Apollo Advanced WSON Solution

Apollo advanced WSON adds *pre-planned restoration* routing tables and *regenerator pools* to a basic WSON architecture. These enhancements bring multiple benefits. They reduce costs by requiring fewer transponders for backup light paths and enhance restoration, boosting network and service availability.
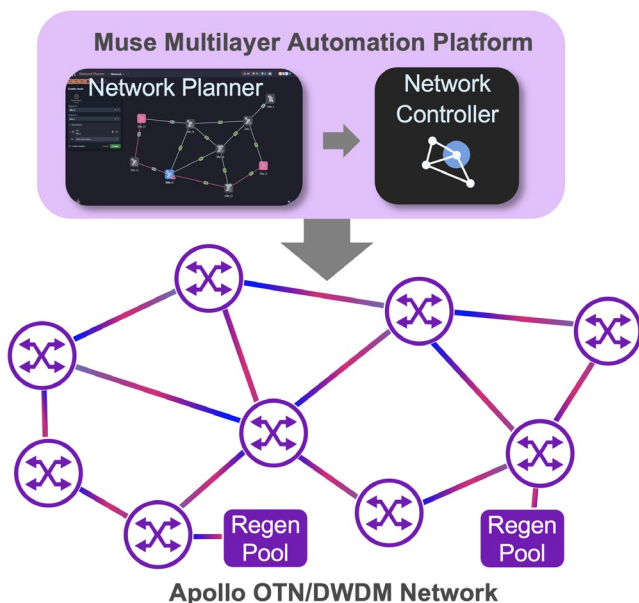
Apollo delivers flexible and robust optical networks, built on multiple capabilities like CDC ROADMs, C+L bands with flexible grid, protection schemes including 1++, 1+ OLP, and 1+R, and WSON restoration. This solution brief discusses Apollo's innovative Advanced WSON solution.

WSON (wavelength switched optical network) dynamic restoration uses shared transponder resources to increase network availability without adding significant cost. It complements protection switching for wavelengths that do not require the highest level of availability and addresses more complex mesh network scenarios where protecting each wavelength is cost-prohibitive.

In the event of a fiber cut or other loss of service condition, basic WSON calculates a restoration path 'on-the-fly' using a CSPF algorithm and establishes the path using GMPLS signaling. However, this approach faces limitations in the following situations:

- Complex mesh networks where CSFP may not provide the optimum alternate routes.

- Multiple failures, where the algorithms running simultaneously on several nodes lead to crankback cycles until the network settles to a steady state, delaying restoration.

- Needing to re-route wavelengths onto longer routes that do not support the required OSNR without regeneration.

Apollo Advanced WSON addresses these with two major innovations: Pre-planned Restoration routing tables and Regenerator Pools. The diagram below summarizes the approach.

Muse Multilayer Automation Platform

Network Planner → Network Controller

Apollo OTN/DWDM Network

- Muse **Network Planner** creates optimized **pre-planned restoration** routing tables, taking into account the availability of **regenerator pools** for longer routes

- Muse **Network Controller** distributes the routing tables to the Apollo nodes

- When failures occur, Apollo nodes implement the **pre-planned restoration** routes using GMPLS

- If failures go beyond the routing tables' scope, Apollo nodes use **on-the-fly algorithms** as backup

Pre-planned Restoration

Apollo Pre-planned Restoration is a component of a comprehensive network plan that provides an optimized solution for the basic provisioning of an optical network as well as its protection and restoration schemes. PPR considers a "big picture" view and can analyze multiple failure scenarios. It can design restoration schemes that operate more effectively and faster than "on-the-fly" algorithms with limited network views.

As part of a network design Muse Network Planner includes NE topology, the services matrix, protection, and restoration paths. It considers up to two levels of failure in the restoration design. Upon completion of the network design, Muse Network Controller downloads the pre-planned restoration paths to the Apollo nodes. Benefits of pre-planned restoration include:

- An optimized and predictable network: It is part of a comprehensive network plan covering provisioning, protection, and restoration. Less predictable on-the-fly restoration is used only as a final option.

- Eliminating crankbacks and restoration delays, which can occur with multi-level failures.

Regenerator Pools

Apollo Regenerator Pools allow network operators to optimize the allocation of regenerators to support a given traffic matrix without sacrificing network survivability. Any wavelength path can be regenerated, including main, protection, and even restoration paths. Key use cases include:

- Establishing a shared pool of transponders that are available with high probability across many paths, reducing the need for expensive dedicated protection and lowering the overall cost of the network.

- Overcoming OSNR penalties on longer distance restoration paths, enabling the original signal speed to be maintained. For instance, if the original path is 400G but an extended restoration path supports only 200G due to lower OSNR, Apollo regeneration ensures the 400G rate is maintained, thus preserving network performance.

Muse Network Planner includes an allocation strategy for regenerator pool locations and quantities at each location based on the traffic matrix and network availability targets. A final point, Apollo Regen Pools are green. When not in use, they are in a low power sleep mode and consume power only when operational on restoration paths.

The diagram below is an example of pre-planned restoration and regenerator pools working together.
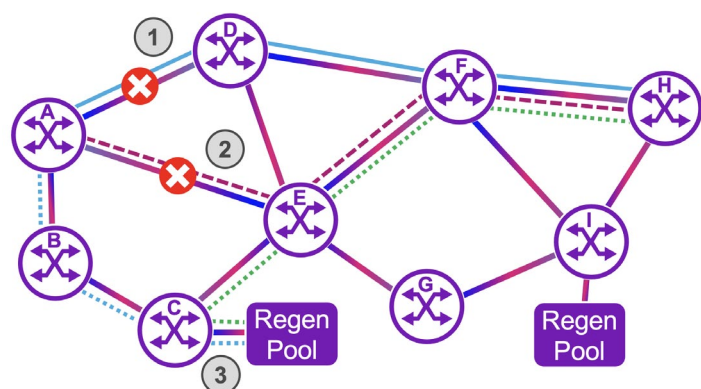
1. Main path A-D-F-H has a fault on A-D.

2. Using pre-planned restoration the network re-routes the path to A-E-F-H on a different color wavelength. This path then also has a fault on A-E.

3. Again, using pre-planned restoration the network re-routes the path to A-B-C-E-F-H, using the regen pool and two different wavelengths. The original wavelength rate is maintained on this much longer path.

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