1/287 01-FGC1010609 Rev B

ASON for Optical Networks

Ericsson Control Plane for DWDM Optically Switched Networks

ASON for MHL3000

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Introduction

The growing demand for multiple service is changing the network architecture of the transport creating mesh topology that are introducing switching in the optical domain (realized with Wavelength switches-WSS). This introduces all-optical technologies in meshed topologies of the optical transport.

Feature evolution towards a Distributed Control Plane based on ASON architecture and GMPLS protocols on DWDM will improve Network Utilization and Availability, reducing both CAPEX and OPEX in a similar way to what happened in SDH networks with an enhanced Control Plane.

The main benefits provided by a Distributed Control Plane in a DWDM network can be summarized as follows:

- Card sharing: that reduced CAPEX (as tributary costs and spare parts)
- Wavelength sharing: reduced infrastructure cost (40 channel infrastructure instead of 80 channel for equivalent working capacity)
- Increased network resiliency allowing the network to recover against double failure
- Dynamic fault recovery without human intervention
- Service differentiation via different degrees of protection/restoration

The evolution of the ASON control plane to the DWDM layer will increase the availability of the entire solution through a saving of network resources.

Network resilience with an ASON control plane is improved not only because several protection/restoration schemes are available for re-routing of optical channels in the event of a failure of the worker path, but also because it’s possible to survive in the case of multiple failures.

In traditional protection schemes if both the worker and protection path of an SNCP protected circuit fails all traffic is lost. With the ASON control plane implemented at the DWDM layer, restoration schemes can recover traffic as long as there is physical connectivity between the termination points.

Network resource will also be saved as the restoration path is activated dynamically only when needed (in the case of a fault) avoiding a waste of protection bandwidth as in the case of classical Ring protection schemes.

Moreover, as already proven at the SDH level, the introduction of ASON protocol awareness at the DWDM level will allow the possibility to:

- simplify provisioning procedures

- differentiate services using different degrees of reliability
- reduce OPEX and CAPEX.

ASON for Optical

ASON/GMPLS for optical allows the automation of some provisioning and restoration mechanisms, taking advantage of reconfigurable add-drop/switching functionality based on WSS and other agile optical technologies.

The features include:

- Pre-planned restoration with Lambda sharing - protection wavelength is shared between different light paths to reduce resource utilization
- Pre-planned restoration with card sharing - no need to duplicate transponder cards
- Combination of the above restoration schemes for higher reliability
- ASON Planning Tool with embedded wavelength routing and assignment
- Network auto-discovery using OSPF-TE

In these schemes, pre-planning of the alternate routes is always assumed. In fact, the restoration paths in photonics require a path design, to ensure feasibility of the lightpath, and resource allocation, in particular where the lightpath requires regeneration. Sharing of the restoration resources in turn requires accurate and coherent design of the network.

Restoration with Lambda sharing

The restoration with lambda sharing calculates the worker and the protection lightpath before the failure. The recovery resources are reserved and are activated only in case of failure. In case of path failure, the recovery path resources are reserved and can be shared among different recovery paths;

Restoration with Lambda sharing is pre-planned and it is beneficial in ring and meshed networks where the amount of bandwidth used by protection paths can be reduced. A pre-planned protection path can be used by more than one mutually diverse worker paths, with the path being used only by the path that has failed.

Traditional OSNCP protection is realized with a lightpath for the primary route and a lightpath, normally on the same lambda, for the protection route.

The protection is assumed to use a dedicate lambda, thus it cannot overlap with other services.

The following figure shows a typical OSNCP protection applied to a ring topology with 3 working paths (services):

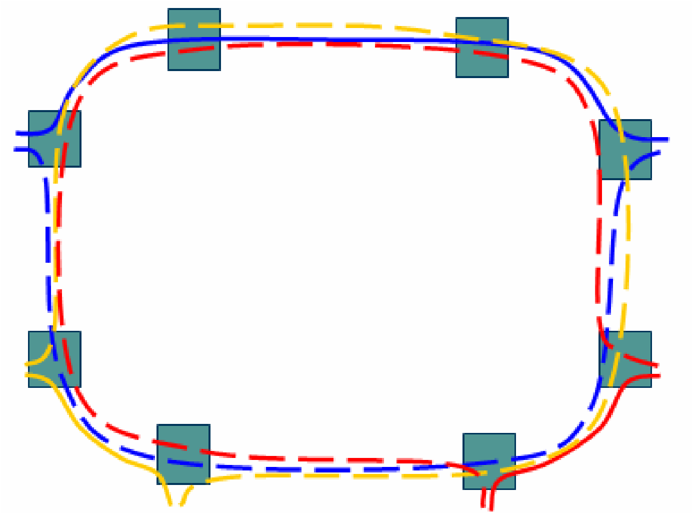


Figure 1

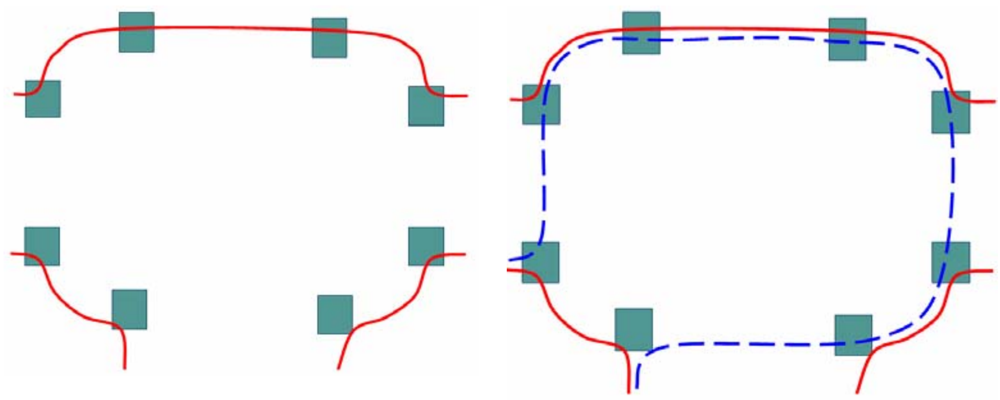
Figure 1 - O-SNCP Example: 3 services, 3 wavelengths

On the primary routes if two services do not share common points of failure, it is assumed that they will not fail simultaneously.

The sharing of the restoration wavelength allows a more efficient wavelength usage.

With a shared restoration scheme, it is possible to use only 2 lambdas for N protected services, if these do not overlap in their primary path.

The following pictures show this concept: three not-overlapping services are protected by using only two wavelengths instead of three as in the OSNCP scheme



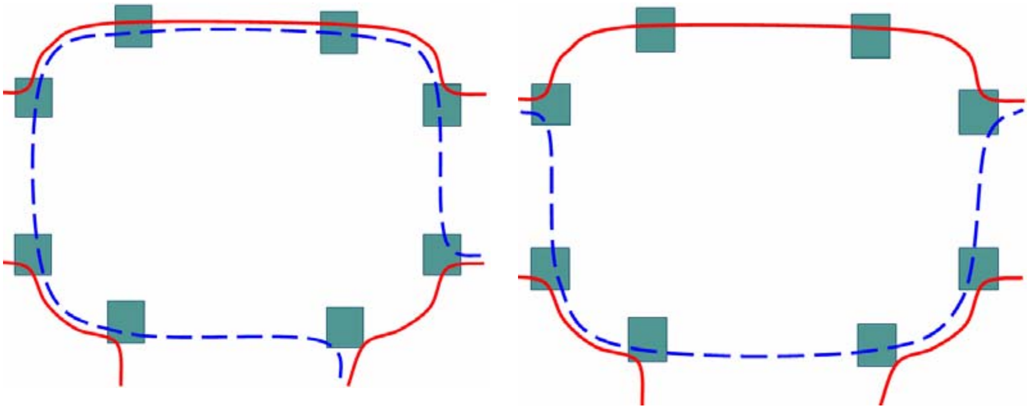


Figure 2 - Restoration Example: 3 services, 2 wavelengths

Lambda sharing can also be advantageous in long-distance networks, where the regeneration points can be shared among different restoration paths.

Restoration with card sharing for directionless and colorless solution

Pre-planned restoration with card sharing allows OSNCP-like protection but without duplicating transponder cards. Traffic is always re-routed after failure.

In order to implement this restoration scheme for a given service a transponder at each endpoint of the circuit is connected with a flexible optical switch (WSS directionless). Two or more alternative paths are defined and physically validated in advance (possibly with regeneration points). One is implemented as working path.

After a fault occurrence, the working path is deleted and one restoration path is implemented (break before make). In this scheme the working and protection paths are based on the same wavelength, or on different wavelengths if the colorless function is used (see below).

- If more than one restoration paths are available, they are chosen with a predefined order.

- If the routing protocol or alarm system informs in advance the path selection function, the choice can be forced if one of the restoration paths is unusable due to multiple fault conditions.

- If the chosen restoration path is unusable, but the path selection function is not informed about that, crankback mechanisms are used.

The Transponder Sharing restoration mechanism is depicted in the following pictures:

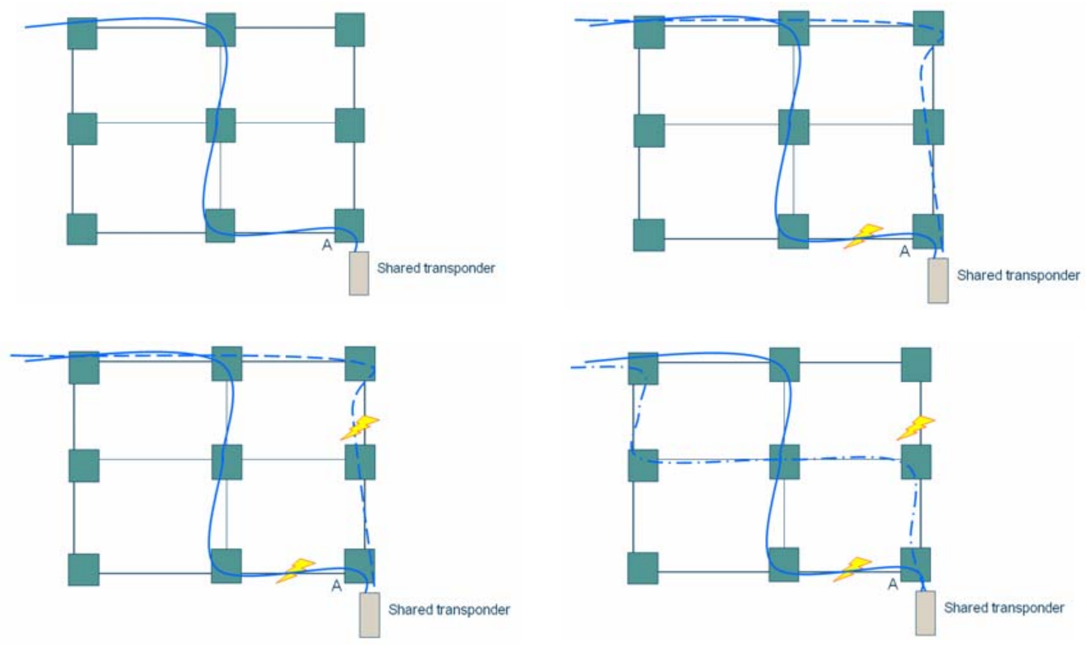


Figure 3 - Transponder Sharing Scheme

Restoration with card sharing can also be applied to either or both sides of an OSNCP protection, where fast switching must be combined with survivability to multiple faults.

The directionless and colorless are hardware configurations that are satisfied with the Restoration with card sharing.

The directionless function provides a fixed fiber port interface for any direction. Directionless switching adds more flexibility to the network. In this case the wavelength can be rerouted in case of failure, congestion or maintenance. It allows all optical switching enabling the card sharing restoration described here.

The colorless function provides the ability to drop any wavelength or group of wavelength from any physical port. Any transponder can be connected to any physical port, and any transponder can be tuned to any wavelength. The optical node can be configured to drop another wavelength from the same port without extra fiber management. It simplifies inventory, installation and maintenance. In the card sharing restoration mechanism, it allows using different wavelengths for alternative routes.

Network discovery with extended OSPF-TE

Although the paths are computed in advance during the network design phase (see below section 4), if multiple restoration paths can be chosen (such as in card sharing restoration), it is always desirable to have an updated knowledge of the network resource status.

The OSPF-TE routing protocol is the established way to keep the control plane updated about the resource status and usage during the network lifetime. The path selection engines that must select the best alternative route after a fault, maintain a constantly updated database about the network resource status. The OSPF-TE, with GMPLS extensions for optical, allows the description of DWDM networks and their status and occupancy (e.g., faults and used wavelengths).

When the OSPF is not fast enough, misalignment may occur between the network representation and the actual resource status. In that case, crankback mechanisms allow the path selection engine to have a quick update of the real status and to choose the appropriate alternative path.

ON Planner

To help planning, developing, managing Network Operators, the network planning tool maximizes both the quality of service and the network resources. ON-Planner is the optimum tool for planning and simulating networks that requires an automated control plane (ASON/GMPLS), or have challenges on Optical design (photonic networks), or demands a complex interaction among services and network resources (data network). ON-Planner offer the flexibility of manage a multi-layer's transport and provides the benefits of adopting Traffic Engineering's policies to emulate all network that demands a control plane to optimise the resource utilization.

The On Planning tools allocate efficiently the network resources reducing the hardware equipments (CAPEX saving).

A further challenge is introduced if all-optical networks are considered.

It is well known that physical impairments force the use of regeneration sites on long lightpaths in all-optical communications. As the regenerator represents a noticeable cost in the network design, it is recommended to keep low the number of regenerators.

The application of lightpath routing to meshed topologies favors the sharing of optical transmission resources among several lightpaths. If schemes with wavelength sharing are used and they require regeneration, the regenerators are eligible for resources sharing as well.

Placing the regeneration sites commonly among several lightpaths may bring considerable advantages. In the aforementioned shared wavelength restoration schemes, it may represent a further saving in the number of regenerators.

Moreover, a set of unrelated lightpaths that are partly routed on common resources may share the regenerator sites. Even if different wavelengths require their own regenerators, regenerators sharing the same site may advantageously use common mechanical arrangements, with both CAPEX and OPEX improvements.

The aim of ON Planner, as regard the photonic layer, is to offer a way to plan resources considering all the characteristics of an all-optical network with automatic control plane and shared restoration capabilities (this means a optimal allocation of resources, reducing the overall network cost, with respect to a static optical network, with the same service protection degree).

The whole process can be resumed in six steps depicted in Figure 4. The "yellow area" is related to physical items, the "pink area" is related to logical items.

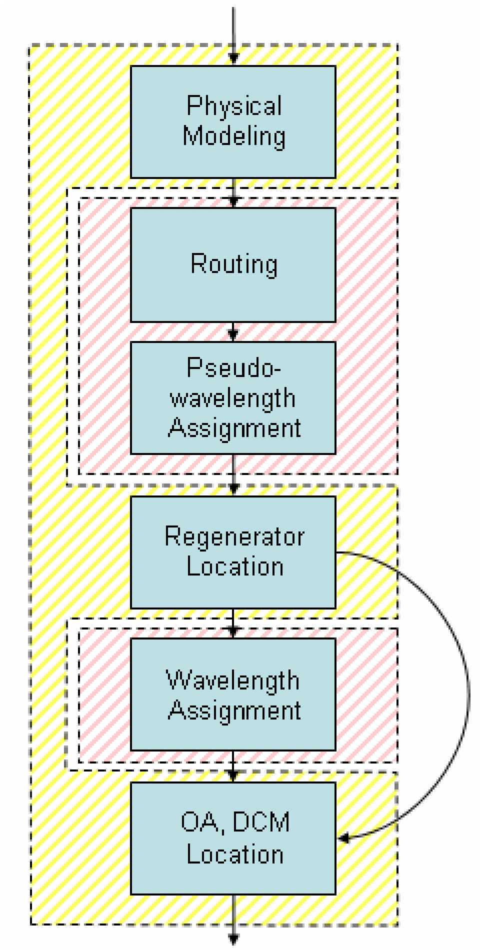


Figure 4 - Resource Planning block scheme

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Conclusions

Agile optical components introduce useful flexibility in the optical transport networks.

The usage of ASON control planes together with adequate planning tools are the necessary steps to exploit effectively this flexibility and represents a noticeable improvement in the design, deployment and operation of a DWDM network.

These improvements are realized in terms of:

- simplification of the network design
- efficient resources' usage
- improved service reliability