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Fault management by prioritized alarm correlation in multi-layer GMPLS networks

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Abstract
Fault management by prioritized alarm correlation was proposed in multi-layer GMPLS networks. The proto-type of the GMPLS network management system successfully analyzed the root cause of the failure during the GMPLS recovery operation.

1. Introduction

Generalized multi-protocol label switching (GMPLS) technology enables the unified control of network elements in different layers from the wavelength to the packet and is intensively investigated [1]. In order to accelerate the deployment of such network architecture, a GMPLS integrated network management system (NMS) represents one of the big challenges to develop, because the existing network is generally managed and operated through a set of EMS's (Element Management System) per network element vendors or an NMS per type of network. We have so far proposed and preliminarily developed a prototype of the MPLS/GMPLS multi-layer network management system [2], which can manage inventories and simple alarms, as well as provide a label switched path (LSP) and linkage MPLS and GMPLS LSPs. However, alarm correlation over multiple layers to specify the cause of failure is not considered. Generally speaking, many failures occur over dense wavelength division multiplexing (DWDM) links, and therefore the cause of failures cannot be specified without considering alarms generated from DWDM equipment.

In this paper, the alarm correlation mechanism has been investigated during the occurrence of network failure and recovery operation. We extended the GMPLS network management system so as to include DWDM equipment, which interworks with photonic cross-connect (PXC) in the level of the GMPLS control plane, and which has prioritized all alarms during a certain period. By using these extensions, alarm correlation over multiple layers could be successfully implemented.

2. Fault management by prioritized alarm correlation

The alarm correlation function is the key to comprehending the cause of failure on a timely basis as well as the influence on services because the current network environment, i.e. multi-vendor or multi-layer networks, increase the difficulty to localize the cause of failure more than before. By correlating alarms, we can identify the cause of failure and filter the unnecessary alarms, even across multiple layers. To realize the alarm correlation, the NMS must implement a mechanism to specify the alarm of the root cause from another alarm generated by the same cause within a specific period of time. Fig.1 shows our proposed flowchart of the NMS fault management. When failure occurs and multiple simple network management protocol (SNMP) trap messages are received, these messages are internally transferred to the filtering process to select the specified messages such as WDM trap, link management protocol (LMP)-MIB trap, IF-MIB trap and MPLS-TE MIB trap. These are defined in the filter configuration file. Subsequently, the selected messages are transferred to the alarm correlation process to identify the cause. To narrow down the received message generated by the same cause, the transferred messages are categorized within a specific period of time as well as with respect to the associated network resources. Finally, these classified messages are prioritized in order of data-link, traffic-engineering (TE)-link and LSPs, based on the priority configuration file as shown in Fig. 2. This alarm correlation process selects the series of highest prioritized alarm messages as the root cause of failure, and transfers them to the event process, which summarizes these messages. Consequently, the alarm correlation function is performed and the root cause is displayed.

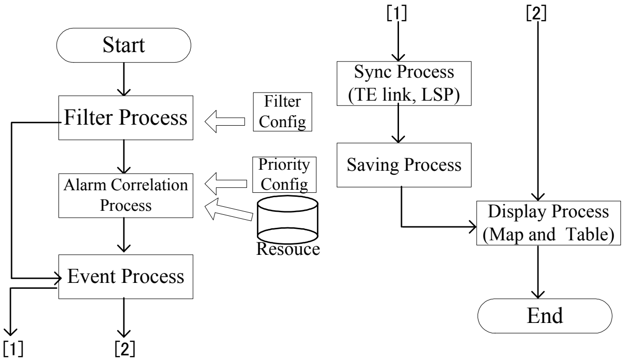


Fig.1 Flowchart of the alarm correlation function

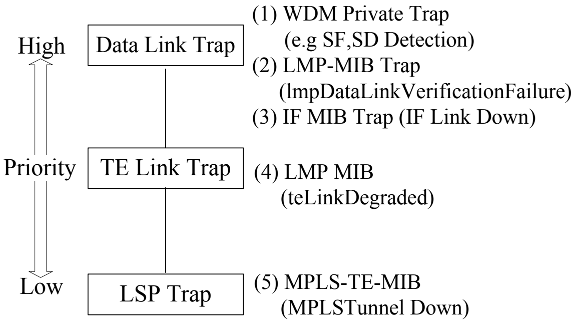

High
Priority
Low
Data Link Trap
TE Link Trap
LSP Trap
(1) WDM Private Trap (e.g SF,SD Detection)
(2) LMP-MIB Trap (lmpDataLinkVerificationFailure)
(3) IF MIB Trap (IF Link Down)
(4) LMP MIB (teLinkDegraded)
(5) MPLS-TE-MIB (MPLSTunnel Down)

Fig.2 Detailed priority of generated traps

In addition, MPLS and GMPLS networks are facilitated to support various recovery mechanisms when failure occurs. Therefore, as part of the fault management function, the NMS is designed not only to manage LSP route information before and after the failure, specifying the root cause, but also to store the route information in the form of a history, as shown in Fig. 1. These functions are realized by a synchronization process and a saving process in Fig.1.

3. WDM link management

In order to identify the cause of failure lying from the lower layer to the packet layer, the management of TE-links related to DWDM equipment is quite significant. In the GMPLS network, such TE-links are generally managed by the standardized LMP-WDM protocol [3] between DWDM and PXC equipment. To date, the NMS has been developed to collect and manage TE-link information through the OSPF-TE database. However, TE-links between DWDM and PXC, hereafter referred as LMP-WDM TE-links, cannot be obtained from such a database, and another mechanism to manage such TE-links is required. Fig. 3 shows the conventional TE-links between two PXCs, and the LMP-WDM TE-links between the PXC and DWDM. The NMS is developed in order to correlate these different TE-links and Data-Links by looking for a TE-link interface identifier (IF-ID) with the same Data-Link IF-ID. Such information of IF-IDs can be retrieved from the teLinkTable object in TE-LINK-STD-MIB [4], the lmpDataLinkTable object in LMP-MIB [5] and the ifStackTable object in IF-MIB [6], respectively. Consequently, the NMS is able to resolve the relationship between the nodes and TE-links, and therefore all the network topology in the MPLS/GMPLS networks can be comprehended and displayed.

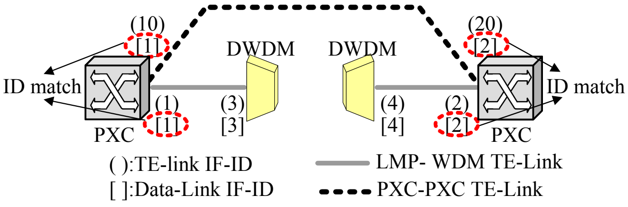


Fig.3 Relationship of TE-links between PXCs and WDMs

4. Demonstration of the multi-layer NMS

To validate our proposed fault management function in the multi-layer network, we evaluated the developed NMS using an MPLS/GMPLS network testbed. Fig. 4 shows the network topology view of the MPLS/GMPLS network testbed. DWDM equipment could be appropriately managed and displayed in addition to PXCs, GMPLS routers and MPLS routers. Two LSPs were provisioned between two pairs of GMPLS routers. A failure to one of the LSPs via PXC1, PXC2 and PXC3 was caused by removing a fiber from the input of one of GMPLS router1. Once the failure occurred, the NMS received multiple SNMP traps from each node, which are IF Down traps sent from GMPLS routers, mplsTunnelDown traps sent from GMPLS routers, TeLinkDegraded sent from PXCs, and mplsTunnelDown sent from MPLS routers, respectively. Thanks to the implemented correlation functionality, the NMS successfully resolved the correlation of MPLS and GMPLS networks and indicated the node having detected the failure, while the event view table appropriately indicated the root cause of failure after the alarm correlation of the MPLS and GMPLS networks, as shown in Fig. 5. Furthermore, the NMS visually displayed the restored LSPs with the updated route information collected by SNMP. Thus, we confirmed the feasibility of the alarm correlation function in the multi-layer network by the developed NMS. As a next step, the evaluation of developed NMS is required under actual operational environment for concept proof.

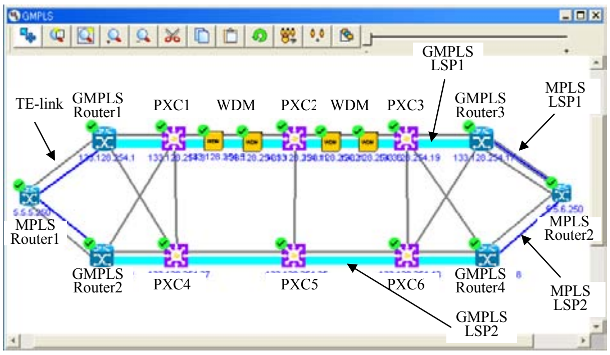
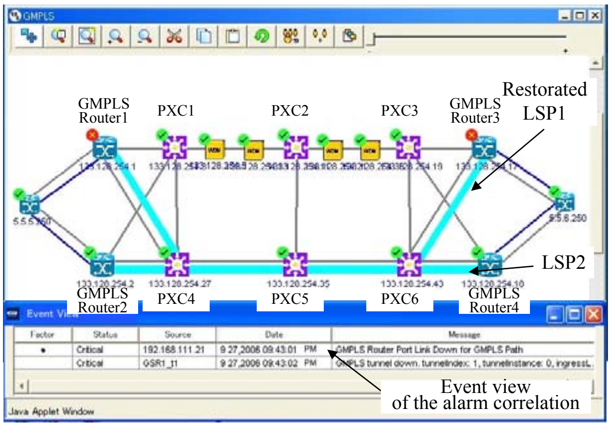


Fig.4 Network topology view of the GMPLS NMS



Factor	Status	Source	Date	Message
•	Critical	192.168.111.21	9 27,2006 09:43:01 PM	GMPLS Router Port Link Down for GMPLS Path
	Critical	GSR1_11	9 27,2006 09:43:02 PM	GMPLS tunnel down. tunnelIndex: 1, tunnelInstance: 0, ingressL

Fig.5 Correlated alarm view of the GMPLS NMS

5. Conclusion

We proposed and developed the GMPLS NMS with the fault management by prioritized alarm correlation for multi-layer MPLS/GMPLS networks, and successfully identified the cause of failure and updated the route information of the restored LSP via the MPLS/GMPLS testbed. This concept is broadly applicable and is expected to improve network operation.

6. References

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[6] K. McCloghrie, et al, IETF, RFC2233, November 1977