Overview of GMPLS Protocols and Standardization

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Abstract

MPLS (multiprotocol label switching) introduced the concept of label switching in IP layer-2 networks to facilitate network operation using a path. GMPLS (Generalized MPLS) extends the label to TDM (time division multiplexing), wavelength, and fiber switching networks to facilitate path operation in various switching networks. GMPLS protocols enable multi-vendor interoperability, switched connection service, and unified control of a multi-layer network. This article presents an overview of GMPLS protocols and standardization efforts in the Internet Engineering Task Force (IETF).

1. Label extension

In MPLS (multiprotocol label switching) networks, an IP packet is labeled with an MPLS label and handled according to operations associated it. This packet handling mechanism in MPLS network is called "label-switching". The label-switching concept brings about flexibility in handling packets in the network. Virtual private networks (VPNs) and traffic engineering are implemented using the label switching concept. The MPLS label is used to distinguish the VPN group. The label switched path is routed to avoid congested links.

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MPλS (multiprotocol lambda switching) was proposed to extend MPLS technology to wavelength switching network control [1]. MPλS was extended to GMPLS to include TDM (time division multiplexing), wavelength, and fiber switching networks. TDM time slots, wavelengths, and fiber switch ports are treated as "generalized labels" in GMPLS, as shown in **Fig. 1**.

2. GMPLS protocols

In GMPLS, signaling, routing, and link management protocols are defined. The concept of "switching capability" is introduced in GMPLS protocols to handle various switching technologies: layer-2

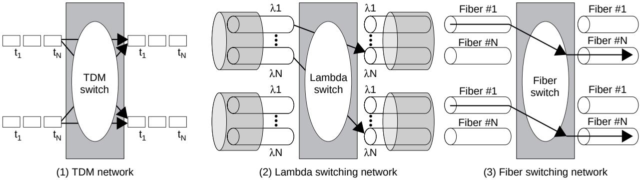

Fig. 1. Label switches of each bus networks.

switches, TDM, lambda switches, and fiber switches. Five capabilities are defined to distinguish switching technology, as shown in **Fig. 2**: PSC (packet switch capable), L2SC (layer-2 switch capable), TDM, LSC (lambda switch capable), and FSC (fiber switch capable). GMPLS adds various functions to MPLS to facilitate path operation in GMPLS networks. Unlike IP/MPLS networks, the control plane is separated from the data plane in TDM, wavelength switching, and fiber switching networks. A bi-directional path is used in those networks while a uni-directional label-switched path (LSP) is used in an IP/MPLS network. GMPLS adds functions for separating the control and data planes and for setting up and tearing down bi-directional LSPs.

3. Signaling

RSVP-TE (resource reservation protocol traffic engineering) [2] is extended to facilitate path setup in a GMPLS network [3]. Label Request Object is extended to include switch type, encoding type, and G-PID (generalized protocol id), which are used to identify TDM, wavelength switching, and fiber switching networks as shown in **Fig. 3**. Upstream Label Object is newly defined for bi-directional LSP setup/teardown. RSVP_HOP Object is extended to include a new class type for control and data plane

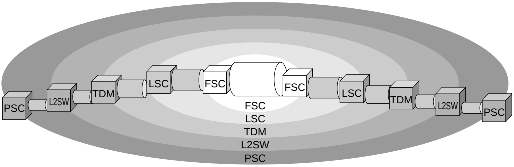

Fig. 2. GMPLS network.

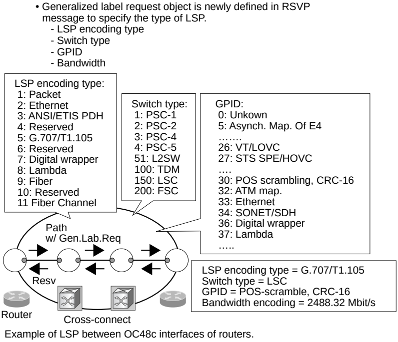

Fig. 3. RSVP-TE GMPLS extensions.

separation. Label Set Object and Acceptable Label Set Object are newly defined for explicit label control. Protection Object is newly defined to implement failure recovery LSP switching.

4. Routing

OSPF-TE (open shortest path first-traffic engineering extensions) [4] is extended to facilitate link-state routing. Link state is flooded throughout the area of the GMPLS network. All nodes in the area of a GMPLS network learn the network topology and associated information such as available bandwidth. Link state advertisement is extended to include new sub-TLVs to carry the following information: interface switching capability descriptor (ISCD), link protection type, and shared risk link group (SRLG) as shown in **Fig. 4** [5]. ISCD sub-TLV is used to identify switching capability and encoding type. The link protection type sub-TLV and SRLG sub-TLV are used to recover from a failure.

5. Link management

Link management protocol (LMP) is defined for operation and maintenance of link between adjacent nodes [6]. The link between adjacent nodes consists of control and data links. A Hello packet is used to check whether the control link is alive. For data link management, summarization of multiple data links and failure localization procedures is defined [6]. The functions of LMP are shown in **Fig. 5**.

6. Standardization status

GMPLS is mainly being standardized by the CCAMP-WG (common control and measurement plane working group) of the Internet Engineering Task Force (IETF). CCAMP-WG is defining GMPLS protocols based on requirements documents produced by TE-WG (traffic engineering) and IPO-WG (IP optical). It also liaises with ITU (International Telecommunication Union). **Figure 6** shows the recent history of standardization in IETF CCAMP-WG. RFCs (requests for comments) for basic signaling protocols have been published. RFCs for routing protocols and link management protocols are under way. The next items include failure recovery including protection and restoration, ASON (automatically switched optical network) signaling & routing, and multi-area/multi-region traffic engineering.

7. Closing remarks

GMPLS is expected to introduce new services and a new operating scheme in the telecommunication industry. BoD (bandwidth on demand), optical VPN, and multi-GoS/availability services could be developed (GoS: grade of service). Standardization of GMPLS protocols promotes multi-vendor interoperability and flexible network design and operation.

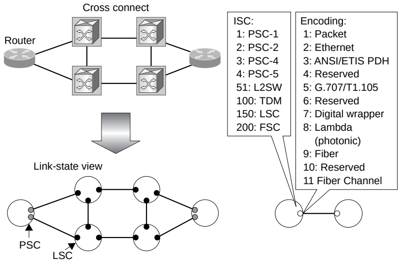

Fig. 4. OSPF-TE GMPLS extensions.

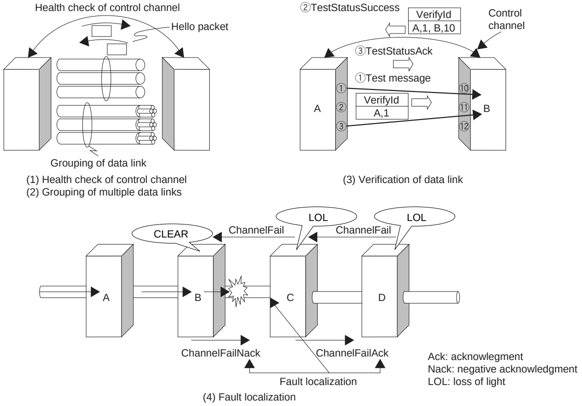

Fig. 5. Link management protocol (LMP).

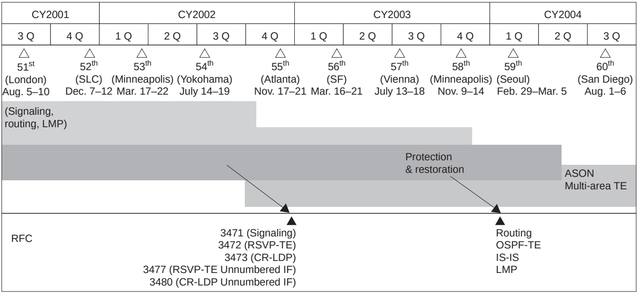

Fig. 6. IETF standardization.

References

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