ND1124:2000/09

SDH INTERCONNECT BETWEEN UK LICENSED OPERATORS

OVERVIEW

Issue 6

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Normative Information

If you have any comments concerning the accuracy of the contents of this document, please write to:

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1.0 INTRODUCTION

1.1 Document History

3.0	June 95	First formal release of the recommendation covering 2Mbit/s circuits only carried in VC-12 format over STM-1 (155Mbit/s) interconnects only.
Draft 4a	30th April 96	This release addresses interconnection at additional defined line rates namely STM-4 (622 Mbit/s) and STM-16 (2488Mbit/s), together with tributaries at 2Mbit/s (VC-12), 34Mbit/s (VC-3) 140Mbit/s (VC-4) and STM-1 Electrical and Optical.
Draft 4b	12th May 97	Modified in accordance with agreements at PNO-TIG meeting 29-4-97.
4.1	4th July 97	Release offered to PNO-IG for approval.
5.0	February 98	First draft of recommendation covering additionally ATM, 1.5Mbit/s, 45Mbit/s circuits and G.707 (1996).
	September 98	Second draft incorporating changes discussed at June 98 meeting of PNO-TIG.
	March 99	Final draft for presentation to PNO-IG following changes agreed at PNO-TIG SDH "wash up" meeting Mar 99.
Draft 6a	September 00	First Draft incorporating STM-64 rate, the latest version of ITU-T Recommendation G.707, the mapping of VC-4-Xc, Asynchronous Transfer Mode (ATM), Internet Protocol (IP) and other client payloads.
Draft 6b	September 00	Second Draft following review at PNO-IG-TIG mtg. No. 15 on 11.09.00. Addition of STM-256 rate, ITU-T Rec.s references up-dated.
Issue 6	September 00	Final draft incorporating minor editorials following review by correspondence.

1.2 Normative References

(1) ITU-T Rec. G.707 (00)
Network node interface for the synchronous digital hierarchy (SDH)

(2) ITU-T Rec. G.957 (99)
Optical interfaces for equipments and systems relating to the synchronous digital hierarchy

(3) ITU-T Rec G.958 (11/94)
Digital line systems based on the synchronous digital hierarchy for use on optical line systems

(4) ITU-T Rec. G.803 (00)
Architecture of transport networks based on the synchronous digital hierarchy (SDH)

(5) ITU-T Rec. G.805 (00)
Generic functional architecture of transport networks

(6) ITU-T Rec. G.841 (98)
Types and characteristics of SDH network protection architectures

(7) ETSI: TS 101 009 (28/11/97) (ex DTS/TM-03025)
Transmission and multiplexing (TM): Synchronous digital hierarchy (SDH); network protection schemes ; types and characteristics

(8) ETSI: TS 101 010 (28/11/97) (ex DTS/TM-03041)
Transmission and multiplexing (TM): Synchronous digital hierarchy (SDH);network protection schemes; interworking : rings and other schemes

(9) ETSI: ETS 300 746 (24/2/97) (ex DE/TM-03042)
Transmission and multiplexing (TM): Synchronous digital hierarchy (SDH); network protection schemes; automatic protection switch (APS) protocols and operation

1.3 Definitions/abbreviations

1.3.1 Definitions

(1) **Public Network** - a network providing switching functions and features to the general public

(2) **Interconnect** (In technical terms only) - connection between the network domain of one operator and that of another

(3) **Interoperability** - the ability to function fully with another entity

(4) **Service Level Agreement (SLA)** - an agreement between operators defining quality of service (QOS) and performance.

1.3.2 Abbreviations

AIS	Alarm Indication Signal
APS	Automatic Protection Switch
ATM	Asynchronous Transfer Mode
AU	Administrative Unit
DCC	Data Communications Channel
ETSI	European Telecommunications Standards Institute
IBI	In-Building Interconnect
IP	Interconnect protocol
ISI	In-Span Interconnect
ITU-T	International Telecommunications Union (Telecommunications Standardisation Sector)
LOP	Loss of Pointer
MSOH	Multiplex Section Overhead
NICC	Network Interoperability Consultative Committee
PNO-CSI	Public Network Operators - Committee for SDH Interconnect.
PNO-TIG	Public Network Operators - Transport Interconnect Group
POI	Point of Interconnect
RSOH	Regenerator Section Overhead
SDH	Synchronous Digital Hierarchy
STM-N	Synchronous Transport Module - Level N
TM	Transmission and Multiplexing
TU	Tributary Unit
VC	Virtual Container
VCPOH	Virtual Container Path Overhead.

1. 4 Scope

Increasing opportunities for SDH interconnect between licensed telecommunications operators both within the United Kingdom and between the United Kingdom and overseas, together with advances in technology and developments in international standards have necessitated an update of the previous PNO-TIG (release 5.0) package of documents. This had led to the creation of a new “release 6” work package, which includes a complete set of new documents. This particular document represents the “Overview” part of the new set.

Previous releases, which concentrated ostensibly on basic SDH Interconnect, using STM-N (N = 1,4,16), have been updated with this new set which includes the requirements of the latest version of ITU-T Recommendation G.707 (00), the inclusion of STM-64 and STM-256 rates, the mapping of VC-4-Xc/Xv, Asynchronous Transfer Mode (ATM), Internet Protocol (IP) and other client payloads.

It is assumed that international interconnect activity will still be covered at international level in such fora as the ITU-T and ETSI.

Broadly speaking national interconnect can take one of the following forms:-

> **Source to destination interconnect** - in this form of interconnect traffic flows direct from one operator to another . The traffic may be switched or point to point leased, telephony, data or video, and may be carried in a number of ways ie using particular transmission techniques, such as synchronous or asynchronous transfer mode, via a photonic, copper or wireless medium.

> **Transit interconnect -** this form of interconnect is where traffic from one operator to another (or in some cases the same operator) is carried over the network of a third (different) operator or operators. The type of traffic carried is identical to that in the first example of interconnect.

> **Shared restoration interconnect -** in this case two or more operators may agree to share spare capacity within each others’ transmission systems for restoration purposes in the event of a major system failure within their own network.

This document is applicable exclusively to SDH interconnect between operators as defined above.

1.5 Purpose

The PNO-IG is mandated to follow ETSI and other international standards where available. Documents that are produced are not in themselves mandatory but aim to represent the consensus views of UK operators.

The PNO-TIG (Transport Interconnect Group), is a sub-group of the PNO-IG (Public Network Operators Interest Group. This group sits within the umbrella of the UK NICC (Network Interoperability Consultative Committee), founded by OFTEL in 1993, to establish interoperability between UK network operators and for customer terminal access.

The continuing aim of these documents is to facilitate interconnection between different operators' networks , by providing a common set of recommendations to which operators can work. The recommendations are not mandatory, although operators may choose to use the recommendations as a basis for contractual agreements. It is hoped that the voluntary adoption of a common set of recommendations will help to ensure consistency between operators, and will simplify the task of offering services across multiple interconnected networks.

Ultimately in order that successful interconnection may be achieved in the most cost-effective manner, it is expected that equipment from different vendors will become fully interoperable.

It is also envisaged that any agreements reached, and principles adopted within this forum, in the quest for full interoperability of equipments, should be used to influence developments in international standards groups such as ITU-T and ETSI TM through the medium of the UK Standards Coordination Committees.

2. DOCUMENTATION STRUCTURE

The objective of the PNO - TIG is to produce a set of documents relating to transmission interconnection between different operators networks. The set of documents in this (release 6) package comprises the following:-

Overview - (this document).

Technical recommendation - This document covers the technical aspects of interconnect, and considers technical issues such as physical interfaces, end-to-end performance, monitoring, service protection, synchronisation, and optical safety. The document also considers standardisation issues raised by multi-vendor networks.

Interconnect commissioning recommendation - This document describes the test procedures to be used to establish that the interconnection between the networks is operating correctly.

3. PRINCIPLES OF SDH INTERCONNECT

3.1 General

The following principles need to be recognised when planning a transmission interconnect between two SDH networks:

Transparency

In order to preserve circuit management information the Path or Virtual Container (VC) overhead (POH) must be carried across the Point of Interconnect (POI) between the two networks. Link interconnection however will always take place at the STM-N level (where N=1 either electrical or optical, and N=4,16, 64, 256 optical only). Moreover, the Regenerator Section Overhead (RSOH) and/or the Multiplex Section Overhead (MSOH), will always terminate at the network element adjacent to the interconnect boundary, thus affording exchange of circuit management information between adjacent interconnect elements.

For cell-based traffic such as ATM the byte structure of each ATM cell is aligned with the byte structure of the VC payload, and is thus confined within the VC.

Protection

Two physically separate Points of Interconnect must exist in order to permit path protected services to be passed from one network to another . Operators have the option of providing link protection only where the paths terminate on a single network element, or both link and node protection where separate network elements are used at each end. In this case the NE's may be in the same site or in separate sites. It is recognised that some interconnects may not be required to support pathprotected services at all and in this situation a single Point of Interconnection may be adequate. In this situation operators may also choose a third option namely card protection within the NE itself. However this would be restricted to interconnects using the tributary card on an add/drop multiplexer.

Management

Presently management systems are still not sufficiently mature to permit secure provisioning and fault/performance monitoring across different operator network boundaries. In recognition of this each operator should "manage" their own network up to the POI. The Data Communications Channels (DCC) in the RSOH and MSOH should therefore be disabled at the POI along with any spare bytes which may be used to carry third party circuit management information, in order to preserve the security and integrity of the two networks. Interconnect link management will be facilitated by means of the inherent visibility of each individual gateway element to the management system in each operator's domain.

Service

The end to end performance of a service should be clearly defined by Service level Agreements (SLA's) between operators whose networks carry the service.

3.2 Types of Interconnect

The diagrams below illustrate the two principal types of SDH interconnection:-

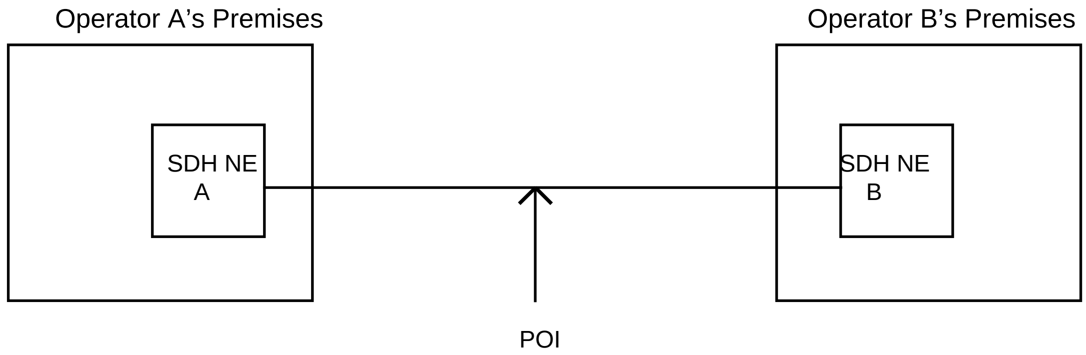

Figure 1 - In-Span Interconnect

Figure 2 - In-Building Interconnect

Figure 1 shows an In-Span Interconnect (ISI) while Figure 2 shows an In-Building Interconnect (IBI). The characteristics of these two forms of interconnection are listed below:-

The In-Span Interconnect avoids the need for one operator to locate any of his equipment on the premises of the other operator (and vice-versa). This eliminates a number of the issues that are encountered when implementing an In-Building Interconnect (access to equipment, security, power arrangements, rental of space etc....)

In most situations , both operators are likely to own a proportion of the fibre link. In the case of the In-Span Interconnect, the Point of Interconnect can be located at the point where fibre ownership changes. For the In- building Interconnect , on the other hand , there may be a difference between the point where the fibre ownership changes and the point where a service is actually handed over from the management domain of oneoperator to that of the other; this can complicate the Service Level Agreement, since one operator is managing services across a length of fibre belonging to the other operator.

An In-Span Interconnect is based upon optical interfaces, and so can operate at any defined SDH rate (STM-1, 4, 16, 64 or 256). However, rates above STM-1 are not defined for electrical SDH interfaces, so an In-Building Interconnect using an electrical interface is restricted to STM-1. Accordingly, two forms of In-Building Interconnect are defined: In-Building Interconnect - Electrical (IBI-E), and In-Building Interconnect - Optical (IBI-O), depending on the physical arrangement used.

Where SDH networks supplied by two different vendors are being linked, an IBI-E avoids potential incompatibilities in the optical systems (laser power levels, re-start procedures etc...). However, problems should not occur if both vendors meet the requirements of G.957/G.958, and experience so far suggests that optical incompatibilities between vendors are not a major problem. (Such incompatibilities as do exist tend to relate to the interpretation of particular bits within the SDH framing structure, and these incompatibilities can cause problems for both types of interconnect).

The In-Building Interconnect and the In-Span Interconnect both assume that fixed links are used between the two networks, but a pair of equivalent techniques could be derived for situations where networks are linked by SDH radio. In the case of radio, however, an In-Span Interconnect (or , more correctly, an In-Air Interconnect), has not been considered in this document.

An In-Building Interconnect is therefore normally used where the networks are linked by SDH radio.

3.3 Interconnect Topologies

Figure 3 illustrates the simplest form of SDH In-Span Interconnect. Traffic enters the SDH network of Operator A at an Access Point on an SDH network element. It then traverses that network (as a VC-n) , crosses the STM-N interconnect link to Operator B's network and terminates at a network element in Operator B's network.

Note that the term 'Network Element', is used generically when referring to SDH transmission equipment. This recognises the fact that a variety of equipment could be used (e.g line terminals, add/drop multiplexers, 4/1 cross-connects).

Figure 3 illustrates the generic interconnection case where the network elements providing the access points for a PDH circuit are different from the network elements terminating the STM-N section at each end of the interconnect. Note however, that the circuit access points could be located on the network elements used to terminate the STM-N section.

The arrangement shown in Figure 3 is vulnerable to a failure in the interconnecting STM-N section or in either of the two network elements that terminate the STM-N section. An arrangement that protects against a failure in the interconnecting fibres is shown in Figure 4.

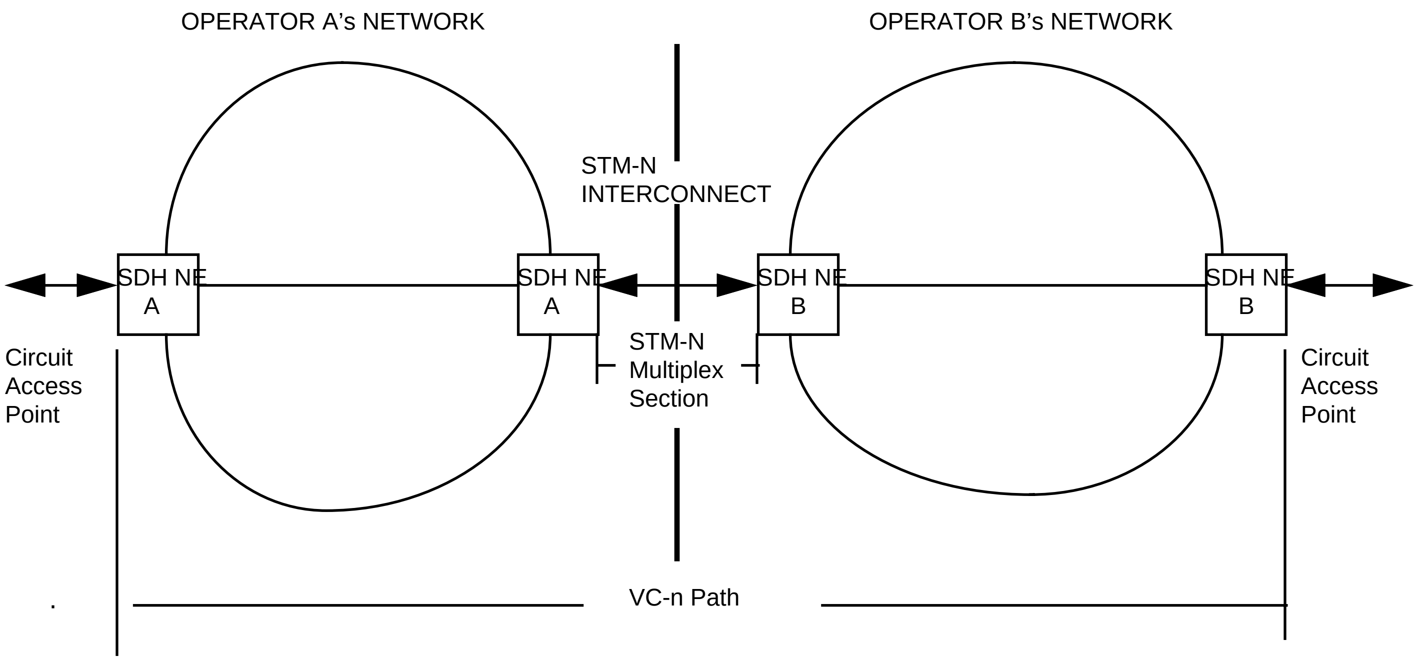

Figure 3 - Generic SDH Network Interconnect

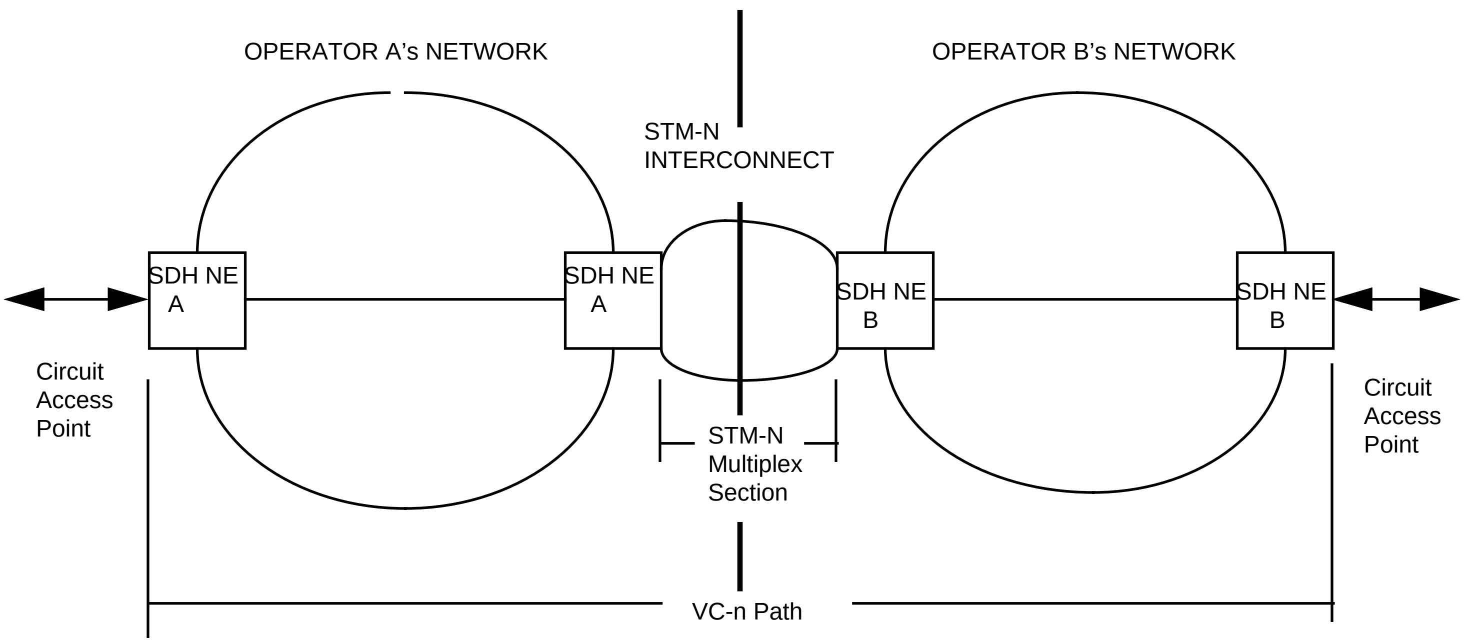

Figure 4 - Network Interconnect with Link Protection

Two STM-N interconnects are used together with a traffic duplication mechanism such that each STM-N link carries identical traffic signals. The two bi-directional fibre pairs should ideally be routed in separate cables and ducts. The receiving SDH network element selects one of the duplicated signals and can switch to the secondary signal in the event of failure (or a planned outage) in the primary. The generic arrangement shown in Figure 4 could be used to support the Multiplex Section Protection, VC Path Protection, or Sub-Network Connection Protection mechanisms discussed in section 3.4.

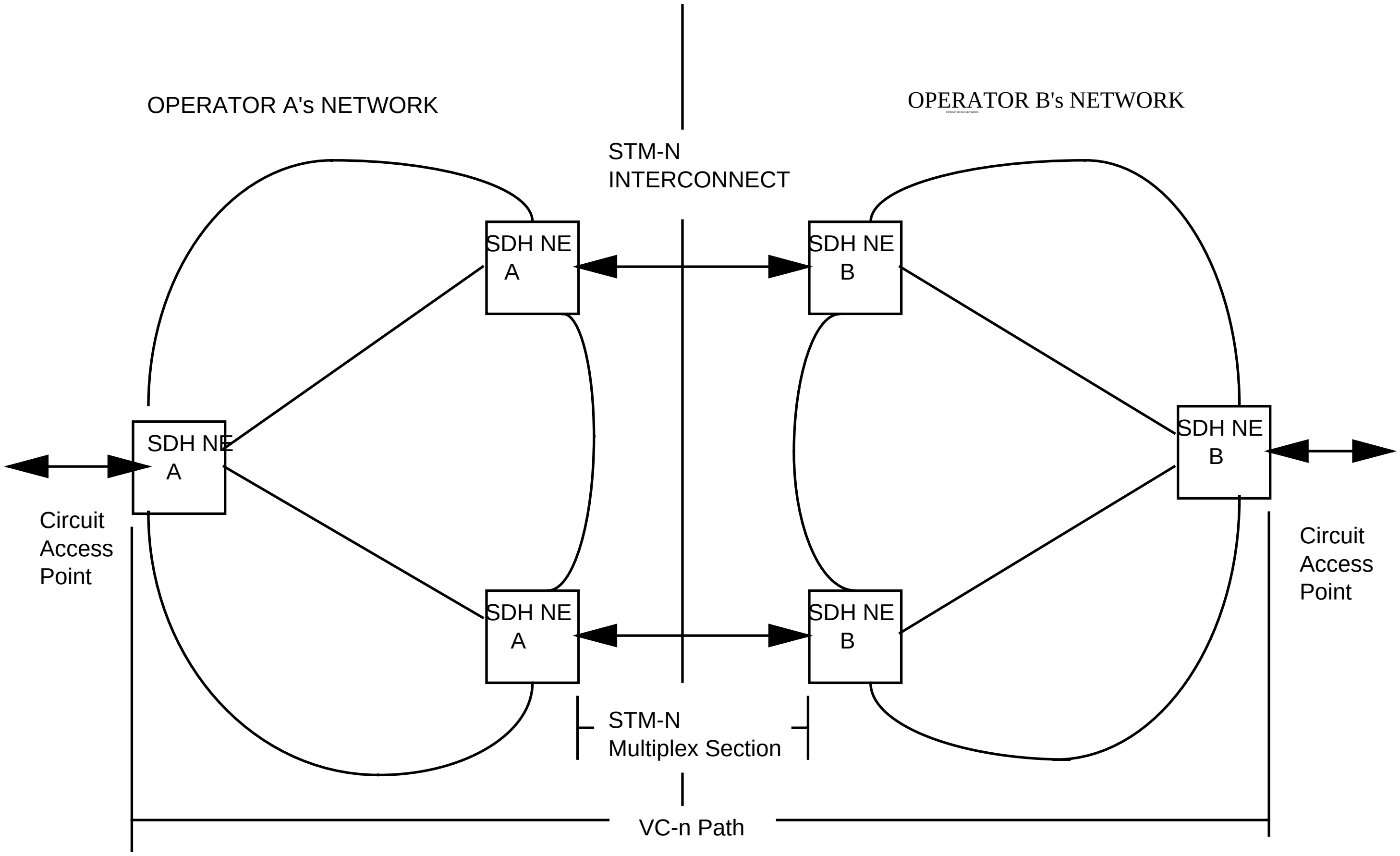

Figure 5 - Network Interconnect with link and node protection

The arrangement of Figure 4 is still vulnerable to failures in the network elements terminating the STM-N multiplexer section. To protect against such a failure, the arrangement shown in Figure 5 can be used.

In this arrangement , two STM-N interconnects are used, and each STM-N section terminates on a separate network element at each end. The two VC-n paths of a duplicated traffic signal are transmitted diversely over the duplicated STM-N sections as well as through separate section terminating network elements. Thus, the interconnect arrangement can survive a single failure of either an STM-N section or of the section terminating network elements.

The selection of one of the VCs in the receiving network is performed in one of the other network elements according to the protection mechanism being used. The arrangement can be used with both VC Path Protection and Sub-Network

Connection Protection. Note that it is also possible to protect an interconnect using the arrangement of Figure 4 on one end of the interconnect and that of Figure 5 on the other end.

3.4 Protection Mechanisms

A number of SDH Trail protection mechanisms have been proposed and standardised in ITU-T and ETSI TM for use in SDH networks. Only those protection schemes that are considered to be most applicable to an interconnect between two different operators' networks will be considered in this document.

Multiplex section protection

This protection mechanism is used for point to point applications and protects all the traffic on a section, e.g across an interconnect, against section failure. It does not provide end-to-end service protection, and it does not discriminate between services or levels. Although this mechanism is useful if the interconnect section is served by two physically separate fibre routes, the interconnect is still vulnerable to the failure of the NE itself at either end of the section, (with the exception of the node interface card). The switching action is triggered through request, status, and acknowledgement messages (APS Protocol) carried in the K1 and K2 bytes of the MSOH. Both 1: n and 1+1 architectures, unidirectional or bidirectional operation and revertive or non-revertive modes are specified, however in practice the most commonly used form is 1+1, bidirectional, non-revertive.

VC Protection

VC trail /path protection allows an individual service (VC payload), to be protected across all parts of a trail where physically separate routes exist. The VC may traverse not only an interconnect section across a boundary but also the various different sections carrying the service, within each operators' network. An APS protocol is currently being defined for this type of protection and this is being promoted within the appropriate standards groups of ITU-T and ETSI. As in the former case a 1+1, bidirectional switching scheme is being proposed. The APS protocol is carried in the K3 byte (for higher order VC's) and the K4 byte (for lower order VC's), of the VC Path Overhead (VCPOH). Because this mechanism allows for extension beyond the interconnect section, it can facilitate an interconnect combining both link and node protection.

Sub-Network Connection Protection

Whilst VC Protection provides protection across the whole length of a path, Sub-Network Connection Protection provides protection across a segment of a path. Sub-Network Connection (SNC) Protection can be the simplest method of protecting services across an SDH interconnect, if the switch operation is determined only by the detection of Loss of Pointer (LOP) or Alarm Indication Signal (AIS). This can occur at either Administrative Unit (AU) level (in the case of HO SNC), or Tributary Unit (TU) level in the case of LO SNC. This mechanism may therefore be used in any sub-network or section which provides two separate routes between adjacent nodes.

When used in a 1+1 (unidirectional) mode, SNC Protection does not need a special protocol since bridging can be done at the entry node (to the protected section) and switching performed autonomously at the exit node (of the protected section) without any need for backward signalling.

Both the latter forms of protection where switching is performed at the sub-layer may be used across “dual parented” interconnects thus offering both link and NE protection.

When used to interconnect SDH rings in adjacent operator domains however there may be network management and planning implications. This particular application is therefore for further study.

Further details of SDH Protection Schemes can be found in the following documents:-

TS 101 009 (ex DTR/TM-03025) - SDH Network Protection Schemes: Types and Characteristics.

TS 101 010 (ex DE/TM-03041 - SDH Protection Interworking.

ETS 300 746 (ex DE/TM-03042 - SDH Network Protection Schemes: APS Protocols and Operation.

ITU-T G.803 - Architecture of Transport Networks based on the SDH.

ITU-T G.805 - Generic Functional Architecture of Transport Networks.

ITU-T G.841 - Types and Characteristics of SDH Network Protection Architectures.

Although this document does not include all the options for protection across an SDH Interconnect, it does not preclude the use of additional protection mechanisms within an operators' network. Such methods as Multiplex Section Shared Protection Ring (MS SPRING), are well publicised in the above documents, and may well be suitable for additional protection within each operators' own domain. However, due care needs to be taken to prevent protection mechanisms within and between networks and network layers interacting, (e.g Multiplex Section Protection and Sub-Network Connection Protection as both may try and rectify the same fault).

Hold -off times may be used to prevent such protection schemes interacting between transport layers and networks.These should be dealt with under bilateral agreement.

Annex A

List of items for possible further study:

1. CBI - Cross border interconnect.

2. PAPI - Path access point identifiers (J0,J1,J2 bytes)

3. TCM - Tandem connection monitoring (N1 byte)

End of Document