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Dynamic link holdoff adjustment methods in multi-Layer Control Plane networks via NMS/SDN controller

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ABSTRACT

The present invention proposes to dynamically propagate and adjust control planes (such as ASON, GMPLS, PNNI, etc.) via SDN Controller/NMS based on Lower Layer Circuit Protection status. An SDN Controller sends a pre-defined nonzero value to L1CP links whenever an L0 circuits protection health status is good. The SDN Controller sends “Zero” hold off to L1CP links whenever the L0 Circuits dont have protections available, so that L1 CP can heal the circuit immediately on network faults when L0 layers cannot heal it.

DETAILED DESCRIPTION

Background/Existing Functionalities:

- Companies support L0/L1/L2 control planes on many of their products. Multi-layer control planes can co-exist in customer deployments i.e., L1 CP going over L0 CP i.e., Bharti, Lumen etc.
- Example of few network configs where L1CP and L0 CP co-exist.

Based on L0 Circuit protection status and NMS tracking how many L1 OSRP Links are going into a particular L0 circuit, Dynamic hold off can be sent to appropriate L1 OSRP links. OSRP = Optical Signaling and Routing Protocol.

a. Single L1 CP link goes as single Wavelength into a L0 SNC

Fig1

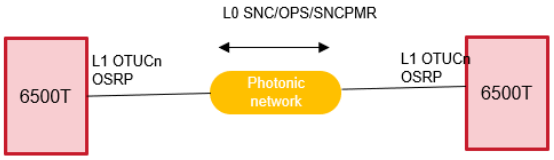

Figure 1

b Multiple L1 CPs link goes as single Wavelength into a L0 SNC

Fig2

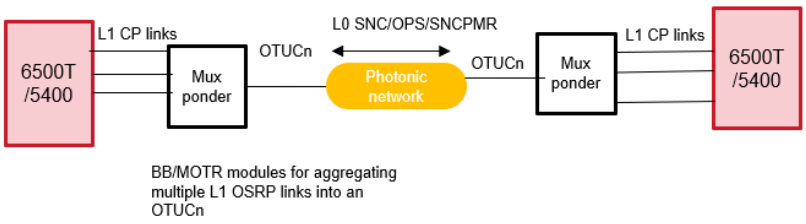

Figure 2

- Current implementations define various user provisioned hold off timers to hold or delay traffic switching at a particular layer in multi-layer protections/mesh environment.
    - **Control Plane level holds off timers** -
        - **OSRP Link Level Hold off timer** – All SNC circuits on an OSRP link are delayed/held off during link failure.
        - SNC Level hold off - Low Priority SNC can be hold off during link failure on its current route.

    - **PU level Hold off timers** - These Hold off values are provisioned at PU/PG level of various protection schemes such as SNCP/APS etc.

- SDN controller Manage, Control and Plan (NMS) is aware of multilayer traffic flowing across the network. Currently it allows visualization and navigation across multilayers and has a roadmap to allow propagation of data, advice, and shared risk link etc. across the layers including L0, L1, L2 and L3.

Problem description:

- Faults detection on Lower layer (i.e., L0) is a mesh restoration trigger as well as protection switch triggers on both Lower Layer (L0/WDM) as well higher layers (L1/OTN or L2).
- Currently Higher layer control plane i.e., OTN can be hold off with static pre-provisioned values during lower WDM layer faults until lower layer control plane heals the network.
- Static hold offs methods are not fully efficient as they don't have runtime network visibility of Lower layer Protection resiliency which can lead to unwanted/increased traffic interruptions as explained below
    - For Example – a L1 SNC riding over L0 CP SNCs, Initially L0 CP SNCs might have enough protected routes for mesh and L1 Control plane static/user defined hold offs can work, however due to dynamic nature of network, when Protect routes of L0 SNC gets exhausted, L1 CP should immediately mesh to minimize traffic interruptions however pre-provisioned Static Hold off at L1 CP network in this case will prolong traffic interruptions. Due to Static hold off, in worse case scenarios, L1 SNCs may not find bandwidth as other circuits (with no hold off) might have consumed bandwidth making traffic permanently down for the SNC which in this case in due to Static hold off provisioning (existing implementation)
    - A user defined static hold off may not work in all conditions. For Example – L0 SNC will take a longer mesh time when more hops/links are involved as compared to smaller hops on its home route/protect route, so Static hold value is difficult to decide – a low hold off value may not work when L0 SNC is using more hops and higher value may be a problem when L0SNC has no protection route available, and L1 CP has taken long to mesh.

Solution:

The present invention proposes to dynamically propagate and adjust “OSRP Link level Hold off “values to Higher Layer/L1 control plane via SDN Controller/NMS based on Lower Layer/L0 Circuit Protection status. (If L0 SNC or OPS configuration has protection available)

- SDN Controller sends a pre-defined/precalculated nonzero “OSRP link level Hold off” value to L1CP links whenever L0 circuits protection health status is good. L1 CP doesn’t kick in as L0 CP or L0 OPS Layer is expected to heal the network/Circuit.
- SDN Controller sends “Zero” hold off to L1CP links whenever L0 Circuits doesn’t have protections available so that L1 CP can heal the circuit immediately on WDM/network faults when L0 layer cannot heal it.

The present disclosure provides the following novel benefits:

- A new User provision able “Dynamic Hold off” feature support available at NMS for L0 circuits. “Enabling” the feature allows to adjust Hold off values dynamically at higher layer (L1 CP layer). “Disable” Option allows backward compatibility.
- SDN Controller/NMS Coordinating with NE Control Plane layer to set “OSRP Link hold off” values based on detecting protection/Resiliency status of Lower Layer/ L0 circuits.
- Flexible NMS Rule Engine to define trigger points/conditions to send dynamic hold off higher layers – This allows scalability to any future needs/support.

Use cases:

L1 SNCs riding over L0SNC and L0 SNC has protection path available

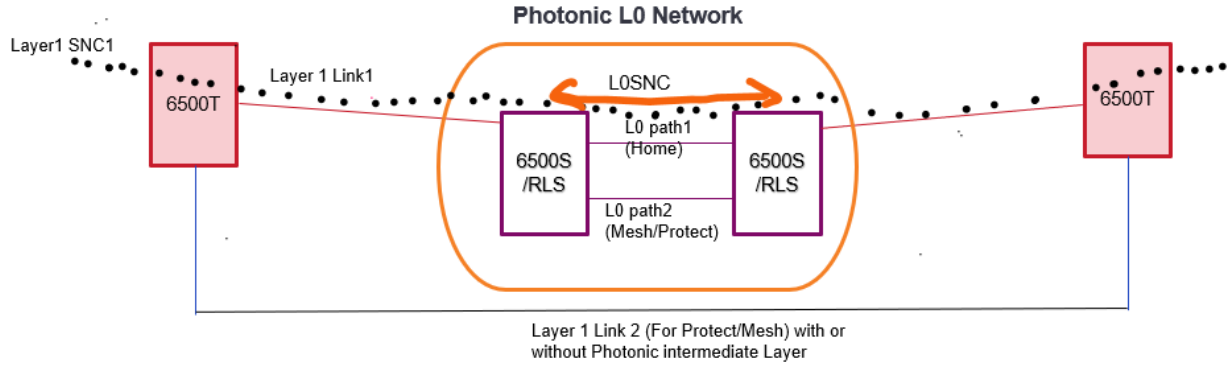

Figure 3

- Per above figure 3 –Layer 1Link1 is fed as a wavelength to Photonic cloud and comes up when L0SNC is established between Photonics NEs on L0 path1 above.
- Layer1 SNC1s (shown as dotted black line) can be provisioned b/w end to end 6500T nodes – L1SNCs is using Layer 1 Link1 path and further going thru L0SNC on L0 Path1.

- NMS Visualizes the end of end cross layer path. L0SNC association with L1 Links. Also NMS checks if L0SNC has protection path. Per above diagram L0SNC has protection path available as L0path2.
- If Dynamic hold off feature is available, NMS Sends “OSRP Link Hold off values” to Layer1 Link1 at both 6500T ends to ensure Layer 1 SNCs/Links are holdoff/not impacted until L0SNC mesh restores to L0path2.
    - The Value of hold off to be sent to higher layers can be pre-characterizied/pre-decided based on internal L0 Mesh timings tests i.e mesh timings are usually dependent of number of hops on current route and mesh route. Based on these number of hops on current and protect route, NMS Rules engine can be programmed to send appropriate hold off values to higher layer.
- Whenever L0SNC goes down, L1 Links/SNCs should not be impacted as L0SNC should recover before hold off timer expiry on L1 OSRP Links (figure 4)

L1 SNCs riding over L0SNC and after first Cut ,L0 SNC has No protection path available

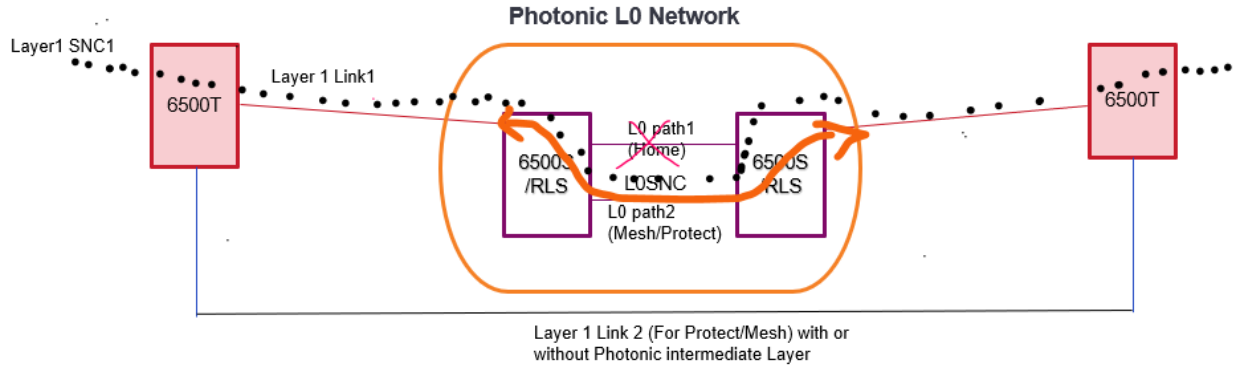

Figure 4

- For First Cut – Cut L0 path 1, L0 SNC has meshed to L0path2 but now it doesn’t have any protect path available.
- If Dynamic hold off feature is available, NMS disables OSRP link hold off (sends Zero OSRO hold off value) to Layer1 Link1 at both 6500T ends to ensure Layer 1 SNCs can mesh restore immediately via L1 Control plane

Below are the Details/Operating principles of Proposed Invention:

- SDN Controller/NMS discovers the multi-layer L0/L1 configuration. i.e. L1 CP Links going into L0/Photonics cloud and L0 configurations involved (L0 SNC or OPS/SNCPMR configs at L0)
- NMS dynamically Monitors the protection/resiliency status of L0 circuits. I.e. will the L0 circuit be protected if active traffic line goes down – This can be predicted based on Protect path computation status of SNC or checking the standby path in case of L0 CP OPS/SNCP configurations.
- A new user provision-able attribute “Dynamic hold off” will be defined for the Lower Layer/L0 circuit at NMS layer which if enabled will push hold off timer values to NE

at higher layers (L1) based on the current protection status of circuits at lower layers (L0). Whenever this attribute is disabled, that will represent legacy behavior/backward compatibility.

- Send precalculated nonzero hold off values to L1 layers, but if L0 cannot protect, update Hold off values at higher layers to 0. These changes will be happening in runtime due to dynamic nature of the network. (Sometime L0 SNC will have protect path and sometimes not based on failures in networks)

NMS Rule Engine: NMS advance apps will allow users to create their own rules based on dynamic hold off rules engine where customer can define the trigger points which will initiate dynamic hold off timer updates from lower layer to higher layer. For example,

- Photonic MR-SNC has protection DTLSet where the health of protection DTL's shown in NMS UI (Based on Photonic Performance Gauge Data). DTLSet health is good for mesh restoration.
- NMS sends dynamic hold off timer update when photonic SNC has at least one available protection.
- NMS keeps on monitoring the DTL health and during period DTLSet health went down, NMS continuously listens the change which indicates the rule check breach for hold off, NMS sends updated hold off message to higher layer where hold off is now set to "OFF".
- OPS/SNCPMR configurations can also be part of rules definition. i.e. L0 may have OPS configuration with/without L0 Control plane. If protect leg is available, Dynamic hold-off can be sent to L1CP links.

How to Decide Hold-off Values

- ***Only L0 SNC protection in photonic network*** **-** Define the number of rules in NMS rules Engine and let user to choose any combination of the rules . For Example - NMS can learn the current route and protect route of L0 SNC, The restoration time of L0 SNC usually depends upon number of hops on failed path (release path) and protect path (mesh path) and mode type of SNC. So rough calculations of L0 SNC mesh restoration timings can be calculated based on inhouse calculated x Hop to y Hop performance data or Planner tests and these values can be fed to NMS rules Engine to make decisions in runtime for different hop-hop/mode type scenarios.
- ***L0 SNCPMR/OPS protection in Photonics network -*** SNCPMR/OPS usually restore traffic within 60ms whenever protect leg is up. So NMS can send 60ms + few ms tolerance hold off values to L1 CP links.

Similar rules engine is currently available in NMS Plus for restoration assurance feature.

NMS ability to trace the higher layer services or links passing through the Photonic layer SNC OSRP links.

- NMS "Transport Services" page having "Depends On" and "Supports" tabs to show the dependent higher layer services.

- NMS “Transport Infrastructure” page having details of dependent multilayer services”
- NMS photonic SNC topology view show the status of OPS and control plane SNC DTLSet.

Overall NMS has all ingredients to establish link across layers and propagate hold off timer.

Other Considerations:

- It is proposed to send dynamic hold off to only immediate L1 OSRP Links entering the L0 Cloud and not to L1 Links beyond this span. This is to avoid un-necessary L1 mesh restorations delays incase fault occurs in any L1 spans outside WDM layer. Customers can enable/disable this feature based on their network configuration to realize maximum benefits of this invention.
- This Invention can be generalized to include Layer2/IP circuits as well, i.e., holding off L2 control plane whenever L1 or L0 Control planes can heal the IP circuit. But not putting details into this document due to limited knowledge of L2 area.

List of Acronyms

PU/PG – Protection Unit/Protection Group
MR-SNC – Mesh restorable - Sub Network Connection
OSRP – Optical Signaling and Routing Protocol
OPS – Optical Protection Switch
SNCPMR- Sub network connection Protection (Mesh Restorable)
CP – Control Plane
DTL – Designated transit list

It will be appreciated that some embodiments described herein may include one or more generic or specialized processors (“one or more processors”) such as microprocessors, digital signal processors, customized processors, and Field-Programmable Gate Arrays (FPGAs) and unique stored program instructions (including both software and firmware) that control the one or more processors to implement, in conjunction with certain non-processor circuits, some, most, or all of the functions of the methods and/or systems described herein. Alternatively, some or all functions may be implemented by a state machine that has no stored program instructions, or in one or more Application-Specific Integrated Circuits (ASICs), in which each function or some combinations of certain of the functions are implemented as custom logic. Of course, a combination of the aforementioned approaches may be used. Moreover, some embodiments may be implemented as a non-transitory computer-readable storage medium having computer-readable code stored thereon for programming a computer, server, appliance, device, etc. each of which may include a processor to perform methods as described and claimed herein. Examples of such computer-readable storage mediums include, but are not limited to, a hard disk, an optical storage device, a magnetic storage device, a ROM (Read Only Memory), a PROM (Programmable Read-Only Memory), an EPROM (Erasable Programmable Read-Only Memory), an EEPROM (Electrically Erasable Programmable Read-Only Memory), Flash memory, and the like. When stored in the non-transitory computer-readable medium, the software can include instructions executable by a

processor that, in response to such execution, cause a processor or any other circuitry to perform a set of operations, steps, methods, processes, algorithms, etc.

Although the present disclosure has been illustrated and described herein with reference to preferred embodiments and specific examples thereof, it will be readily apparent to those of ordinary skill in the art that other embodiments and examples may perform similar functions and/or achieve like results. All such equivalent embodiments and examples are within the spirit and scope of the present disclosure.