IP based DCN for Optical Products using ITU-T G.7712

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Overview

This white paper provides a brief summary of the rational and mechanisms for the migration from OSI to IP based protocols for telecommunications management networks. The new global standard for this is ITU-T G.7712, which is applicable to DWDM, OTN, ASTN, SONET, SDH and PDH networks.

The value of moving the DCN from OSI to IP

The current standards for the SDH management data communications network (DCN) are defined in ITU-T G.784 and Q.811. The equivalent standard for SONET is GR-253. These standards define a SONET/SDH DCN based on OSI network layer protocols (CLNP, ES-IS & IS-IS). The vast majority of deployed SONET and SDH management networks are based on these protocols.

However there are good reasons to move to IP based SONET/SDH management networks going forward. The chief reason being the operational cost for the Network Operators is higher for OSI than IP. This is due to the wide spread knowledge of IP network administration amongst trained networking staff. In addition there is much greater support for product development using IP based management. Therefore there is a move to migrate to IP based working in new SONET/SDH products and networks, because it is in effect a cost reduction scheme.

Due to the large installed base of OSI equipment, the mechanism that provides a migration to IP needs to be backward compatible. This allows for an incremental network upgrade, which may take place over a period of years as new equipment and software loads become available. Another potential option is to use an IP specific overlay network, but this generates a significant extra cost and complexity.

In order to provide a standard for the migration from OSI to IP, the ITU-T has developed G.7712 (Architecture and Specification of Data Communication Network). This standard defines the requirements for a DCN that supports distributed management communications related to the Telecommunications Management Network (TMN). The standard allows for OSI, IPv4 and IPv6 protocols to co-exist in the same data network.

The ITU-T has been made G.7712 available to the IETF at (ftp://sg15opticalt:otxchange@ftp.itu.int/tsg15opticaltransport/COMMUNICATIONS/isis/index.html). The same approach to the combination of IPv4 and IPv6 networking is covered by the IETF in the IS-IS for IP Internets working group.

The main aspect of G.7712 that supports the migration from OSI to IP in an incremental manner is an extension to the IS-IS routing protocol (ISO 10589) to allow automatic encapsulation of one protocol within another. The standard defines OSI only nodes, IP only nodes and dual (OSI+IP) nodes. The dual OSI+IP nodes allow IP networking to be introduced into an otherwise OSI based SONET/SDH DCN. Due to the large amount of legacy equipment, new SONET/SDH NEs should be developed as dual OSI+IP nodes. The need to work with the legacy network was one of the main reasons for selecting the Integrated IS-IS protocol (RFC1195) for IP networking rather than OSPF. Integrated IS-IS has been used for IP routing since 1990.

Network Topology

There are several network topologies to consider. The most likely in practice is the requirement to manage new IP based SDH equipment via the existing OSI based SDH DCN. However as IP based equipment becomes more established in the network, islands of OSI managed equipment will require management access via the new IP based SDH DCN.

The essential components of an SDH DCN are shown below. They comprise of the Management platform, a router network and the SDH NEs connected by DCC links.

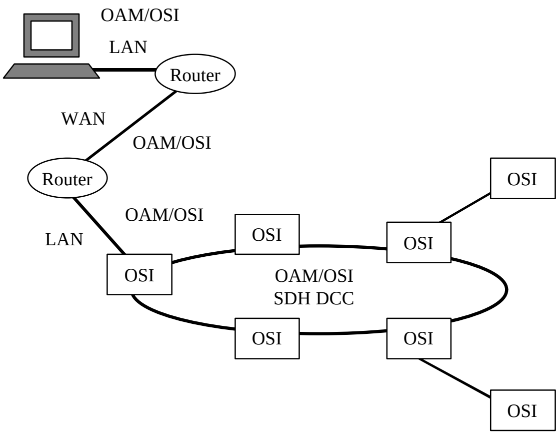

Figure 1 SDH DCN

The essential components of a SONET DCN are shown below. They comprise of the Management platform, a router network and the SONET NEs connected by DCC links.

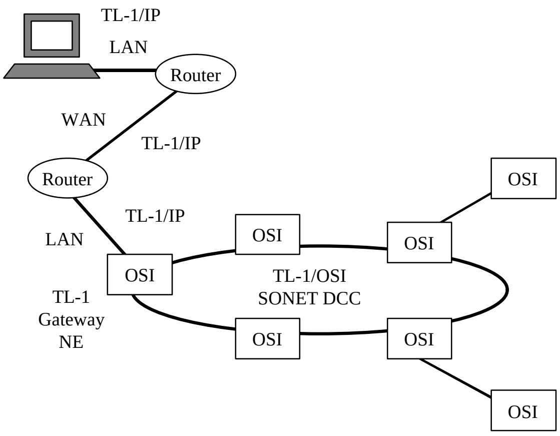

Figure 2 SONET DCN

The migration to include IP networking in the SDH DCN is shown in the following figures. The process is similar for SONET networks.

First dual (OSI+IP) nodes are introduced into the SDH DCC, which allows the introduction of IP networking, in an otherwise OSI network. The new generation of edge access SDH NEs is expected to operate in this mode. The head end dual OSI+IP and tunnel/encapsulation function can be located in an external DCN router or a separate adaptation unit. External DCN routers conventionally route IP and OSI traffic at the same time.

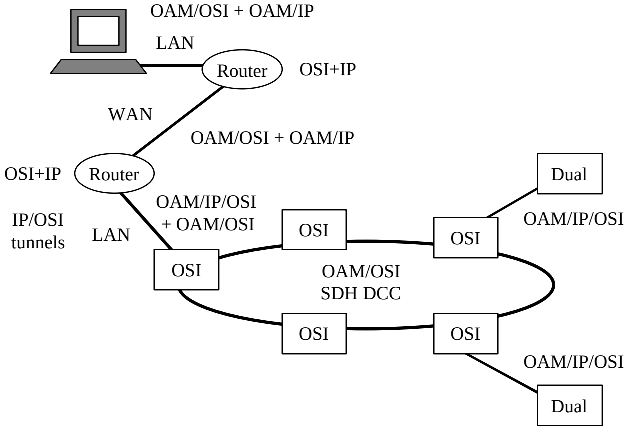

Figure 3 Introducing Dual nodes

Once dual (OSI+IP) mode software loads are available for the legacy SDH NEs, it will be possible to introduce pure IP nodes into the network and a greater degree of IP networking. This will allow the option to phase out OSI routing from the network over time.

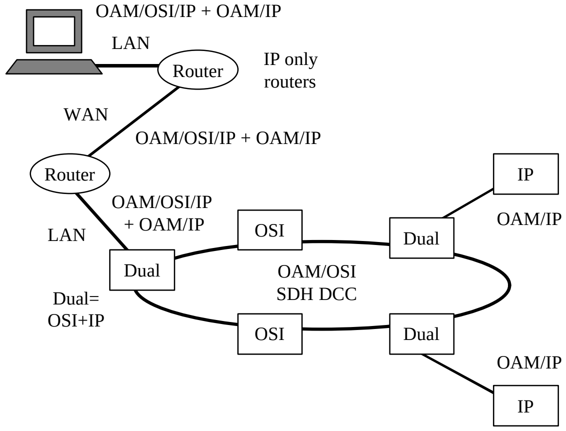

Figure 4 Introducing IP only nodes

The sequence described above ensures that management access is available to both legacy and new systems during the network upgrade. This is an essential requirement for any Operator with a live network to consider.

Protocols

This section describes the mechanism and protocols need to accomplish the introduction of IP networking into the SDH DCN. Note that CLNP is the OSI equivalent of IP.

There are two main network layer protocol elements that support IP networking for SDH. Firstly the ability to encapsulate one network layer protocol within another, which is defined by the Generic Routing Encapsulation (GRE) scheme. The second element is the use of the Integrated IS-IS routing protocol, which is used to distribute routing information for IP and OSI.

The ability to encapsulate one network protocol in another provides a standard scheme to allow CLNP/GRE/IP (RFC 2784) and IP/GRE/CLNP (RFC 3147). The operation of this encapsulation scheme or tunnel can be static (manual set up) or automatic (IS-IS).

The IS-IS routing protocol can support routing for CLNP, IPv4 and IPv6 at the same time. IS-IS was originally defined in ISO 10589; this was extended to support IP as Integrated IS-IS defined in IETF RFC1195. A further extension to Integrated IS-IS provides support for automatic routing encapsulation, which avoids the need to set up manual or static tunnels.

G.7712 mandates IS-IS for OSI nodes and Integrated IS-IS for IP and dual (OSI+IP) nodes. IP nodes may in addition support OSPF as well or other routing protocols. Integrated IS-IS was chosen as the prime routing protocol for interoperability, because it supports routing for multiple network layer protocols. It has wide support in both SONET/SDH telecommunications networks and in the backbone IP networks of the Internet. It does not require any other network layer protocol to operate, which enhances the stability of the network and it can prove useful when commissioning new network elements.

The protocol stacks for the ECC and LAN interfaces of IP only nodes, Dual nodes and OSI only nodes are shown below.

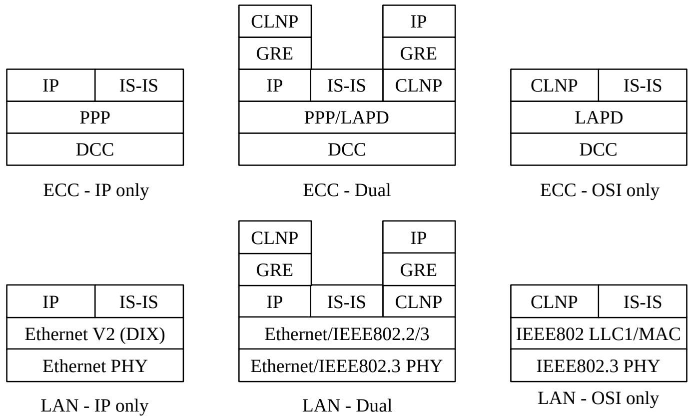

Figure 5 Protocol stacks

The data link layer definitions given by G.7712 are IP only nodes support IP/PPP, OSI only nodes support OSI/LAPD and dual nodes support (OSI+IP)/PPP or (OSI+IP)/LAPD. LAPD is the layer 2 protocol defined in ITU-T Q.811 and Q.921 for use over the SDH Data Communications Channel (DCC). PPP over HDLC defined in IETF RFC1661/1662, is the IETF equivalent that can support many network layer protocols. PPP extension RFC1377 is needed for IS-IS protocol support.

Some legacy systems have LAPD support in hardware, if they are upgraded to support IP in the future, they may run IP and IS-IS directly over LAPD rather than PPP. An alternative is for them to function as dual nodes. This results in IP/GRE/CLNP/LAPD/DCC on the SDH Embedded Control Channel (ECC).

The following figures illustrate some specific cases of networking OSI, Dual and IP systems. The protocol stacks appearing on the physical interfaces and the encapsulation type required are shown. The encapsulation scheme can static or automatic as described earlier.

The figure below illustrates how a new IP managed SDH NE can be accessed via a legacy OSI based SDH DCN.

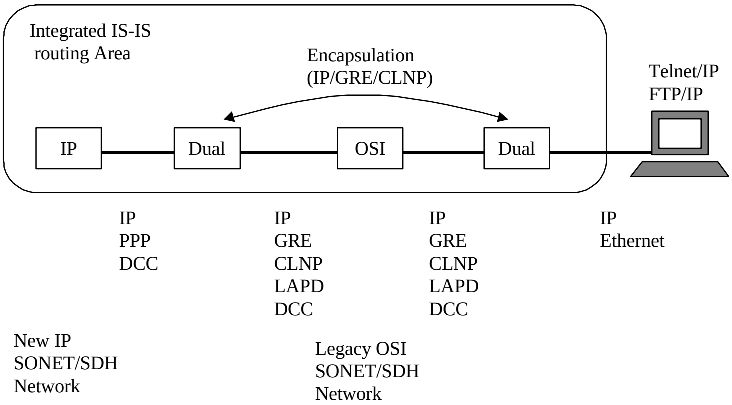

Figure 6 IP over OSI

The figure below illustrates how a legacy OSI managed SDH NE can be accessed via a new IP based SDH NE. The figure shows OSI protocols used between the management platform and the first SDH NE. This arrangement is possible, due to the support for OSI protocols in the routers connecting the SDH NEs to the Element Management systems.

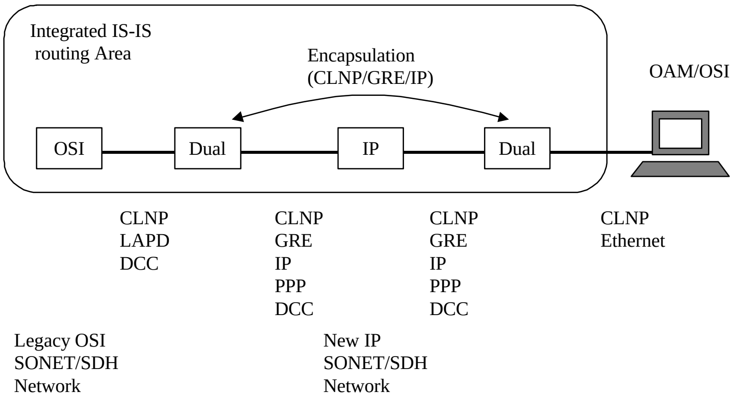

Figure 7 OSI over IP in the SDH DCC

The figure below illustrates how a legacy OSI managed SDH NE can be accessed via a new IP based SDH DCN. The figure shows IP protocols used between the management platform and the first SDH NE. Part of the move to introduce IP networking into the SDH DCN has included removing OSI networking from the router network connecting the SDH NEs to the Element Management systems.

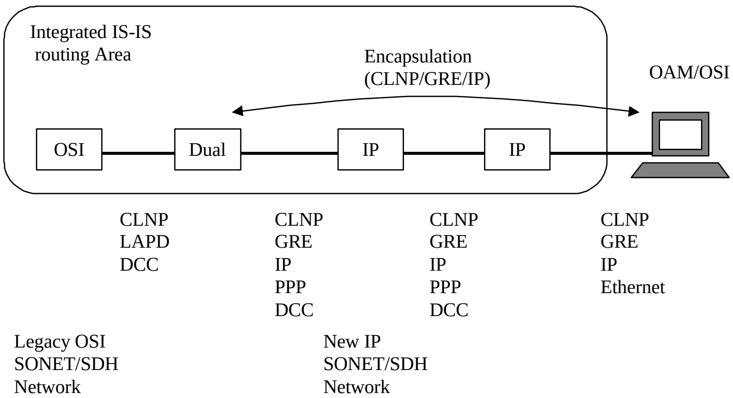

Figure 8 OSI over IP in the DCN

In a real telecommunications network there will be a complex combination of systems. It may be possible to use static or manually provisioned tunnels to provide the connectivity required. However an automatic encapsulation scheme is more desirable, since it requires less operator intervention and maintenance. This scheme is described in detail in ITU-T G.7712 and involves an enhancement to Integrated IS-IS.

The IETF IS-IS for IP work group (http://www.ietf.org/html.charters/isis-charter.html) has extended the original IS-IS protocol definition in ISO 10589. Some of these extensions include IPv4 support in RFC1195 and three-way hand shaking for point-to-point adjacencies RFC3373.

In addition to the above extensions, automatic encapsulation has been added, which works in the following manner. Integrated IS-IS determines routes for CLNP, IPv4 and IPv6 using a single Shortest Path First (SPF) calculation. It assumes that all IS-IS systems can route all protocols. If that is not the case, then topology restrictions must prevent “black holes” being formed. This would happen when packets of a particular protocol type are sent to an IS-IS system that cannot forward them. Clearly this would be the case for legacy OSI SDH NEs receiving IP packets to forward.

The Integrated IS-IS automatic encapsulation extension overcomes the problem described above. It does this by detecting when a packet of a particular type is about to be forwarded to a system that cannot route that type of protocol and automatically encapsulates it in a protocol that the next hop system can route. The encapsulation is removed at the next system that can forward the original packet protocol type on the path to the packet destination. In order to support this behaviour Integrated IS-IS distributes information about the protocols and encapsulation capability that each system supports. The information is sent to other IS-IS systems via Link State Protocol data unit (LSP) extensions.

The extension to Integrated IS-IS to allow automatic encapsulation is defined by the ITU in G.7712 and by the IETF in an Internet-Draft, which can be found at IS-IS work group. (http://www.ietf.org/html.charters/isis-charter.html)

The router network associated with the SDH DCN that currently support OSI routing would be able to migrate to IP operation with the introduction of G.7712 dual mode SDH NEs and Element Management systems. The option to add IP/GRE/CLNP tunnels and the automatic encapsulation extensions for Integrated IS-IS to routers will remain generally useful until the SDH DCN is completely IPv6.

The network operator’s router network may be required to use OSPF for IP routing. In this case it would be necessary to use Integrated IS-IS and OSPF on the routers connected directly to the SDH NEs and then re-distribute IP routing information between the two protocols.

For more information consult the Murton Consultancy & Design web site:

(http://www.murtoncd.co.uk/)