National Ethernet

Customer service description

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Contents

1. Service Overview

1.1 What is National Ethernet?

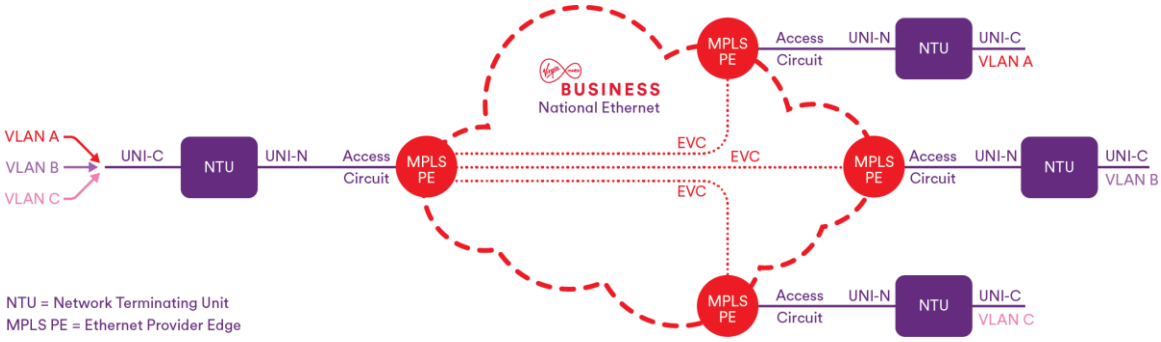
National Ethernet is a Metro Ethernet Forum (MEF) aligned E-line national reach Ethernet transport service and can be configured as either an Ethernet Private Line (EPL) or Ethernet Virtual Private Line (EVPL) service types.

National Ethernet circuits provide layer 2 Ethernet connectivity between sites ready for the overlay of networks such as Internet connectivity, access to private or public Cloud services, and Virtual Private Networks including SD-WAN.

Service Multiplexing enables the customer to connect a site to multiple destinations such as Cloud Provider, Internet Provider and Data Centre through a single fibre access circuit and a single physical interface. Resilince options are available to maximise the availability of critical services and QoS can be added to ensure that traffic performs as needed in all conditions.

Virgin Media's Cloud Connect Product is available to overlay dedicated bandwidth between a customer site with National Ethernet and Equinix Cloud Exchange Fabric for the consumption of AWS & Microsoft Azure

The service comprises three main elements; Access Circuits, Ethernet Virtual Connections (EVC's), and Network Termination Units (NTU's). The diagram below depicts these elements with three circuits in a hub and spoke configuration.



1.2 Access Circuits

All on-net Access circuits will be physically delivered via a 1 Gbps bearer or a 10 Gbps bearer, and rate limited accordingly. This allows for a faster upgrade path for these types of circuits, as the bandwidth control is done by remote configuration rather than hardware changes. Off-net Access circuits can be delivered as 10 Mbps, 100 Mbps, 1 Gbps or 10 Gbps as required.

All access circuits can carry a single EVC or scaled to carry multiple EVC's across the Virgin Media Business (VMB) network. This may be on-net with VMB or provided off-net from a range of 3rd party suppliers.

1.3 Ethernet Virtual Connection (EVC) – bandwidth path

Capacity across the network will be uncontended between 2Mbps and 10Gps with incremental options at 2, 4, 6, 8, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 200, 300, 400, 500, 600, 700, 800, 900 and 1Gbps, then on 10Gbps access circuits 1, 2, 3, 4, 5 & 10Gbps.

The service ingress and egress Ethernet ports are 802.1Q Tunnels and will pass any Customer Ethernet II frames from point "A" to point "B", please see later sections on the processing of Layer 2 Control Protocols.

The EVC is a path configured over the VMB Multi Protocol Label Switching (MPLS) network. MPLS paths segregate customer data from other traffic passing across the IP Core.

The MPLS core network is fully resilient and uses various protocol methods, for example LSP (Label Switch Path's) tunnels and FRR (fast re-route) to ensure resilience is actively provided. The various methods used within the core network to achieve this resilience will in exceptional circumstances become visible to customer connections. If a core node route fails (for example a fibre break) the core will re-route traffic around the failure to provide continued service. In the act of providing this re-route the core will 're-converge'. Regional circuits re-converge in 10s of milliseconds but National Ethernet circuits (with no RSVP-TE or Fast Reroute) can take several seconds causing circuit transport to 'pause' as this convergence occurs.

1.4 Network Terminating Unit - NTU

The service is presented via an NTU at each Customer Site providing the connection to the edge of the VMB network. The NTU's will be located on Customer Sites (at the locations specified in the order placed by the Customer and accepted by VMB) and the service will be presented with either RJ45 Copper interface for 10/100Mbps service or 1000Mbps fibre (singlemode 1310nm or Multimode 850nm) LC for 1000Mbps as standard. A Copper, RJ45 presentation of 1000Mbps is available on request.

10Gbps interfaces are available with fibre presentation 10Gbps Base-SR or 10Gbps Base-LR.

Further information on NTU's and available interfaces can be found in appendix A.

Customers will be expected to provide a suitable (as determined by the VMB survey agent) location for termination of the service NTU. Within formal shared Telehotel environments VMB will terminate the service within the customers own location in the Telehotel, or by specific request and arrangement within an appropriate meet me room. VMB will not provide rack space for NTU's within a Telehotel environment.

NTUs are detailed in appendix 6

1.5 Circuit Management

All National Ethernet circuits are managed inband. No additional circuits or NTU is required for the management link. Each NTU device has a network connection to the VMB management system.

2. Service Presentation

2.1 Overview

National Ethernet from Virgin Media Business (VMB) are point to point circuits, however they can be delivered in different ways to build single point to point, point to multipoint or mesh topologies. To aid these network builds each circuit can select either Port or VLAN presentation.

This section illustrates example topologies to demonstrate service presentation using Port & VLAN User Network Interfaces.

1) **Port Presentation** offers 'all to one bundling' at the UNI port of customer VLANs and will pass all tagged and untagged frames to a single service.

2) **VLAN presentation** offers aggregation at the UNI port known as 'Service Multiplexing' using a single VLAN for each service to aggregate multiple services to a single port. Only frames tagged with agreed VLAN IDs can be passed.

Where VLAN presentation is done at a User Network interface (UNI) the VLAN is referred to as a C-VLAN by IEEE and uses the Ethertype 0x8100, this is the traditional and most common delivery.

A hand off for Service Providers who use National Ethernet as an access method for their own network is referred to an an External-Network to Network Interface (E-NNI). Where the VLAN presentation is done at an E-NNI then the VLAN is referred to as an S-VLAN by IEEE with the Ethertype 0x8100. On request an E-NNI can use other ethertypes on a 'per port basis'.

E-NNI can be provided with an NTU in the customers site, or as a Direct E-NNI with not NTU, or 'wires only' In selected locations and this should be specificed on the order form. Both types can be oversubscribed- see section 2.5.

The multiplexing tag (C-VLAN or S-VLAN) is only carried between the customer's device and the MPLS PE where it is added or stripped as appropriate.

'Bundling' of more than one C-VLAN to a service on a VLAN Presented port is not currently offered. 'All to one bundling', 'Service Multiplexing' and 'bundling' are Metro Ethernet Forum defined service attributes.

2.2 Port to Port

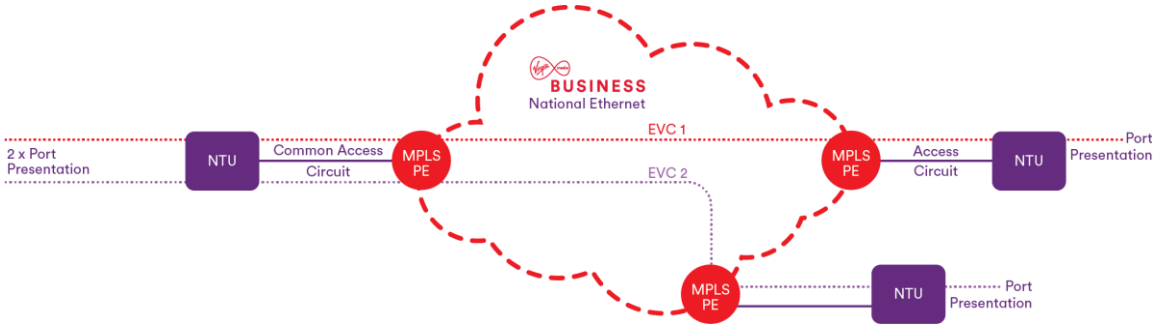
This configuration provides a single path across the network between two NTU UNI ports. The service is a MEF Ethernet Private Line (EPL) service and uses Port presentation at both ends.

In this topology VLAN tags can be used for traffic segregation between two end points creating multiple layer 2 broadcast domains. This can be achieved by configuring connected ports at both ends as 802.1Q VLAN Trunks so a VLAN tag is added by the customer. The service has VLAN preservation and all-to-one bundling attributes meaning customers can use any VLANs and make any changes without needing to make VMB aware.

Multiple VLAN tags can be stacked on an Ethernet frame such as Q-in-Q but only the outer most tag presented to the NTU can be examined by the Virgin Media Network for QoS information if required. The limit to the number of tags is the max MTU size.

When Virgin Media present double tagged frames to a customer the outer & inner tags will have the 802.1q 8100/8100 Ethertype code. Multiple Port to Port circuits can be presented on a single NTU using a common

Access Circuit allowing Point to Multipoint or mesh networks while maintaining port level separation between circuits. VMB use separate Provider VLANs on the Access circuits to separate each service and direct it to a dedicated customer facing port.



2.3 VLAN to VLAN

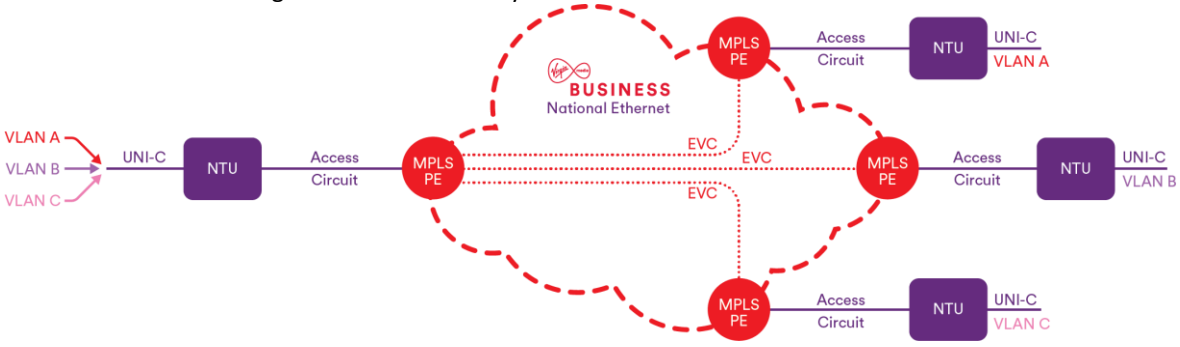
The service is a MEF Ethernet Virtual Private Line (EVPL) service. This configuration provides multiple paths across the network between many NTU UNI's on different customer sites in a 'Hub and Spoke' or mesh configuration. It uses VLAN presentation at both ends to provide a service multiplexing function i.e. both hub & spoke ends have the option of additional circuits on the same UNI port. The service supports symmetrical tagging- where frames have the same VLAN tag configuration at both ends of a circuit although the C-VLAN numbers do not need to be the same at each end. Layer 2 Control Protocol tunnelling on EVPL services can be enabled on request.

Service Multiplexing aka VLAN Presentation, enables both customers and VMB to multiplex more that one service on a single port, i.e. circuits going to multiple B- ends are presented as different C-VLAN numbers on a single A end physical port. The circuit becomes an EVPL circuit because of the 'virtual' presentation at one or both ends. A VLAN presented circuit needs a C-VLAN tag agreed between Virgin Media & customer that identify the destination circuit, this can be any number chosen by the customer.

Where a customer's circuit implements both Service Multiplexing & Traffic Segregation Ethernet Frames will be double tagged, the outer tag doing the Service Multiplexing and the inner tag doing the Traffic Segregation.

When Virgin Media present double tagged frames to a customer the outer & inner tags will have the 802.1q 8100/8100 Ethertype code.

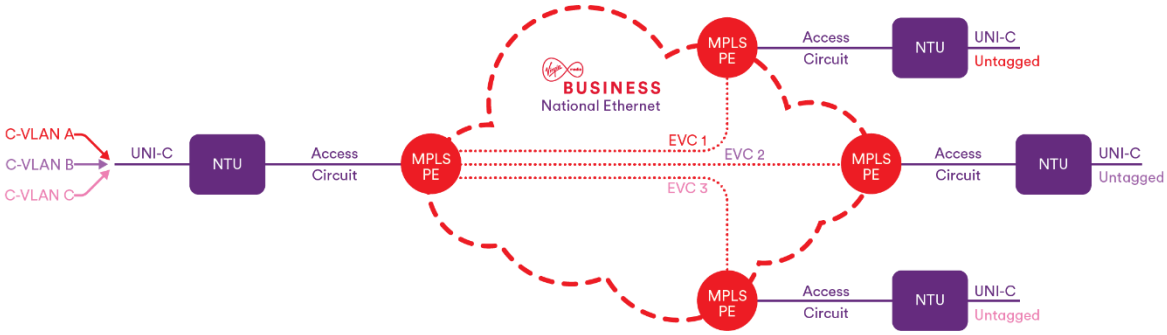
A service attribute that provides more than one service per port AND can map more than one C-VLAN to a service is called "Bundling". This is not currently available from VMB.

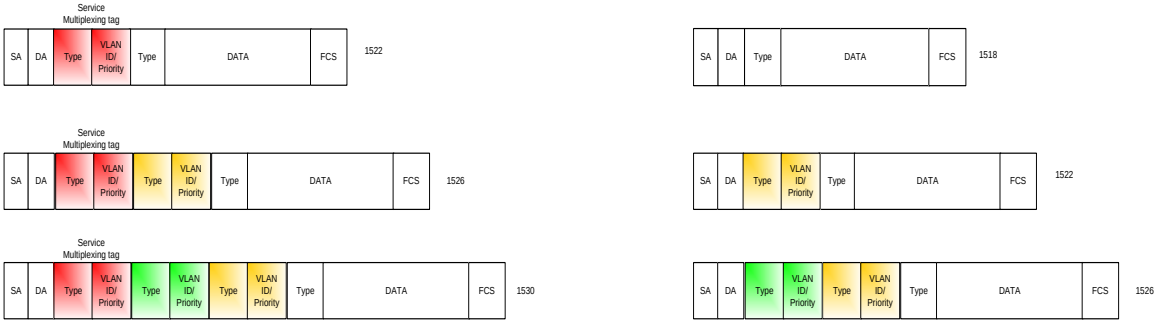


2.4 Port to VLAN

The service is a MEF Ethernet Virtual Private Line (EVPL) service. This configuration provides multiple paths across the network between many NTU's UNI's on different customer sites in a 'Hub and Spoke' configuration. It uses VLAN presentation at the Hub end and Port presentation at the Spoke sites. Layer 2 Control Protocol tunnelling on EVPL services can be enabled on request.

Service Multiplexing aka VLAN Presentation, enables both customers and VMB to multiplex more that one service on a single interface, i.e. circuits going to multiple B- ends are presented as different C-VLAN numbers on a single A end physical port. The circuit becomes an EVPL circuit because of the 'virtual' presentation at one or both ends. A VLAN presented circuit needs a C-VLAN tag agreed between Virgin Media & customer that identify the destination circuit, this can be any number chosen by the customer.





Where a customer's circuit implements both Service Multiplexing & Traffic Segregation, Ethernet Frames will be double tagged with the outer tag doing the Service Multiplexing and the inner tag doing the Traffic Segregation.

In Port to VLAN configuration any tags presented at the Port end become inner tags at the VLAN end as a multiplexing tag is added at the egress MPLS PE. Likewise when a double tagged frame is presented to the VLAN end, the outer tag is stripped and only the inner tag carried.

The example frames above show how untagged, tagged and double tagged frames presented at the Port based site are presented at the VLAN based site, the red tag being the Service Multiplexing tag/ C-VLAN exchanged between VMB and the customers device.

When Virgin Media present double tagged frames to a customer the outer & inner tags will have the 802.1q 8100/8100 Ethertype code. Other Ethertypes can be used on request.

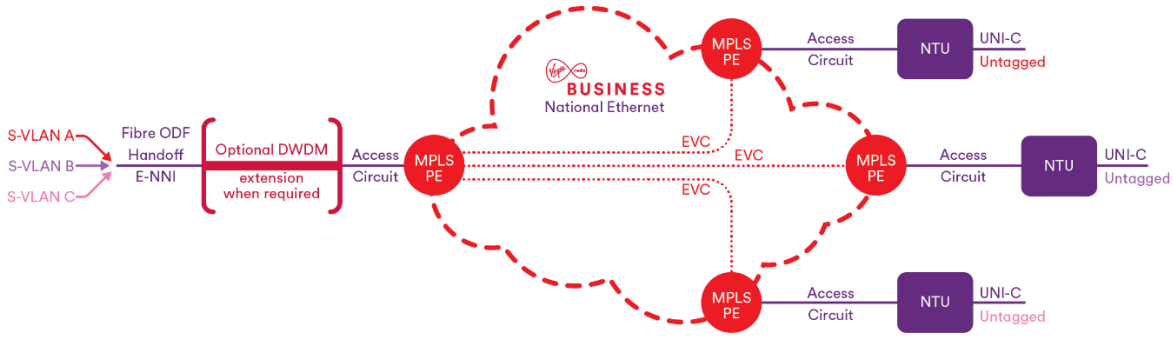
2.5 Direct E-NNI (External-Network to Network Interface)

There are a number of features that differentiate a Direct E-NNI from a NTU terminated E-NNI making it aimed at Service Providers and Network Operators as opposed to enterprises and large organisations requiring multiple circuits at a single site.VMB's Direct E-NNI solution connects customers networks directly into the MPLS PE switch without an NTU, this provides the following benefits;

- VLAN tagging flexibility-choice of Ethertype to determine S-VLAN or C-VLAN
- Hair pinning support- back to back Ethernet switching
- Greater frame transparency
- Less space & power required in customers racks- delivered via fibre only or layer 1 NTU
- Oversubscription

The Direct E-NNI benefits from the features above, however VMB's standard solution with a managed NTU at each end of a circuit also benefits from detailed diagnostics on the NTU, performance reporting as well as other OAM based features which may be launched at a future date. By using the Direct E-NNI one set of benefits are traded off for the other.

All frames on the E-NNI will be tagged with a multiplexing tag including layer 2 control protocols.



Direct E-NNI

Where VLAN tagged framed are presented to the UNI at the spoke sites they will emerge from the E-NNI with the additional S-Tag and the original tag underneath.

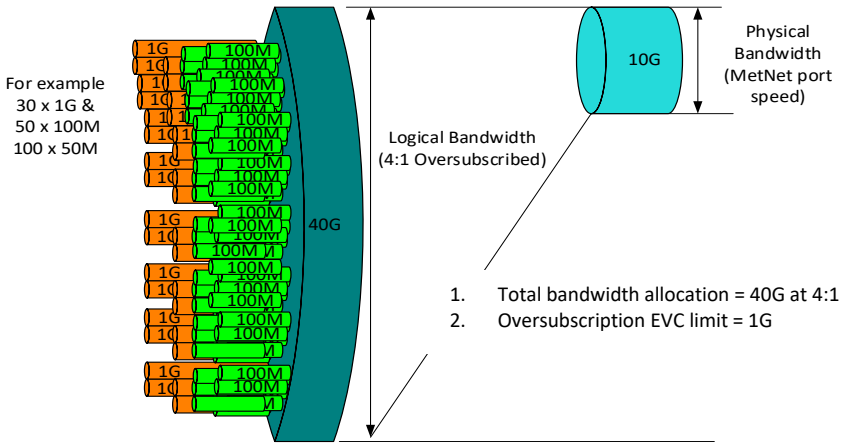
2.6 E-NNI Oversubscription

Oversubscription enables an E-NNI to be configured with mutliple services whose bandwidth exceeds the port bandwidth. This is standard industry practice for efficient use of resources through the statistical multiplexing principle where most circuits don't use all their bandwidth at the same time therefore there is spare capacity to add more services without degrading any of the services.

A sales agreement is required to use oversubscription to indemnify VMB from packet loss responsibility if the feature is misused and it comes with 2 pieces of guidance to reduce the risks of over-ultisation which leads to packet loss;

1. No individual service should be greater than 10% of the port bandwidth. For example 1Gbps is the maximum individual service bandwidth on a 10G E-NNI. This Is a recommendation, however each customer Is free to assess their own risk level based on their traffic profile and may exceed 10% If specified on the sales agreement.

2. The oversubscription ratio must be specified on the E-NNI order, or subsequent change request so that capacity management systems can record it. i.e to enable 40Gbps total (such as 40 x 1Gbps services) on a 10Gbps port, then it has 4:1 oversubscription.



3. Access Circuit Configurations

3.1 General

Virgin Media Business operates its own fibre access network and will unless specifically requested by a customer, seek to utilise this network in the provision of the National Ethernet service. All on-net circuits will be physically delivered via a 1 Gbps bearer circuit to allow rapid upgrades in speed. Customers may purchase access speeds of on-net circuits from 100 Mbps, 1 Gbps and 10 Gbps

In certain circumstances Virgin Media will offer to provide a third party access tail to support a service when using VMB's own network is not feasible. Currently the suppliers of choice are BT Openreach, BT Wholesale, Vodafone and TalkTalk Business. Off-Net circuits can be physically delivered via 100 Mbps or 1 Gbps.

If a third party access circuit is used, VMB will continue to provide a fully managed solution, presenting its service using a VMB NTU device. This NTU will be in addition to any NTU that the third party supplier provides as part of the access circuit.

Access Circuit	Ethernet Virtual Connection Rate (EVC)
On-Net	
100 Mbps [1]	2, 4, 6, 8, 10, 20, 30, 40, 50, 60, 70, 80, 90 & 100 Mbps Ethernet
1000 Mbps (1 Gbps)	100, 200, 300, 400, 500, 600, 700, 800, 900 & 1000 Mbps Ethernet
10Gbps*	1, 2, 3, 4, 5 & 10Gbps Ethernet
Off-Net	
10 Mbps	2, 4, 6, 8 & 10 Mbps Ethernet
100 Mbps	10, 20, 30, 40, 50, 60, 70, 80, 90 & 100 Mbps Ethernet
1000 Mbps (1 Gbps)	100, 200, 300, 400, 500, 600, 700, 800, 900 & 1000 Mbps Ethernet

Ethernet Virtual Connection Rate (EVC) = Transmission rate available to customer over the allocated Access Circuit. Third party access circuits maybe used at on-net sites to gain a level of diversity between two circuits, please see appendix C for further details.

- [1] 100 Mbps is the contracted Access Circuit bandwidth, it will be built on 1000 Mbps for future rapid upgrade capability.

3.2 Connecting the service to a customer network

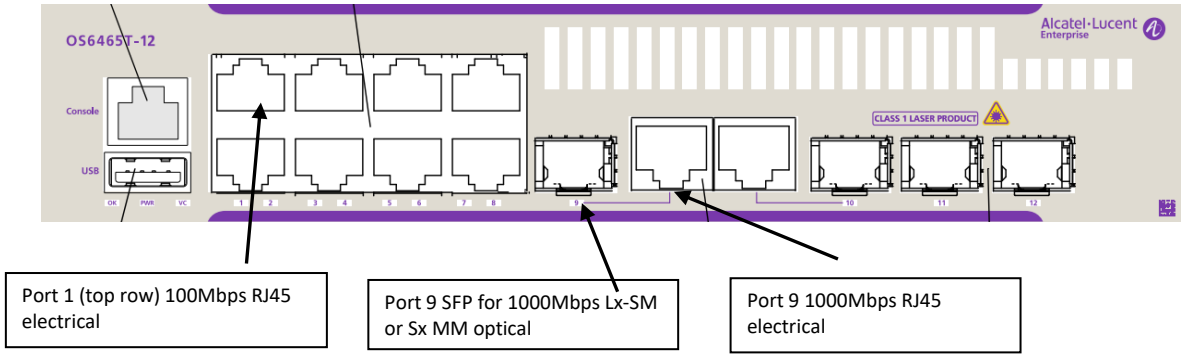
The service demarcation point is the relevant enabled Ethernet port on the NTU. This will either be a RJ45 10/100 port or 1000Mbps SFP based port.

Circuits purchased with a 1000Mbps Access Circuit can specify their 1000Mbps physical interface to be delivered as 1000Base-T RJ45, 1000Base-Lx SM, or 1000Base-Sx MM.

Circuits purchased with a 100Mbps Access Circuit can choose to have it delivered on a 100Mbps RJ45 interface or select a 1000Mbps interface to enable hands free upgrades in the future if their equipment has a corresponding 1000Mbps interface. The 1000Mbps interface types are as stated above and will need to be specified on the order.

Customers who choose delivery on 100Mbps RJ45 will have their circuit delivered on both 100Mbps RJ45 as requested and 1000Mbps RJ45 . The circuit will be live and active on both ports which enables the customer to change their chosen interface at any time and permits the purchased bandwidth to be upgraded above 100Mbps remotley without the need for a VMB site visit.

The handover ports will be confirmed on the Brought Into Service (BIS) certificate.



Note that orders for 100Mbps Access Circuits will be delivered using 1000Mbps ports within the VMB network to enable rapid upgrades of purchased bandwidth upgrades in future.

The appropriate port(s) on the NTU should be connected directly to the customers LAN either to a switch port or router and the connected ports should be set to fixed speed and full duplex.

Both Off Net and On-Net Access Circuits will be set to either 100Mbps or 1Gbps.

Fractional bandwidths, for example 20Mbps over a 100Mbps access circuit are policed and rate limited on Ingress to the MPLS network, excess traffic will be discarded at this point and QoS applied where requested.

It is highly recommmended for performance reasons for Customers to apply admission control limiting traffic egress from the customer's local environment to the Ingress into the VMB NTU.

All Ethernet broadcast frames reaching the NTU port will be delivered across the circuit.

Unicast frames to MAC addresses learnt across the network will also be transported over the circuit. The circuit is layer 2 and is unaware of IP addresses; therefore any required routing is the responsibility of the customer.

If the remote site(s) are in different IP subnets, then the customer will normally need to provide a router or layer 3 switch to communicate with the remote devices and it is suggested routing is performed across the link to manage potential routing issues.

Auto-negotiation is set to 'No' as default within the VMB Network and can not be changed.

3.3 Third Party access circuits

Virgin Media Business offer local access circuits through BT Openreach and a national reach access through BT Wholesale (Wholesale Ethernet), Vodafone, and TalkTalk Business.

These 3rd party operators deliver connectivity between your site and a VMo2 network site where the Ethernet Virtual Connection will be carried across the VMo2 network to the other access circuit/ E-NNI.

Please refer to Service Level Agreement for variation in availability SLA.

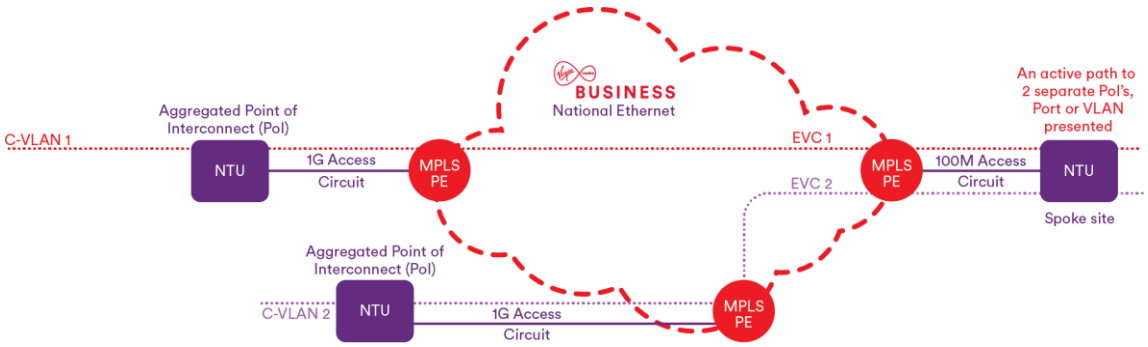
4. Service Options

4.1 Active / Active Single NTU Resilience (aka shadow VLAN)

Diversity options for services that require separation are detailed in appendix C. These diversity solutions range in complexity and some will require non standard quotation and/or delivery.

Where a single service is supplied that requires additional resiliency over and above the MPLS network protection described in section 1.3, the Virgin Media can offer active/active single NTU resilience, aka a shadow VLAN.

A customer's service will be provided with two Ethernet Virtual Connections (EVC's) between their B-end and their two aggregation sites. These can presented at the B-end NTU service multiplexed as VLANs on a single port or two Port-based interfaces. Each EVC will be of the same bandwidth. Any upgrade, downgrade cease or amendment will apply to both EVC's.



The customer's router or switch will be in control of which path their traffic takes. During a failure of the EVC1 path, routing convergence (or HSRP/VRRP) will move their traffic to EVC2.

In the example above, customer's traffic could fail-over to a redundant interconnect after loss of connectivity to the primary interconnect.

This service is available up to the full bandwidth of the access circuit, for example a resilient 100Mbps service on a 100Mbps Access Circuit will be configured with 2 x 100Mbps EVC's. This allows the full bandwidth of the access circuit to be utilised over a single EVC with a routing protocol only running over the backup path. This configuration is dependant upon the customer controlling the bandwidth used on each EVC to avoid causing frame loss occurring, for example 2 x 100Mbps=200Mbps would result in discards severely impacting performance on a 100Mbps access circuit.

The customer may use either EVC as the primary path or backup path or load share across both providing the sum of the bandwidth used on both paths does not exceed the purchase bandwidth, i.e., if loads-sharing with a 80Mbps service only 40Mbps is available on each path.

4.2 Class of Service Options

VMB has implemented Edge QoS which allows traffic to be managed according to its priority at the edge of the network should the purchased bandwidth be exceeded.

VMB provides uncontended passage across its core network for all business services. During temporary backbone fault conditions some contention may occur on Standard class data. Traffic classified with any other class using a Edge QoS template will remain uncontended under fault conditions. Irrespective of the above the Ethernet services have an SLA target of 99.9% packet delivery for all classes of service.

Traffic priority is determined by examining the customer allocated 802.1p priority bit value. It is important if double tagging is used that the 802.1p bit in the outermost tag is carrying the customers required priority. The model below is used to manage the 7 classes.

802.1p Values	Name	CIR/PIR recommendations	Core CoS / queue
6	Customer Control	CIR = PIR	Critical Data 1
5	Real Time 1	CIR = PIR < 50% of link BW	Realtime 2
4	Application 1	0 < CIR < PIR =< link BW	Critical Data 1
3	Application 2	0 < CIR < PIR =< link BW	Critical Data 1
2	Application 3	0 < CIR =< PIR =< link BW	Critical Data 1
1	Application 4	0 < CIR =< PIR =< link BW	Critical Data 1
0	Standard	0 =< CIR =< PIR =< link BW	Standard 0

From the base QoS/CoS settings six default templates have been constructed to enable simple customer choice. These templates are as follows;

- **Classic** – historical National Ethernet settings with a single data class, therefore no differential QoS is supported
- **Standard CoS** – the basic classification providing QoS support
- **Complex Data Environments** – for advanced data environments with different identified application types
- **Converged Applications** – mixed simple data and voice environments
- **Multi-Media Application** – voice and video centric environments with simple data
- **Advanced Environments** – next generation application aware environments, with managed CPE control elements covering voice, video and mixed data applications.

The individual percentage allocations within the templates can be varied by agreement with Presales Consultants, but is limited by design rules. Time of day profiles may also be requested with different bandwidths being allocated to classes dependant upon a pre agreed template for bandwidth and time of day.

The detailed configurations for these templates are as follows.

- CIR is Committed Information Rate
- PIR is Peak Information Rate
- % refers to the percentage of the EVC bandwidth
- The applications noted in the comments column of each template are examples to enable discussion and for information only.

Template Name	Class Name	802.1p Settings	CIR (%)	PIR (%)	Comments
Classic	Standard	0	100	100	All data types
Standard	Application 3	2	60	100	Oracle/SAP
	Standard	0	10	100	E-mail & Internet
Complex Data Environments	Application 2	3	30	60	Mainframe (e.g. SNA Environments)
	Application 3	2	20	60	Oracle/SAP
	Application 4	1	20	80	E-mail
	Standard	0	10	100	Internet
Converged Applications	Real Time 1	5	40	40	Voice
	Application 3	2	30	100	Oracle/SAP, SIP Trunking
	Standard	0	10	100	Internet and E-mail
Multi-media Application	Real Time 1	5	30	30	Voice
	Application 1	4	20	20	Video Broadcast and Conferencing
	Application 3	2	20	100	Oracle/SAP, SIP Trunking
	Standard	0	10	100	Internet and E-mail
Advanced Environments	Customer Control	6	2	2	CPE Management
	Real Time 1	5	25	25	Voice
	Application 1	4	20	20	Video Broadcast and Conferencing
	Application 2	3	10	30	Mainframe (e.g. SNA Environments)
	Application 3	2	10	30	Oracle/SAP
	Application 4	1	10	100	E-mail
	Standard	0	3	100	Internet

If no template is requested, services are implemented with the default template, 'Classic'. This template does not provide for differential treatment between differing customer-marked Ethernet traffic but will transparently carry 802.1p markings. Any 802.1p markings presented to the service with Classic template cannot be re-mapped between inner & outer tags, therefore customer equipment using Service Multiplexing and using 802.1p QoS will need Q-in-Q capability to read the markings from the inner tag.

For templates other than Classic the 802.1p QoS markings will be transparently carried with frames across the circuit and re-mapped to a Service Multiplexing tag where appropriate.

If modifications to the QoS templates are required the following design rules will be observed.

No more than 80% of link bandwidth can be reserved (CIR) amongst the queues. Any class can use the unreserved bandwidth, as long as it is not consumed by overheads.

No more than 50% of link bandwidth must be assigned to the Real Time traffic (Voice and Video, with the exception of a voice or video only solution).

If a pure IP Telephony solution is offered, the Real Time can be provisioned at 70% maximum. A further 10% may be reserved for signalling plus OAM&P. 20% must remain unallocated (0% CIR). The critical classes should not be used.

For circuits below 10Mbps, Real Time Video should not be used alongside voice in the Real Time class. This is due to the associated negative impact on the Voice SLAs. The video traffic will need to be placed in a lower class (this may have an impact on their video service as only a single real time queue can exist) or the circuit EVC bandwidth increased.

All QoS profiles must contain the Standard class (with PIR = 100%). This parameter is used by the performance monitoring platform to define the speed of the link in customer reports and so will enable Performance statistics to be gathered correctly.

If traffic is marked with a 802.1p bit not supported within the assigned template, then this traffic will be placed in the standard queue.

The Classic CoS template is the default; other templates are chargeable options that should be specified on both quote request and order.

In the event that the customer equipment connecting to the NTU has not implemented rate limiting or QoS , and the purchased bandwidth is exceeded by greater than 20%, then additional rate limited maybe performed on the NTU to protect the VMB network edge from contention.

4.3 Transport of Layer 2 Control Protocols

VMB's NTU's & network will pass Layer 2 control protocols (L2CP) unchanged .

The table below describes how VM would implement control frame tunnelling. Pass means the L2CP frames are passed through the VM network and Discard means the frames are dropped without being forwarded.

Protocol	Default
STP	Pass
OAM (Link 802.3ah)	Pass
GVRP	Pass
LLDP	Pass
RSTP	Pass
LACP	Pass
LACP Marker protocol	Pass
802.1x/EAPOL	Pass
PAUSE (802.3x)	Discard
GARP	Pass
MSTP	Pass
STP Fast Uplink	Pass
CDP	Pass
PVST/PVST+	Pass
PagP	Pass
VTP	Pass
UDLD	Pass
VLAN Bridge	Pass

Although not a L2CP in the same sense as the above protocols, Y.1731 Service OAM frames are passed without the need for tunnelling however VMB reserve OAM MEG Level 4 for its own use. Therefore customers may pass service OAM frames using MEG levels 5-7.

Older Ethernet services provided via World Wide Packet NTU's use a different method of L2CP tunnelling, the Alcatel NTU's are backward compatible with the method. Further information can be found in the Legacy Features addendum to this document available on request.

Hairpin switching- This operation is supported at Wires only ENNI but not supported at UNI's as standard. Hairpin switching can be a result of a customer device Ethernet switching a frame back out of an Interface with a different VLAN it was received on, or by using the same virtual mac-address on more than one logical Ethernet circuit on the same Interface. Virtual Router Redundancy Protocol (VRRP) is an example of this and can be overcome by changing the default virtual mac address to a unique value.

Layer 2 Control Protocols – via Third Party Access Circuits

Certain third party access circuits may not pass all Layer 2 control protocols. Specific guidance is provided for TalkTalk Business in Appendix D.

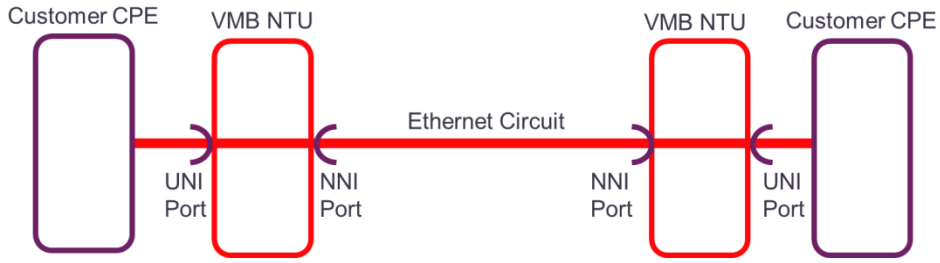
5. Further information

5.1 Remote loopback

To help check new services and to speed up fault finding National Ethernet circuits now includes a loopback feature on the NTU's. These enable the customer to perform standard Ethernet tests to the near end and far end of a circuit.

Key features of the remote loopback

- The loopback is non service affecting and permanently on therefore requires no process or portal to turn it on/off.
- Delivered and activated by default, no need to quote, order or activate it/ deactivate it
- Full service bandwidth supported enabling throughput testing, test traffic will follow the same path as user data and be subject to the same QoS controls
- Customer integration simply involves configuring test equipment with a unique destination mac address shown below.
- Can be operated through direct connection to NTU or remotely through your own network connected to the NTU
- Can be operated on Port presented (UNI) services and Service VLAN based (E-NNI) services

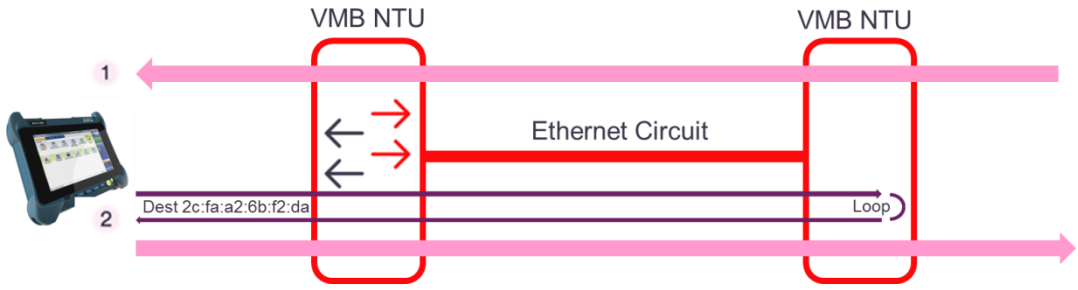


Each NTU has 2 x directional loopbacks, one returns traffic from the local customer connected port (UNI) and the other on the Network connected port (NNI) returns traffic from the remote end.

UNI loopback returns traffic sent to destination mac address 2c:fa:a2:87:ce:b0

NNI Loopback returns traffic sent to destination mac address 2c:fa:a2:6b:f2:da

Loopbacks in practice



1. With the loopback applied customer traffic flows in both directions as normal, unaffected by the loopback
2. Test traffic with a unique destination address will be returned with source & destination address swapped

A video guide to setting up test equipment to operate around these loops can be streamed from here

Compatible NTU's

This feature is available on all currently deployed NTU's, however it is not available on older equipment, non-standard solutions or Direct E-NNI interconnects that have no NTU. The tables below identify which NTU's are supported or not. A non-compatible NTU at one end will not prevent loopback works to the compatible end.

All the NTU's installed since June 2020 have the new firmware code and loopback feature.

Compatible NTU's on older firmware will require a firmware update to use loopbacks. This incurs an approximate 5 minute downtime and will be performed as standard procedure during VMB fault diagnosis and during a bandwidth upgrade.

Non compatible NTU's don't have loopbacks but will pass test traffic destined for a compatible NTU.

Compatible NTU's

	NTU	Notes
	Alcatel 6465T-12	Standard since 2024
	Alcatel 6570-12	Standard since 2024
	Alcatel 6570-U28	Standard since 2024
	Alcatel 6250-8M	Delivered between2012 to 2023
	Alcatel 6250-24M	Delivered between 2013 & 2022
	Alcatel 6450	Delivered between 2018 & 2023

Non compatible NTU's

	NTU	Notes
	E-NNI (no NTU)	Preferred Interconnect
	WWP LE 46/311	Last deployed 2012
	Accedian EDU5	Non-standard
	ALU 6850	Last deployed 2017

Loopback FAQs

- How will we know if a particular circuit is enabled with the loopback?
  - ✓ If your loopback test fails it could be due to a fault or there being no loop configured. If you believe there is a fault then log it with the FMC who will upgrade & apply loopback as part of their fault process
- Can the loopback be applied to older circuits?
  - ✓ Yes on compatible NTU's, it will require an NTU reboot therefore will be treated as an in-life circuit change and require an order
- How does the test engineer select the right circuit to test?
  - ✓ Through connecting the UNI port or configuration of Service Provider test equipment to a service VLAN
- Can this run tests or just enable tests?
  - ✓ The loopback enables a customer's own equipment to run tests, testing is not provided by VMB
- Can the firmware update & loopback config be applied during a fault scenario logged with FMC ?
  - ✓ Yes- the standard fault response is to ensure every NTU is running the latest firmware and any action performed on the NTU will result in the loopbacks being applied
- An A end test does not check the service bandwidth, why not ?
  - ✓ A test run over the interconnect to the A end NTU is looped back before reaching the MPLS PE router where the bandwidth control is, therefore the A end test is to be used to confirm interconnect integrity and correct function of test equipment before testing to the B end

5.2 MTU sizes

National Ethernet circuits are configured to allow customer frames of up to 2036 bytes as standard although the Service level agreement commits to a minimum of 1544 bytes to allow for some limitations.

These are where;

1) BT Openreach WES circuits (1544) or BT EAD (1996) are used for local access.

2) TalkTalk Wholesale Ethernet circuits (1994) are used for local access.

Note that VMB place a 4 byte overhead on each frame on the access circuit, therefore the MTU size available to the customer is the access circuit MTU less 4 bytes.

BT Openreach WES is no longer available for new sales therefore the minimum MTU would be 1994 with a TTB tail. If you require higher than 1994 bytes then check with your account team if any of these limitations apply.

If you require higher than 2036 bytes, please discuss with your Sales Engineering consultant. Where larger MTUs cannot be provided across National Ethernet, High Capacity Services and Ethernet Extensions products are available with a larger MTU size in excess of 9000 bytes.

5.3 Throughput

There is a small variation in actual throughput depending upon the frame size due to a 4 byte VLAN header added by the NTU to identify originating NTU port. These 4 bytes in every customer frame have negligible affect with normal traffic patterns. The table below shows typical throughput figures from actual circuit tests for a policed circuit at different frames sizes. The typical use of a circuit will in practice have a mixture of frames sizes with an expectation of 99% throughput or greater.

Frame size (Bytes)	Throughput (%)
64	95%
128	97%
256	98%
512	99%
1024	99%
1280	99%
1518	99%

Example throughput of Policed Ethernet with 4 byte overhead

In addition to customers own data there is a very small amount of NTU management data periodically running in the access circuit, the VMB network separates management data from customer data before the bandwidth policing is done, therefore this data has no impact on bandwidth policing.

Exceptions

Raw Ethernet versus policed Ethernet throughput

An Ethernet circuit whose bandwidth is less than the physical circuits carrying it (i.e. a 20Mbps circuit on 100Mbps port and Access Circuit) has its throughput determined by VMB bandwidth policing. Policing is done on actual frame data throughput excluding the interframe gap and preamble and the throughput should be similar those in the table above. An Ethernet circuit whose bandwidth is the same as or close to the physical circuits carrying it (i.e. 100Mbps circuit on a 100Mbps port and Access Circuit) will have its throughput determined by the limits of raw Ethernet which include an equivalent of 20bytes of overhead caused by interframe gap and preamble. This will be lower than policed bandwidth throughput and the same as simply having an Ethernet cable between devices. The table below shows the calculated raw Ethernet throughput for various frame sizes.

Raw Ethernet frame size inc. IFG & Preamble (Bytes)	Frame size (Bytes)	Throughput (%)
84	64	76.19%
148	128	86.49%
276	256	92.75%
532	512	96.24%
1044	1024	98.08%
1300	1280	98.46%
1538	1518	98.70%

Calculated throughput including Interframe gap & preamble

Therefore a National Ethernet circuit with port speed greater than purchased bandwidth will have greater throughput than a raw Ethernet circuit despite the 4 byte overhead for Network control.

The added benefit to all on-net circuits being built on 1 Gbps access ports is that a higher throughput of upto 20% can be gained in 100M purchased bandwidth when ordered with 1 Gbps physical interfaces.

Bandwidth Policing & TCP windowing

Customers using TCP/IP should be aware that when their circuit has bandwidth lower than the physical port speed facing the NTU, TCP flow control can work poorly if the actual bandwidth exceeds the purchased bandwidth. This is because the TCP window size would be appropriate for a 100Mbps link not a 20Mbps link. If the circuit is over subscribed with frames being discarded, it can result in a reduced throughput as the TCP stack on customer's devices attempts to manage throughput by reducing window size/ throughput. Therefore it is advisable that customers perform their own queuing, policing or rate limiting such as Committed Access Rate 'CAR' or Shaped Round Robin 'SRR' on the device connected to the NTU using the same bandwidth as the purchased circuit which will improve throughput.

Packet Delivery versus Throughput

Throughput figures should not be confused with 'Packet Delivery' stated in the SLA. Throughput is a rate of delivery expressed as a percentage of the purchased bandwidth. Packet Delivery is a measure of the percentage of frames transmitted at one end of the circuit being received at the other, also known as frame loss.

For further information on carrier Ethernet throughput please ask Technical Pre Sales or BSG for a copy of the Metro Ethernet Forums white paper on Bandwidth throughput Testing.

5.4 Test & Handover

Circuits are tested prior to handover to the customer to prove connectivity and performance. Below is a brief outline of the tests conducted.

- Visual inspection of NTU & cabling
- BERT G.826 for 20 minutes to check for frame loss
- RFC2544 tests for latency, jitter & frame delivery, data passed at maximum EVC bandwidth
- End to end for point to point (EPL) services
- End to spare NTU port for point to multipoint (EVPL) services so not to disrupt existing services on same port.

Additional tests are run on circuits with CoS to prove the CoS implementation.

Once tests have been successfully completed the customer is issued with a Brought Into Service (BIS) certificate as a formal handover of the circuit.

See Appendix B for details of the BIS Certificate.

For VLAN presented services the 1st service on a port will be tested as above to prove the port is error free as well as the circuit. Once live services are running on a port subsequent VLAN based services to the same port will be presented at a test port for testing towards the B end then reconfigured back to the customer facing port to avoid disrupting existing services.

5.5 Security Compliance

VMB have developed our National Ethernet services in line with industry best practice. The services have been externally audited by UKAS accredited auditors and are ISO 27001:2013 certified. In order to support the needs of our significant Public sector install base, we have committed to maintaining our services to be

compliant with appropriate CESG guidance, allowing us to provide customers with solutions that are capable of transmitting traffic up to UK HMG Government Security Classification of OFFICIAL.

Traffic may include more sensitive data caveated at OFFICIAL-SENSITIVE where approved by the system owner. The Government Security Classifications (GSC) policy states that OFFICIAL-SENSITIVE should 'still be managed within the "OFFICIAL" classification tier, but may attract additional measures (generally procedural or personnel)'. The GSC does not define these 'additional measures' but leaves it to the data or system owner to decide as the 'controls will be data and system dependent'. Therefore we are able to handle information marked at OFFICIAL-SENSITIVE in accordance with our existing information management policies and commercial good practice, which comply with GSC guidance for OFFICIAL classification.

This capability is achieved by having our network services are assured to CAS(T), which is a CESG approved assurance scheme that builds upon our ISO27001:2013 Certification by mandating specific physical, personnel, procedural and technical security controls relevant to a communications services provider. CAS(T) demonstrates compliance to CESG Security Procedures Telecommunications Systems and Services, which are designed to enable Communications Providers to provide assurance to customers that their telecommunications systems and services are adequately protected against risks to the confidentiality, integrity and availability of information classified as OFFICIAL. The customer should advise that a CAS(T) certified network is required so that VMB can ensure the premises housing the relevant network switches have been security hardened and any 3rd party providers used are also CAS(T) certified.

6. Appendix A NTU Configurations

6.1 Summary

Under normal circumstances VMB will use the following NTU's for delivery of Ethernet services at the customer site. The NTU names in bold align with options in VMB quote & order systems & process but the actual devices supplied are periodically updated to keep up with vendor lifecycle events. This document shows the current devices supplied.

- **Alcatel 8 Port-** Alcatel-Lucent OS6465T-12 (Single AC PSU Version)
- **Alcatel 24 Port** Alcatel-Lucent OS6570-U28 (Single AC or DC PSU version)
- **Alcatel High bandwidth**- Alcatel-Lucent OS6570-12 or 12D (AC or DC single PSU version)

All NTU's come with single power supply unless a backup was specifically requested as part of the quote and order.

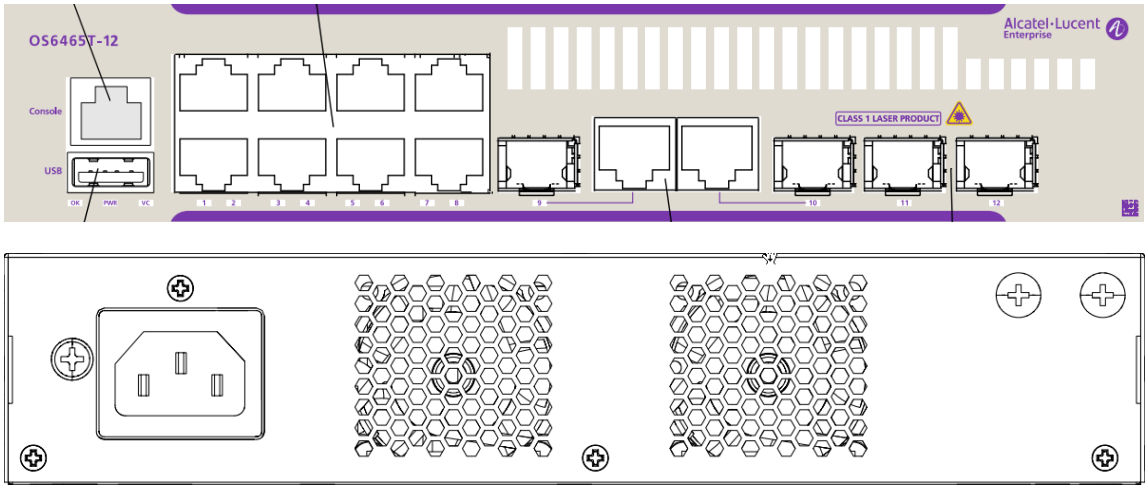
In addition to the models above a compact hardened device (6465-P6) is available for 1Gbps services with DIN rail mounting. This is currently only availabe for non-standard bids through Account managers & Sales Engineering.

6.2 Alcatel 8-Port - Alcatel-Lucent OmniSwitch 6465T-12

The 6465T-12 can deliver up to 4 x 1Gbits/s services, has a single internal AC power supply and is temperature hardened to operate between -10ºC to +60ºC.

There are 8 x 10/100/1000Base-T ports to use as customer facing ports.

It has 2 x 1000base-X SFP ports and 2 x combo ports that can either operate as fixed RJ45 10/100/1000BaseT or as SFP at 100/1000Base-X. These can operate as network facing links and / or customer facing ports.



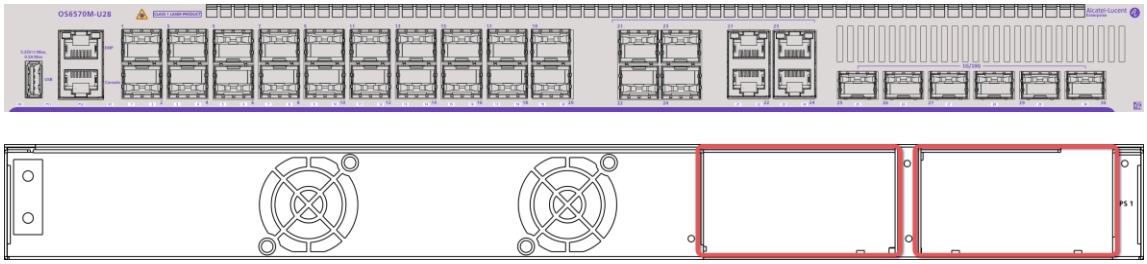
Component	Description
Total 10/100/1000Base-T ports	8 (1-8)
Total combo 10/100/1000Base-T / 100/1000Base-X ports	2 (9-10)
Total 1000Base-X ports	2 (11-12)
Chassis Width	217.4mm
Chassis Height	44mm (1RU)
Chassis Depth	280.7mm
Chassis Weight	1.78kg
Power Consumption (idle)	16W
Operating Humidity	5% to 95% non-condensing
Storage Humidity	10% to 95% non-condensing
Operating Temperature	-10°C to +60°C
Internal Temperature Range	-15°C to +77°C
Input Voltage Range	100-240V AC

6.3 Alcatel 24-port - Alcatel-Lucent OmniSwitch 6570-U28

The 6570-U28 can aggregate up to 24 x 1Gbits/s services or up to 3 x 10Gbits/s. It is supplied with single AC or DC power as standard and upon request can be supplied with a backup AC or DC power supply.

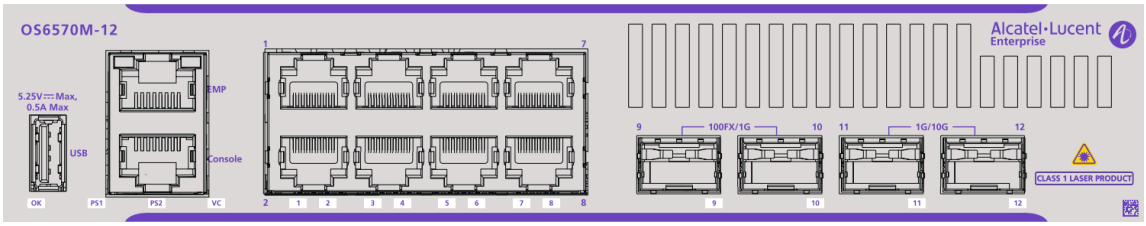
There are 24 x 100/100Base-T customer facing ports and the 6 x 10Gbits/s SFP ports can be network facing links and / or customer facing.

It has 4 x combo ports that can either operate as fixed RJ45 10/100/1000BaseT or as SFP at 100/1000Base-X. These can operate as network facing links or customer facing ports.



Description	Value
Total 10/100/1000Base-T ports	20 (1-20)
Total combo 10/100/1000Base-T / 100/1000Base-X ports	4 (21-24)
Total 10GBase-X ports (2x 10G enabled without license)	6 (25-30)
Chassis Width	440mm
Chassis Height	44mm (1RU)
Chassis Depth	350mm
Chassis Weight	4.08kg
Power Consumption (idle)	71W
Operating Humidity	5% to 95% non-condensing
Operating Temperature	0°C to +50°C

6.4 Alcatel High Bandwidth - Alcatel-Lucent 6570-12



The 6570-12 can deliver up to 4 x 1Gbits/s services and a single 10Gbits/s. Both AC & DC powered variants are available and upon request can be supplied with a backup AC or DC power supply.

There are 8 x 10/100/1000Base-T ports to use as customer facing ports.

It has 2 x 100/1000base-X SFP ports and 2 x 1G/10Gbits/s ports. These can operate as network facing links and / or customer facing ports.

Description	Value
Total 10/100/1000Base-T ports	8 (1-8)
Total combo 10/100/1000Base-T / 100/1000Base-X ports	2 (9-10)
Total 10G Base-X ports	2 (11-12)
Chassis Width	217.2mm
Chassis Height	44mm (1RU)
Chassis Depth	280.7mm
Chassis Weight	1.7kg
Power Consumption (idle)	23W
Operating Humidity	5% to 95% non-condensing
Operating Temperature	0°C to +50°C

7. Appendix B Example of a BIS certificate

Brought Into Service (BIS) Certificate

Customer details

Customer:	
Site:	
Date service ready for use:	

Please keep these details in a safe place - they'll be a useful reference if you need to get in touch with us.

Service information

Circuit reference:		Service:	National Ethernet Service
Force reference:			
Faults reference:			
Bandwidth:			

A-end information:	Address:	

B-end information:	Address:	

Additional information:	

We've handed your service over for in-life support. If you have any questions, please call our Customer Services team on **0800 052 0800**, or email **businesscustomerservices@virginmedia.co.uk** and they'll be happy to help.

Thanks for choosing Virgin Media Business.

Yours faithfully,

8. Appendix C Diversity

It is possible to have two diverse connections to the Virgin Media network from a single site allowing diverse circuits to be designed. VMB have defined a number diversity options to allow balancing of diversity and price requirements. Most diversity requirements are handled as non-standard requests, the information below is a guide to enable discussions with your Account Manager.

These diverse circuits will provide 2 paths with minimal likelihood of being affected by the same fault. The responsibility of traffic routing over the circuits is fully under the customers control whether that be Main Circuit/ backup circuit or load sharing/ link aggregation setup.

Within the MPLS network traffic will take follow the least cost path to the destination which will be protected as described in section 1.4. This does mean that unless engineered otherwise, traffic may share a common protected path for part of the route.

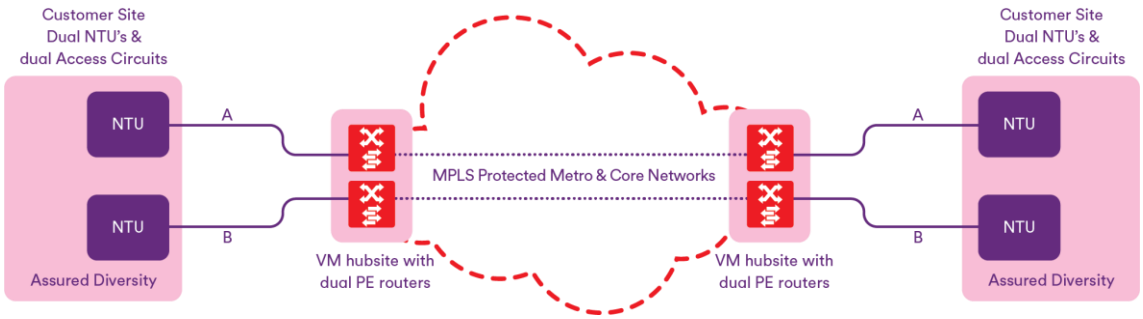
There are 4 topology types defining how customer sites connect to equipment in Virgin Media hub sites and 4 choices of how the access circuits between customer sites and Virgin media hub sites are provided. A pair of circuits may have a different topology and access circuit configuration for A & B ends of the circuits.

Type	Access Circuit Configurations	Description	Notes
1	On-net / on-net electrical diversity	Separate NTUs. Separate fibre cores, maybe same fibre cable/duct	Standard Product
2	On-net / off-net supplier diversity	Separate NTUs. One VM Access Network cct, one 3rd party Access cct, no shared fibre or duct or building entry	Standard Product, ensure 2nd cct is 3rd Party
3	Off-net / off-net diverse	Separate NTUs. Both ccts provided by 3rd parties to be diverse to the VM hubsite/s	Non-standard Pricing
4	On-net / on-net diverse	Both ccts provided by VM Access network, separate fibres, duct & building entry, unless agreed otherwise	Non-standard design & pricing. Subject to feasibility; additional build costs.

Type	Topology	Description	Notes
1	Assured Diversity	Access ccts to same hubsite, different MPLS PE routers terminate each access cct	Standard Product – notes needed on order form to specify separate PE router connections
2	Assured Separation	Access ccts to separate hubsites	Standard Product, Sales Support to select separate hubsites. The hubsites may share a common core MPLS node, diverse core connection may be possible upon request.
3	Partial diversity	Access ccts share hubsite, shared PE in hubsite. For location where assured Diversity is not available.	Standard Product. Where sites have a single PE router, that PE is typically of a high availability architecture
4	Different B-ends	Where A ends need diversity by B end are different sites	Standard Product

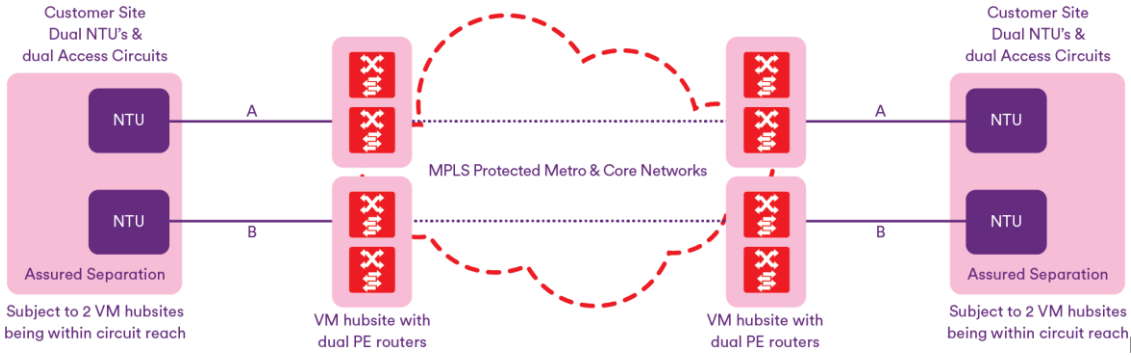
8.1 Assured Diversity

Assured diversity is available where VM have 2 PE routers within the same hubsite. These PE routers are dual powered and may reside in the same room & rack.



8.2 Assured Separation

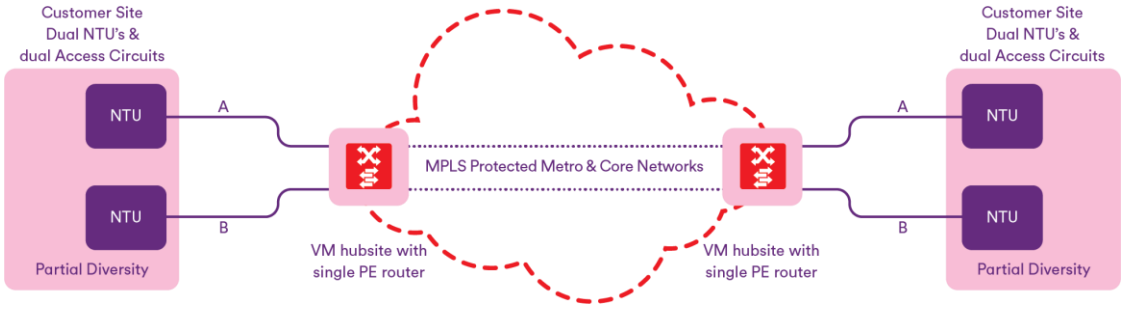
Assured separation is available where 2 VM hub sites are within reach of VM local access fibre and/or 3rd party circuit reach, usually 25km radial distance.



For National circuits, in most cases the A & B connection to 2 VM hub sites will share a dual fed connection between the MPLS Metro area and the core MPLS network causing an MPLS protected common point. In some cases diversity can be maximised by providing A & B connections to VM hub sites that connect different MPLS core nodes, this is available subject to access circuit distances.

8.3 Partial Diversity

Partial Diversity is available where there is a single PE router in the serving VM hub site therefore Assured Diversity cannot be provided, but access circuit diversity can still provide benefit.



8.4 Different B ends

Different B ends can be provided where the A end uses any of the above topologies.

For further information on diversity please call your technical contact in Virgin Media or your Account Manager.

9. Appendix D Layer 2 Control Protocols Third Party Access

TalkTalk Business

The interconnect between TalkTalk Business network and VMB network is not entirely transparent to Layer 2 control protocols. The Ethernet services sold by Virgin Media Business are transparent, so when a Virgin National Ethernet service has its reach extended using TalkTalk Business that transparency may be lost, restricting what customers can use it for.

To overcome this limited transparency Virgin Media Business can use a feature known as mac-tunnelling to hide the L2CP from the TalkTalk Business network allowing them to pass. This is dependant upon having a Virgin Media NTU at both ends of the circuit that is setup to perform mac-tunnelling. The default configuration on most VMB NTU's is for all circuits on an NTU to be transparent and not mac-tunnel, this can be changed with limitations in a number of scenarios:

A) Where an existing 6850 NTU is used for hub & spoke circuits then any existing circuits are likely to be setup as transparent, to add a circuit that needs mac-tunnel may require not just the 6850 NTU to be reconfigured but all spoke NTU's causing minor downtime and risks of NTU's not reloading correctly. Where a Direct E-NNI is used then mac-tunnelling is not an option. The recommended solution to this issue is to use a separate hub NTU dedicated to mac-tunnel mode for TalkTalk Business access circuits and ensure the NTU is only used for TalkTalk business tail circuits, but see scenario C below.

B) Some customers such as service providers use L2CPs with multiple VLAN tags, the mac-tunnel method will not support a double tagged control frame and TalkTalk Business should not be used until they can at a future date make their network transparent.

C) The mac-tunnel method has limitations on the number of L2CP frames it can process, this will limit the number circuits that can use tunnelling on an NTU. Cisco PVST protocol has been known to exceed these limits on a single circuit.

D) The Generic Bridge Protocol Tunnelling protocol (GBPT) is used by many service provider customers and cannot be used in conjunction with mac-tunnelling, therefore cannot be used on TalkTalk Business circuits. Customers who require this protocol should not purchase a TalkTalk access circuit until at a future date TalkTalk Business is able to pass GBPT.

E) Note that the Alcatel Omniswitches can support transparent and mac-tunnel at the same time, however it is limited by C) and D) above

Layer 2 Control Protocols Supported in Virgin Media Mac-tunnel Mode on TalkTalk Network

When Virgin Media Business configures its network in mac-tunnel mode, TalkTalk is able to transport the following L2CPs across its network.

Protocol	Default
STP	Pass
OAM	
GVRP	Pass
LLDP	Pass
RSTP	
LACP	Pass
LACP Marker Protocol	Pass
802.1x/EAPOL	
PAUSE (802.3x)	
GARP	
MSTP	
STP Fast Uplink	
CDP	Pass
PVST	Pass
PagP	Pass
VTP	
DTP	Pass
UDLD	Pass
VLAN Bridge	

Thanks for your business – we're looking forward to working with you. If you have any questions, we'd love to hear from you. Please call our Customer Services team on 0800 052 0800.