Overview of MPLS-TP Standardization

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Abstract

The recent prevalence of IP (Internet protocol) based services has increased the demand for transport network technology that can efficiently accommodate both packet-based and circuit-based traffic while achieving almost the same operation and maintenance capabilities as traditional transport networks such as synchronous digital hierarchy or optical transport networks. Thus, ITU-T (International Telecommunication Union, Telecommunication Standardization Sector) has developed a packet transport technology called MPLS-TP (multiprotocol label switching-transport profile) in collaboration with IETF (Internet Engineering Task Force).

This article introduces the overview and history of MPLS-TP standardization.

1. Outline of MPLS-TP technology

Telecommunication carriers have employed transport technologies standardized by ITU-T (International Telecommunication Union, Telecommunication Standardization Sector) including synchronous digital hierarchy (SDH) or optical transport networks (OTNs) in their core networks that convey large capacity traffic over long distances. Recently, a packet-based technology that can accommodate packet-based data more efficiently than the current SDH or OTN has been demanded because packet-based traffic has become dominant in these networks as the number of Internet protocol (IP)-based services has increased. However, traditional packet network technologies have been problematic for telecommunication carriers to adopt in networks because of a lack of sufficient OAM (operation, administration, and maintenance) functions, fault localization, and fast switching in the event of a failure. Thus, a new packet-based transport network technology that has the same operation and maintenance capabilities as traditional transport network technology is required.

One of the significant features of packet transport network technology is that a path for packets between two network elements (NEs) is explicitly determined, and the connectivity of the path is periodically monitored to allow network operators to manage the path condition; this is called being *connection-oriented*. Other key functions should include protection switching, which promptly recovers a particular path when the route of the path has a fault; alarm transfer, which promptly transmits information about faults to other NEs; and traffic engineering, which enables operators to flexibly assign a bandwidth on a path.

MPLS (multiprotocol label switching) has been standardized in IETF to make it possible to explicitly determine the path route of IP packets by attaching a label to an IP packet and forwarding the packet by inspecting only the label instead of the IP address header itself, as shown in **Fig. 1**. MPLS, however, does not have sufficient maintenance operation functions as required in transport networks, and thus, some inherent features, including PHP (penultimate hop popping), ECMP (equal cost multi-path), and label merging could disrupt the management of a connection-oriented path between the two end points because of a lack of traceability. Moreover, MPLS technology makes it difficult to secure user data traffic in telecommunication carrier networks. This is because all the paths in MPLS are basically controlled by the control plane (part of the autonomous control) through a soft state procedure in which any fault that occurs during the exchange of control messages about a path causes a disconnection of the paths in the data plane even though they are not experiencing

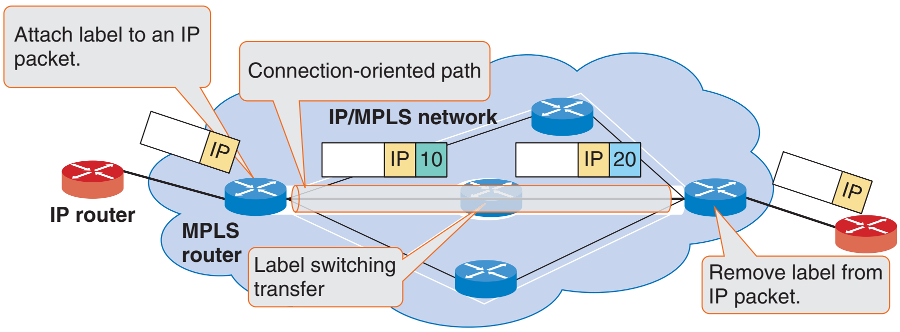

Fig. 1. Data forwarding in MPLS label switching.

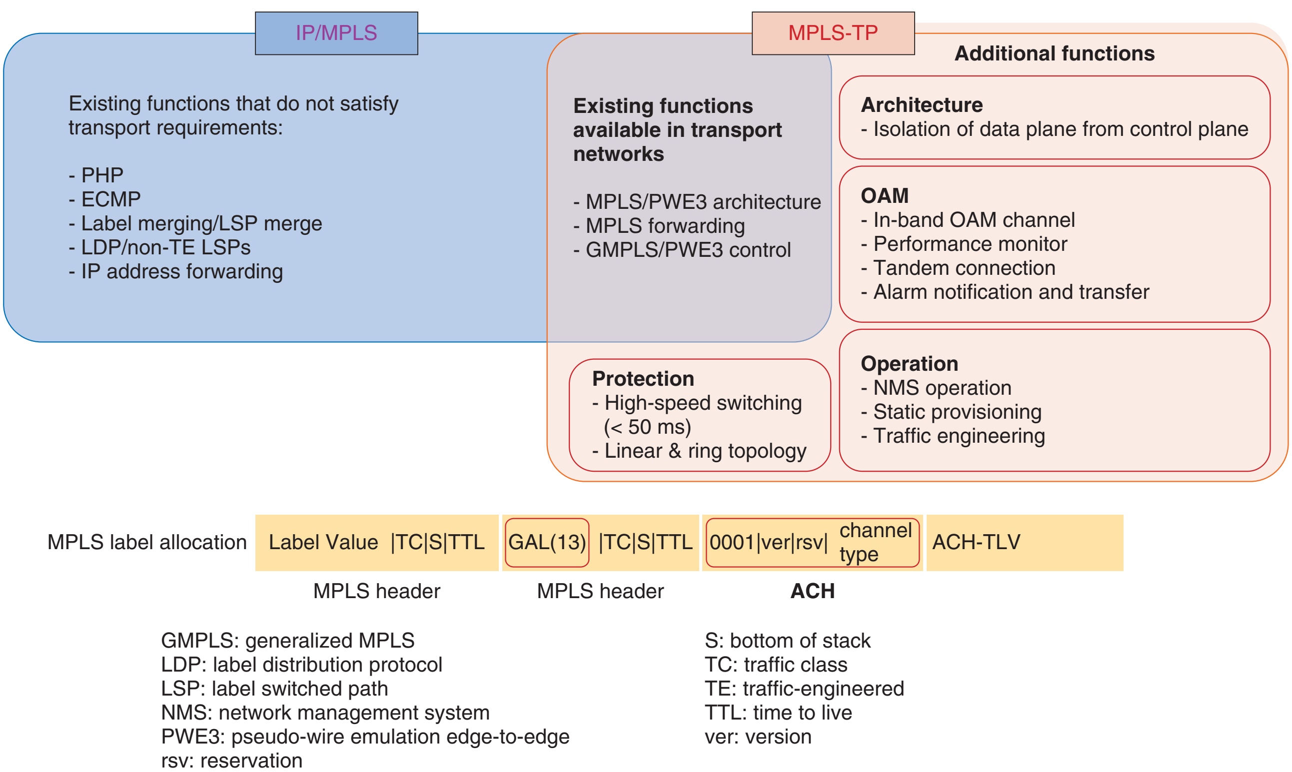

Fig. 2. Differences between IP/MPLS and MPLS-TP.

a failure.

In contrast, MPLS-TP emphasizes operation and maintenance capabilities by improving the data plane control mechanism, introducing static and central operations by the management plane, and implementing various OAM functions and high-speed protection switching, while some MPLS features that could disrupt transport network operation are disabled, as shown in **Fig. 2**. A GAL (generic associated channel label) is newly defined in the MPLS header stack for identifying the OAM packet, and each OAM function is differentiated by an ACH (associated channel). MPLS-TP also enables the paths in the data plane to be controlled by the management plane and allows network operators to manually and intentionally manage all the paths. Moreover, when a control plane is introduced, MPLS-TP employs an ASON (automatically switched optical network), described in

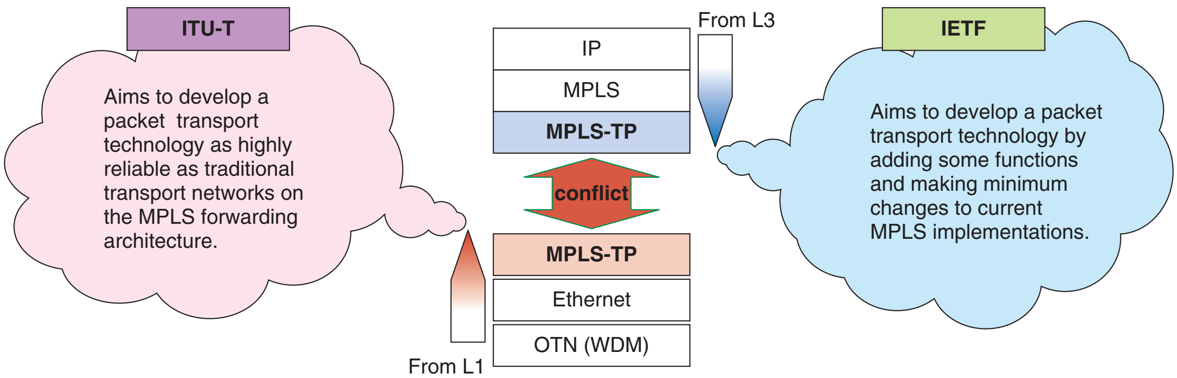

Fig. 3. Differences between ITU-T and IETF concepts.

ITU-T Recommendation G.8080, which isolates paths in the data plane from any failure in the control plane so that a fault in the control plane never affects the user data traffic. Thus, MPLS-TP can provide highly reliable network services, which is one of the most significant attributes required for transport networks.

As such, MPLS-TP was created as a merger of the transport network technology mainly standardized by ITU-T and MPLS technology mainly standardized by IETF. This merger has brought out some differences in the concepts of the two standardization organizations, as shown in **Fig. 3**. ITU-T's aim was to develop packet transport technology with the high reliability of traditional SDH or OTN transport networks by creating a new mechanism on the MPLS forwarding architecture irrespective of existing MPLS implementations. By contrast, IETF has persisted with the current MPLS implementations in their aim to develop an MPLS-TP technology with minimum changes. Therefore, the MPLS-TP specifications tended to deviate from the original concept and to be complicated due to the constraints from the existing MPLS implementations. Another point in the controversy is that IETF follows a process called *rough consensus*, in which there are no definite rules in the decision-making process in developing their standard RFCs (requests for comments), while ITU-T has clearly defined rules for approving Recommendations based on the unanimous agreement among member states as an affiliate in the United Nations. With these backgrounds, MPLS-TP standardization has created a major controversy between the organizations.

2. History of MPLS-TP standardization

2.1 2005 to 2010

ITU-T began standardizing T-MPLS (Transport-MPLS) in 2005. This standardization effort introduced OAM and protection functions to the MPLS data forwarding mechanism in order to satisfy packet transport network requirements and was based on ITU-T's experience in developing standards for transport network technologies. ITU-T approved the main T-MPLS recommendations in 2006 and 2007; these include G.8110.1 (Architecture of Transport MPLS (T-MPLS) layer network), G.8121 (Characteristics of Transport MPLS equipment functional blocks), G.8112 (Interfaces for the Transport MPLS (T-MPLS) hierarchy), and G.8131 (Linear protection switching for Transport MPLS (T-MPLS) networks.

However, IETF claimed that T-MPLS did not conform to the existing MPLS specifications when ITU-T had made progress on the LC (last call) of G.8114 (Operation & maintenance mechanism for T-MPLS layer networks) and G.8113 in January 2008. In anticipation of future collaboration with IETF on this topic, ITU-T stopped the LC of G.8114 and established a Joint Working Team (JWT) with IETF so they could cooperate on the packet transport network standardization in February 2008.

In December 2008, after T-MPLS was renamed as MPLS-TP, ITU-T and IETF agreed to publish some IETF RFCs based on T-MPLS Recommendations by June 2009, and they therefore developed several MPLS-TP RFCs, including those regarding the framework and requirements.

At the 74th IETF meeting in March 2009 ITU-T experts asserted their intention to employ the OAM tools defined in Y.1731 for MPLS-TP because they had already been proven to meet the requirements of the transport network and were sufficiently mature for deployment. At the 75th IETF meeting in July 2009, however, the IETF MPLS working group took a unilateral decision to give priority to backwards compatibility with existing IP/MPLS protocols and said that they would develop and support only one solution based on extensions of bidirectional forwarding detection (BFD) and label switched path (LSP)-ping, which they had been developing for IP/MPLS.

The ITU-T experts regarded the complex OAM tool sets developed for compatibility with the existing IP/MPLS implementations preferred by IETF as a deviation from the primary MPLS-TP concept. Therefore, at the SG (Study Group) 15 plenary in June 2010, ITU-T decided, with support from many member states, to develop an MPLS-TP OAM Recommendation, G.8113.1 and to proceed with the standardization of both types of OAM tools to satisfy the demands of ITU-T and IETF. ITU-T also requested IETF/IANA (Internet Assigned Numbers Authority) to assign a codepoint to differentiate these two OAM solutions. In August 2010, the ITU-T TSB (Telecommunication Standardization Bureau) director had a direct talk with the IETF chairman to settle the controversy, but they were unable to reach a resolution. The IETF chairman thus unilaterally declared that IETF would not accept any other OAM solutions than those developed by IETF.

2.2 2011

At the SG15 plenary in February 2011, the approval of two OAM Recommendations, G.8113.1 advocated by ITU-T and G.8113.2 by IETF, were discussed, but the progress of the meeting stalled due to an intense dispute. Finally, the ITU-T SG15 chairman decided to move G.8113.1 forward to the approval process based on the result of a vote among member states, although it was exceptional to take such action at an ITU-T SG meeting. Then, IETF issued a comment in a newsletter criticizing the decision made in ITU-T [1], and ITU-T also issued an article titled "THE FACTS" in the ITU-T newslog to reveal the history of MPLS-TP standardization [2]. Hence, the serious conflict between the two organizations came to light. Japanese telecom carriers and vendors had dedicated discussions in the TTC (Telecommunication Technology Committee) in Japan to decide the position of Japanese member states on the MPLS-TP standardization, because any final decisions must be made at the member state level in ITU-T.

In June 2011, a circular letter was issued by the ITU-T TSB asking member states to respond to an inquiry on proceeding with the traditional approval process for G.8113.1. With support from 33 member states including Japan and against opposition from 5 member states, it was decided that G.8113.1 would move forward for approval at the following SG15 plenary. Since a further dispute at the SG15 plenary was expected, Japan submitted a contribution to propose a compromise as a member state in a relatively neutral position after holding repeated discussions with the stakeholders including the ITU-T bureau, the SG15 chairman, and management members. However, G.8113.1 was finally disapproved at the SG15 plenary held in December 2011 due to opposition from 4 member states (the USA, Israel, the UK, and Finland) that was unable to be resolved despite the intense formal and informal discussions and negotiations conducted throughout the day and night. As a result, the SG15 Chairman declared a deadlock in the approval of Recommendation G.8113.1, and the decision was committed to the WTSA (World Telecommunication Standardization Assembly)-12 held in November 2012. The ITU-T TSB director issued a comment on the ITU-T newslog in which he gave a detailed account of the event and expressed his great appreciation to the member state of Japan for its efforts to settle the situation [3].

2.3 2012

NTT participated in further discussions on MPLS-TP standardization in CJK (China Japan Korea) meetings held with Chinese and Korean experts who shared the same opinion and submitted a common proposal document by the three countries to move G.8113.1 forward as well as a series of related MPLS-TP Recommendations at the APT (Asia-Pacific Telecommunity) meeting held in August 2012. The proposal was supported at the meeting and approved to be an APT common proposal to WTSA-12.

At the SG15 meeting in September 2012, a degree of progress was made, as some MPLS-TP Recommendations were approved or consented to. A proposal from Canada that G.8113.2 should also be approved in WTSA-12 was agreed, and the approval of both draft Recommendations became a matter for simultaneous discussion at WTSA-12.

At the beginning of the WTSA-12 meeting held in November 2012, these two draft Recommendations were simultaneously submitted for approval and were

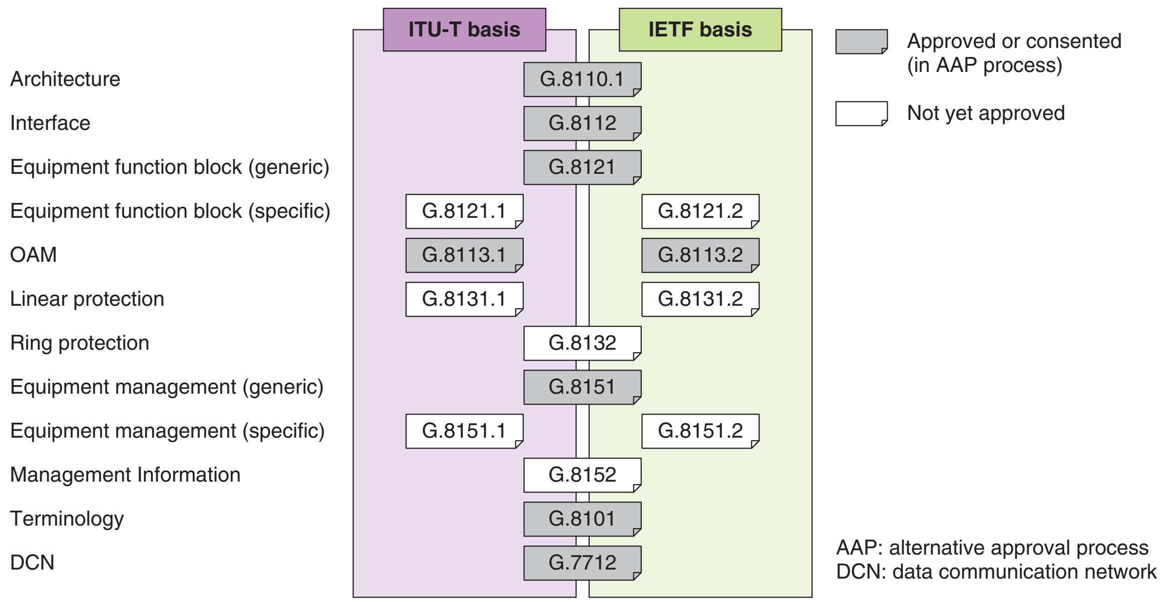

Fig. 4. Structure of MPLS-TP Recommendations and current status.

successfully approved with no opposition. Finally, IANA formally notified ITU-T that it would assign an ACH codepoint for identification of an OAM packet based on G.8113.1, and the two OAM solutions respectively preferred by ITU-T and IETF finally came to be international standards.

3. Future activities

The controversy of MPLS-TP standardization that continued for more than seven years since the standardization of T-MPLS was successfully resolved in part because of the work done to gain approval of the OAM Recommendations at WTSA-12. The status of international standardization of MPLS-TP is now as shown in **Fig. 4**. Other draft Recommendations including equipment functional blocks and protection schemes will be further discussed and approved. Additionally, some other significant issues related to MPLS-TP including a point-to-multipoint connection scheme and layer integration are expected to be standardized in the future.

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He received the Ph.D. degree in electrical engineering from the University of Tokyo in 2009. He joined NTT in 1988 and initially engaged in R&D of long haul transmission systems using optical amplifiers and coherent modulation/demodulation schemes at the emergence of those technologies. After completing development and deployment of a commercial optically amplified submarine system, he continued R&D of WDM (wavelength division multiplexing) systems to further increase the fiber transmission capacity. From 2001 to 2003, he worked for NTT Communications, where he was engaged in construction and operation of international communication networks mainly in the Asia-Pacific area. Since 2003 he has been an active participant in ITU-T SG15 and has been involved in R&D of large-capacity photonic network systems and standardization of optical transport networks. He is currently the chairman of the transport networks and EMC WG in TTC, Japan.

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