OAM Technology of Packet Transport Network

He Tingzong
(ZTE Corporation, Shenzhen 518005, P. R. China)

Abstract:
The Packet Transport Network (PTN) technology includes Transport Multi-Protocol Label Switching (T-MPLS) and Provider Backbone Transport (PBT). T-MPLS is the simplified and reformed Multi-Protocol Label Switching (MPLS). It drops MPLS' connectionless features and its transport-unrelated forwarding processing, but adds the network model of the transport layer, protection switching and Operation, Administration and Maintenance (OAM) functionality. PBT enforces both OAM and protection functions, adds Time Division Multiplexing (TDM) business simulation and clock functions, and strengthens multi-service support capability. But PBT has no functions of traditional Ethernet address learning, address broadcast and Spanning Tree Protocol (STP). Both T-MPLS and PBT can well satisfy the requirements of packet transport. Compared to PBT, T-MPLS has better OAM functions.

Packet Transport Network (PTN) is deemed as the developing trend of future transport network. At present, its two mainstream technologies are Transport Multi-Protocol Label Switching (T-MPLS) and Provider Backbone Transport (PBT). Both work well for the transport network.

As a connection-oriented packet transport technology, T-MPLS is the simplified and reformed Multi-Protocol Label Switching (MPLS). It drops MPLS' connectionless features and its transport-unrelated forwarding processing, but adds the network model of the transport layer, protection and Operation, Administration and Maintenance (OAM) functionality[1].

The PBT technology, considering its compatibility with the traditional Ethernet switch, enforces both OAM and protection functions, adds Time Division Multiplexing (TDM) business simulation and clock functions, and strengthens multi-service support capability. But PBT has no functions of traditional Ethernet address learning, address broadcast, and Spanning Tree Protocol (STP). The forward table of Ethernet is completely controlled by the management plane (or the future control plane).

1 Standards of PTN OAM

The PTN comprises the physical layer, packet transport section layer, packet transport tunnel layer, and packet transport pseudowire layer. Each layer has their own OAM functions conforming to ITU-T G.8114 (T-MPLS), ITU-T y.1731 (PBT) and IEEE 802.1ag (PBT)[2-4].

Figure 1 shows the OAM standards employed by the PTN layers.

2 PTN OAM

2.1 PTN OAM Frame Format

PTN defines special OAM frames to fulfill the OAM functions:

(1) T-MPLS uses the dedicated T-MPLS OAM frame, Label 14, to transport OAM messages[5], as shown in Figure 2.

(2) PBT uses the dedicated Ethernet OAM frame, EtherType 0x8902, to transport OAM messages[2,6], as shown in Figure 3.

2.2 PTN OAM Functions

PTN OAM covers fault, performance, and other OAM related functions[2-4,7-8].

2.2.1 Fault-Related OAM Functions

(1) Continuity and Connectivity Check

The Continuity and Connectivity check messages are sent periodically to check whether the connection is normal. The types of faults that can be detected include Loss of Continuity (LOC), mismerge, unexpected Maintenance Entity Group End Point (MEP) and unexpected period.

(2) Alarm Indication Signal (AIS)

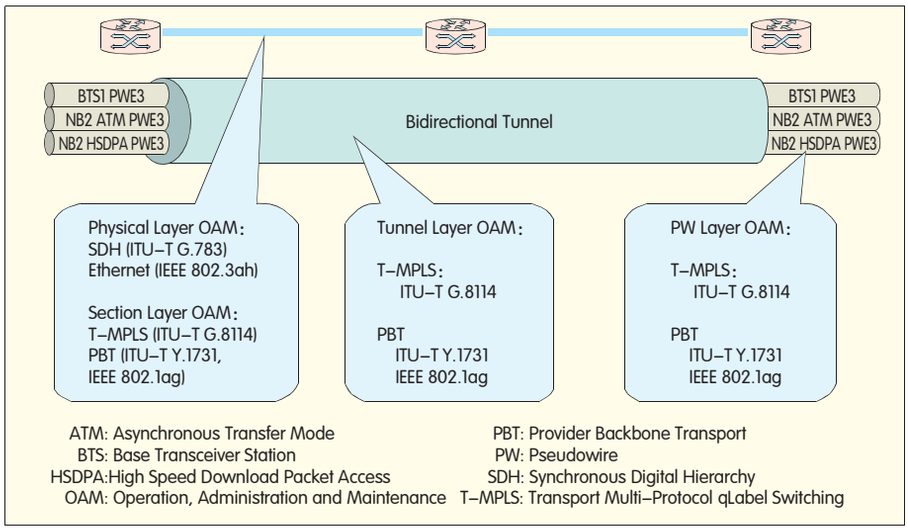
AIS is used to surpress the upper layer alarm when a service layer fault is detected. When a fault is detected at the service layer, the client layer is notified to surpress the alarm. A fault can be the signal failure when CC is enabled, AIS when CC is disabled, or Locked (LCK) condition when CC is disabled.

(3) Remote Defect Indication (RDI)

RDI is used to notify the remote end of the local fault. When a local signal failure of the service layer happens, the RDI is sent to the remote end.

(4) Loopback (LB)

The LB function is used for bidirectional connectivity verify, bidirectional in-service diagnostics test, and bidirectional out-of-service



▲Figure 1. OAM standards employed by PTN layers.

diagnostics test.

(5) Test

The test function is used for unidirectional in–service diagnostics test and unidirectional out–of–service diagnostics test.

(6) Locked

The locked function is to notify MEP that the normal service of corresponding service layer or sub–layer MEP has been interrupted for administrative needs. In this way, the MEP is able to determine whether the service interruption is expectable or caused by a fault.

(7) Client Signal Failure (CSF)

The CSF function is to transfer the client signal failure indication. When an ingress client signal failure is detected, the CSF indication is transferred to far–end T–MPLS client–specific sink–adaptation process, in case the client layer itself does not support an alarm suppression mechanism, e.g. AIS.

(8) Linktrace

The linktrace function, available for PBT only and not for T–MPLS, is used to locate faults and find the topology.

2.2.2 Performance–Related OAM Functions

(1) Packet Loss Measurement (LM)

The LM function is used to the near–end and far–end frame loss and packet loss rate measure. The function includes dual–ended LM and single–ended LM that feature different measurement methods.

(2) Packet Delay and Packet Delay Variation Measurements (DM)

The DM function is to measure delays. The function includes two–way DM and one–way DM that feature different measurement methods. The one–way DM requires that the clocks for sending and receiving MEP are synchronized. The two–way DM does not have such clock requirements.

2.2.3 Other OAM Functions

- Automatic Protection Switching (APS), used for protection switching;
- Management Communication Channel (MCC), used to provide communications on the management plane;
- Signalling Communication Channel (SCC), used to provide communications on the control plane;
- Synchronization Status Message (SSM), used to transfer Synchronization information;
- Experimental function, used to send frames in a management domain for experimental use;
- Vendor Specific (VS) function, used to send OAM frames with specific functions provided by the equipment vendor.

2.3 Comparison of PTN OAM Functions

The OAM functions of T–MPLS are more powerful than those of PBT (see Table 1), although they seem to be generally similar to each other.

3 T–MPLS Evolution: MPLS Transport Profile

In February 2008, the International Telecommunication Union Telecommunication Standardization Sector (ITU–T) and the Internet Engineering Task Force (IETF) set up Joint Working Team (JWT) to develop T–MPLS technology and related standards. JWT decides to integrate the T–MPLS and MPLS technologies into MPLS Transport Profile (MPLS–TP)[9–10] that absorbs the T–MPLS transport technologies for OAM, protection and management.

The development of the MPLS–TP standards follows these principles:

- Compatibility with current MPLS;
- Meeting the transport requirements;
- Providing the minimum function set.

MPLS–TP has many changes in terms of OAM as compared to T–MPLS.

3.1 OAM Frame Structure of MPLS–TP

The OAM frame structure of MPLS–TP is different from that of T–MPLS. MPLS–TP uses the Associated Channel (ACH) to identify the OAM frame. LSP ACH and PW ACH adopt the same OAM mechanism. Figure 4 shows the OAM

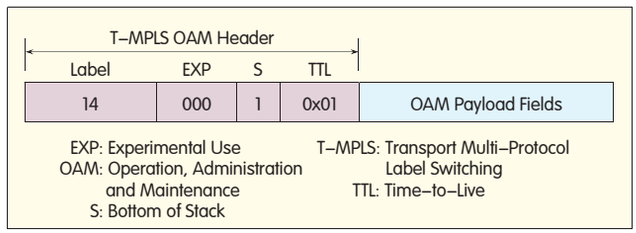


Figure 2. ▶ OAM frame format of T–MPLS.

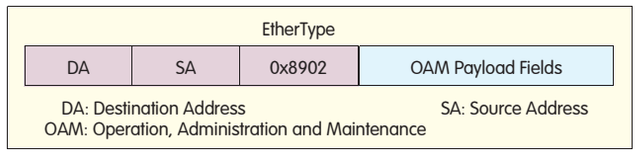


Figure 3. ▶ OAM frame format of PBT.

▼Table 1. PTN OAM function comparison

Function	OAM	T–MPLS	PBT
Fault Management	Continuity and Connectivity Check	CV Supported	CC Supported
	AIS	FDI/AIS Supported	AIS Supported
	RDI	Supported	Supported
	Loopback	Supported	Supported
	Test	Supported	Supported
	Locked	Supported	Supported
	Client Signal Failure	Supported	Not Supported
	Linktrace	Unavailable	Supported
Performance Management	Dual–Ended and Single–Ended Packet Loss Measurement	Supported	Supported
	Two–Way and One–Way Packet Delay and Packet Delay Variation Measurements	Supported	Supported
Other OAM	Automatic Protection Switching, Management Communication Channel, Experimental Function, Vendor Specific Function	Supported	Supported
	Signalling Communication Channel, Synchronization Status Message	Supported	Not Supported

AIS: Alarm Indication Signal
CC: Continuity Check
CV: Connectivity Verification
FDI: Forward Defect Indication
OAM: Operation, Administration and Maintenance
PBT: Provider Backbone Transport
RDI: Remote Defect Indication
T–MPLS: Transport Multi–Protocol Label Switching

frame structure of T–MPLS. Figure 5 and Figure 6 show the OAM frame structure of MPLS–TP.

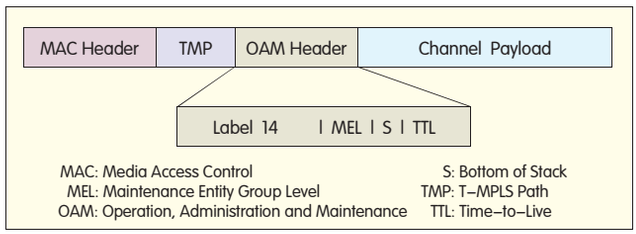
3.2 OAM Differences Between MPLS–TP and T–MPLS

The differences of OAM between MPLS–TP and T–MPLS include:

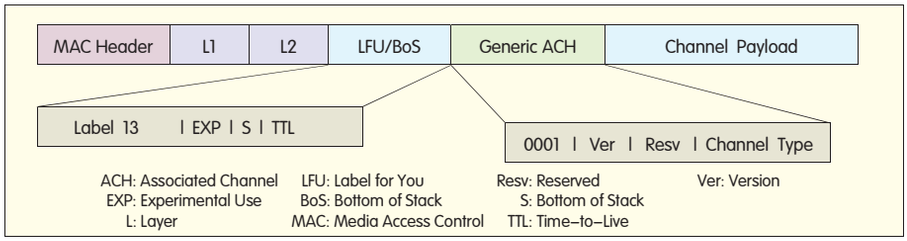
(1) T–MPLS uses the reserved Label 14 as the OAM identifier, while JWT suggests that MPLS–TP should use Label 13 as the OAM identifier.

(2) T–MPLS uses the type of "+1" and "–1" values of Maintenance Entity Group Level (MEL) to indicate the nesting of OAM, while MPLS–TP uses label stack to indicate the nesting of OAM.

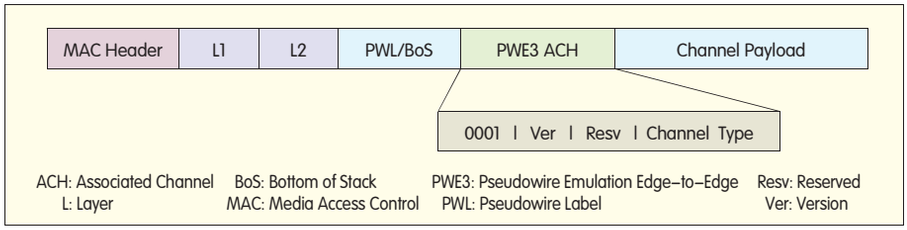
(3) MPLS–TP uses Time–to–Live (TTL) to trace the MIP path and monitor the loopback status , while T–MPLS uses TTL in the OAM packet header label to identify Management Entity Group Intermediate Point (MIP), as shown in Figure 4: TTL=MIP hops+1, and MIP processes the OAM frames with MEL=0 and TTL=2. MPLS–TP uses TTL in the LSP or PW label only, as shown in Figure 5.



◀Figure 4. OAM frame structure of T–MPLS.



▲Figure 5. OAM frame structure of MPLS–TP LSP.



▲Figure 6. OAM frame structure of MPLS–TP PW.

4 Conclusion

Both T–MPLS and PBT can well satisfy the requirements of packet transport. Compared with PBT, T–MPLS boasts of better OAM functions. T–MPLS will evolve to MPLS–TP. Being a new carrier–class transport technology, the PTN technology and related standards are currently undergoing continuous improvement and evolutions.

References

[1] **朱召胜, 赵福川**. T–MPLS**分组传送技术最新进展** [J]. **世界电信**, 2007(10): 76–77.
[2] ITU–T G.8114. Operation & Maintenance Mechanism for T–MPLS Layer Networks [S]. 2007.
[3] ITU–T Y.1731. OAM Functions and Mechanisms for Ethernet Based Networks [S]. 2006.
[4] IEEE 802.1ag. Virtual Bridged Local Area Networks—Amendment 5: Connectivity Fault Managements [S]. 2007.
[5] ITU–T G.8121. Characteristics of Transport MPLS Equipment Functional Blocks [S]. 2007.
[6] ITU–T G.8012. Ethernet UNI and Ethernet NNI [S]. 2004.
[7] IEEE 802.1:802.1 Qay. IEEE Standard for Local and Metropolitan Area Networks—Virtual Bridged Local Area Networks—Amendment: Provider Backbone Bridge Traffic Engineering [S]. 2008.
[8] CCSA. **基于分组的传送网技术研究** [S]. 2008.
[9] ITU–T—IETF Joint Working Team. MPLS Architectural Considerations for a Transport Profile [S]. 2008.
[10] **张海懿**. PTN: IP**浪潮下的必然选择** [N]. **人民邮电报**, 2008–08–28.

Biography

He Tingzong

He Tingzong received his master's degree from Tsinghua University. He is now a product planning manager responsible for optical transport products of the bearer network at ZTE Corporation. He was one of the compilers of the standard YD/T 1266–2003 Test Methods of Protection Schemes for SDH Rings initiated by China Communications Standards Association (CCSA), and published a paper named "Protection Technology of Packet Transport Network".