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Marconi OMS 1600
Optical MultiService Metro

Topic 3: Technical Product Description

Release 2.1.2

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Chapter 1: Introduction

1.1 Introduction

This topic provides the technical description for the Marconi OMS 1600 equipment.

Chapter 2: Product Description.
Provides an outline level description of the Marconi OMS 1600 equipment. It includes configuration options and a brief explanation of compatibility issues.

Chapter 3: Functional Overview.
Provides an explanation of the functions of the system and individual cards. Functionality includes network management and access via the LCT and LCTs. It also covers protection principles applied by the LCT and LCTs. Further details are provided in Topic 5.

Chapter 4:Typical Applications.
A range of typical application scenarios is discussed, together with operator configurable options.

Chapter 5:Ethernet LAN Services in Marconi OMS 1600.
Provides information regarding the transport of Ethernet traffic over SDH networks.

Chapter 6: Layer 2 Application Scenarios.
Illustrates examples of the various scenarios in which the 10M/100M/1000M Ethernet Layer 2 card can be deployed.

Chapter 7:Communications Theory.
Provides generic information about communication protocols, configurations, channels and routeing.

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Chapter 2: Product Description

2.1 Equipment Overview

The Marconi OMS 1600 is a range of advanced SDH multiplexers designed to meet the appropriate sections of ITU-T recommendations: G.703, G.704, G.707, G.783, G.957, G.7041 (GFP), G.7042 (LCAS), G.841, G.842, G.707 and G.709, supporting interconnections between 2 Mbit/s up to 10 Gbit/s (STM-64). They are designed to provide efficient transport solutions in networks with an increasing proportion of data traffic and to provide a straightforward solution for operators in the high growth metropolitan, regional and national backbone networks. Different configuration and subrack dimensions options extend the original Marconi OMS 1600 concept to meet specific functional and space requirements.

The Marconi OMS 1600 provides very high-density solutions reducing space and power consumption whilst offering extreme flexibility. All multiplexers can be configured as Terminal, Add/Drop and Cross-connect multiplexers to work in line, ring, star and meshed networks, fulfilling the requirements of multiplexers according to ITU-T G.782.

Marconi OMS 1600 is based on an extremely flexible internal SDH structure. The equipment consists of a number of standard cards (Line/Tributary, LTU, and Comms Controller Unit (CCU)) that can be installed in the standard shelf, and specific cards for different applications. A combination of booster and booster/pre-amp cards can be used with amplifiable cards to extend the section reach. For example, they can be used with the STM-16/STM-64 amplifiable cards to support interfaces providing section spans up to 200km.

Point-to point Ethernet services are provided using three Ethernet mapping cards supporting GFP (Generic Framing Procedure), LCAS (Link Capacity Adjustment Scheme) and VCAT (Virtual Concatenation) which map Ethernet traffic into SDH VCs to deliver a cost effective Ethernet Private Line service. There are three Ethernet tributary mapper cards available with this release:

- 10M/100M Ethernet Card (16 Ports)
- 1000M Ethernet Card (2 Ports)
- 100/1000M Ethernet Card (8 Ports).

For applications requiring Layer 2 functionality, there is a layer 2 card available:

- 10M/100M/1000M Ethernet Layer 2.

This Layer 2 card is used to aggregate signals to suit a number of different communication scenarios: Ethernet to Ethernet, Ethernet to SDH, and SDH to Ethernet.

An Ethernet Port Extension Module (EPEM) is used to convert the electrical signal from the customer’s Ethernet to an optical signal suitable for launching onto the fibre for the data card.

A Coarse Wave Division Multiplexer (CWDM) Mux/Demux Tray is available to separate/combine signals of different wavelength in a single pipe.

A DWDM STM-64 (C band) tuneable card is available for interworking with the Marconi MHL3000 Photonics equipment.

2.2 System Architecture

Within Release 2.1.2 of the Marconi OMS 1600, there are six distinct variants available.

Standard shelf versions:

- OMS1684 with 384 x 384 switch
- OMS1664 with 128 x 128 switch
- OMS1634 uses the STM-4/16 core card in the standard shelf.
  - Mainly intended for delivery of a high number of PDH interfaces for minimal outlay.

Compact shelf version:

- OMS1674 with 384 x 384 switch
- OMS1654 with128 x 128 switch
- OMS1644 using the STM-4/16 core card in the compact shelf.
  - The core card includes an STM-16 Interface and smaller switch function.

Figure 2-1: Examples of Marconi OMS 1600 Standard and Compact Shelf

Table 2-1: Marconi OMS 1600 Switch Functionality

	Product Name	
Switch Size	**Standard Shelf**	**Compact Shelf**
384 x384	OMS1684	OMS1674
128 X 128	OMS1664	OMS1654
STM-4/16 core card	OMS1634	OMS1644

Note: (1) When the OMS1684 switch (384 x 384) is implemented in a standard shelf there are no bandwidth restrictions.

Note: (2) The switch (128 x128) restricts the maximum worker bandwidth to 128 x STM-1. Therefore the maximum number of worker ports is:

- STM-16 = 8
- STM-4 = 32
- STM-1 = 128.

Note: (3) The STM-16 core card supports a switch (64 x 64) with an integrated STM-4/16 interface. Of the 64 x 64 switch bandwidth, 32 x STM-1 is for use by the core cards, therefore this restricts the maximum worker bandwidth to 32 x STM-1.

Note: (4) On multi-port cards, ports share the total bandwidth available to the card in the specific slot fitted, either STM-16 or STM-32.

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Chapter 3: Functional Overview

3.1 Network Management

ServiceOn Optical Element and Network Managers achieve integrated network management control via a 'Q' interface.

Alternative network management control is achieved by ServiceOn Access (SoA) via a device driver. The Marconi OMS 1600 can then be managed in SoA managed networks.

Both management systems provide a comprehensive range of fault, status and performance monitoring functions with configurable parameters. Interactive operator control is provided for sub-rack commissioning, traffic connection management, maintenance and diagnostics.

In-field control is provided by an 'F' interface to a PC based Local Craft Terminal.

3.2 Synchronisation

Marconi OMS 1600 equipment supports diverse synchronisation functionality. It offers:

- Two T3 clock inputs according to G.703/G.704
- Two T4 clock outputs according to G.703/G.704.

The SETS functionality is located on the TDM switch unit and can clock the system from:

- T1: from two independent STM-N input signals per slots (in total 32 sources)
- T2: from two independent 2 Mb/s input signal per slots
- T3: from one of the two T3 connectors
- SETG: Internal oscillator with 4.6 x10-6 stability.

3.3 Protection

The Marconi OMS 1600 is capable of supporting different protection schemes. The appropriate protection scheme is chosen based on the target application and interface types.

The Marconi OMS 1600 release 2.1.2 supports the following protection schemes:

Card protection

- 1:N Card Protection - STM-1 card, 34/45M card, 2M card (EQP protection)
- 1+1 switch cards.

Traffic protection

- MSP
  - 1+1 MSP
  - 1:n MSP.
- MS-Spring.

- 2 fibre (one ring sharing bandwidth)
- 4 fibre (two rings, 1 worker, 1 protection)
  enables more protection options

Table 3-1: MSP Protection Types Available

	MSP		MS-SPRING	
	1+1	1:n	2 fibre	4 fibre
STM-1	✓	✓	X	X
STM-4	✓	✓	X	X
STM-16	✓	✓	✓	✓
STM-64	✓	✓	✓	✓

- 1+ 1 SNCP
- 1+ 1 PDH port Protection.

Additional protection features:

- Inherent PSU Protection
- In-service replacement of failed unit
- Use of standard traffic units as protection unit.

3.3.1 Power Distribution

Marconi OMS 1600 is powered from a 48/60volts DC power supply.

All cards support three inputs (power feed from Power LTU A, Power LTU B and hold-up). All cards generate their required voltages by using on-card DC/DC converters.

Hold-up is provided by the power LTU.

3.3.1.1 Traffic LTU Power Protection

To provide additional resilience against traffic LTU DC/DC failure, power protection is provided from the Management and Sync LTU.

3.4 Cross Connections

Cross-connections can be made for VC-12s, VC-2s, and VC-3s. Any allowed mix of VCs can be multiplexed into the STM-1 signal and these VCs can be cross-connected from one timeslot in an incoming STM-1 signal to another timeslot in the outgoing STM-n signal.

3.5 Engineer's Order Wire (EOW)

The Marconi OMS 1600 product has a bespoke AUX/EOW Unit. Refer to section 7.6 for more detail.

3.6 Tandem Connection Monitoring (TCM)

All SDH cards support TCM sub-layer performance monitoring (full TCM).

3.7 Ethernet LAN Services in Marconi OMS 1600

For a detailed explanation, see Chapter 5:

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Chapter 4: Typical Applications

4.1 Network Applications

Due to the increasing demand for bandwidth, the loads on existing STM-1 and STM-4 multiplexers are exceeding their limits. An update to STM-16/STM-64 multiplexer working is essential to keep the network running. The Marconi OMS 1600 can replace existing networks based on stacked PDH and SDH multiplexers. It also saves space and simultaneously increases network flexibility.

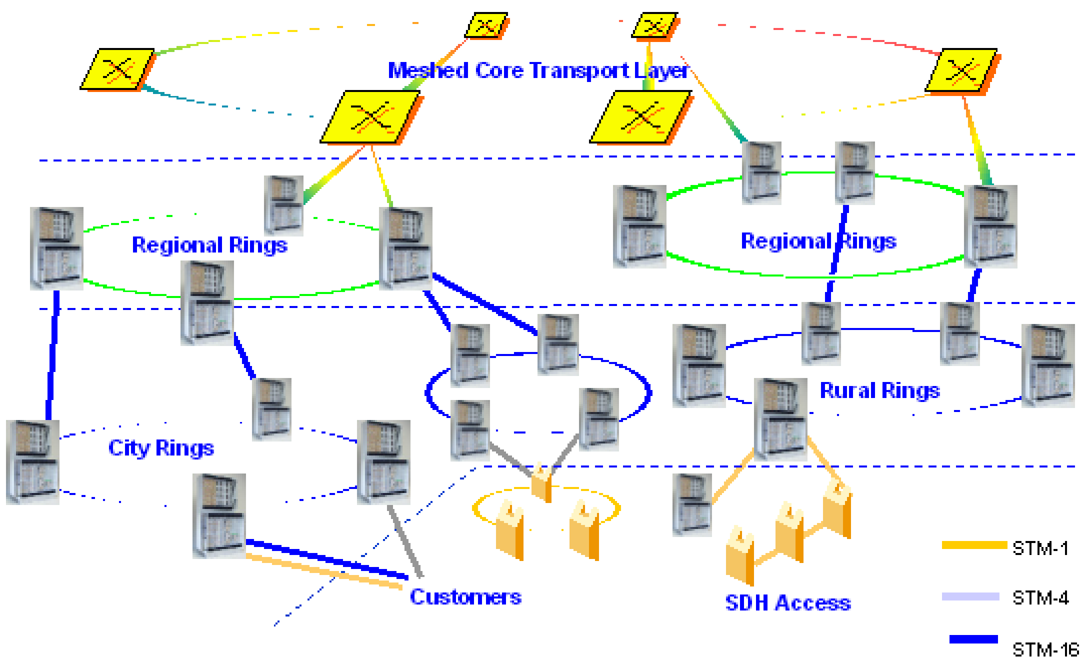
Compliance with SDH standards and a common management solution also allow the Marconi OMS 1600 to be deployed in existing networks alongside current equipment. It can cover all applications and required interfaces. Due to its highly flexible architecture and features, it drastically reduces the amount of technical equipment needed at one location. The Marconi OMS 1600 provides a solution avoiding the enormous costs of laying new fibre routes.

To illustrate the flexibility of the Marconi OMS 1600, some examples of network applications are shown in Figure 4-1.

Below you can see a general SDH network application based on STM-16 down to STM-4 network level. All of these structures can be covered by the Marconi OMS 1600 in different compositions allowing optimisation for each application in the different network levels.

In the examples below, for simplicity, CWDM Trays, Boosters and Pre-amps are not shown.

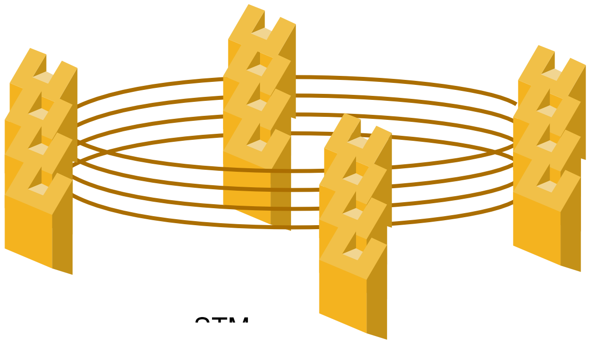
Figure 4-1: Applicable Network Levels



4.1.1 Stacked Networks

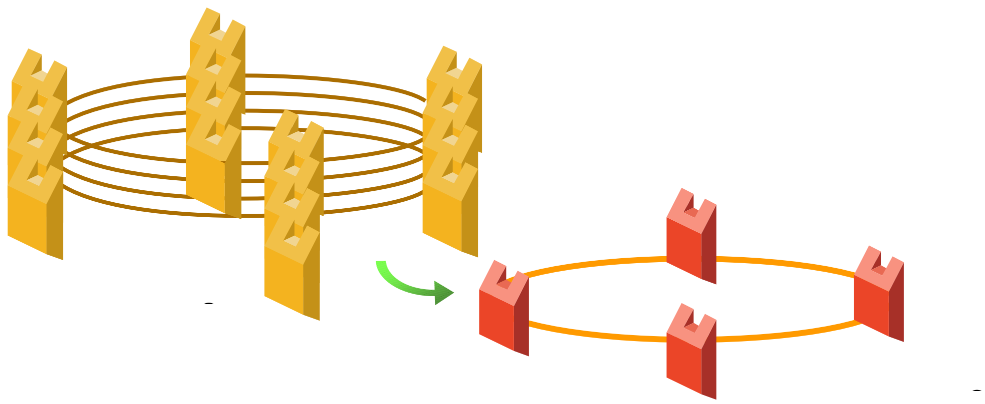
Stacked or layered networks are very common today. Coarse VC granularity (VC-4) multiplexers are used for the high bandwidth transport (e.g. STM-64) and at sites with PDH interfaces (e.g. 2 Mb/s); different multiplexers are used with a finer VC granularity (VC-12 and VC-3) into a VC-4 signal.

Figure 4-2: Common Solution with Stacked Networks



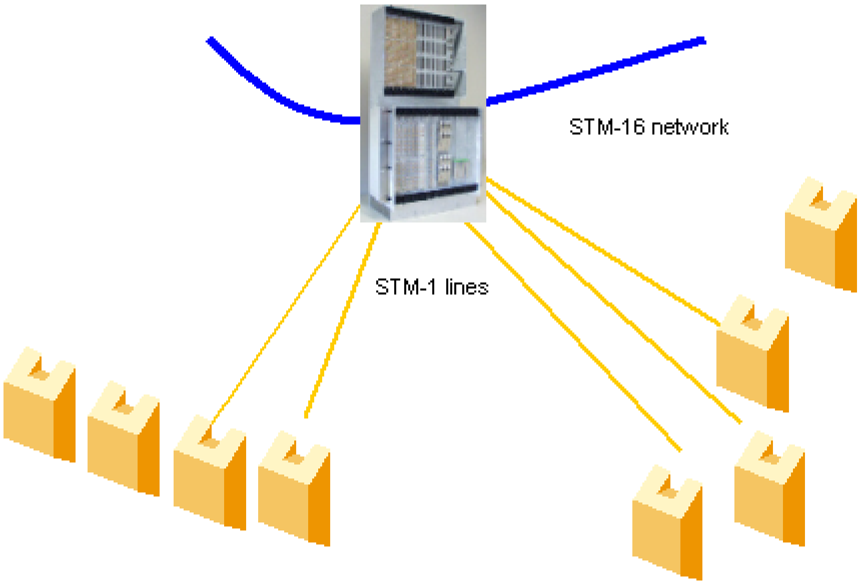
The Marconi OMS 1600 makes obsolete such stacked networks. A network with Marconi OMS 1600 units can also transmit VC-12 and VC-3 as well as VC-4 in STM-1/4/16/64 networks. This single box solution reduces network complexity, saves costs, space and operational effort. It increases flexibility because the Marconi OMS 1600 provides almost any service without requiring additional boxes. Mixed networks with VC-4 multiplexers are also possible. Marconi OMS 1600 equipment enables an easy upgrade from an STM-16 at VC-12 to higher transport capacity with STM-64 by replacing only the line interface and the switching card.

Figure 4-3: Marconi OMS 1600 Makes Stacked Networks Obsolete



4.1.2 Hubbing Application

Figure 4-4: Hubbing STM-1



4.1.2.1 Summary

OMS1684

This variant is able to hub or consolidates:

- Switch Size 384 x 384 STM-1:
  - Up to 192 STM-1 lines in a Add/Drop Multiplexer application (2 x STM-64 line interfaces)
  - Up to 224 STM-1 lines in a Add/Drop Multiplexer application (2 x STM-16 line interfaces)
  - Up to 224 STM-1 lines in a Terminal Multiplexer application (1 x STM-64 line interface).

OMS1674

This variant is able to hub or consolidates:

- Switch Size 384 x 384 STM-1:
  - Up to 64 STM-1 lines in a Add/Drop Multiplexer application (2 x STM-64 line interfaces)
  - Up to 80 STM-1 lines in a Add/Drop Multiplexer application (2 x STM-16 line interfaces)
  - Up to 80 STM-1 lines in a Terminal Multiplexer application (1 x STM-64 line interface).

OMS1664

This variant is able to hub or consolidates:

- Switch Size 128 x 128 STM-1:
  - Up to 96 STM-1 lines in a Add/Drop Multiplexer application (2 STM-16 line interfaces)
  - Up to 112 STM-1 lines in a Terminal Multiplexer application (1 STM-16 line interface).

OMS1654

This variant is able to hub or consolidates:

- Switch Size 128 x 128 STM-1:
  - Up to 80 STM-1 lines in a Add/Drop Multiplexer application (2 STM-16 line interfaces)
  - Up to 80 STM-1 lines in a Terminal Multiplexer application (1 STM-16 line interface)

OMS1644

This variant is able to hub or consolidates:

- Switch Size 64 x 64 STM-1:
  - Up to 32 STM-1 lines in a Add/Drop Multiplexer application (2 STM-16 line interfaces)
  - Up to 32 STM-1 lines in a Terminal Multiplexer application (1 STM-16 line interface)

OMS1634

This variant is able to hub or consolidates:

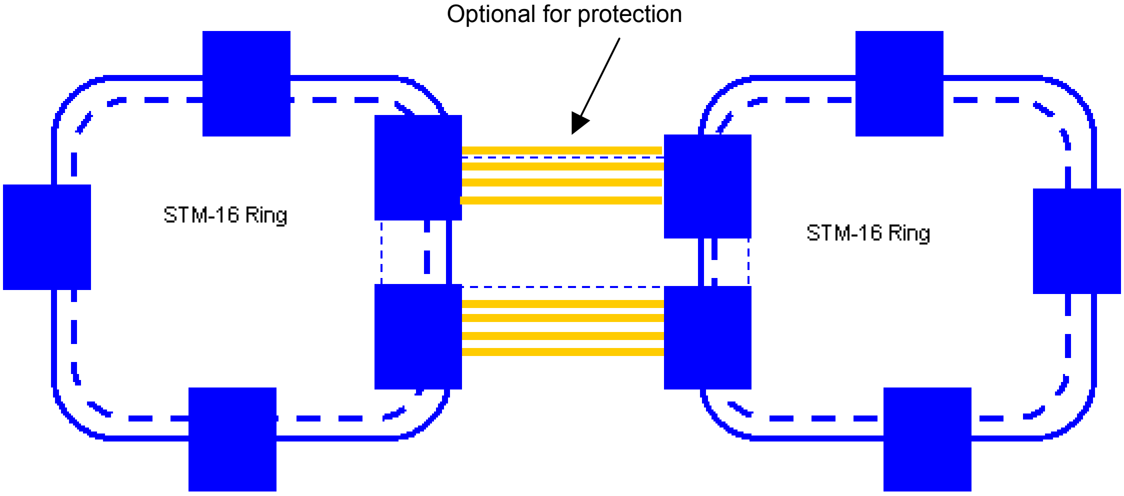
- Switch Size 64 x 64 STM-1:
  - Up to 32 STM-1 lines in a Add/Drop Multiplexer application (2 STM-16 line interfaces)
  - Up to 32 STM-1 lines in a Terminal Multiplexer application (1 STM-16 line interface)

4.1.3 Replacing STM-16/ STM-64 Ring Interconnection Points

Ring interconnection multiplexers connect two or more SDH ring networks to cross the traffic between the ring subscribers. The connection is based on STM-1 or STM-4 signals (STM-16 is also possible).

4.1.3.1 Current Solution

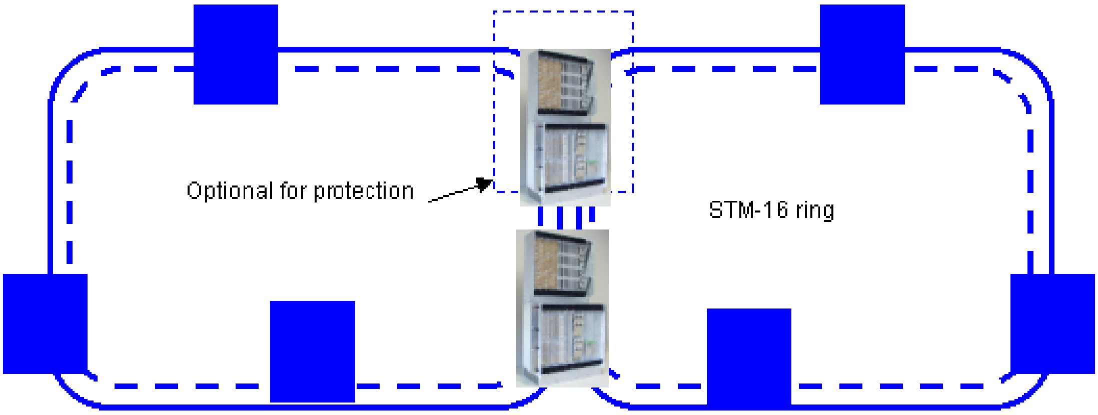
Figure 4-5: Current STM-x Ring Interconnection



Replacing the traditional existing SDH Multiplexers by Marconi OMS 1600 saves on the cost of the second interconnection multiplexer, the interfaces between both multiplexers, and reduces the possibility of errors, the required space, power consumption and cost. Additionally it reduces the numbers of managed network elements and the effort needed to reconfigure for an increase in interconnection traffic.

4.1.3.2 Optimised Solution

Figure 4-6: Current STM-x Ring Interconnection (Optimised solution)



Note: For STM-16: OMS1664 supports four fibre Dual Node Interconnection (DNI)

4.1.4 Cross Connect Multiplexer

Marconi OMS 1600 variants can be used as a DXC (cross connect multiplexer) on several network levels. It is possible to configure them as an STM-64, STM-16, STM-4, or STM-1 DXC, which are able to switch all signals on a VC-12 base.

Figure 4-7: Cross Connect Multiplexer

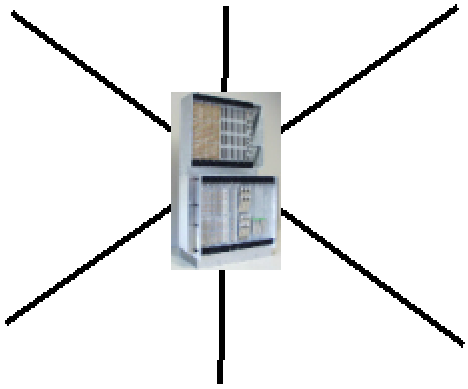


Table 4-1 lists the number of aggregate lines that can be used:

Table 4-1: Number of Usable Aggregate Lines

	STM-1	STM-4	STM-16	STM-64
OMS1664	128 lines	32 lines	8 lines	
OMS1654	96 lines	32 lines	8 lines	
OMS1644	32 lines	8 lines	N/A (Max 2 lines, 1 per Core card)	
OMS1634	32 lines	8 lines	N/A (Max 2 lines, 1 per Core card)	
OMS1684	256 lines	96 lines (1)	24 lines (2)	
OMS1674	96 lines	48 lines (3)	12 lines (4)	2 lines

Notes:

(1) Number of STM-4 lines increased from 64 to 96 in this release through introduction of 2xSTM-16 equivalent capacity STM-16/4/1 multirate traffic card.

(2) Number of STM-16 lines increased from 16 to 24 in this release through introduction of 2xSTM-16 equivalent capacity STM-16/4/1 multirate traffic card.

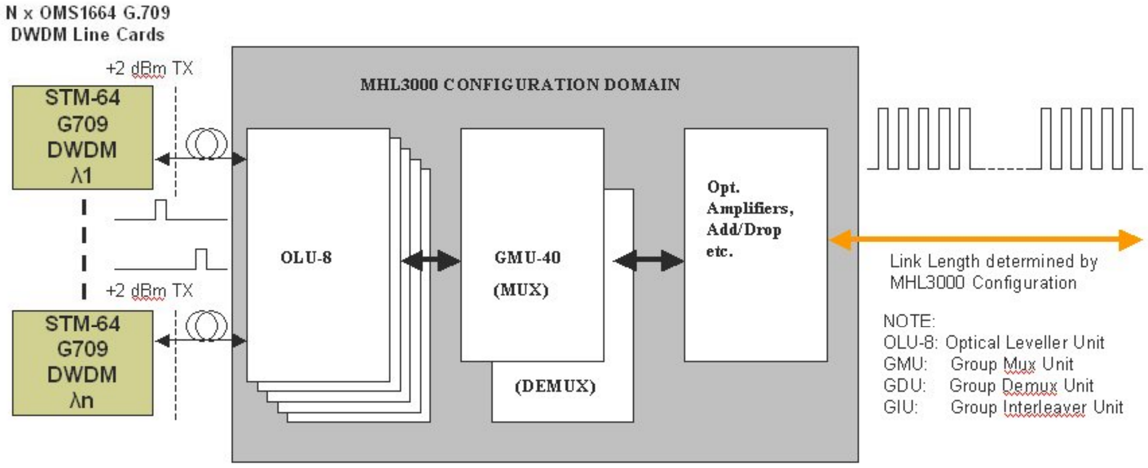
(3) Number of STM-4 lines increased from 32 to 48 in this release through introduction of 2xSTM-16 equivalent capacity STM-16/4/1 multirate traffic card.

(4) Number of STM-16 lines increased from 8 to 12 in this release through introduction of 2xSTM-16 equivalent capacity STM-16/4/1 multirate traffic card.

4.1.5 STM-64 DWDM G.709/MHL3000 Application

This DWDM tuneable C-band variant of the STM-64 G.709 card is intended to be used with the Marconi MHL3000 equipment and has a nominal transmission distance of 40km. However, when used in conjunction with the MHL3000, the transmission distance is only limited by the MHL3000 equipment itself. There is also a non-DWDM amplifiable 'standard' ITU STM-64 variant of this card. See Topic 4 for further information on this card and its variants.

Figure 4-8: STM-64 DWDM G.709 Card/MLH3000 Application



4.1.6 *Data Applications*

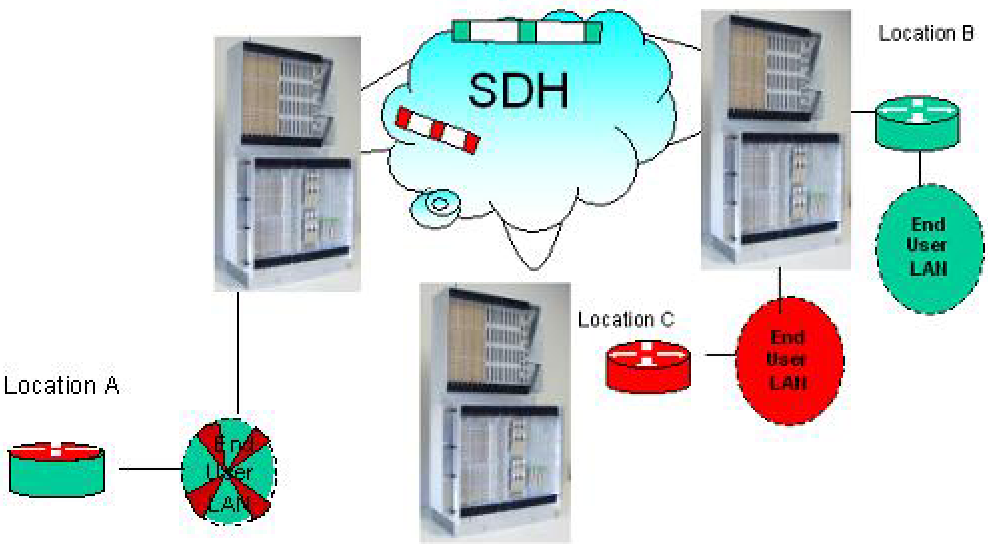
4.1.6.1 Ethernet Private Line

Ethernet Private Line (EPL) is a well-known Transparent LAN service. This application is supported for 10/100/1000M Ethernet signals. Based on multi-port Ethernet interfaces, more than one connection can be established from a location A to B and C.

Each packet arriving from an end user LAN is mapped via Generic Frame Procedure (GFP) into the SDH-leased line. See section 5.6.1 for further information on GFP. The transfer capacity may be a fixed or flexible leased line, resized via the Link Capacity Adjustment Scheme (LCAS). See section 5.7.1 for further information on LCAS. There are four types of Ethernet tributary cards available at this release:

- 10M/100M Ethernet card (16 ports)
- 1000M Ethernet card (2 ports)
- 100/1000M Ethernet card (8 ports)
- 10M/100M/1000M Ethernet Layer 2 card which provides traffic aggregation.

Figure 4-9: Ethernet Private Line



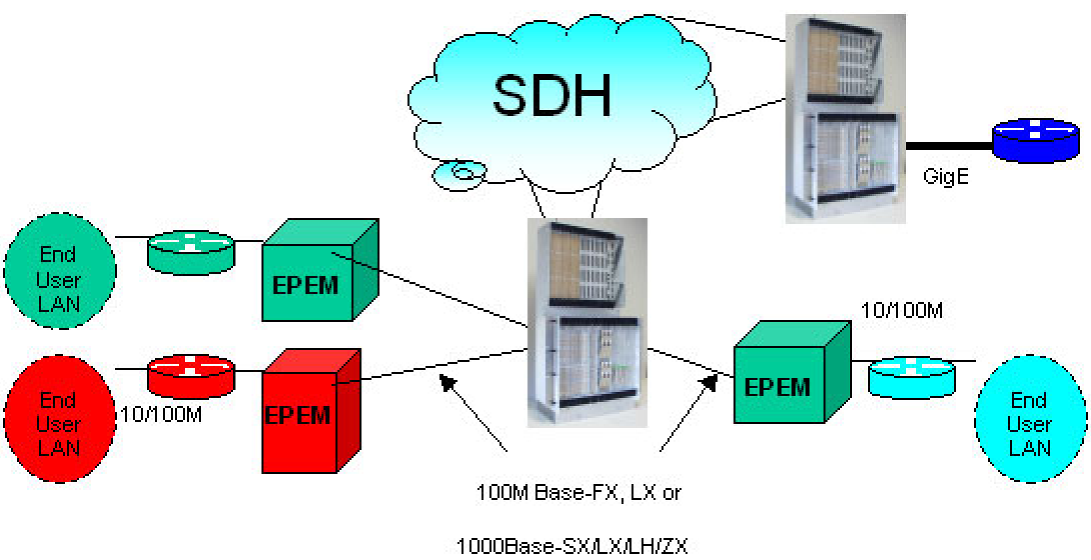
Chapter 5:gives an introduction to the underlying technology and concepts in Ethernet/SDH interworking and how it is used to deliver various types of Ethernet traffic.

Chapter 6:gives a detailed explanation of how Ethernet Layer 2 functionality is used to deliver and optimise different telecommunication scenarios.

4.1.6.2 Ethernet Port Extension Application

The Ethernet Port Extension (EPE) application provides transport of Ethernet data from customer location via optical fibre to Marconi OMS 1600. Depending on optical interface type, distant destinations can be reached. The network management of Marconi OMS 1600 controls the Ethernet Port Extension Module (EPEM) at the customer premises.

Figure 4-10: Ethernet Port Extension Application



The EPEM provides a client port to the end user, and a WAN port for the optical fibre connection to the Ethernet card.

EPEM allows the provision of Ethernet ports without requiring an SDH add/drop multiplexer at the same site. EPE management is simply an extension of the existing scheme used to manage Ethernet service in the SDH network. To carry Operations, Administration and Maintenance (OAM) information to and from the PEM, an OAM channel is provided on the same fibre that carries the Ethernet service.

For further information of the various EPEM units available, refer to Topic 4.

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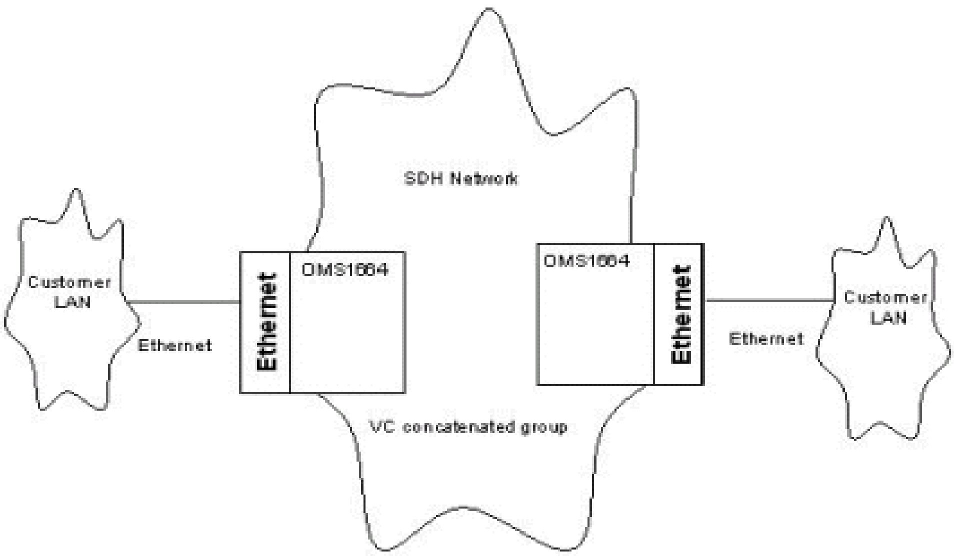
Chapter 5: Ethernet LAN Services in Marconi OMS 1600

5.1 Introduction

The Ethernet cards in Marconi OMS 1600 are used for Ethernet over SDH applications. They permit the point-to-point transmission of Ethernet traffic between two distant Ethernet devices over the SDH network. These cards carry the Ethernet traffic transparently from one end of the SDH network to the other using encapsulation GFP (Generic Framing Procedure). The traffic path across the SDH network is a single VC or concatenated group of VCs (VCAT).

Figure 5-1: Transparent LAN Services



5.2 Ethernet Port Configuration

5.2.1 Auto-Negotiation

Auto-negotiation permits the Ethernet port and the Ethernet equipment connected to the port to automatically select the Ethernet connection parameters based on the connected equipment capabilities. The connection capabilities include such parameters as connection speeds supported and full/half duplex operation. In addition, it is possible to further constrain the auto-negotiation process by restricting the advertised port capabilities.

If auto-negotiation is disabled, a default set of port parameters is used instead. This default port setting is configurable.

5.2.2 MAU Type

You can configure on a per port basis, the default MAU type (to be used when auto-negotiation is disabled) to one of the types shown in Table 5-1.

If auto-negotiation is not enabled or not implemented on the card, changing the default MAU type forces the MAU into the specified operating mode.

If auto-negotiation is enabled and implemented on the card, the operational type of the MAU is determined by auto-negotiation, and the value of the default MAU type denotes the type to which the MAU reverts to if auto-negotiation is later disabled.

Table 5-1: MAU Type

MAU Type	Default MAU	Operational
10 Base-T Half Duplex	✓	✓
10 Base-T Full Duplex	✓	✓
100 Base-T4	✓	✓
100 Base-TX Half Duplex	✓	✓
100 Base-TX Full Duplex	✓	✓
100 Base-T2 Half Duplex	✓	✓
100 Base-T2 Full Duplex	✓	✓
1000Base-X Half Duplex	✓	✓
1000Base-X Full Duplex	✓	✓
1000Base-T Half Duplex	✓	✓
1000Base-T Full Duplex	✓	✓
Unknown		✓

5.2.3 Pause Capability

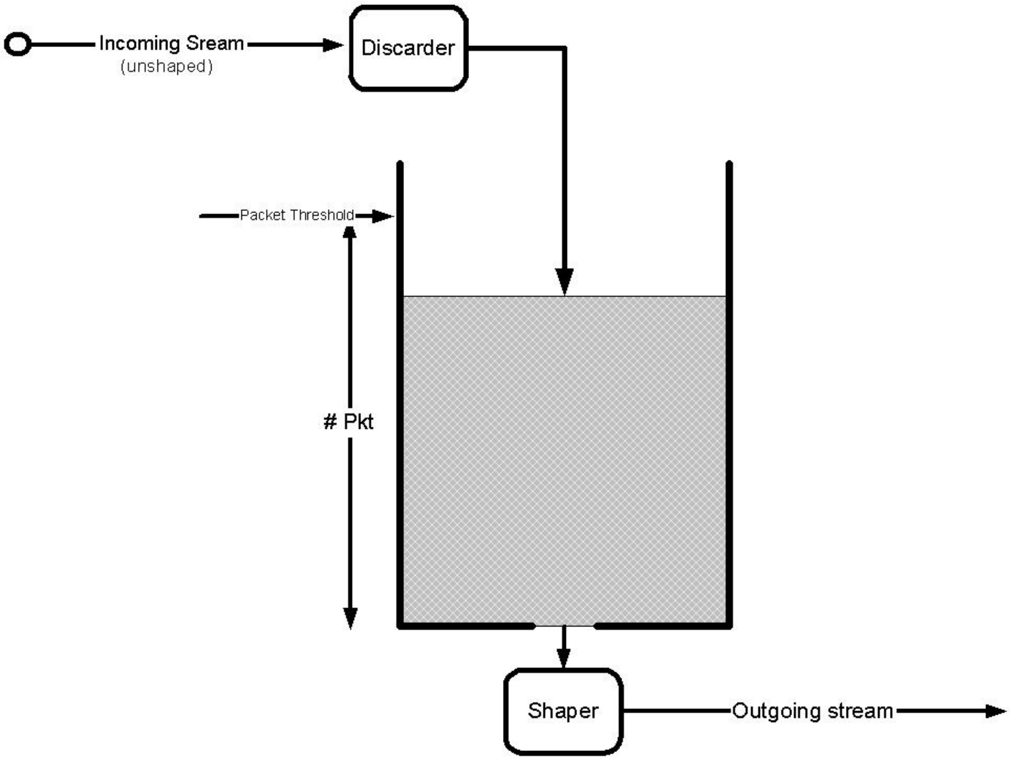
Pause frames provide a flow control mechanism for Ethernet, slowing down the aggregate rate of frames that the other end is sending.

5.3 Traffic Management

The Ethernet packets received from the port may be subjected to the following processes:

- Discard - To throw away packets during periods of congestion
- Queuing - To buffer packets
- Shaping - To control the flow of packets from the queue
- Policing - To restrict the bandwidth available to specified Ethernet sources, or to attach priorities to packets based on the Ethernet data type.

Figure 5-2: SVCQ Flow Control



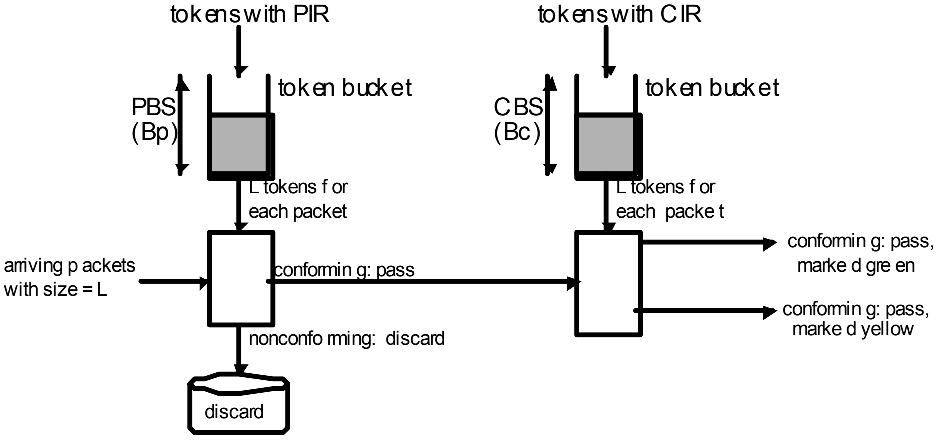
5.3.1 Policing

The two rate three colour marker (trTCM) mechanism defined in the standards documents (see RFC2698) are used to monitor whether arriving traffic conforms to the service level agreement (SLA). The traffic profile of a SLA is described using:

- Committed information rate (CIR)
- Committed burst size (CBS)
- Peak information rate (PIR)
- Peak burst size (PBS).

The trTCM is implemented using two token buckets (see Figure 5-3).

Figure 5-3: Two Rate Three Colour Marker Policing Algorithm



The first token bucket monitors the PIR (measured during an interval of PBS). If PIR or PBS is exceeded, the trTCM discards those packets. The second token bucket monitors the CIR (measured during an interval of CBS). The trTCM marks packets, which are in conformance with CIR and CBS as green, packets, which are not in conformance with CIR, and CBS as yellow.

The queuing discard types ‘Weighted Tail Drop’ and ‘Weighted Random Early Detection’ are able to discard yellow packets with a higher probability as compared to green packets during a time of traffic congestion.

For EVPLAN policing is on a per bridge port basis.

5.3.1.1 Ingress Interface

The 10M/100M/1000M Ethernet Layer 2 card performs policing at the ingress interface (either Ethernet or SDH). The rate (CIR, PIR) configured in the SLA is enforced against the size of the arriving frame regardless of whether a VLAN tag –used to differentiate between the aggregated Ethernet applications -will be added or removed at the egress. Therefore, the actual measured rate might be different to CIR or PIR specified in the SLA.

The actual rate will be:

- Higher, when a VLAN is added
- Lower, when a VLAN is removed.
- The same, when no modification is performed.

Depending on the direction of the traffic, the worst-case difference happens for 64 byte frames and is about 6.25%. For larger frame size, the difference becomes smaller. For example:

- For 1500 byte frames, the difference is 0.27%.
- For a typical frame size for Internet traffic of 370 bytes, the difference is 1.1%.

5.3.2 Queuing Discard

The 10M/100M/1000M Ethernet Layer 2 card provides FIFO scheduling with a single FIFO queue per egress port for EPL/EVPL: and EVPLAN.

In order to provide rate guarantees for Ethernet flows, the 10M/100M/1000M Ethernet Layer 2 card performs per-flow policing. When various Ethernet flows are mixed in a single egress queue, the burstiness of a single flow might increase in the queue. This effect is referred to as frame clumping.

When policers in downstream NEs use the same traffic parameters as policers at the network ingress, downstream policers might discard or mark traffic as non-conforming even if this traffic has been conforming at the network ingress. To avoid this problem, downstream policers should take into account the changed traffic characteristics due to frame clumping. This means compared to the traffic parameters at the network ingress the operator should configure increased burst size parameters (PBS, CBS) in downstream NEs.

For example, assume Ethernet flow 1 with PIR=10 Mbit/s and PBS=10,000 byte is to be transported.

1. Bursty traffic is sent which is and fully utilises the PBS.
2. The traffic enters the network in NE1 and leaves the network in NE2.
3. Between NE1 and NE2 flow 1 is mixed with other traffic.
4. NE1 performs policing on flow 1. All frames are conforming, no frames are discarded.

5 In the egress queue of the NE, the traffic characteristic of flow 1 is changed because other traffic in the egress queue is bursty.

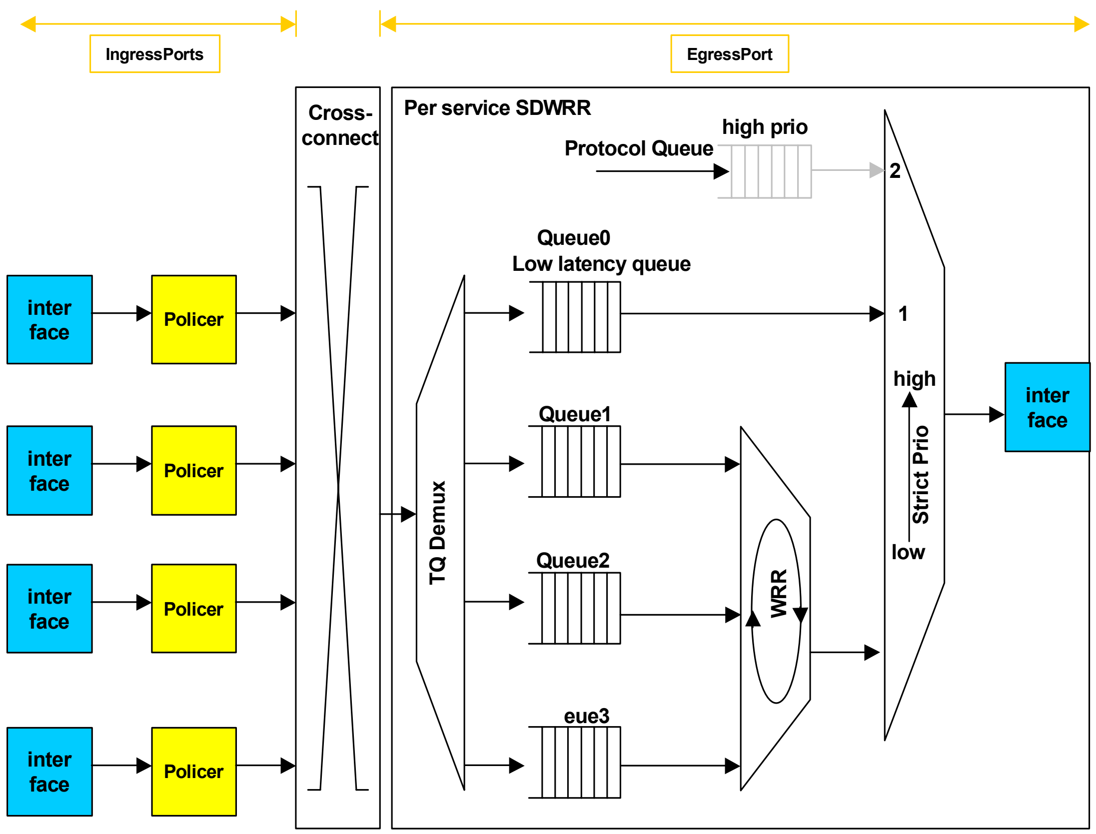
6 When flow 1 enters NE2, NE2 performs policing on flow 1.

7 Now, if NE2 uses the same parameters (PIR=10 Mbit/s and PBS=10,000 byte) for policing, NE 2 will detect non-conforming frames because of the changed traffic characteristic.

Note: To avoid the problem, the policer in the NE should be configured with an increased PBS, e.g. PBS=100,000 byte..

In addition the 10M/100M/1000M Ethernet Layer 2 card in R2.1.2 introduces per-service SDWRR scheduling using four queues per interface for EPL/EVPL services, as depicted in Figure 5-4 below.

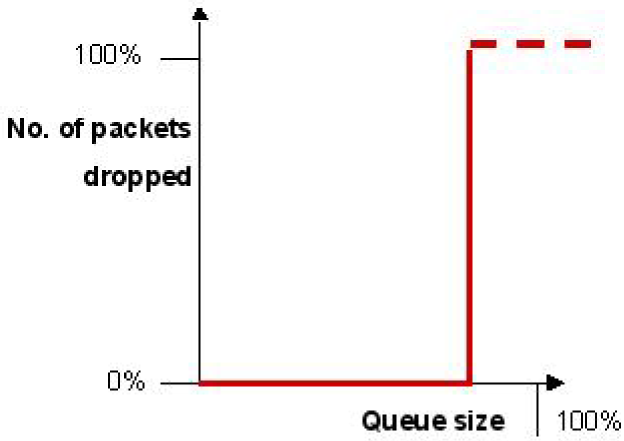
Figure 5-4: Per-service SDWRR Scheduling for EPL/EVPL



5.3.2.1 Tail Drop Discard

Tail drop discard is the default algorithm for queue full scenarios, which may be typically caused during bursts of Ethernet traffic. Once the queue buffer overflows, tail drop discard occurs and all additional packets are dropped.

Figure 5-5: Tail Drop Discard Queue Algorithm



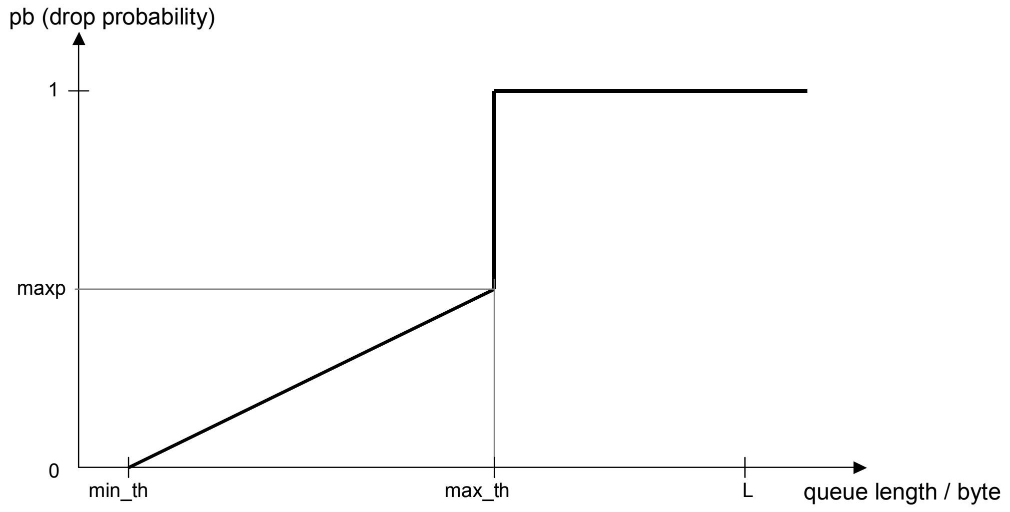
5.3.2.2 Random Early Discard

Random Early Discard (RED) is a congestion avoidance mechanism that takes advantage of TCP's congestion control mechanism. TCP (Transport Control Protocol) uses dropped packets as an indication of congestion in the network and can ramp packet transmission accordingly. By randomly dropping packets before periods of high congestion, RED tells the packet source to decrease its transmission rate.

Figure 5-6: Random Early Discard (RED) Algorithm

On the layer 2 card the maximum drop probability is maxp=0.1=10%, this is different compared to Ethernet mapper cards, where the maximum drop probability is maxp=1=100%.

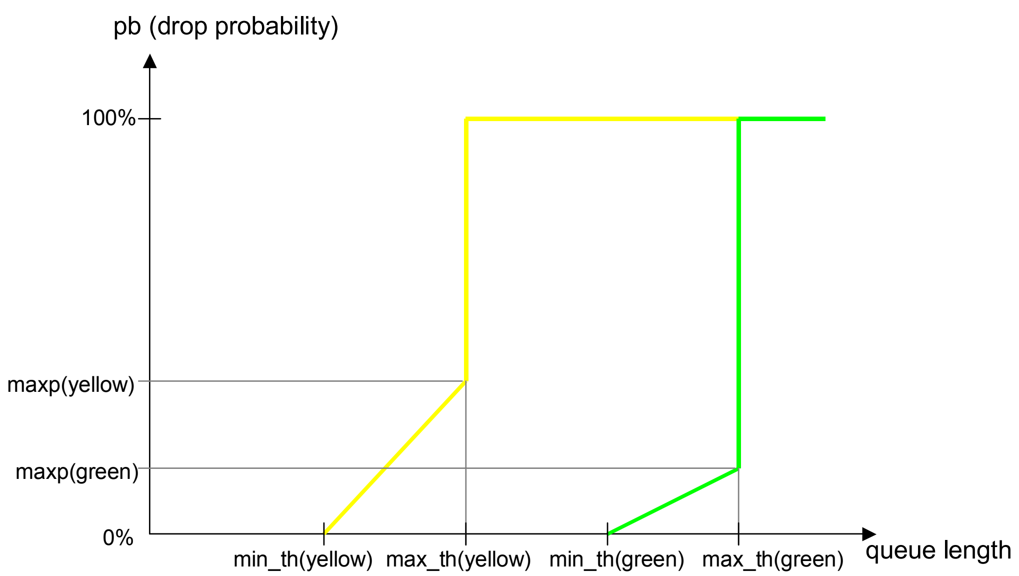
Figure 5-7: Maximum Drop Probability



5.3.2.3 Weighted Random Early Discard

Weighted Random Early Discard (WRED) is a combination of RED and WRED. It provides the same drop mechanism as RED but provides separate drop curves for each colour. This is shown in Figure 5-8.

Figure 5-8: Weighted Random Early Discard (WRED) Algorithm



5.3.3 Shaping

The shaping function delays the transition of packets within a data stream to force it to conform to a defined temporal profile. As such, the shaping function may typically introduce latency into the system.

5.3.4 Pause Flow Control

The card may also employ pause control due to bottlenecks in the packaging of Ethernet frames into the SDH pipe. For example, should the Ethernet data rate exceed the VC pipe capacity, the card may employ pause control frames to reduce the data rate transmission from the far end of the Ethernet link.

5.4 Bridging and Switching

The Layer-2 Aggregation card in OMS1664 Product Family release 2.1.2 introduces support of bridging functionalities acc. to 802.1Q (VLAN aware bridge), thereby enabling realisation of Ethernet Private LAN applications. This extended functionality may be implemented as an upgrade to already existing Layer-2 Aggregation cards via software download.

The Data Plane provides a connectionless service. This comprises MAC address learning and MAC based forwarding for unicast traffic.

Multicast traffic is flooded in the context of the relevant VLAN.

The Data Plane supports Customer traffic separation through VLANs and multiple Filtering Databases (FDBs). By assigning each VLAN a separate FDB, MAC address spaces of Customers can be kept completely separate in the device.

The Control Plane provides the means to support loop resolution. The Rapid Spanning Tree Protocol (RSTP according to IEEE802.1w) provides loop-free connectivity in the Bridged LAN through a base spanning tree context. Rapid migration to the forwarding state and rapid re-configuration in case of failures is guaranteed as much as backward compatibility with older STP capable devices.

5.5 Layer 2 Control Protocols

5.5.1 Layer 2 Protocol Handling

The following Layer 2 Control Protocols are handled:

- Pause
- Link Aggregation Control Protocol (LACP)
- Link Aggregation Marker Protocol (LAMP)
- 802.3ah Ethernet in the First Mile (EFM)
- Spanning Tree BPDU
- GARP Multicast Registration Protocol (GMRP)
- GARP VLAN Registration Protocol (GVRP)
- 802.1X Port Authentication
- All LAN Bridge Management Group.

5.5.2 Layer 2 Protocol Options

For a set of Layer-2 control protocols it is possible to determine on each interface (Physical Port or VCG Transport Port) how the protocol shall be handled. The following alternatives for the handling of a control protocol are supported.

- Discard The card discards all ingress frames carrying the specific layer-2 control protocol and the card does not generate any frames carrying this layer-2 control protocol.

- Process The card acts as a peer to the equipment that is attached to the card. i.e. the layer-2 control protocol is terminated by the card and processed by the application.
- Tunnel Any incoming frame carrying a layer-2 control protocol is forwarded by the card either according to a configured cross-connection in case of a line service or according to forwarding rules of a bridge in case the interface is associated with a bridge.

5.5.3 Supported Layer 2 Protocol Options

For the layer-2 control protocols it is possible to define their respective handling on a per interface level (Physical Ethernet Port or SDH Transport Port) as follows:

Table 5-2: Layer 2 Control Protocol Options

Layer 2 Control Protocol	Supported Options	
	Port Used for EPL/EVPL Service	Port Used for EVPLAN Service
Pause	Process, Discard or Tunnel	Discard
LACP (Link Aggregation Control Protocol)	Discard or Tunnel	Discard
LAMP (Link Aggregation Marker Protocol)	Discard or Tunnel	Discard
EFM OAMiF (802.3ah Ethernet in the First Mile)	Discard or Tunnel	Discard
BPDU (STP, RSTP, MSTP)	Discard or Tunnel	Process
GVRP (GARP VLAN Registration Protocol)	Discard or Tunnel	Discard
GMRP (GARP Multicast Registration Protocol)	Discard or Tunnel	Discard or Tunnel
802.1x Port Authentication	Discard or Tunnel	Discard
All LANs Bridge Management Group	Discard or Tunnel	Discard

5.6 Ethernet Mapping/Encapsulation

An encapsulation scheme is required in order to transmit the Ethernet frames over SDH. The only scheme supported at this release is GFP.

5.6.1 Generic Framing Procedure (GFP)

GFP provides a generic mechanism to encapsulate IEEE 802.3 Ethernet MAC frames for transmission over an SDH carrier and is defined in ITU-T Recommendation G.7041/Y.1303.

For GFP-F framing it is possible to enable an FCS check for the payload of a GFP frame.

Regarding the available bandwidth over a VCG, which transports GFP-F encapsulated frames, there is no difference whether the FCS check is enabled or disabled.

5.7 Link Mapping

5.7.1 LCAS

The Link Capacity Adjustment Scheme uses Virtual Concatenation to control the capacity of a link, automatically decreasing the capacity if one or more VCs in the group experience a failure in the network, and increasing the capacity once the fault is repaired. LCAS permits the hitless addition or deletion of VCs to/from a concatenated group.

The LCAS protocol uses the H4 or K4 SDH POH bytes for communication between the two ends of the LCAS link.

For the LCAS feature to operate correctly, both Ethernet cards at the ends of the link must conform to G.7042 and must have the LCAS facility enabled for the relevant virtual concatenation group.

To prevent LCAS reacting unnecessarily to path failures occurring during a SDH protection switch (e.g. SNCP), entry delay and exit delay parameters are provided per VC group Ethernet Fault Types.

The Ethernet cards generate alarms relating to both the Ethernet domain and to the SDH domain. For information on these alarms, see Topic 6.

5.8 Performance Management

Performance management falls into two categories; a selection of Ethernet performance counts are handled using the generic performance collection and reporting of data at 15Min and 24Hr intervals. The remainder of the Ethernet performance counts are available as a snapshot.

5.8.1 Historic Performance Logs

The historic performance logs provide functionality, providing 15 minutes or 24 hours.

5.9 Ethernet Traffic Classification Types

The traffic classification allows the operator to indicate the profile of the traffic that the Ethernet Interface is expected to carry. It is equivalent to the Service Level Agreement (SLA) and is only configurable where classification cannot be determined from the traffic itself. In such situations, the operator is required to enter the desired classification, which in turn determines the method of alarm, and performance monitoring that will be applied to the traffic.

5.9.1 Ethernet Voice

Voice traffic is highly sensitive to loss, delay and jitter (delay variation) and as such is considered high priority traffic. Although voice traffic can be bursty in nature, it is expected to stay rigidly within its CIR and hence its use should never exceed 100%. The following assumptions are made with regard to its nature:

1. The maximum bandwidth per individual voice connection is known.
2. The maximum number of voice connections to be carried is known.
3. From Step 1 and Step 2 it is assumed the maximum CIR can be accurately determined.
4. The level of use may creep close to the CIR on a regular basis.
5. A call will not be connected if there is insufficient bandwidth.
6. A PIR will not be used.

7 Voice traffic will be significantly lighter during the night.

8 Packets should not be dropped.

From the above it is assumed that the Service Level Agreement will take the following form:

- CIR = PIR
- Burst Duration = 0
- SLA = Enforced.

5.9.2 Ethernet Interactive Video

Interactive video, such as video conferencing, typically has the same Quality of Service requirements as voice, however the traffic patterns are radically different. Video conferencing supports mixtures of large packet sizes at high rates where ‘full-sample’ video is transmitted and small packet sizes at low rates where ‘predicted’ or ‘differential’ frames are sent. The following assumptions are made with regard to its nature:

1. The maximum bandwidth at low rates is known.
2. The maximum bandwidth at high rates is known.
3. The duration of ‘full sample’ video is short.
4. From 1 and 2 it is assumed the maximum CIR and PIR can be accurately determined.
5. The level of use may be close to the CIR for long durations.
6. The level of use will rise above the CIR into the PIR frequently.
7. Interactive video traffic will be significantly lighter during the night.
8. Packets should not be dropped.

From the above it is assumed that the Service Level Agreement will take the following form:

- CIR <= PIR/X (Factor of X is unknown at present)
- Burst Duration < 100ms
- SLA = Enforced.

If interactive video is carried as EPL then it should be given a classification of voice since the PIR is not relevant.

5.9.3 Ethernet Voice Control

Typically IP phones use a TCP control connection to communicate with the call manager. Such signals will carry data such as instructions to play dial tones or ‘Camp-on-busy’. If such traffic is dropped or delayed significantly then the user will not receive the required signal and the phone will appear to be faulty. The following assumptions are made with regard to its nature:

1 The maximum bandwidth is known.

2 From Step 1 it is assumed the maximum CIR can be accurately determined.

3 The level of use may creep close to the CIR on a regular basis.

4 A PIR will not be used.

5 Voice control traffic will be significantly lighter during the night.

6 Packets should not be dropped.

From the above it is assumed that the Service Level Agreement will take the following form:

- CIR = PIR
- Burst Duration = 0
- SLA = Enforced.

5.9.4 Ethernet Gold Data (Mission Critical)

Mission critical applications are those that directly contribute to the core operations of an enterprise. Such applications are typically highly interactive and are therefore sensitive to both loss and delay. Examples of Gold Data would be Lotus Notes, SNMP or X Windows. The following assumptions are made with regard to its nature:

1 The maximum bandwidth may not be easy to predict.

2 From Step 1 it is assumed the maximum CIR cannot be accurately determined.

3 The traffic possesses an irregular pattern but should not exceed the CIR.

4 A CIR is chosen with room for growth and level of use should not creep too closely to it.

5 A PIR will not be used as this does not guarantee bandwidth.

6 Gold traffic will be significantly lighter during the night since it is normally interactive.

7 Packets should not be dropped.

From the above it is assumed that the Service Level Agreement will take the following form:

- CIR = PIR
- Burst Duration = 0
- SLA = Enforced.

5.9.5 Ethernet Silver Data (Guaranteed Bandwidth)

Silver Class Data corresponds to applications of secondary importance. Such applications are generally highly asynchronous and would typically correspond to Netmeeting or intranet browsing. Streaming video would also be designated as Silver rather than the higher priority Interactive Video. The following assumptions are made with regard to its nature:

1 The maximum bandwidth may not be easy to predict.

2 From Step 1 it is assumed the maximum CIR cannot be accurately determined.

3 The traffic possesses an irregular pattern but should not exceed the CIR.

4 A CIR is chosen with room for growth and level of use should not creep too closely to it.

5 A PIR will not be used as this does not guarantee bandwidth.

6 Silver traffic will be significantly lighter during the night since it is normally interactive.

7 Packets should not be dropped.

From the above it is assumed that the Service Level Agreement will take the following form:

- CIR = PIR
- Burst Duration = 0
- SLA = Enforced.

5.9.6 Ethernet Bronze Data (Best Effort)

This is the default category. While some of these applications are interactive, they require no bandwidth guarantees and typical examples would correspond to E-mail and generic Internet browsing. The following assumptions are made with regard to its nature:

1 The maximum bandwidth may not be easy to predict.

2 From Step 1 it is assumed that neither the maximum CIR or PIR can be accurately determined.

3 The traffic possesses an irregular pattern and will exceed the CIR regularly.

4 A CIR is chosen to allow an acceptable level of service.

5 The PIR may be significantly higher than the CIR and its burst duration may be lengthy.

6 Bronze Data may be active during the night as this is typically when systems are backed-up.

7 Packet Loss is expected.

From the above it is assumed that the Service Level Agreement will take the following form:

- CIR <= PIR/X X is unknown but is expected to be greater than 3.
- Burst Duration = Indefinite
- SLA = Not Enforced.

Thresholds have been chosen to yield information rather than trigger events.

5.9.7 Ethernet Less-Than-Best-Effort Data

This is non-critical, potentially bandwidth-intensive data traffic. Such traffic would be non interactive and typically correspond to batch updates of large file transfers. The following assumptions are made with regard to its nature:

1. The maximum bandwidth may not be easy to predict.
2. A CIR is not necessary.
3. From 1 it is assumed that the PIR cannot be accurately determined.
4. The traffic possesses an irregular pattern.
5. The burst duration will be long.
6. Less than Best Effort data may be active during the night as this is typically when systems are backed-up.
7. Packet loss is expected.

From the above it is assumed that the Service Level Agreement will take the following form:

- CIR = 0
- PIR = X
- Burst Duration = Indefinite
- SLA = Not Enforced.

Thresholds have been chosen to yield information rather than trigger events.

Usage is calculated as a percentage of the PIR.

5.9.8 Ethernet Multiplexed Services

This is a special traffic class designed for use by the SDH network operator. Where a number of different customers have been multiplexed then the type of traffic carried will be mixed and thus none of the previous traffic classifications may best describe the traffic carried. The following assumptions are made with regard to its nature:

1 The maximum bandwidth will be based on the summation of Ethernet services to be multiplexed.

2 From 1 it is assumed the maximum CIR can be determined with a reasonable degree of accuracy.

3 The traffic possesses an irregular pattern and may exceed the CIR due to the PIR of its constituents.

4 A CIR may be chosen with extra capacity to allow for the PIR of its constituents.

5 A PIR will not be used as this does not guarantee bandwidth.

6 The level of use may exceed 100% on a regular basis due to the PIR of its constituents.

7 Muliplexed services may be active during the night since it may carry best effort data.

8 Packet loss is expected due to the unpredictable nature of its constituent traffic.

From the above it is assumed that the Service Level Agreement will take the following form:

- CIR = PIR
- Burst Duration = 0
- SLA = Enforced.

Thresholds have been chosen to yield information rather than trigger events.

Chapter 6:
Layer 2 Application Scenarios

6.1 Ethernet Layer 2 Functionality

Note: In this chapter the term ‘Ethernet Layer 2 card’ is a generic term. The specific available Ethernet layer 2 card is called the: 10M/100M/1000M Ethernet Layer 2 card. The use of the lable ETA on some of the diagrams should be taken to refer to a generic Ethernet tributary mapper card. The material in this chapter is designed to provide a generic description of Ethernet Layer 2 application scenarios.

6.1.1 Ethernet Private Line (EPL)

Ethernet Private Line (EPL) applications are commonly used for interconnecting Local Area Networks (LAN), Ethernet Metro Networks as well as Wide Area Networks (WAN). The intention is to transfer data traffic from a number of nodes to a smaller number of concentration centres.

Figure 6-1: Data Transport Network Using EPL Service Model

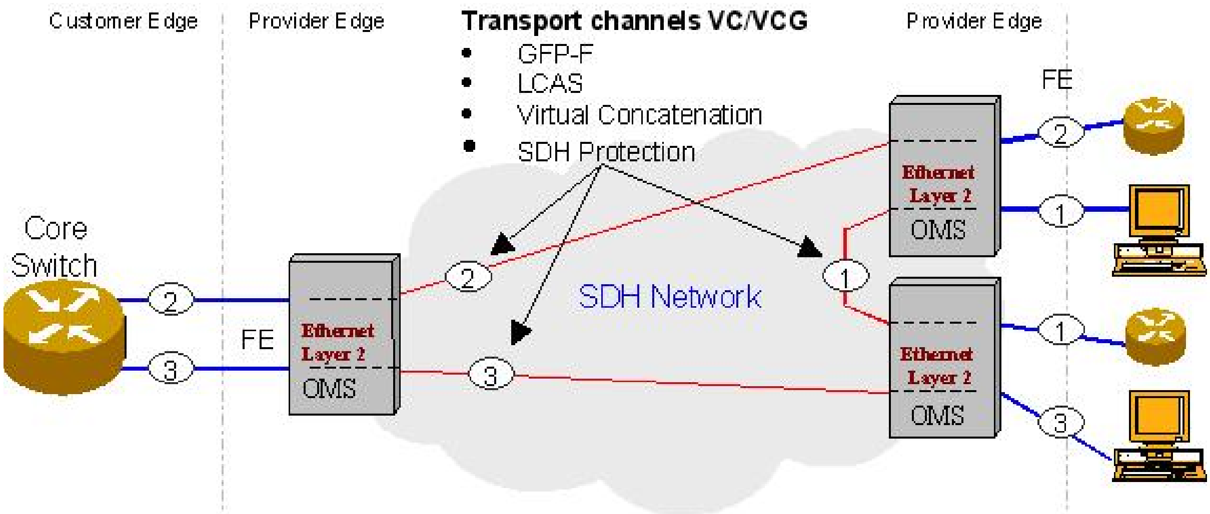


Figure 6-1 shows a network providing the EPL service. The SDH transport network connects Ethernet ports on each side of the network. Each of the private lines (1) to (3) is completely separated, which means there is a port per customer on each side of the network. The ports are connected via separate SDH transport container groups. That is no say no aggregation of Ethernet flows is taking place.

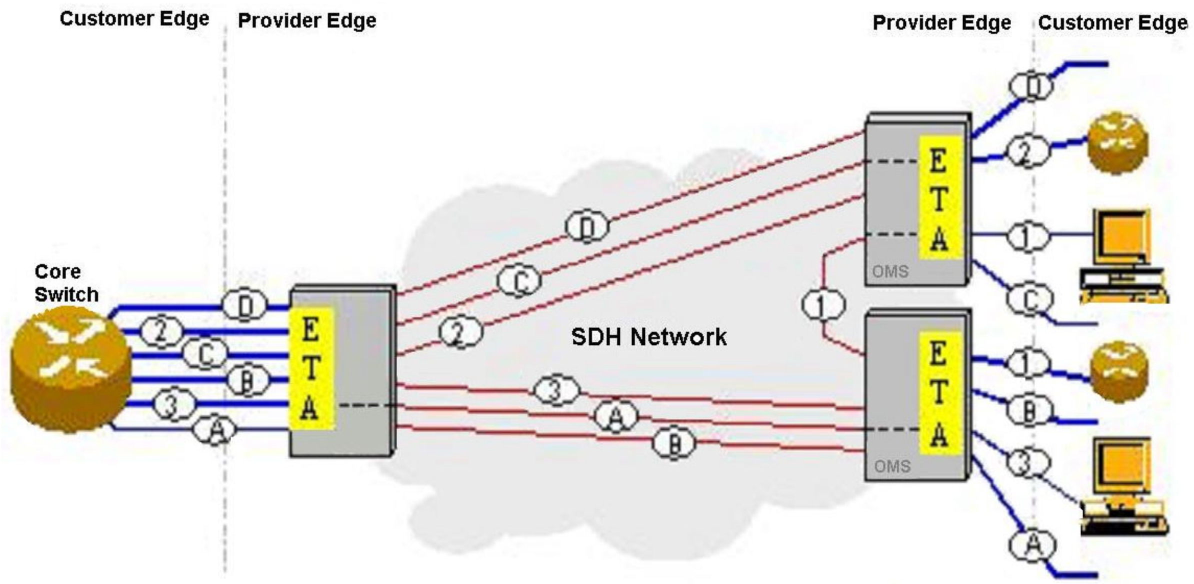
On the network side of an EPL product, each Ethernet flow is mapped into an appropriate SDH transport container, a single container (VC-12/VC-3/VC-4) a group of virtual concatenated containers (VC-12-nv, VC-3-nv-and VC-4-nv). On the access side the Ethernet flow is mapped to an Ethernet port. The complete Ethernet frame is transmitted, including the MAC header.

6.1.2 Multiple Ethernet Private Line (M-EPL)

In Figure 6-2 an EPL scenario as shown with tens of interfaces at the customer premises. For each port, a single VC (or VC group) has to be allocated. The high numbers of customer interfaces require also tens of interfaces at the transport equipment connected to the core switch and the core switch itself.

As traffic may have been shaped before entering the SDH network, each of the tunnels may carry only a fractional part of the physical Ethernet bandwidth. This leads to inefficient use of interfaces in both the transport devices and the core switch resulting in a higher than necessary network cost.

Figure 6-2: Data Transport Network Using EPL Service Model

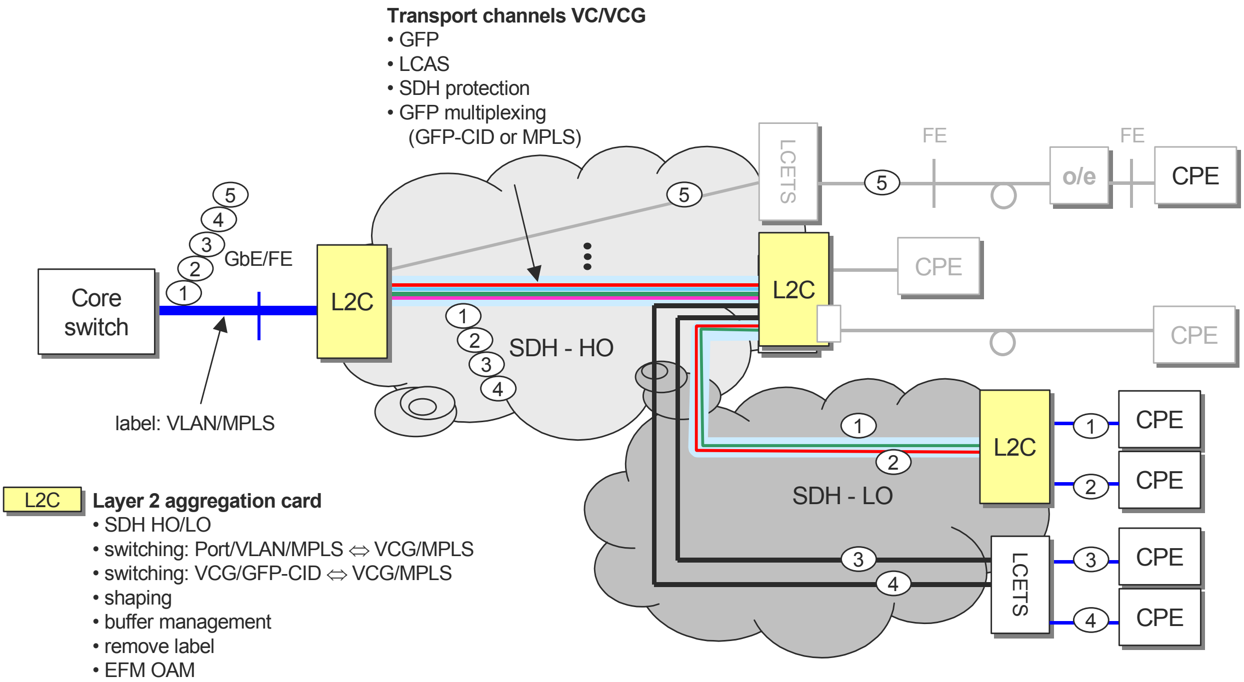


6.1.3 Ethernet Virtual Private Line (EVPL)

6.1.3.1 Ethernet Aggregation

EVPL provides aggregation into an access link in the same way as the MEPL service (refer to Figure 6-4 in section 6.2.2). However, rather than assigning a dedicated transport channel (SDH VC or VCG) to each customer private line, multiple private lines may share the transport bandwidth: the private line becomes Virtual. The layer 2 card on the left hand side in Figure 6-3 operates in such a mode; it aggregates a private line (5) and several virtual private lines (1 to 4) into a single access link to the core switch.

Figure 6-3: EVPL with GFP/MPLS Multiplexing



6.2 Optimisation of the Network

The fixed network structure shown in Figure 6-1 and Figure 6-2 occurs during the initial introduction of Ethernet services on a standard SDH network. The basic network infrastructure is unchanged because only new add-on cards are equipped to carry the extra data types. The network is still based on SDH and does not use any typical aspects of Ethernet Data traffic behaviour, e.g. statistical multiplexing or multipoint connectivity.

For optimisation, a number of different steps of Ethernet traffic aggregation can be introduced. These reduce the numbers of Ethernet ports in the network giving reduced network expenditure (CAPEX) as well as reduced operating costs (OPEX) and more efficient usage of the SDH transport capacity.

6.2.1.1 Bandwidth

The Layer 2 card supports a maximum unidirectional data rate, which depends on the frame size distribution of the overall traffic arriving at the Layer 2 card. If the data rate of the traffic to be transported exceeds the throughput capacity, the Layer 2 card may discard traffic in an uncontrolled manner.

Scenario 1:

Under worst case traffic conditions, the unidirectional throughput is limited to 2.4 Gbit/s. Therefore, if the user cross-connects Ethernet flows with a maximum data rate higher than 2.4 Gbit/s, the Layer 2 card will raise the maximum b/w Exceedence alarm.

The Layer 2 card raises this alarm if the sum of the data rates of all enabled interfaces on the card exceeds 3.3 Gbit/s. This is the limit for arriving traffic under worst-case traffic conditions.

The worst-case traffic conditions are:

- Frame size distribution: frame size is constantly in the range 64-69 byte
- Load: 100% of actual load (peak information rate) on all enabled/cross-connected interfaces concurrently.

Those worst-case conditions are not realistic in real world scenarios. For other traffic conditions, the performance of the card is higher. Therefore, the user may not observe any traffic loss due to overload even for much higher load.

In the best case (large frames > 1000 bytes), the maximum unidirectional card throughput is limited to about 4 Gbit/s. For typical Internet traffic with an average frame size in the range of 300 to 400 bytes, the maximum unidirectional throughput will be around 3.5 Gbit/s.

Furthermore, in many scenarios it is realistic to assume that the load is very rarely 100% of peak information rate on all Ethernet flows concurrently. Therefore, the configured peak rate of the Ethernet flows may be even higher than the above values without any problem to expect.

Scenario 2:

Under certain circumstances (see below), four additional internal overhead bytes are added to each frame on an Ethernet interface. Therefore, the maximum possible throughput on an Ethernet interface may be limited below the maximum theoretical net throughput.

For 64 byte frames, the maximum theoretical net throughput of Ethernet frames (including FCS, excluding preamble, excluding start of frame delimiter, excluding interframe gap) is 76.1 Mbit/s on Fast Ethernet and 761 Mbit/s on Gigabit Ethernet interfaces.

Due to the additional four bytes, the throughput decreases to 72.7 Mbit/s on Fast Ethernet and to 727 Mbit/s on Gigabit Ethernet interfaces, which is 94.1% of the maximum theoretical net throughput.

- The efficiency of 94.1% described above for 64 bytes is the worst case.
- For large Ethernet frames, the efficiency is higher, e.g. 99.7% for 1518 byte frames.
- For typical Internet traffic with an average frame size of 370 bytes, an efficiency of 98.9% can be expected.

The problem is present if one of the following circumstances is true:

9 When for a physical port on the Ethernet side a connection ID of type either 'VLAN' or 'Destination MAC' is used

10 When for a physical port on the Ethernet side a connection ID of type 'None' is used and on the SDH side a connection ID of type 'VLAN' is used.

6.2.2 Ethernet Aggregation (SDH into Ethernet)

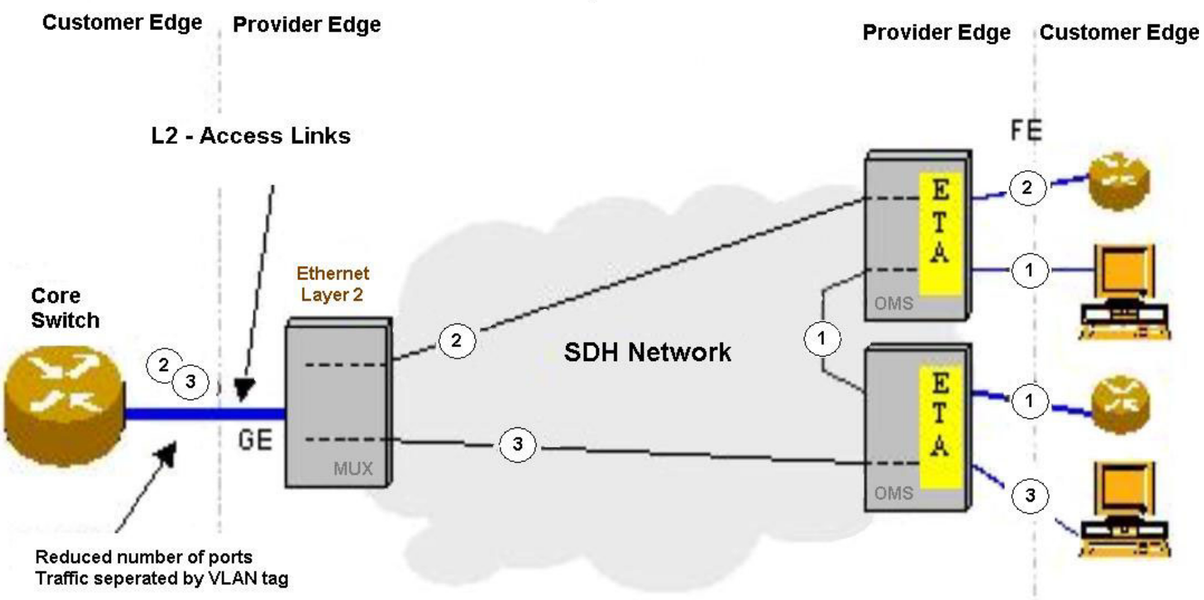
In this application, the aggregated signal appears on an Access port (where Access port means the external GigE or FastE ports). This is referred to as an Ethernet Aggregation function.

When both private lines (2) and (3) are terminated on the same equipment at the same location, e.g. at the core switch, it makes sense to aggregate the traffic and hand-off to the core switch on a common Ethernet interface.

Figure 6-4 indicates the network solution. All the customer flows are still transported via single VCs (or VC-groups) and each packet channel ends at the core switch location to be aggregated into a single link. The packet channels 2 and 3 are now aggregated into a single access link carrying multiple private lines using the Ethernet Layer 2 Card. On the aggregating access link, the 'virtual' lines are differentiated using a VLAN tag.

The Core router is configured to use sub-interfaces, which adds VLAN tags that the Ethernet Layer 2 card can recognise.

Figure 6-4: Access Link Aggregation



6.2.3 SDH Transport Channel Aggregation (SDH or Ethernet into SDH)

In this application, the aggregated stream is mapped to an access port (external GigE or FastE ports) as well as to a trunk port (VC-group). This is referred to as an access (node 4) or trunk (node 1,2,3) aggregation dependent on the node type. With the given definitions, nodes 1 and 2 perform aggregation, node 3 performs SDH Transport Channel Aggregation, and node 4 performs both Ethernet and SDH Transport Channel aggregation.

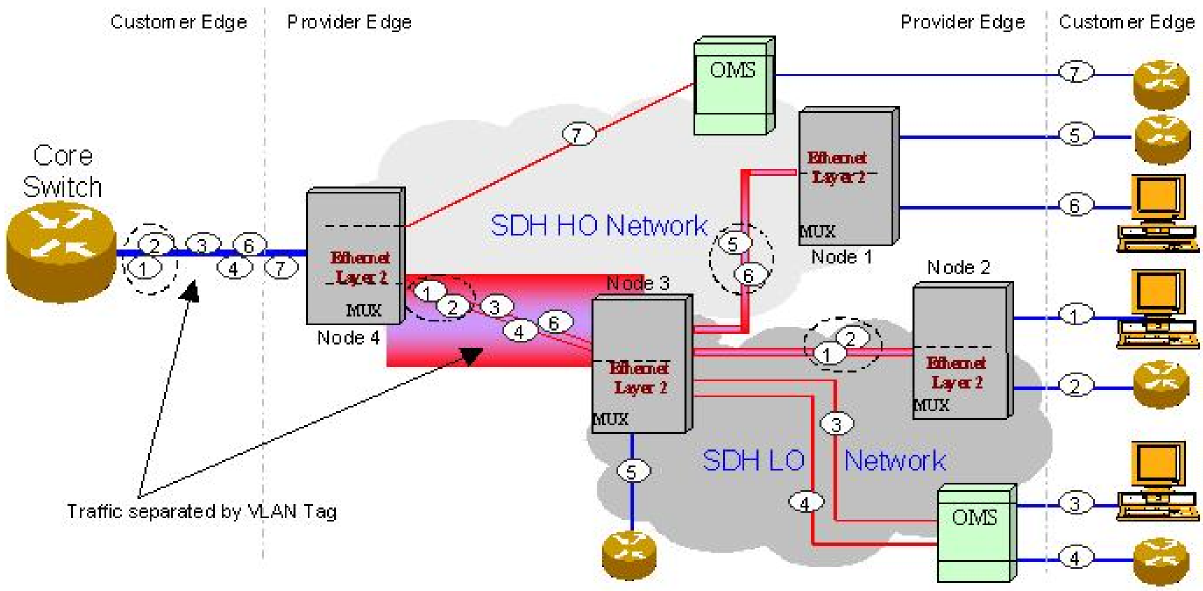
The next step to optimise the network is to aggregate the private lines (3) and (4) between the customer site and the core switch to reduce number and size of used VCGs as early as possible. Such an aggregation point can also aggregate pre-aggregated signals (1), (2) delivered by Node2 as well as (5), (6) delivered by Node1. The Layer 2 card is aggregates any mixture of Access and Trunk aggregation and when the external Ethernet Access ports of an Ethernet Layer 2 card are not used the term ‘Blind Card’ is used as shown in Figure 6-5.

Aggregation at a trunk link means carrying several customer flows by using only one large VC-group instead of using many separated smaller VC-groups to the far end of the network. This type of aggregation provides the following additional benefits:

- Improved utilisation of transport bandwidth. Ethernet virtual private line services are sold at bandwidths far below the physical line rate of the access links.
- In the same way that an Ethernet Layer 2 card has a maximum number of external Ethernet Access ports, there is also a restriction on the number of SDH Virtual Concatenation Groups (VCGs), which can be supported. By using trunk link aggregation this restriction is avoided and a large number of number of channels (or VPCs) can be configured in the network.

Whether or not pre-aggregated flows like (1)(2) and (5)(6) are forwarded with/without decomposition has to be configured in any transfer Ethernet Layer 2 card for each flow. As shown in Figure 6-5 the pre-aggregated flow (1) (2) is forwarded as one input to the next stage. Flow (5) (6) has been terminated and distributed in two different directions.

Figure 6-5: Trunk Link Aggregation (and Ethernet Layer 2 ‘Blind Card Mode’)



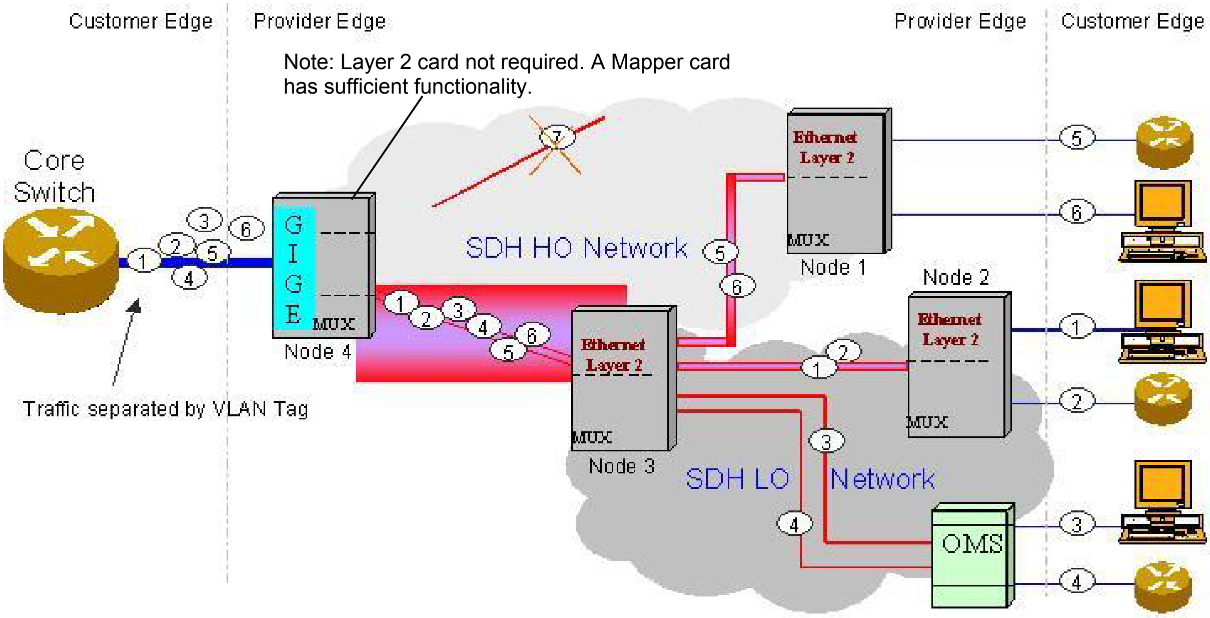
6.2.4 Trunk Link Aggregation with Remote Ethernet Access Port

Figure 6-6 shows another scenario of trunk link aggregation. In this scenario it assumes that the Ethernet flow (7) does not exist, so the last aggregation stage is not necessary. In such applications, a standard Fast Ethernet or a Gigabit Ethernet mapper card can carry out the connectivity to the Core Switch rather than a Layer 2 card. The last Ethernet Layer 2 card (Node 3) sends the Ethernet flows to the mapper card, which forwards them transparently via the Access port to the Core Switch. The GigE card acts as a remote Ethernet interface.

Based on the extent of the utilisation of the SDH network and the number and locations where customer access ports are available, the network could be configured in two different ways:

- Have only one aggregation point at the Core Switch location and use a lot of SDH capacity between customer access ports and the head end.
- Have more distributed Ethernet Layer 2 cards in the network, reducing the SDH capacity requirements close to where the Ethernet flows originate, by aggregating the flows at the earliest opportunity.

Figure 6-6: Trunk Link Aggregation with Remote Ethernet Access Port



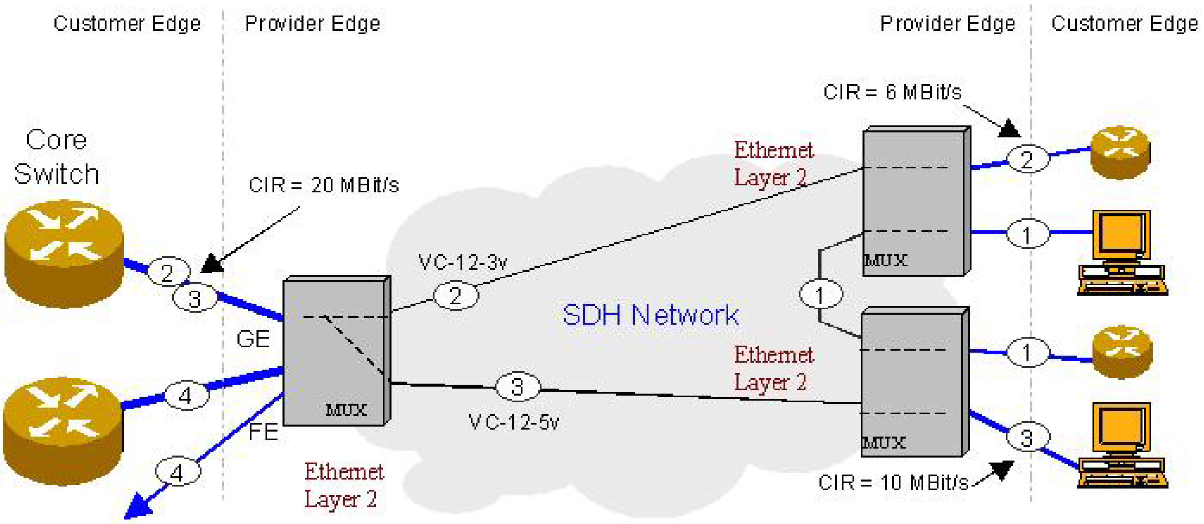
6.2.5 Burst Compensation

The trend to offer Ethernet equipment with interfaces based on Gigabit Ethernet physical layer specification independently of the real port bandwidth applications with partially filled GigE flows should be considered.

As an example, the customer port has been set to a CIR of maybe 20 Mbit/s but the physical layer is based on the Gigabit Ethernet specification. A burst can appear (2)(3) with Gigabit Ethernet speed and has to be stored in Ethernet Layer 2 Card. The Ethernet Layer 2 card maps the single Ethernet flows (2), (3) as configured into two VCGs, which consists of some low order VCs (5 x VC-12 and 3 x VC-12). If traffic bursts for a sustained period above the CIR, the Ethernet Layer 2 card limits the rate, enabling efficient adjusting of used SDH bandwidth according to the application demand.

Additionally in some applications it may be useful to have a Fast Ethernet interface instead of a partially filled Gigabit interface. The Ethernet Layer 2 card may be used to convert partially filled GigE pipes (4) into a cheaper and more appropriate FastE pipe (4) as well as vice versa.

Figure 6-7: Burst Compensation

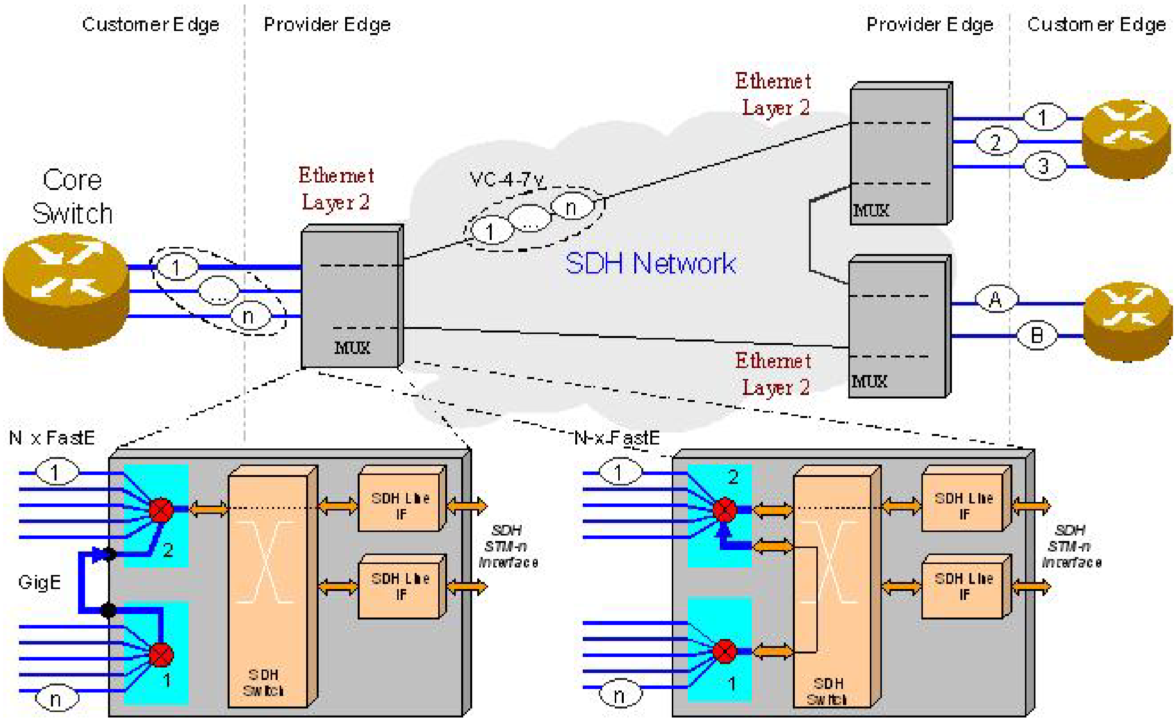


6.2.6 *Cascading Ethernet Layer 2 Cards*

In applications, where the demand for Access or Trunk interfaces is larger than that supported by one Ethernet Layer 2 Card, it's possible to cascade two or more Ethernet Layer 2 Cards to reach a higher number of interfaces. This is achieved in two different ways as shown in Figure 6-8 below.

6.2.6.1 Access Port' Cascade

Figure 6-8: Access Port Cascade



As shown in Figure 6-8 (left part) cascading can be achieved via an external GigE/FastE port if both Ethernet Layer 2 Cards are available in the same location. N x FastE interfaces could be aggregated on Ethernet Layer 2 Card-1. The aggregation output is available at the GigE port and is connected to the GigE port of Ethernet Layer 2 Card-2. It aggregates all its own FastE ports as well as the pre-aggregated flow from ELS-1000 Card-1. The final aggregation flow is inserted into an appropriate VCG and transferred to the SDH network.

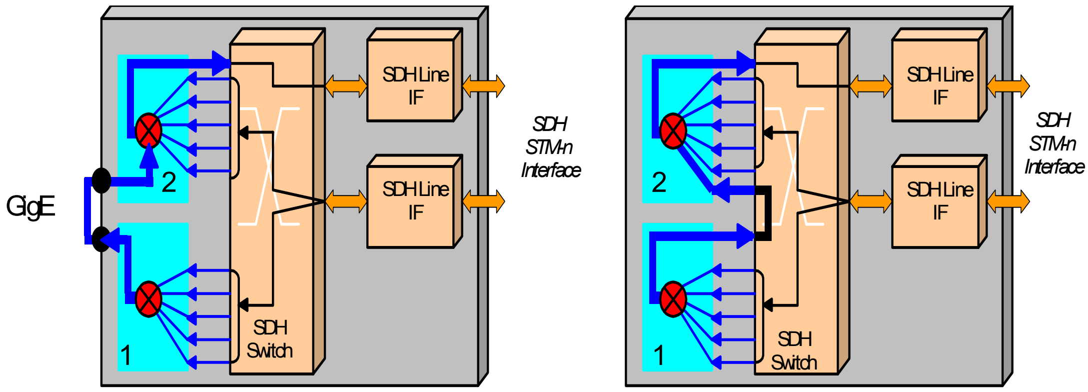
Similarly as shown in Figure 6-8 (right part) cascading can be achieved by connecting both Ethernet Layer 2s via the SDH switch. In such applications, locations for Ethernet Layer 2 Card-1 and Ethernet Layer 2 Card-2 could be different, because connectivity can be achieved via the local SDH switch or via the SDH network. Note: the overall bandwidth of Ethernet Layer 2 Card-2 is lower than that in the classical cases, because each pre-aggregated packet has to pass through the card twice via the backplane, once when entering the Ethernet Layer 2 Card-1 and a second time when leaving it.

Note: The two cascaded Ethernet Layer 2 Cards still appear as two different instances in the management system.

6.2.6.2 'Trunk Port' Cascade

In some applications, particularly in LO SDH networks the demand of virtual channels (particular on small VC-12 groups) may be larger than that supported by one Ethernet Layer 2 Card. In this case, it is possible to cascade two or more Ethernet Layer 2 Cards to reach a higher number of virtual channels. This can be done by two different ways shown in both parts of the figure below.

Figure 6-9: Trunk Port Cascade



As shown in Figure 6-9 (left part) cascading can be achieved via an external GigE/FastE port if both Ethernet Layer 2 Cards are available in the same location. N x VC-12s could be aggregated on Ethernet Layer 2 Card-1. The aggregation output is available at the GigE port and is connected to the GigE port of Ethernet Layer 2 Card-2. This card aggregates all its own VC-12s as well as the pre-aggregated flow from Ethernet Layer 2 Card-1. The final aggregation flow is inserted into an appropriate VCG and transferred to the SDH network.

Similarly as shown in Figure 6-9 (right part) cascading can be achieved by connecting both Ethernet Layer 2 Cards via the SDH switch. Note: the overall bandwidth of the Ethernet Layer 2 Card-2 is lower than that in the classical cases, because each pre-aggregated packet has to pass through the card twice via the backplane, once when entering the Ethernet Layer 2 Card-1 and a second time when leaving it.

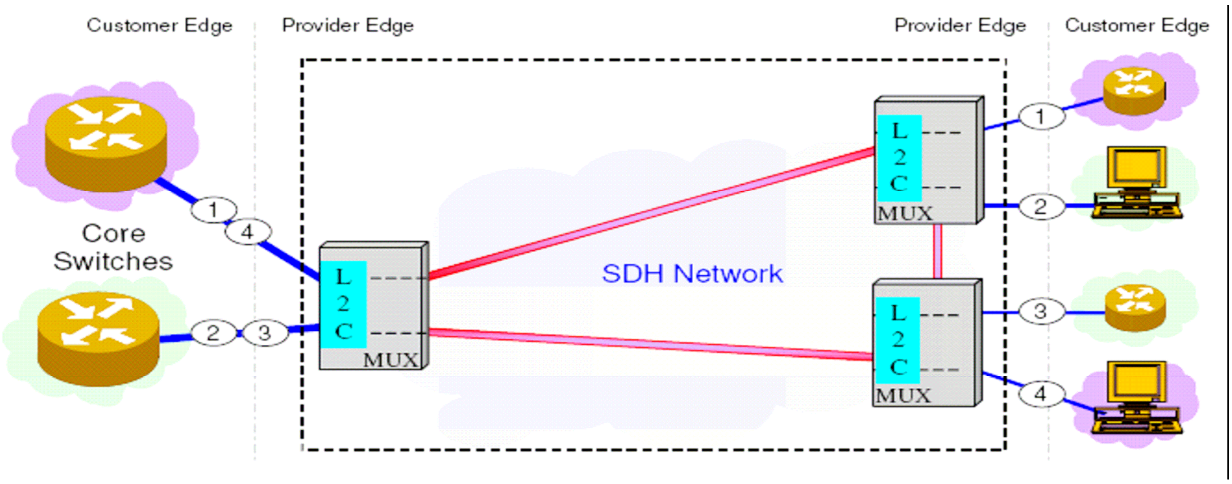
6.2.6.3 'Mixed' Cascade

Finally mixed applications between Access and Trunk Cascade are dependent on the number of access ports, the number of supported VC-groups as well as the SDH bandwidth between Ethernet Layer 2 card and SDH switch.

6.2.7 *Ethernet Private LAN (EPLAN, EVPLAN)*

The Marconi OMS 1600 release 2.1.2 introduces support for Ethernet Private LAN service. In contrast to the EPL and EVPL services, which provide connection-oriented point-to-point transport following a leased line model, the EVPLAN service is a connection-less multipoint-to multipoint service between multiple sites of a customer. EVPLAN introduces address learning and multicasting, which simplifies network operation significantly for the customer. When a new device is added to one of the network sites, it is directly visible in all other sites.

Figure 6-10: Ethernet Virtual Private LAN Service



Consider the case where a customer wants to connect different LANs at different sites using an EVPL service and routers. If a new router is added to one site, a virtual packet channel must be installed to all the other sites and the routers in the other sites must be configured to reach this new device. New sub-nets must be set up and the VLANs on all the aggregated Ethernet (and possibly SDH Transport Channel) links must be configured. In most of the cases these new connections must be negotiated with the network operator. The automatic address learning that comes with the EVPLAN service simplifies this task. If the transport network appears as a big transparent bridge, there is no configuration effort necessary in remote sites. Only the local, newly added router must be configured. Once this router sends it's first packet the bridge learns the address from the packet's source address and utilises this entry for subsequent forward decisions.

The EVPLAN service allows the implementation of Layer-2 virtual private networks (VPN) directly on top of the transport infrastructure. Benefits of Layer-2 VPNs are:

- The customer retains full control over his connectionless Ethernet network.
- Interactions with the network operator are minimised.
- Once implemented, the Operator can leave routing to the customer.
- A L2 VPN can transport any kind of Layer-3 protocol, not only IP

6.2.7.1 Bridging and Contiguous MAC Layer

In order to properly form an active topology in a L2 LAN, Ethernet bridges must be connected through LANs with contiguous MAC client layers, i.e. two bridges connected through a common LAN segment must have the same view on the availability and status of the attached LAN segment.

Figure 6-11: Mapper Card between two Bridges without LLF

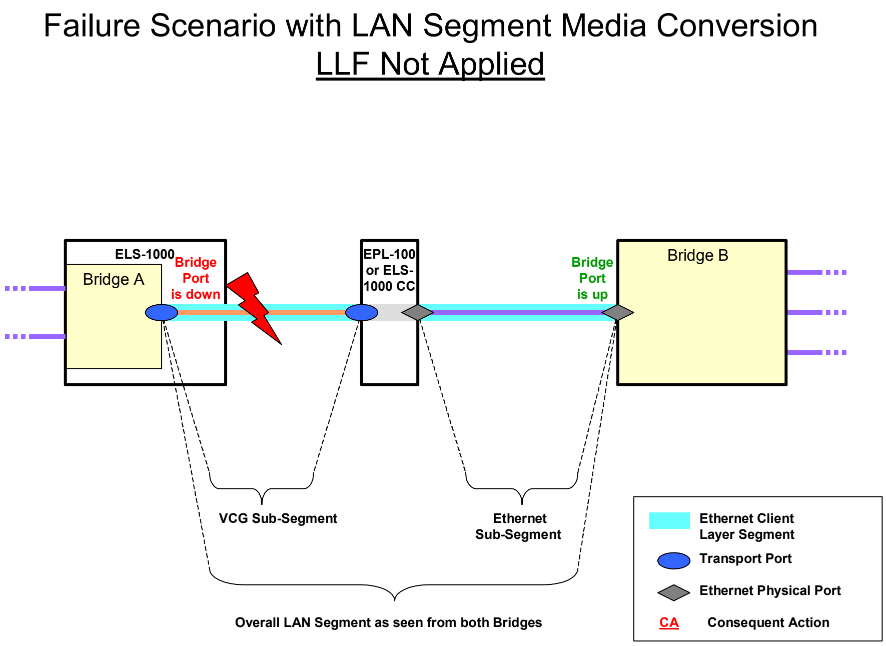


Figure 6-11 presents a scenario in which the MAC layer is not contiguous, i.e. the failure of the MAC layer on the VCG sub-segment is not propagated to the Ethernet sub-segment. As a consequence, Bridge A regards its connected port and hence the whole segment as not operational, while bridge B regards the segment as operational. This results in inconsistent topology information being used by the bridges and consequently the calculated active topology will be erroneous.

To solve this problem, care must be taken with the sub-segmentation of Ethernet segments between bridges resulting from the application of Mapper devices, not to create a situation as depicted in Figure 6-11.

CAUTION!

A failure on any of the server layer sub-segments which support the common MAC client layer segment must be forwarded to the bridge ports at that Ethernet LAN segment.

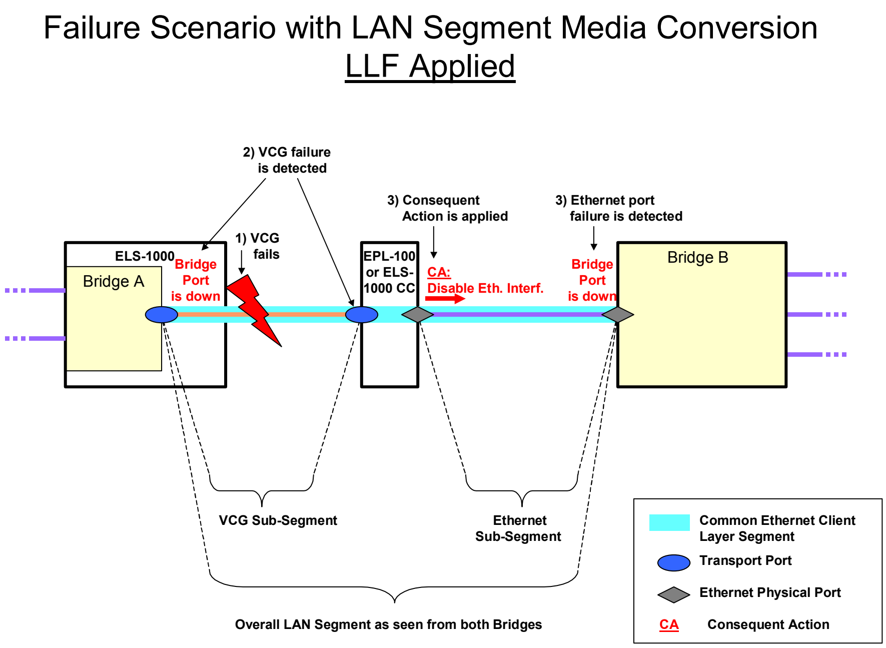
It can be seen that to avoid the situation depicted in Figure 6-11, Link Loss Forwarding (LLF) must be configured on both ports involved on the EPL-100 or ELS-1000 which connects the two sub-segments, in order to cover failure of any of the attached sub-segments.

The VCG must be configured with a Consequent Action (CA) to send GFP CSF frames and the Ethernet interface must be configured with a CA to disable the interface. This ensures that failures of the Ethernet link in the direction from bridge B to the EPL-100/ELS-1000 are forwarded to bridge A via the VCG and that failures of the VCG in the direction from bridge A to the EPL-100/ELS-1000 are forwarded to bridge B. Figure 6-12 presents the resulting configuration in the case of the VCG failure. The MAC client layer is now contiguous thanks to LLF configuration, i.e. the VCG sub-segment failure is propagated to the Ethernet sub-segment.

CAUTION!

Link Loss Forwarding (LLF) must be used to propagate Physical Layer failures through a diverse Physical Layer infrastructure which supports a single contiguous MAC client layer.

Figure 6-12: Mapper Card between two Bridges with LLF



6.3 Point–to–Multipoint Unidirectional Cross Connections

In point-to-multipoint cross connections, one incoming VC from a particular SDH port can be dropped off at multiple points along the chain or ring, with copies being released at various points, or all VCs can be dropped off at the end. In the Interconnect, data can only be set up in one direction, but may be multidirectional in the joined rings or chains, and within an individual node. This feature is used for network scenarios where for example there is a requirement for video broadcast (This functionality is also used in DNI networks.).

Set up and management is described in topic 5, LCT/LCTS Operating Manual of this manual suite. This feature allows a wide variety of possible protection scenarios based on an analysis of each pathway in detail using an OMS solution. Unidirectional pathways are not a feature of other network equipment. The two incoming channels Worker and Protection are conveyed to their relevant output ports; the drop leg is connected to the Worker channel and protected by the Protection channel.

There are no restrictions in the Marconi OMS 1600 LCT software to the number of drop of points which can be created, provided those points already exist. Source to destination has to be created before the cross connection can be made. Points can be added or removed individually.

The network architecture will need to take into account:

- Whether one or both connected rings are bi-directional or unidirectional
- The type of each of the four nodes that make up the dual node interconnect
- The pathway options within each node
- The pathway options across the dual node interconnect.

Collapsed Dual-Node Interconnect is one example of a scenario where unidirectional point-to-multipoint would be required. It uses four different NE’s, configured according to the traffic requirements. Using different cards for the interconnect ring, preferably at different 1664 subrack locations may be the optimal way to protect the broadcast interconnection architecture.

Video distribution networks may use drop and continue interconnects.

Figure 6-13: Video Broadcast

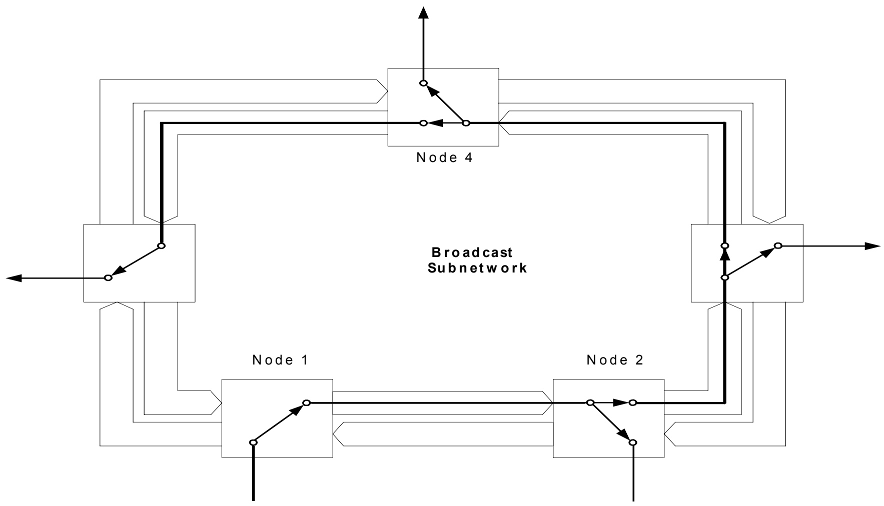
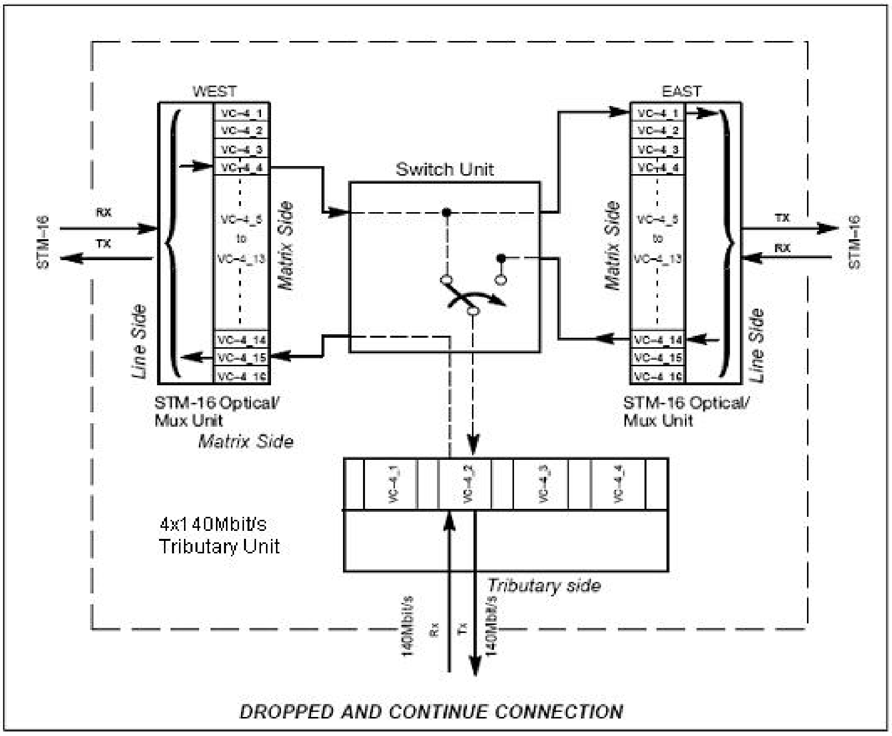


Figure 6-14 shows a Point–to–Multipoint Unidirectional Cross Connections at a single node.

Figure 6-14: Unidirectional Dropped and Continue Connection within a Single Node



In the example illustrated in Figure 6-14, the channel VC4_4 (UCD Worker) incoming to line West is unidirectionally connected to channel VC4_1 outgoing from line East, it is also unidirectionally connected to VC4_2 outgoing from the tributary unit.

The channel VC4_14 (UCD Protection) incoming to line East is provisioned as SNC protection for VC4_4 West and, as such, is also unidirectionally connected to VC4_2 outgoing from the tributary unit. The matrix is able to choose the service from one of the two connected channels to pass to the tributary unit.

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Chapter 7: Communications Theory

7.1 Introduction

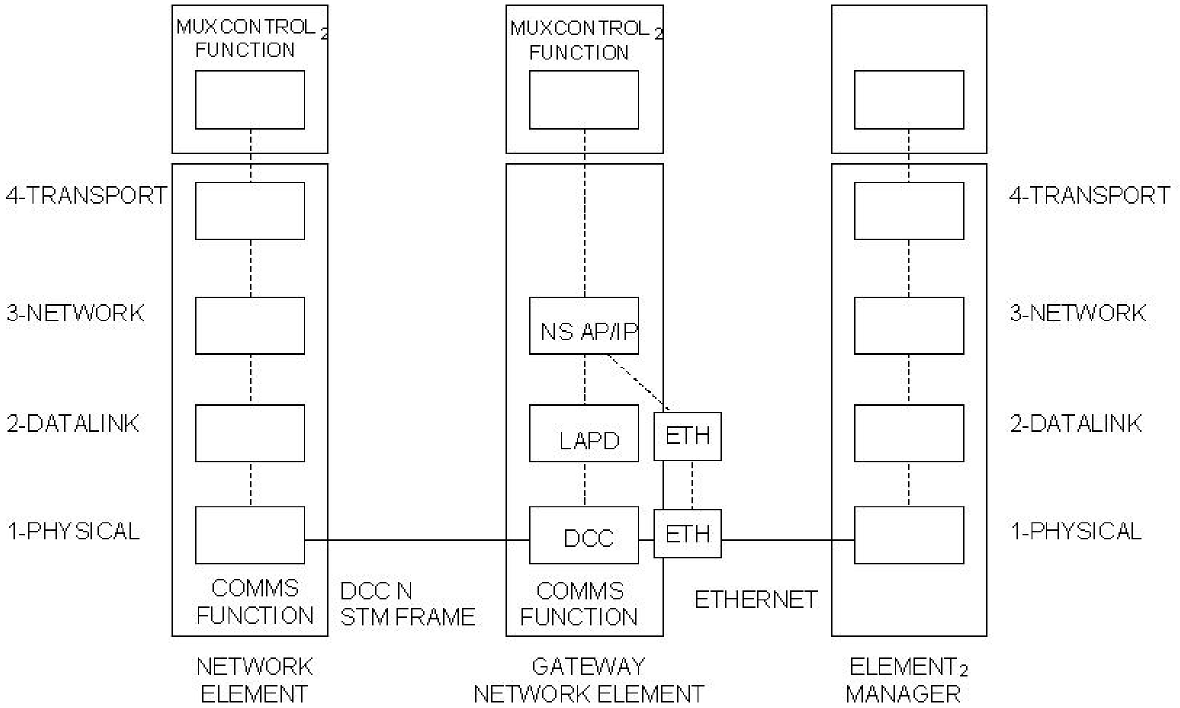
CAUTION!

Network Data Communications Configuration Parameters must not be altered without the authorisation of the Network Design Authority. To do so can result in loss of Network Data Communications that may only be resolved through recourse to a site visit.

Communication channels are provided between:

- The Element Manager (for use by an Operator) and the Gateway Multiplexer, via an Ethernet Local Area Network (LAN).
- The Gateway Multiplexer and the other OMS elements of the network, via the Data Communication Channel (DCC) bytes in the STM frame structure.

Figure 7-1: Gateway Network Element



7.2 Protocol and Layers

The communications protocol between Network Elements (NE) and the Element Manager is based on the ISO Open Systems Interconnect (OSI) seven-layer model. However, only the first four layers of the OSI model are implemented for the OMS series (see Figure 7-1). Each layer performs a specific function and interfaces only with those layers directly adjacent to it. The layers implemented are:

- **Physical Layer** - provides the means to transmit bits of data across a continuous communication path. This layer is concerned with the electrical, optical and mechanical requirements of a communication link. The point-to-point bearer of the communication link may be copper wire, coaxial cable, optical fibre, etc.
- **Data Link Layer** - provides framing for data transfer across a physical connection. The data link layer detects and, where possible, recovers from transmission errors. Where recovery is not possible, the network layer is notified of the error. Various protocols identify the start and end of each frame. Addressing is required at the data link layer for some data link types. Ethernet interfaces require a unique MAC address (or SNPA), which consists of 12 hexadecimal characters (this is required for both stack options).
- **Network Layer** - the responsibility of the network layer is to establish a reliable communications stream between a pair of systems. It resolves routeing of data between elements and controls congestion avoidance. To facilitate routeing, each Network Element (NE) is identified by a unique network layer address. In an OSI network, the address is termed a ‘Network Service Access Point’ (NSAP). In Internet Protocol it is called an IP address.
- **Transport Layer** - ensures error free end-to-end flow of data. It covers flow control, buffering and multiplexing, and also manages call connection and clear-down.

Two alternative stack options are possible:

- OSI (IS-IS routeing)
- IP (OSPF routeing).

7.2.1 Interface Types

The following interface types are used in Marconi OMS 1600:

7.2.1.1 Ethernet ‘Q’

Used for network management access (MV36). (Physically accessed on MAN SYNC LTU – lowest of three RJ45s – marked as ‘NMI (Q)’.)

7.2.1.2 Serial (RS 232) ‘F’

Used for the local craft terminal access. (LCT). (Physically accessed on MAN SYNC LTU – 15-way D-Type – marked as ‘LCT (F)’.)

7.2.1.3 Ethernet ‘F’

Used for the local craft terminal access. (LCT). (Physically accessed on MAN SYNC LTU – highest of three RJ45s – marked as ‘EXP’.)

7.2.1.4 DCC

DCCr apply to the Regenerator Section Overhead frame position and DCCm to the Multiplex Section Overhead frame position. When setting up Multiplexer networks, a choice must be made as to which DCC are used for communications within any particular sub-network.

There are four types of DCC available for network management access:

- DCCr
- DCCm
- DCC-VC4-F2
- DCC E1-OLO.

7.3 OSI Comms

7.3.1 Introduction

Management of the system requires communication between the Element Manager and an SMA Gateway Multiplexer and all other SMA Network Elements in the network. The communication link between the Element Manager and the SMA Gateway Multiplexer is via an Ethernet LAN (IEEE 802.3). Intercommunication between all other SMA elements in the network is via Data Communication Channel (DCC) bytes in the STM frame, or via embedded LANs, using the Ethernet protocol.

The communications network can support all typical topologies found in SDH networks. Typical topologies include:

- Intersecting rings
- Multiple Element Managers (EM)
- Multiple Gateway Network Elements (GNE) on an Ethernet
- Multiple GNEs on a ring
- Interworking between SMAs and SLA line systems
- Mesh’ networks.

Physically, the communications function for Network Element applications is processed by the Multiplexer CCU controller function and communications function, with the former dealing with Transport Layer (4) level communications to the Element Manager and the latter controlling lower layer functions.

Communications configuration parameters can be displayed, set or altered via the Local Terminal (LCT) and Element Manager, as given in full in the appropriate Element Manager and LCT Operator Manuals, the following are the principal parameter levels:

- Transport Layer
- Gateway Interface
- Network Layer
- IS-IS/ES-IS Configuration
- Performance Counts (from the LCT only).
- Routeing Table Display
- CLNS Ping (from the LCT only).
- DCC Configuration
- LAPD Configuration.

Note: When commissioning a new Marconi OMS 1600 into a network, the communications parameters must be entered via a LCT at the element itself, subsequent changes can be made remotely via the Element Manager or using LCT Single Ended Maintenance (SEM).

Note: In the OSI model, data communication starts with the top layer at the sending side, travels down the OSI model stack to the bottom layer, then traveses the network connection to the bottom layer on the receiving side, and up its OSI model stack.

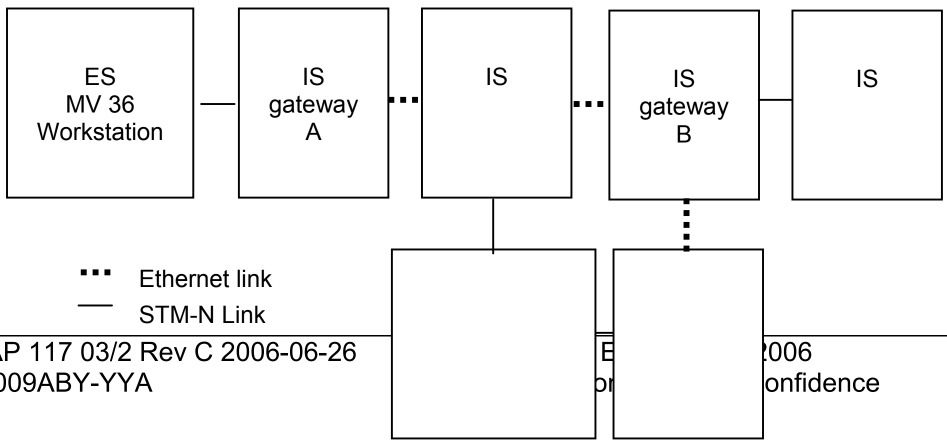
7.3.2 End Systems Intermediate Systems and Gateways

The purpose of a network is to communicate data from 'End System' (ES) to 'End System'. 'Intermediate Systems (IS)' provide the route (or 'service') for the transfer of that data. In an Ericsson system an IS element can contain ES functionality and therefore can be the destination or source of information as well as providing a routeing function. Key to the communications process is how 'elements' within a network know:

- Their own identity, i.e. Network Service Access Point (NSAP) address
- How to connect to other entities ('route').

An Element Manager can be connected to several Gateway Multiplexers simultaneously via the Ethernet. The Gateway Multiplexers and the Element Manager communicate with each other via ES-IS Protocol, with multicast addresses, which are recognised by all Gateway Multiplexers.

Figure 7-2: ES, IS and Gateways



In the network example above, there are two types of Network Element, which process Network Management Data. These are:

End Systems (ES)	These will only process messages intended for them.
Intermediate systems (IS)	These will process messages intended for them, but also will pass on messages intended for other elements.

The All-IS address identifies the target group of entities, (Gateway Multiplexer/Element Manager) to which the multicast relates. Likewise for the All-ES address.

7.3.3 *Communications Routeing*

7.3.3.1 Introduction

Communications routeing between elements in a network is based on ISO 'IS-IS' protocol (ref. ISO 10589) which provides a dynamic solution to routeing CLNP and is a 'link state protocol'.

The routeing requirements shown in Table 7.1 are supported, where 'Q' is the ITU-T Interface used with the OMS series for Network Management via the Element Manager and 'DCC' are the Data Communications Channels within the STM-N frame.

Table 7-1: Comms Routeing Requirements

To/from	To/from
Q	DCCr
Q	DCCm
Q	Control Sub-system
DCCr	DCCr
DCCr	DCCm
DCCr	Control Sub-system
DCCm	DCCm
DCCm	Control Sub-system

7.3.4 *LAPD Protocol*

The Link Access Procedure on the 'D'-channel (LAPD) protocol is used for the data link layer for communications. It requires that each STM port, whether line or tributary, has to be set up as either in User mode or in Network mode.

Setting up during commissioning is via the LCT at the element, but subsequent changes can be made remotely via the LCT using Single Ended Maintenance or via the Element Manager.

Note: As long as both ends of a link are different (that is, one end has to be allocated 'User' and the other 'Network'), which element is which is arbitrary.

It is assumed that the East STM line position of equipment is connected to the West STM line position of the adjacent equipment and so on. The default values are 'Network'.

Note: On addition of a card, the card adopts the default DCC and LAPD configuration parameters.

7.3.5 IS-IS Routeing

7.3.5.1 Introduction

For the OSI communications stack, Marconi OMS 1600 products support IS-IS routeing. Both the two sub-domains, Level 1 and Level 2, are managed.

The IS-IS routeing protocol implements routeing, by calculating optimum routes based on dynamically collected information about the topology of the network, at the initiation of the network. It also dynamically adapts to changes within the network topology, recalculating routes when changes occur.

The IS-IS Protocol uses two new types of Protocol Data Units (PDU), ‘Hello’ PDUs (or ‘neighbour greeting’) and Link-State Packet (LSP) PDUs. These are the fundamental packets of data all elements in a network make available to each other. The PDUs contain the identity, location, status and condition of the links between them.

When a network is initiated, IS elements begin by learning about elements to which they share direct connectivity, i.e. in the same sub-network, via ‘Hellos’. IS elements then construct a Link-State Packet, which contains a list of their neighbours and the ‘cost’ to reach each neighbour (based on a system of ‘cost’ metrics), the IS elements then distribute the LSPs to all other IS elements. On completion of the process, each IS will have received a complete map of the network topology in the form of LSPs.

Each IS element uses these LSPs to compute routes to every destination in the network. The route choice is the ‘least cost’ route.

Should the topology change, e.g. a new element is added, the IS-IS protocol initiates a regeneration of the routeing table scheme and the relevant information is made available via the network links to all the elements in the network, i.e. the network is ‘flooded’ with the new information.

7.3.5.2 Two-Level Hierarchy

In an SDH network in general, SDH Element rings and groups of SDH Element rings will form single IS-IS Areas. The groupings of the rings will depend on the amount of inter-connection of the rings.

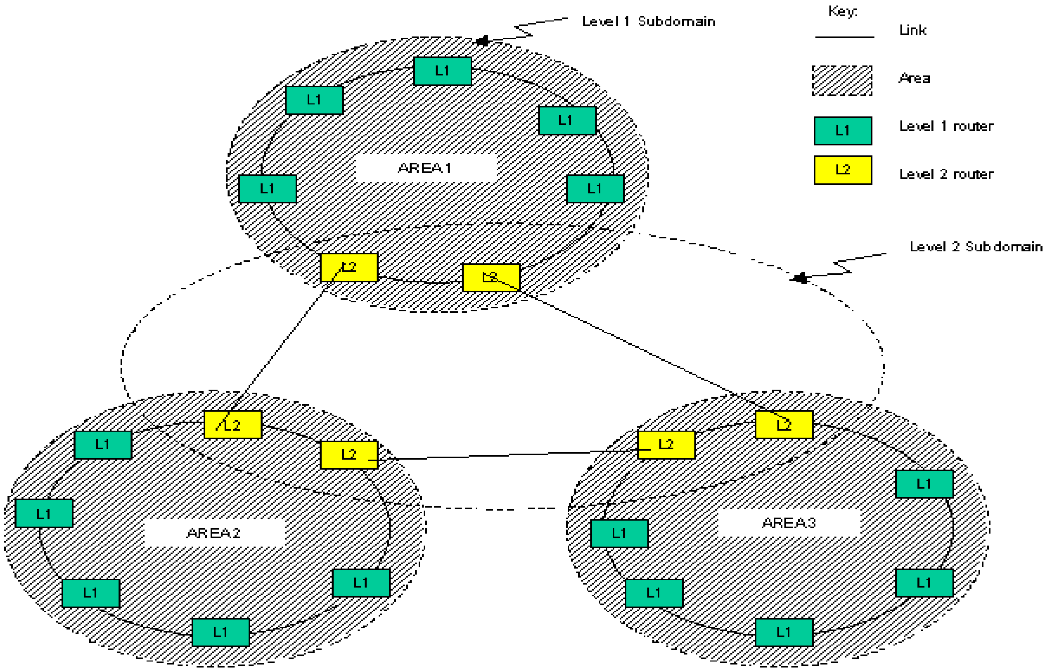
Level 2 Routers are Elements that exist at the boundaries of Areas and are the interfaces between the Areas (See Figure 7-3). The non-boundary Elements are generally Level 1 Routers except where to improve resilience, a Level 2 Router may be used between boundary Elements within an Area where greater resilience is needed in the network.

Level 2 Routers know where each of the other L2 IS elements exists in the network if they all form a contiguous L2 network. Level 2 Routers also have Level 1 Router functionality. Level 2 Routers are only concerned with the Area Address part of the NSAP. Level 1 Routers are only concerned with the System ID (see Table 7-2).

A Level 1 Router only knows about ES and other Level 1 IS elements in its own area and about the ‘nearest’ Level 2 IS, which it can use to forward traffic out of its own area.

Forwarding traffic destined for other routeing domains is a further function of Level 2 IS.

Figure 7-3: IS-IS Area Partitioning



7.3.5.3 Network Service Access Points (NSAPs)

In ISO terminology, the network layer provides a service, and a user or 'client' of the network layer 'attaches' to the network layer with a NSAP (Network Service Access Points). The NSAP is the principle identifier for any Element within a Network. Individual NSAP lengths can be variable, however there is a maximum of 20 octets.

IS-IS Addresses or NSAPs consist of two main parts, the Area Address that is everything up to but not including the System ID (SID) and the System ID itself (plus the NSEL with a value of 01.

Level 1 Routeing is only concerned with the System ID part of the NSAP. IS-IS Area or Level 2 Routeing takes place on the Area (or 'address prefix') part of the NSAP only, which is treated as a single field.

Table 7-2: NSAP Address \formats

Area (Level 2)	See Note	System ID (Level 1)	SEL
IS-IS Address Format			

Note: The shaded part of the Area field indicates that it is possible to extend the SID (as defined by the 'System ID Length' parameter), this is useful in certain circumstances to simplify network planning.

The 'SEL' octet is of historical interest and was introduced during the implementation of the ISO specification. It was originally provided to allow identification of the network layer itself. In all Ericsson implementations, this will have the value of 01.

The SEL is used to distinguish between multiple upper layer entities (layer-4's). The value 00 is used for layer 3 itself.

7.3.5.4 Metrics

Metric values are applicable to Gateway Q Interfaces, DCC interfaces and Reachable Address Prefixes (RAP). Each type of interface is assigned a default value for the metric. This may be changed via an LCT or Element Manager.

Default values are as follows:

- 10 - Ethernet.
- 15 - DCCm bytes.
- 20 - DCCr bytes.
- xx – ECC VC4 F2.

7.3.5.5 Maximum Path Splits

When working In IS-IS, if there are two or more equal cost routes between two elements, the protocol allows for handling the routeing in the following ways, either:

- A Maximum Path Split value of 1 (the default value) is defined during the Network configuration, in which case routeing will be across one path only, all other paths of equal cost being discarded, or:
- A Maximum Path Split value of 2 is defined during the Network configuration, in which case routeing will be toggled at 15-minute intervals across two paths, any further paths of equal cost being discarded.

7.3.5.6 External Domain Flag

The Gateway Interface and DCC interfaces possess a parameter called the External Domain Flag. If set to true, this would have the effect of isolating that interface from operating IS-IS protocol, preventing IS-IS protocols being exchanged over the link. A possible use for this would be at an interface to a competitor's network, to withhold network information from the competitor. Static routes (Reachable Address Prefixes) can be used to allow a limited form of routing to still take place (without 'leaking' internal topology information to the competitor).

Another use of this feature is to allow very large networks to be built, which are too large for a single IS-IS domain. The network is consequently created as a number of individual IS-IS domains with static routes (Reachable Address Prefixes) used to join them together. The External Domain Flag is used at the edge of each domain to turn off the IS-IS routing at that point.

Note: Although the External Domain Flag can be used to turn IS-IS off on an interface, ES-IS protocol is still maintained in either state (always active).

7.3.5.7 Multi-homing (Area Aliasing)

IS-IS routeing supports the assignment of multiple area addresses on the same router. This concept is referred to as multihoming. Multihoming provides a mechanism for smoothly migrating network addresses, as follows:

Splitting up an area – Nodes within a given area can accumulate to a point that they are difficult to manage, cause excessive traffic, or threaten to exceed the usable address space for an area. Multiple area addresses can be assigned so that you can smoothly partition a network into separate areas without disrupting service.

Merging areas – Use transitional area addresses to merge as many as three separate areas into a single area that shares a common area address.

Transition to a different address – You may need to change an area address for a particular group of nodes. Use multiple area addresses to allow incoming traffic intended for an old area address to continue being routed to associated nodes.

Multihoming is not required in any other cases. Therefore, all elements in a correctly configured IS-IS network partitioned in their final Area configuration should have:

- One and only one configured Area address.
- The Maximum Area Addresses value at the default value of 3.

7.3.5.8 Partition Repair

Partition repair is a mechanism by which the protocol circumvents a fault, which has caused a Level 1 area to be split into parts. The facility uses Level 2 links to act as virtual Level 1 links to repair the split.

7.3.5.9 Manual Adjacency (MA) and Reachable Address Prefixes (RAP)

Given that other protocol(s), on the initiation of the network, may not automatically contribute data to the creation of the IS-IS routeing tables, data identifying these elements must be entered manually at the boundary elements operating the IS-IS protocol.

The data may be entered either locally using the LCT or remotely via the Element Manager. The data is then passed automatically around the Domain as if it had been received in an IS-IS update message. Two data types are used according to the level of element being addressed:

- Reachable Address Prefix (RAP). Provides a method of interworking between an IS-IS domain and a non-IS-IS domain, where the non-IS-IS domain nodes have different area addresses from the IS-IS domain and border node. A Reachable Address Prefix is therefore a Level 2 static route.

  Note: The RAP metric type (internal/external) can be used to give a first and second choice route where the internal metric RAP is the first choice.

  Note: When the RAP is configured onto the Q interface, then the SNPA field should be configured with the host LAN card MAC address.

- Manual Adjacency entries provide a form of a mapping between system ID and Port (plus the SNPA for an Ethernet (Q) port) in Level 1 areas. A list of system IDs may be associated with that port, e.g. if there is a chain of elements not running IS-IS protocol beyond the particular element assigned a MA.

7.3.6 ES-IS

The IS-IS protocol in itself provides for communications routeing between IS elements, but requires complementing with a method of ES to IS communication. The protocol implemented in Ericsson systems for this purpose is ISO 9542. This uses its own IS and ES 'Hellos' to establish communication. An ES 'Hello' enables an ES to announce itself to IS elements (and other ES elements) on the same sub-network. An IS 'Hello' enables an IS to announce itself to ES elements on the same sub-network. The two significant factors are 'who is out there?' and 'with whom is it possible to communicate?'

Where the ES is attached to an Ethernet LAN, the ES periodically composes an ES 'Hello', inserting its NSAP address (es), SNPA and a holding time in the ES 'Hello' packet, and sends this packet to the 48 bit multicast Medium Access Control address (MAC) whose value has been set to registered multicast addresses as defined in ISO 10589.

7.3.7 CLNS Ping

CLNS 'Ping' or Packet Internet Groper is an echo message and its reply, used to test if a network element can be reached from another element, when operating within a Connectionless Network Protocol.

Using the LCT, a 'Ping' can be chosen to be single or multiple shot and a route trace can be displayed, if required, on receipt of a successful reply.

Note: Where a Partition Repair has occurred, the path trace will not show the path by which the protocol has implemented the repair.

7.3.8 IS-IS Protocol Operation

Figure 7-4 shows how IS-IS routeing protocol would operate within a simple network. The numbered elements in the hypothetical network consist of SMA IS and Element Manager elements. The IS elements have multiple ports communicating with other IS or ES.

Figure 7-4: Gateway Network Element

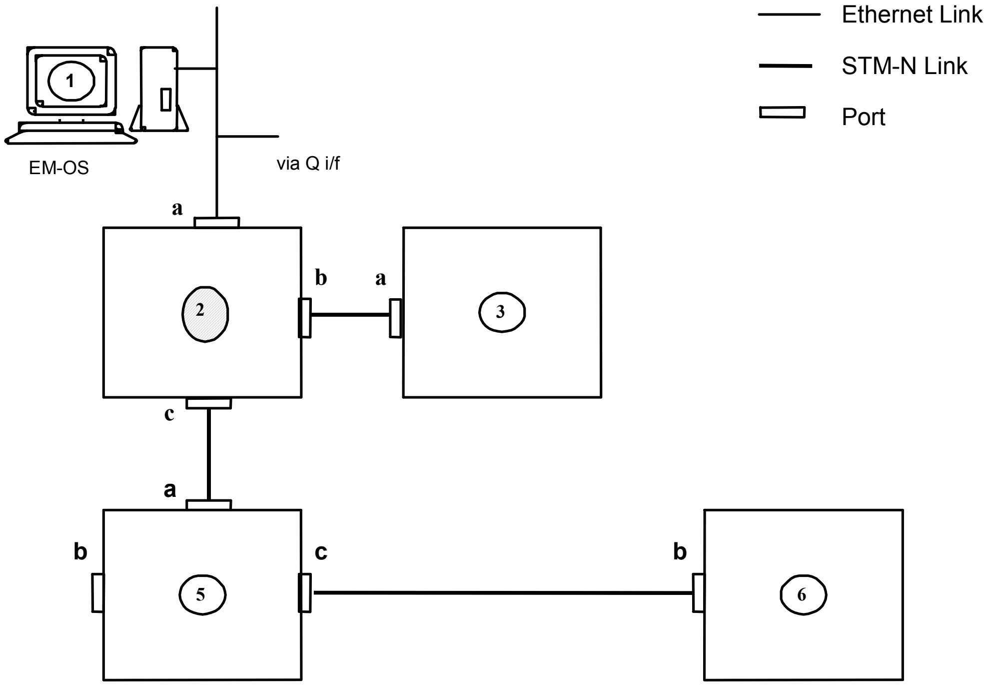


Table 7-3: Element Routing Table

Element to which route is required	Preferred Port by which data must communicate
1	a
3	b
4	b
5	c
6	c

When a network is initiated, the IS-IS Protocol creates routeing tables within each IS element in the network. The tables describe which port of the element data must be directed via, to reach any other element in the network (either IS or ES). The example given in Table 7-2 applies to element 2 (shown shaded) in Figure 7-4.

7.4 IP Comms

7.4.1 Hosts (IP Addresses, MAC Addresses, ARP)

In Internet Protocol terminology, an End System is referred to as a Host. Each host on a network usually has a single IP address and MAC address (assuming it is connected via Ethernet).

The IP address is regarded as being composed of two parts, a ‘host’ part and a ‘network’ part. All hosts connected together on a LAN should have the same ‘network’ part of their address (otherwise a gateway/router is required for intercommunication between different networks).

Note: The terms networks and sub-networks (subnets) are used interchangeably in most IP literature.

To resolve the correspondence between IP addresses and MAC addresses on a LAN a protocol called ‘Address Resolution Protocol’ (ARP) is used. This performs the same function as ES-IS for IP networks. It does not use regular hellos but works on a ‘need to know’ basis.

7.4.2 Routeing (Gateways)

7.4.2.1 Interior Gateway Protocol

An Interior Gateway Protocol (IGP) is a protocol for exchanging routing information between (gateways) within an IP routing domain. The Open Shortest Path First (OSPF) protocol is one of a newer breed of IGPs and addresses many of the shortfalls of first generation protocols such as Routing Information Protocol (RIP). To route between domains other protocols exist but it is expected that this functionality is not required directly in the SDH elements but, if necessary, in external equipment.

The main difference between a router and a host is that the router contains more than one interface (the SDH elements usually contain many DCN interfaces in the form of the DCCs). For IP protocol to work properly each interface must be assigned an IP address with a unique subnet. An exception to this is for point-to-point interfaces (such as the DCCs) where a special ‘unnumbered’ mode can be used.

7.4.2.2 Point-to-Point Protocol (PPP)

PPP is a protocol for communication between two hosts or routers using a serial interface. In SDH elements configured to use IP protocol, PPP is used for the DCC interfaces.

PPP is designed for use with various other protocols. It is sometimes considered a member of the TCP/IP suite of protocols. Relative to the Open Systems Interconnection (OSI) reference model, PPP provides layer 2 (data-link layer) services.

PPP is a full-duplex protocol that can be used on various physical media, including twisted pair or fibre optic lines or satellite transmission.

PPP is usually preferred over the earlier de facto standard Serial Line Internet Protocol (SLIP) because it can handle synchronous as well as asynchronous communication. PPP can share a line with other users and it has error detection that SLIP lacks. Where a choice is possible, PPP is preferred.

7.4.2.3 Open Shortest Path First (OSPF) Routeing

Description

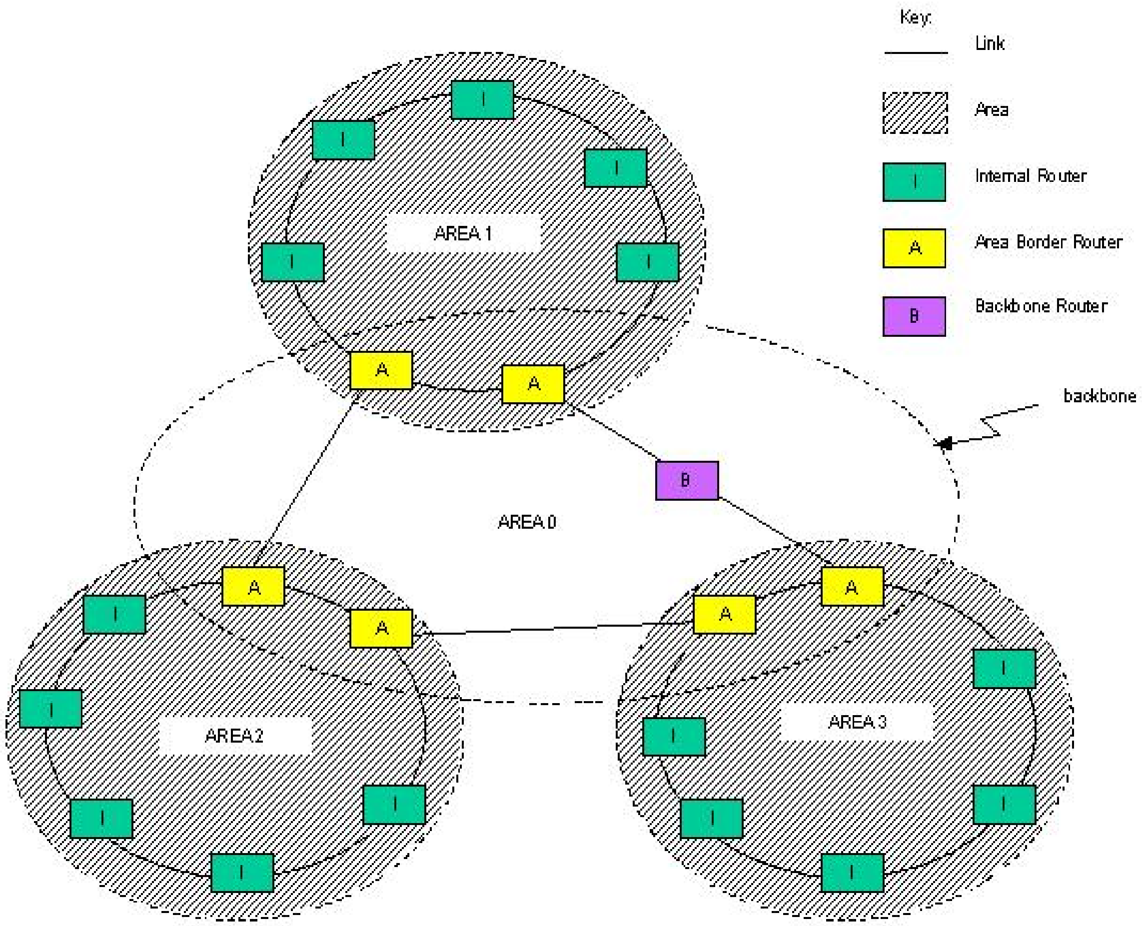
OSPF is a routeing protocol similar to IS-IS in many of its concepts and was developed for large heterogeneous Internet protocol (IP) networks. It has two primary characteristics:

- It is an open protocol and its specification is in the public domain
- It is based on the Shortest Path First (SPF) algorithm.

The OSPF domain is divided into a number of areas. These areas provide a two-stage hierarchy with the upper stage, Area 0, being termed the backbone. OSPF defined areas and a backbone are shown in Figure 7-5. Routers are classified by their function as:

- Internal router
- Area border router
- Backbone router

Figure 7-5: OSPF Backbone, Areas and Area Border Routers



OSPF is a link state routing protocol that calls for Link State Advertisements (LSAs) to all other routers within the same hierarchical area. LSAs may contain data relating to:

- Attached interfaces
- Metrics

- Other variables.

OSPF routers:

- Accumulate link-state information and calculate the shortest path to each node

OSPF has the following features:

- Can operate within a hierarchy with the largest entity being the Autonomous System (AS) or domain.
- Support separate topological databases describing areas (different topological databases) or domains (identical topological databases) of a proportion of the network
- Enables each OSPF AS to pass less routing traffic than if they were not partitioned
- Supports routing within an area or between areas via an OSPF backbone which:
  - is itself an OSPF area using identical router procedures for all access points within the area
  - is transparent to all intra-area routers
  - distributes the routeing information where the information is not wholly contained within an area
  - can be contigous (virtual links) or continuous (direct links).

7.4.2.4 SPF Algorithm Operation

When an SPF router is powered up, it operates the following steps:

- Initialises its routing protocol data structures
- Waits for ‘functional interface’ indications from the lower layer protocols
- Sends and then receives hello packets to its neighbours, which:
  - Confirm the routers are still functional
  - Elects a designated router and backup destination router in situations where the network supports more than two routers i.e. on a LAN.
- Operates designated routers which:
  - Allow a reduction in network traffic and topological database size
  - May be synchronous and therefore determine adjacency and synchronicity with the paired adjacent router and which send and receive packets only on adjacencies
  - Generate LSAs for the entire network which periodically identify adjacencies, failed routers, shortest path route, change failed routes to the new (next nearest) shortest path route with each router as the root of a shortest path tree.

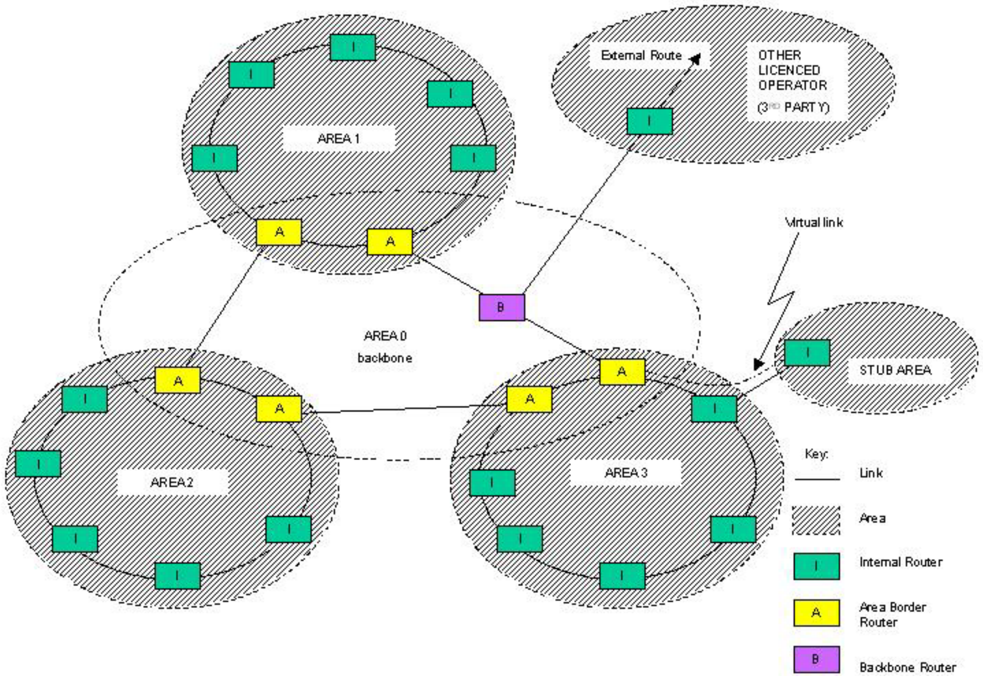
Note: The designated router is responsible for generating LSAs for the entire multi-access network.

7.4.2.5 Practical Issues

There are a number of practical issues relating to OSPF which are addressed by three defined strategic solutions:

- Stub areas
- Static information
- Unnumbered interfaces.

Figure 7-6: OSPF Domain Protocol Practical Issues



7.4.2.6 Stub Areas

Stub areas are areas with only one access link. Some economies in link state can be achieved using stub areas and their associated virtual links. See Figure 7-6.

7.4.2.7 Static Information

Static Information is used for cases where the partner equipment does not support the full set of features:

Route Summaries (RS)

RS are used when the addressing within an area allows a single prefix to be created that represents that area. This reduces the amount of data in the link state advertisements.

Virtual Links

Virtual links are used to provide a direct (tunnelled) link from the router to the backbone where one is not available. These are usually used to provide temporary repair paths.

External Routes

External routes are used to route outside the OSPF domain.

7.4.2.8 Unnumbered Interfaces

According to general IP routing principals, each interface on an IP router should belong to a unique subnet and hence have an IP address. For situations where a router has a large number of interfaces, then this is not practical. To solve this problem, the concept of unnumbered interfaces has been developed for use on serial interfaces where all the serial interfaces adopt a single address. This address could be either:

- A specially configured address or
- One of the existing ports of the router.

The Marconi Marconi OMS 1600 equipment uses the concept of adopting the IP address of the 'Q' interface for its unnumbered interfaces. The serial interfaces (DCCs) support both unnumbered and numbered mode working.

7.4.3 Ethernet LCT

The F-LAN interface is treated as a private subnet (or De-Militarised Zone) and will use a fixed, pre-assigned private address. The F-LAN interface is not expected to be connected to any Ethernet infrastructure but is expected to have a direct connection to the LCT PC (either by a 'cross-over' cable or hub).

The F-LAN interface contains a DHCP server in the NE to provide the address for the LCT PC at boot-up time (this address will be from the same subnet as the F-LAN port). The DHCP server allocates an address to the PC when requested by the PC's DHCP client. It is expected that the PC will always have DHCP client functionality enabled.

7.5 Comms Across Other Licensed Operators (OLO) Networks

7.5.1 OLO Comms – Introduction to the Problem

This section explains the alternative communications channel transport over OLO networks. The concept is used in scenarios where NEs sit at remote locations away from an operator's main network. Traffic transmission and management communications with these remote nodes is over another licensed operator's network (OLO Network), and the standard SDH OH DCC transport channels cannot be used to carry management information to the remote nodes. This is shown in Figure 7-7.

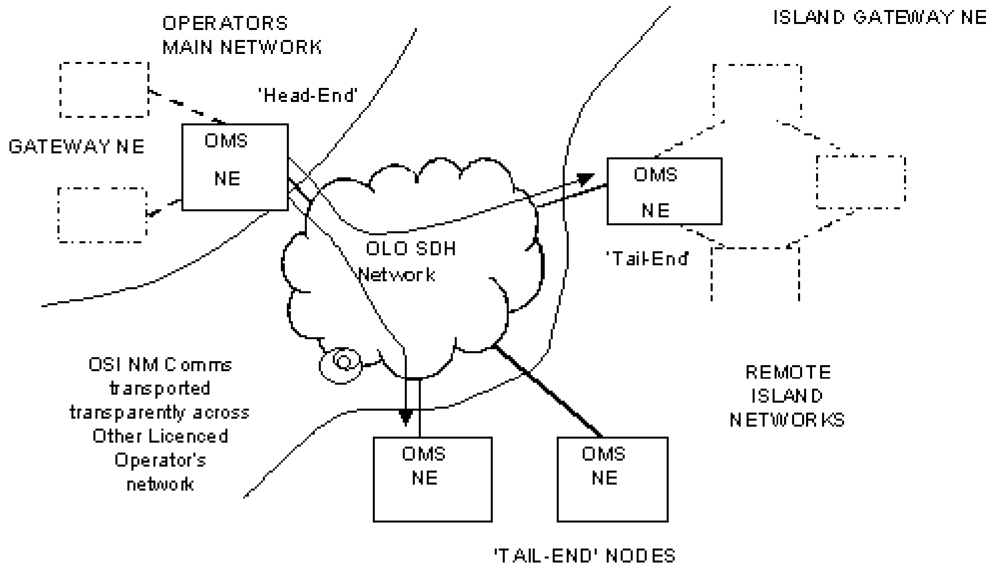
The alternative communications physical channels which the Marconi OMS 1600 equipment supports are as follows:

For STM-n SDH trail interfaces (n=1, 4 or 16) the embedded communications channels (ECCs) supported is ECC-F2 @64kbit/s (G.707, VC-4 POH, F2).

The spare F2 bytes reside within the SDH VC-4 POH at nodes where the chosen VC-4 trail is terminated. The VC-4 may be carrying a C-4 payload (say PDH 140Mbit/s traffic) or it may be a TUG structured server layer VC-4 carrying lower order VC- trails (say VC-12 for PDH 2Mbit/s traffic). In this case, the chosen VC-4 becomes the 'leased line', leased by the network operator who needs to get management communications across an Other Licensed Operator (OLO) Network. The whole VC-4 is accordingly transported transparently across the OLO network.

The E1 OLO comms feature available in the Marconi OMS 1600 is hosted on the P12 AS/Cs daughter board rather than the main card as in earlier 2M solutions, so reducing costs for those customers who do not require this feature.

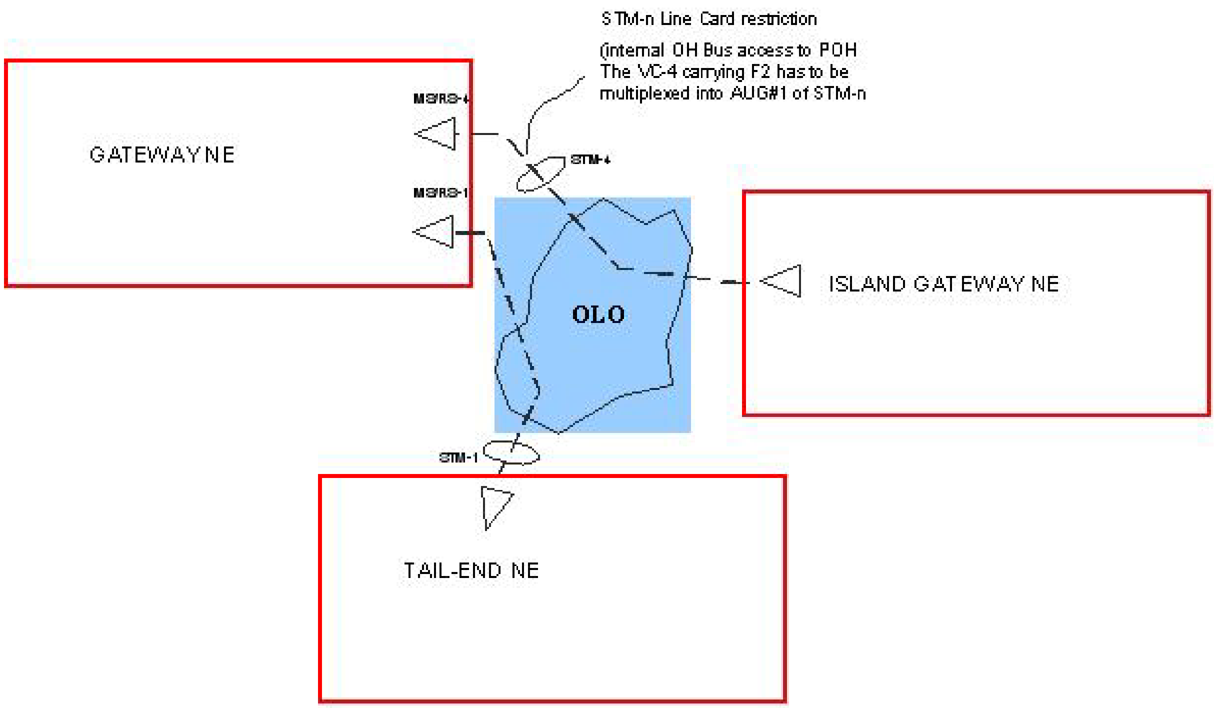
Figure 7-7: OLO Transparency



7.5.2 OLO Detail Solution

A spare overhead of the frame structure allows the following detail solutions to be applied.

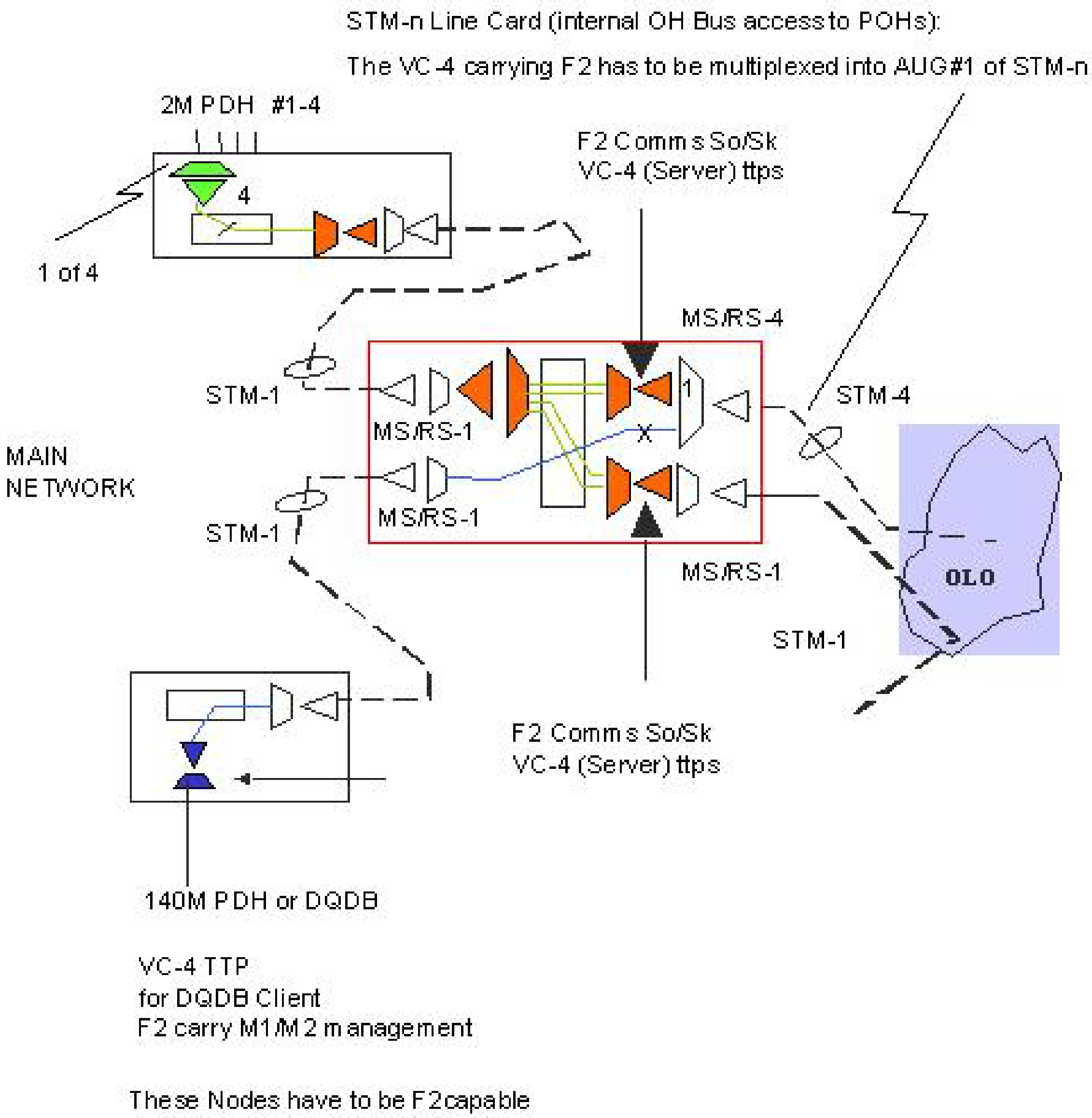
Figure 7-8: OLO and NEs



7.5.2.1 Gateway NE

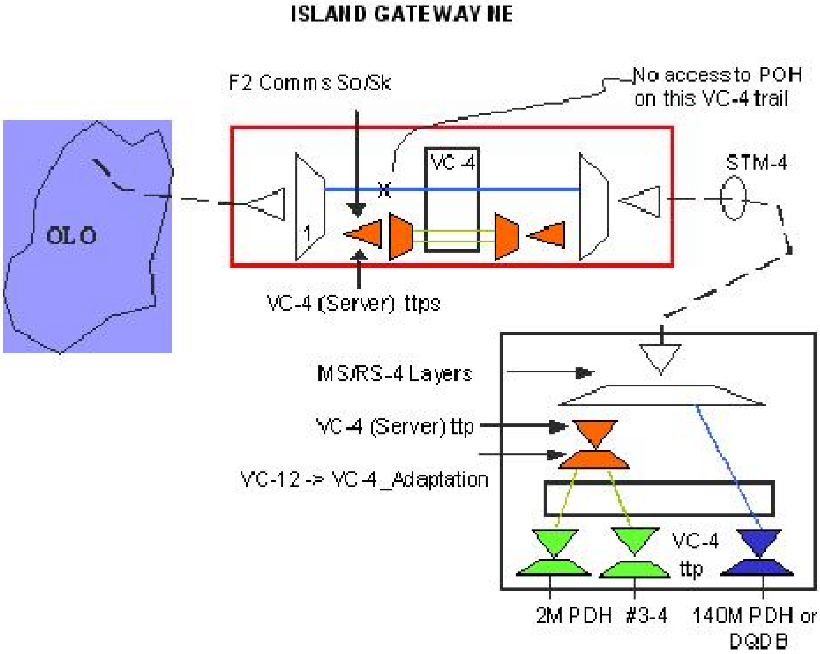
This is a main network 'Gateway NE' type that operates as a head-end distribution mode for communications routing to a number of remote nodes across the OLO network.

Figure 7-9: Gateway NE Detail



7.5.2.2 Island Gateway NE

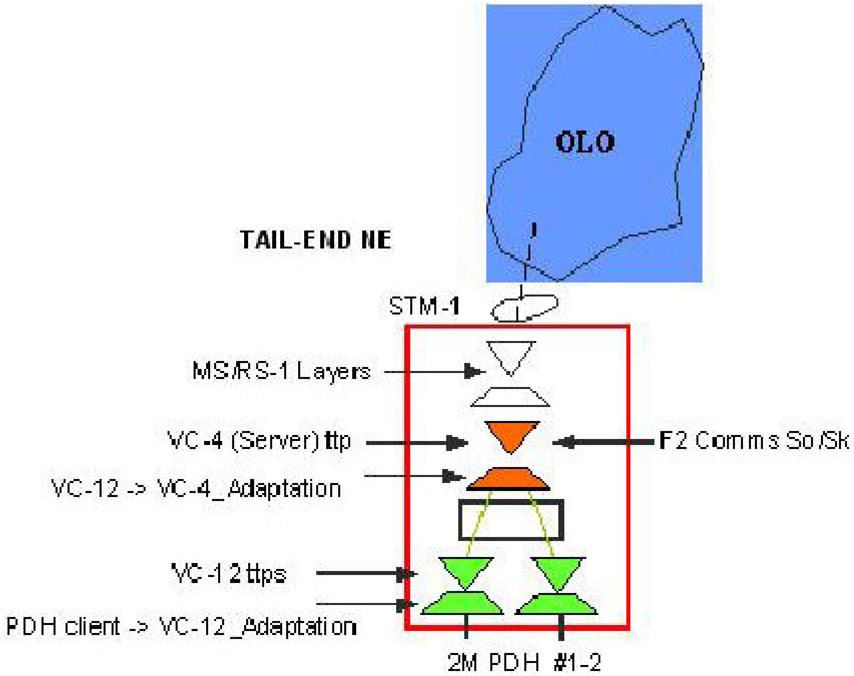
Figure 7-10: Island Gateway NE Detail



An Island Gateway NE operates as a 'tail-end' node for F2 communications with conversion back to SDH OH DCC.

7.5.2.3 Tail-End NE

Figure 7-11: Tail-End NE



An isolated 'Tail-End NE' type operates as a 'tail-end' node for F2 comms.

7.6 Aux Comms via Combined AUX EOW Card

Table 7-4: Comms Applications with AUX EOW Card Abbreviations Table

RIC	Ring Integrity Check (A repetitive code inserted every second to allow the connectivity of the EOW audio path to be monitored)
RIC2	Ring Integrity Check (A repetitive code inserted every second to allow the connectivity of the EOW audio path to be monitored) for 'Enhanced' RIC operation
EOW	Engineering Order Wire (Audio communication system between Network Elements)
SLIC	Subscriber Line Interface Circuit
TRC	Telecommunications Reference Conductor

7.6.1.1 Outline Description

The Marconi OMS 1600 product has a bespoke AUX/EOW Unit. A single AUX/EOW Triple extended Euro card slot has its own dedicated LTU for physical access to AUX data channels.

The AUX card provides the OH processing for the MS/RS overhead and some Path OH Bytes. A dedicated LTU slot (AUX/ANC LTU) is used with the card to provide the physical interfaces.

The DCCr and DCCm are processed by the CCU and are not used on this card.

The card provides:

- Four 64k Data Channels with V.11 interfaces on the LTU
- Eight 64k Data Channels with G.703 interfaces on the LTU
- Two 64k Data channels with 4-Wire audio interfaces on the card where up to two of these can be alternatively configured into the EOW functions
- An EOW function - compatible with SMA/Photonics EOW supporting two up to two ring interconnect operation, local handset (interface handset (interface via a SLIC) and 4-Wire analogue interfaces
- Inventory:
  - Micro/RAM/ROM etc.
  - DC/DC Converter.
- There is only one AUX card per shelf and protection is not provided.

In the Marconi OMS 1600 equipment, the overhead from each card slot is brought to the CCU cards where the DCCr and DCCm is processed and sent to the Comms subsystem. The overhead is then also sent to the AUX/EOW card. The OH is transported in a proprietary frame structures running at 25MHz. Eighteen sets of overhead are brought to the AUX/EOW card from the other system cards.

7.6.1.2 In the Compact Equipment Options (1644, 1654, 1674)

The AUX unit interfaces to the single CCU.

7.6.1.3 In the Full Shelf Options (1634, 1664, 1684)

The AUX unit interfaces to both CCUs selecting data from the working CCU as appropriate.

7.6.1.4 In All Operating Options

EOW Functions:

- Compatible with the existing EOW products
- In addition to the digital EOW channels from the OH (Rings 1 and 2) it is possible to configure two of the 64k G.703, V.11, OH or 4-Wire ports to the EOW function - one into each Ring as a 'spur' input. Alarms are provided as:
  - Local 'Ringing' (buzzer)
  - Three EOW status LEDs and push buttons (intrude/reset) on the front of the unit.

Ring Interconnect:

The EOW supports the operation of two ring interconnect, ring interconnect and the Local 2-Wire handset interface. This requires the four 64k seven EOW 'channels' or Ports. Normally all ports would be connected into the Audio Bridge but further options are provided.

For flexibility in the use of the EOW in Networks, see Table 7-5 below.

Table 7-5: Flexibility of EOW in Networks Table

Internal Designation	Network Designation	Ring Options	Notes
Port A	Ring 1 Port 1 (E)	M/FM/Slave	There shall be an Option to 'detach' Ring 1 and Ring 2. In this mode the Audio path between the rings is not connected. The 'unused' ring (without handset) is bypassed.
Port B	Ring 1 Port 2 (W)		
Port C	Ring 2 Port 1 (E)	M/FM/Slave	
Port D	Ring 2 Port 2 (W)		
Port E	Port E	N/A (fixed 'Spur' inputs)	Port E is fixed to Ring 1
Port F	Port F		Port F is fixed to Ring 2
2-Wire	Local 2-Wire	N/A	Operator configures Ring 1 or Ring 2

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