental principle that RSPs must prove any service issues or faults are outside its own network and equipment before raising a trouble ticket.

RSPs will be provided with access to assist them in trouble shooting service problems for end customers with direct access to the same information available to Fibrus wholesale team.

Where an RSP cannot identify and remediate the customer issue, a trouble ticket can be raised within OWG for the attention of Fibrus.

4.1 Trouble Ticket Resolution Process

Trouble tickets should only be raised when the RSP has identified the trouble as being within the Fibrus network or cannot localise the source of the customer trouble. The five key steps in trouble ticket resolution are:

- Trouble ticket reported – RSP
- Trouble diagnosis and isolation – Fibrus
- Trouble repair - Fibrus
- Trouble ticket updated and closed – Fibrus
- Customer updated – RSP

To complete diagnosis and repair the Fibrus wholesale team may be required to

contact the end customer directly e.g. for access. Fibrus will not open or close tickets directly with end customers.

4.2 Escalation Process

Where an RSP requires to escalate a trouble ticket for resolution this can be done by contacting their Wholesale Relationship Manager. Trouble tickets may only be escalated where they are beyond SLA parameters.

4.3 Outages

Planned Outages

It is recognised that Planned Outages are a necessary, normal and regular occurrence. Where a Planned Outage will impact on the Ethernet Access Services provided to an RSP, the RSP will be notified by email, including a description of the outage, customer impact, date, time and expected duration. Fibrus will endeavour at all times to carry out Planned Outages during the preferred hours of 00:00 to 06:00.

Unplanned Outages

Where an outage occurs that impacts on multiple end-customers, Fibrus will inform RSPs to enable them manage operations and customer expectations effectively.

5. Pricing & Billing

All connection, usage and recurring charges associated with the provision of the Ethernet Access Service are charged on the next billing cycle following completion of an order. All charges are as defined in the contractual agreement with the RSP and/or as published in the Wholesale Price List.

Queries regarding billing and charges must be raised with the Wholesale Relationship Manager for resolution.