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Protection And Restoration in DWDM Metro/Core Application For End to End Recovery

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Abstract: Protection using rings has been the common method of reducing downtime on SONET/SDH based telecommunication networks. With the trend towards IP over DWDM, there is a need for IP based protection and restoration mechanisms. In this paper, the mechanisms being developed at several standards organizations including OIF, IETF, and ITU are described. These mechanisms are in some sense more powerful than the previous SONET/SDH based mechanisms and protect against not only link and node failures but also against domain failures. Here domain refers to an entire region of the network. In particular, Shared Risk Group (SRG) concepts being developed at IETF and OIF is explained.

I. INTRODUCTION

The market of metro optical networking has increased rapidly over the last few years. Traditional telecommunication infrastructure has an emphasis on long-haul optical transmission with ultra-broadband capacity, relying mostly on large pure Dense Wavelength Division Multiplexing (DWDM) systems. Today, however, metro core optical networks take the major role in provisioning local access services and interconnecting service points of presences (POPs) with long-haul transmission. This represents a pivotal point in business operations of data communication services for service providers and large enterprises. In addition, the upper layer data services completely leans upon the substrate wavelength communication, and hence the survivability and reliability issues in the optical domain are now becoming crucial topics. This dissertation provides a detailed discussion around the development process of protection technologies in metro core optical transport infrastructure.

In telecommunications networks, protection and restoration refers to mechanisms used to minimize the downtime due to failures. The difference between protection mechanisms and restoration mechanisms has been a matter of debate at various standards bodies. To avoid this debate, we address them as recovery mechanisms in this paper.

Telecommunications network architectures consist of three component planes: data, control and management. Data plane consists of components and protocols required to transmit data on a given path. The path itself may be determined manually or automatically using an intelligent control plane. The management plane helps monitor and manage the faults, configuration, accounting, performance and security (FCAPS) of the network. Although, these three planes have distinct functions but may or may not be physically separate. For example, a SONET network may be controlled by an IP-based control plane. The IP messages may be sent over the same SONET network or may be sent over a separate data communication network (DCN). Failures can occur at any of these three planes, but *in this paper we are only interested in the data plane failures and their recovery with the assistance of the control plane*.

As stated above, one component of management plane is "configuration" which involves planning the network topology. Current and projected future traffic matrix can be used to determine the most effective topology. Recovery considerations in case of faults may further require changes or additions to the topology. Once the network has been configured and installed, as requests for connection come in, the paths may be provisioned manually or using control plane.

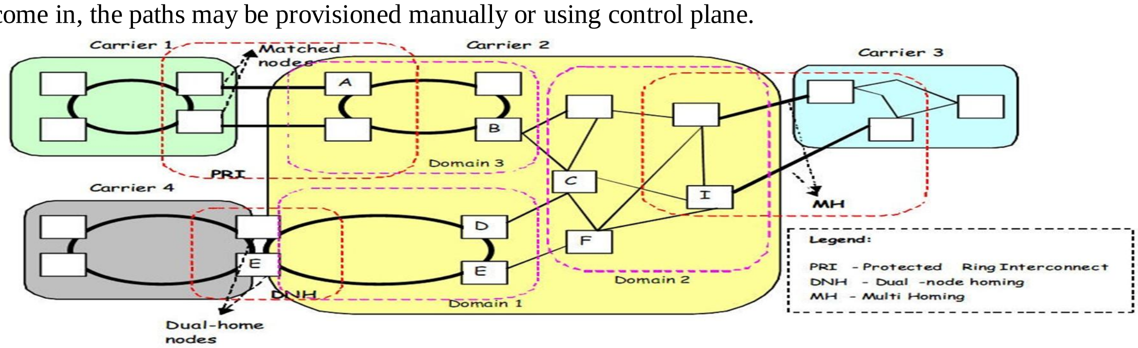

Figure 1 Different inter and intra-carrier interconnecting scenarios

A. Basic Structure of DWDM System

The DWDM system multiplexes several or dozens of optical channel signals with different nominal wavelengths to one fiber for transmission, with each optical channel carrying one service signal.

The basic structure of a unidirectional DWDM system is shown in Fig. 2.

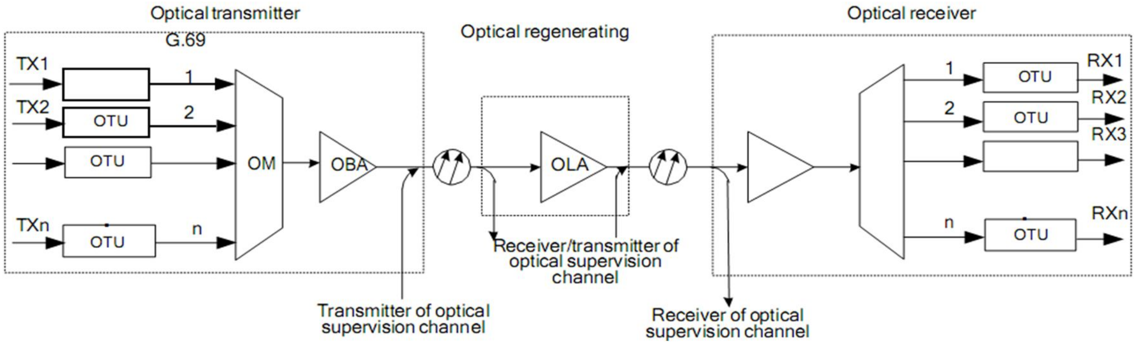

Fig.2 Basic Structure of DWDM System

II. RESTORATION AND PROTECTION IN DWDM METRO

A. Metro architectures and protocol stack developments

The hypothetical network of Figure 3 shows the broad range of customer services converging in metro networks. A portion of this traffic transfers to the high-capacity core network that uses either a mesh or ring architecture. Metro networks often divide into metro-edge (the collector/aggregation segment) and metro-core (the higher capacity segment where bandwidth management occurs). The metro-edge network interfaces to a wide range of access technologies (ADSL, T1/E1, SONET/SDH, 10/100E, GigE), while the metro-core network operates with high-bandwidth interfaces and DWDM optics, usually with 10 Gb/s per wavelength interconnecting to the 10 Gb/s core network. Today, most metro networks use SONET/SDH rings for aggregation, bandwidth management and protection.

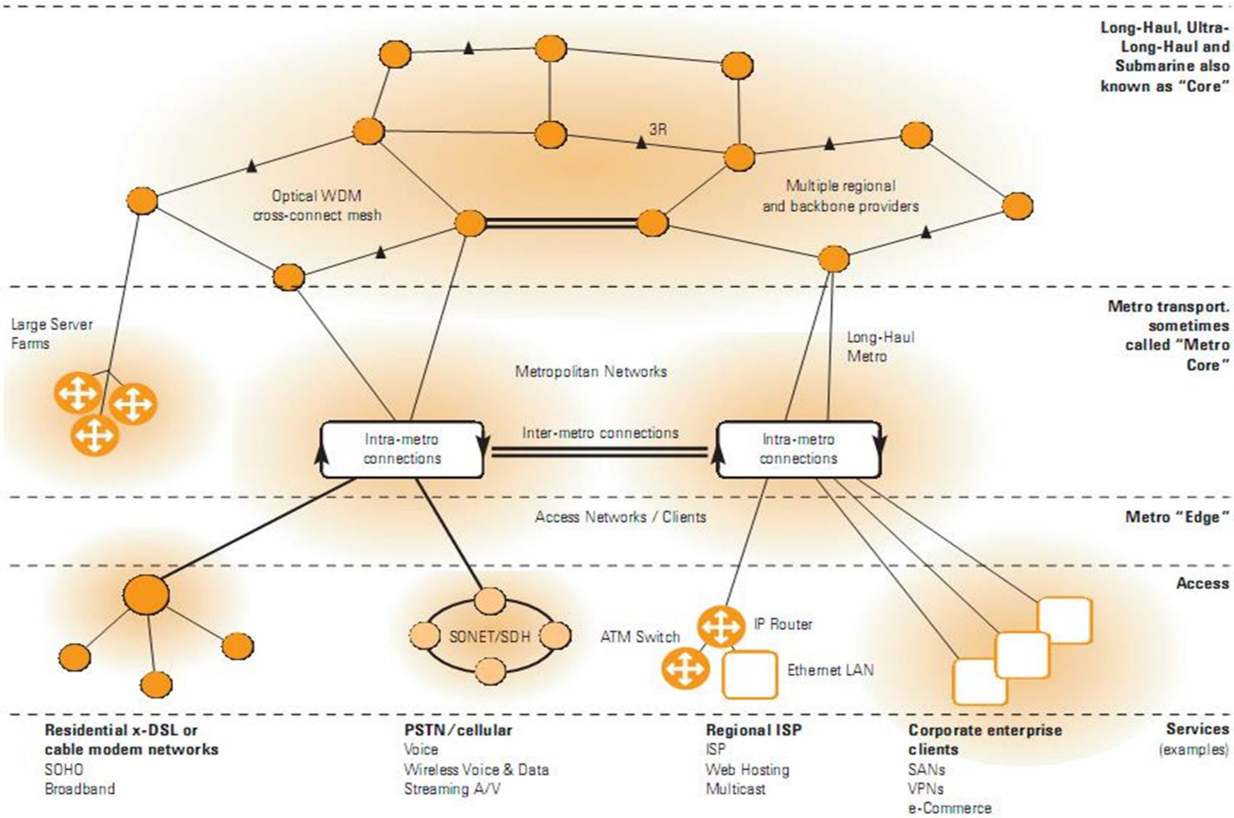

Figure 3: Overall Network Diagram

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B. Restoration and QoS options

Most metro networks rely on Layer 1 SONET/SDH or fiber ring protection to provide a high level of survivability, albeit at the price of stranded protection bandwidth. This underpins most SLAs in terms of "five nines" availability and guaranteed error performance. Service providers are understandably reluctant to move away from these high standards, particularly when they carry significant amounts of legacy traffic. On the other hand, if the traffic is predominantly data, with perhaps a peak to average ratio of 5:1 or 10:1, it doesn't always make sense to have so much protection bandwidth out of service all the time.

when congestion or failure occurs. Layer 2 mechanisms for implementing this strategy include MPLS protection paths (either predefined or set up on demand), Resilient Packet Ring (RPR, IEEE 802.17) and restoration schemes based on the Ethernet MAC such as rapid spanning tree (802.1w) and the proposals of the Metro Ethernet Forum (MEF).

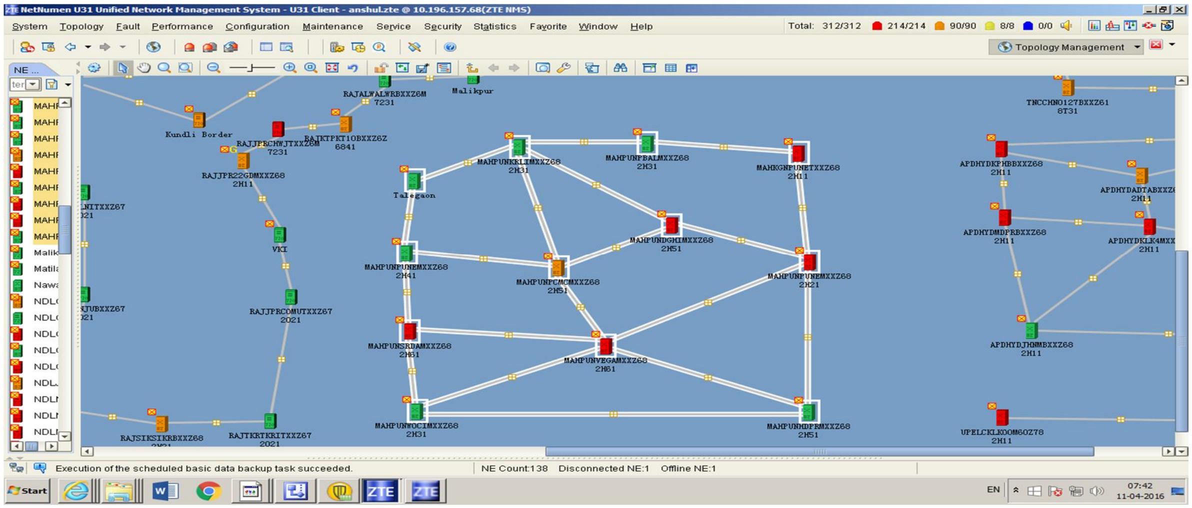

Figure:-4 Network topology

C. Protection

In below figure the protection path is shown by yellow lines, which have one extra node b/w source & destination.

If any fiber cut happened in working path (green path), then service will automatically switch to protection path & all traffic will carried by protection path.

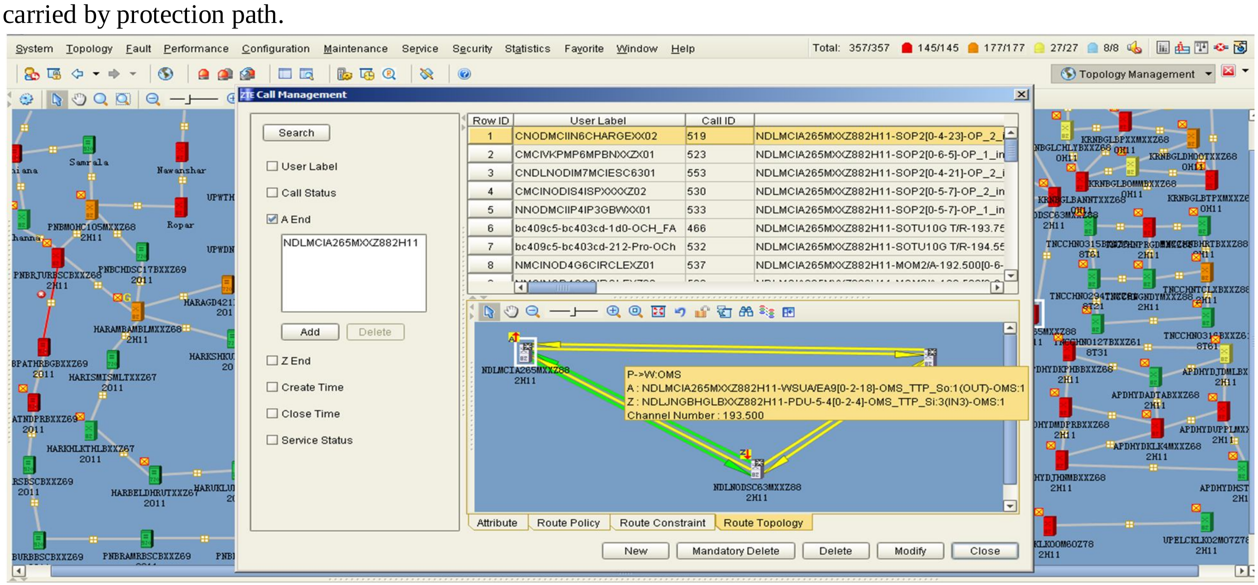

Figure:-5-path generation

III. FAULT NOTIFICATION

For proper operation of any recovery mechanisms, efficient fault identification and notification is a pre-requisite. In the networks built with all-optical Photonic Crossconnects (PXCs), fault monitoring is expensive and cumbersome. But DWDM equipment, located between the pairs of PXCs, already monitors for degradation and faults along the fiber path.

Expensive electronic circuitry monitors such degradations at a wavelength level at each repeater and amplifier along the fiber path. Repeaters and amplifiers detect fiber cuts and pass along the information to other equipment along the path. The failure information is then provided by the DWDM to its client equipment. Since this failure information is carried within SONET streams, expensive electronic circuitry is necessary at the PXCs. A messaging based protocol between

the DWDM and the PXC can provide a cost-effective solution by avoiding this electronic circuitry and also provide the same fault information to non-SONET clients.

IV. APPICATION

We focus on connection recovery in a single layer. Usually, each sub-network or domain will provide its own recovery functions, such as SONET ring self-healing protection, shared mesh restoration, or dynamic restoration. If a connection travels multiple sub-networks or domains, then the recovery may be either domain-by-domain recovery or end-to-end recovery.

A. Metro/core application with end-to-end recovery

When there are no trust and policy restrictions between the domains, one can compute a strict end-to-end path crossing multiple domains. In this scenario, the recovery path should be completely node-diverse an SRLG-diverse from the service path such that the connection can be recovered from any single node or link failure. Unlike in the previous example, an end-to-end path recovery can protect the connection from most of the failures. The disadvantage here is the time it takes to recover from a failure. Note that in such a scenario many recovery mechanisms can be employed with multiple levels of overbooking at different places in the network. Contention for protecting resources occurs in this scenario also.

B. Domain of transparency application with segment recovery

With the technology improvements of optical networks, some carriers may build a high-bandwidth long-haul transmission network over existing sub-networks to reduce cost. For example, an all-optical domain (OOO) may be added to the optical-electronic-optical (OEO) domains. A connection crossing the core may travel an OEO domain, enter the OOO domain, and then return to the OEO domain again.

C. Domain of transparency application with end-to-end recovery

In this application, the two paths can be completely node/SRLG disjoint. However, this application may imp act the architecture configuration and routing/signaling protocols.

V. CONCLUSION

In this paper, we have provided taxonomy of faults and recovery mechanisms. Faults can be classified based on the layer and scope. Recovering entity can similarly be classified by extent, granularity and layer. Protection paths may be pre-computed or provisioned on demand. In either case, the protection path may be dedicated, shared, or best effort.

Several applications including metro-core with domain/end-to-end recovery, domains of transparencies with segment/end-to-end recovery, and inter-vendor clouds with segment/end-to-end recovery were described. Recovery processes require three kinds of entities: fault-detecting entities, fault reporting entities, and deciding entities. These entities may or may not reside in the same box. If they are on different boxes, then protocols are required for communication between these entities. One example of such a protocol, which has been developed recently, is LMPDWDM, which allows fault communication between DWDM and photonic cross connects. Routing protocols, such as OSPF and IS-IS are being modified to allow easy computation of protection paths.

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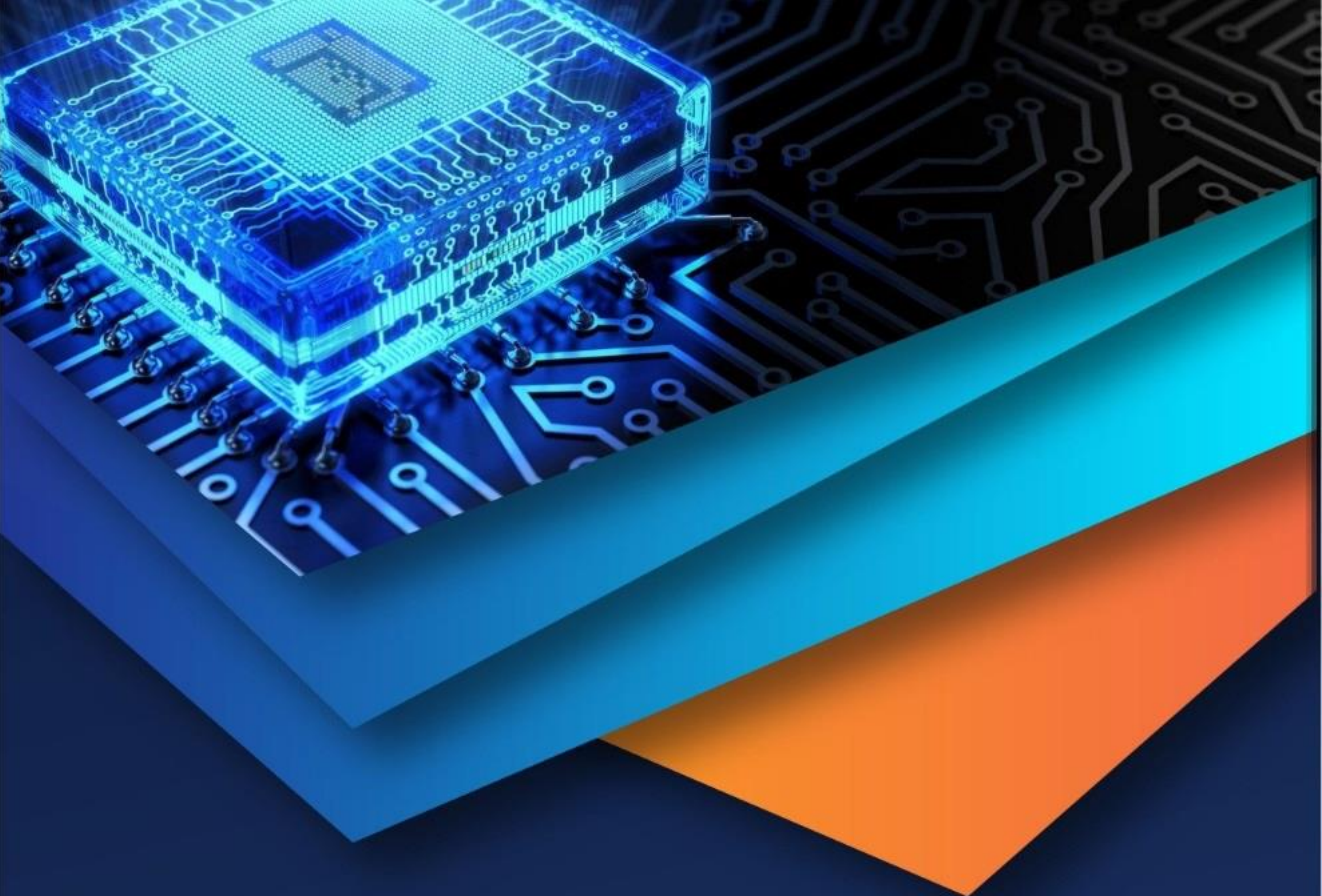

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