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A Novel Ring Protection Switching Mechanism*

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Abstract:Multi-Protocol Label Switching Transport Profile(MPLS-TP) ring protection is one of the key technologies of MPLS-TP network which is still ongoing researched under a Joint Working Team(JWT) of ITU-T and IETF. Through investigating existing ring protection schemes,a novel "Fast Wrapping" ring protection switching mechanism and corresponding distributed implementation method are proposed. Using the "Fast Wrapping" switching mechanism and corresponding distributed implementation method,the data loss can be decreased during the protection switching. At the same time,the protection group volume will be easily increased,the operator of network management will be simplified and the equipment reliability will be improved due to the distributed implementation method.

Key words:MPLS-TP;ring protection;protection switching;fast "Wrapping";distributed implementation
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一种新型的环网保护倒换机制

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摘　要:环网保护是 ITU-T 和 IETF 联合工作组正在研究的多协议标签交换传送应用(MPLS-TP)关键技术之一。在研究现有的环网保护方案的基础上,提出了一种新颖的快速"Wrapping"环网保护倒换机制以及对应的分布式实现方式。运用这种快速的"Wrapping"环网保护倒换机制及其对应的分布式实现方式,可以降低在保护倒换中数据的丢失率。同时,分布式实现方式易于增加保护组容量,简化网络管理操作,增强设备可靠性。

关键词:MPLS-TP;环网保护;保护倒换;快速"Wrapping";分布式实现

1　Introduction

With the rapid growth of packet-based services, Multi-Protocol Label Switching Transport Profile (MPLS-TP) technology is gaining importance as it becomes a dominant solution for a packet-transport network in recent years. MPLS-TP is an ongoing research work under a joint International Telecommunication Union (ITU) and Internet Engineering Task Force (IETF) effort,which gains wide agreement as being a promising technology to bring packet transport capability to network carriers. MPLS-TP bases on the mature MPLS packet technology,aiming at supporting the capabilities and functionalities needed for packet-transport network services and operations through combining

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the packet experience of MPLS with the operational experience and practices of existing transport networks[1].

MPLS-TP is expected to be used in carrier grade metro networks and backbone transport networks to provide mobile backhaul, business services, etc., in which the network survivability is very important. In order to improve the survivability of networks, MPLS-TP networks are often constructed with ring topologies. It calls for an efficient and optimized ring protection mechanism to achieve simple operation and fast, sub 50 ms, recovery performance[2]. There have been many concrete research works on MPLS-TP ring protection mechanism taken by IETF and ITU-T. The draft standards[2-3] are proposed by IETF.

"Wrapping" protection scheme and "Steering" protection scheme are specified in Reference [2-3]. But both of them have disadvantages. For "Wrapping" scheme, it is less complicated in which only the two nodes adjacent to the failure point are required to perform switching actions. It provides for fast and simple recovery with reduced packet loss, compared with "Steering". However, in some scenarios with large networks additional latency may be introduced during protection switching in the ring because protection traffic travels along all the nodes in the ring. Besides, additional bandwidth is occupied because of some loopback path. For "Steering" scheme, there is no overlap between working and protection path. Therefore, no loopbacks are expected. It is superior to "Wrapping" in latency and resource utilization efficiency. However, each node which sources or terminates any Label Switched Path (LSP) needs to perform switching in steering approach, so it is more complex and taken more time to complete switching compared with "Wrapping". Besides, packets will be lost before source and sink nodes perform switching, which might degrade the network performance.

An improved "Short Wrapping" protection scheme is proposed in Reference [2]. With this scheme, data traffic switching is executed only at the upstream node detecting the link failure, and exits the ring in the protection ring tunnel at the exit node. This scheme can reduce the additional latency and bandwidth consumption when traffic is switched to the protection path. But it has the same processing method at the upstream node as "Wrapping" scheme, the switching time has no improvement.

Therefore, ring protection mechanism is still an ongoing research work. There are also some patents and papers about MPLS-TP ring protection mechanism. Reference [4] has the advantage of optimizing the protection data path. Reference [5] makes use of different labels in shared ring protection. Reference [6] proposes a protection mechanism to reduce packet loss. However, they don't cover the solution in the huge volume protection of real ring engineering.

By comparing above protection schemes, this paper proposes a novel "Fast Wrapping" protection scheme with better performance of packet loss, delay and bandwidth efficiency and introduces its corresponding distributed implementation method which has advantages in huge volume protection.

2 Proposed "Fast Wrapping" Protection Scheme

For the novel "Fast Wrapping" protection scheme, it includes mainly the following three steps.

Step 1: As shown in Fig. 1, Fast_wrapping_enable is defined in bit 8 ~ bit 5 of reserved byte of APS PDU. Once Fast_wrapping_enable bit is set to 1, the detection node sends around the ring, and all nodes on the ring will be told in advance to have part "Steering" function in the detection stage, which is called "Fast Wrapping".

Step 2: On detecting a failure, "Fast Wrapping" is carried out immediately to get away from the failed part of the ring, the proposed mechanism is exactly the same as normal "Wrapping". This aims to achieve fast protection switching and less packet loss.

Step 3: Distributed sharing configuration on the network element is implemented after "Fast Wrapping" to provide an optimized protection path which is better than normal "Wrapping" approach. This can help to avoid unnecessary delay, ensure the requirements of bandwidth management and improve the efficiency of network when "Fast Wrapping" supports the sharing of the protection tunnel by multiple working LSPs.

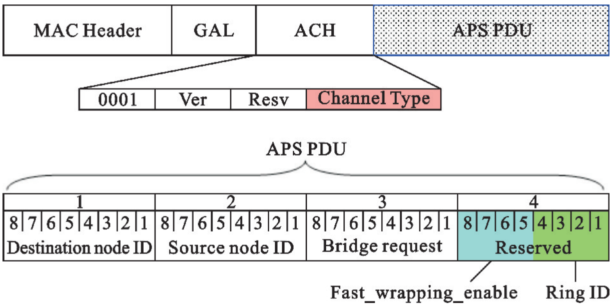


Fig. 1 MPLS-TP OAM and R-APS format
图 1 MPLS-TP OAM 和 R-APS 格式

The ring protection mechanism uses ring auto protection switching(R-APS) format as shown in Fig. 1. The configuration channel types for Operations, Administration, and Maintenance(OAM) and R-APS are required to be different. The default value 0x7FFA is used in MPLS-TP OAM(Section CCM). The other default 0x7FFB is used in MPLS-TP Shared protection R-APS. The first byte is destination node ID and the second byte is source node ID. The third byte is bridge request. The fourth byte is reserved for the device vendor. The ring ID is defined in the low half byte of the fourth. So Fast_wrapping_enable is defined in the high half of the fourth byte. When the bit of Fast_wrapping_enable is cancelled, the ring protection mechanism is back to normal "Wrapping".

When a node detects a signal fail (SF), it will transmit an R-APS message to indicate SF over both ring ports. R-APS(SF) message shall be continuously transmitted by the node which detects the SF condition while this condition persists. The ring protection also requires "Fast Wrapping" function settings for each node to distinguish error-affected LSP and trigger proper protection switching. The "Fast Wrapping" mechanism discards the complexity of steering ring protection and expands the advantage of wrapping ring protection nodes.

The "Fast Wrapping" mechanism is introduced in Fig. 2. Once Fast_wrapping_enable bit is set, the R-APS packets will be passed through the process time of the APS finite state machine and make each node to know about SF prior to normal "Wrapping" mechanism. For example, once the optics fiber between device C and device D is broken, the "Fast Wrapping" will make node C and node D quickly to enter "Ring switching" status of finite state machine. At the same time, B, A, F and E will immediately go into "PASS-Through" status. So the "Fast Wrapping" method will cost less time than normal wrapping especially in the transition of APS finite state machine.

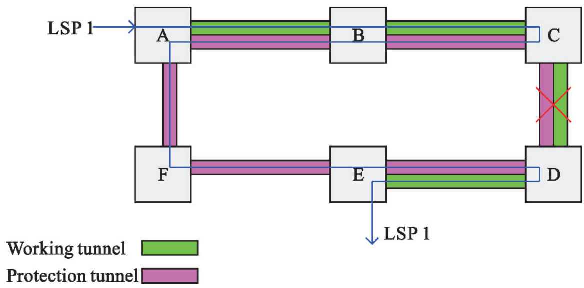


Fig. 2 "Fast Wrapping" mechanism for ring protection
图 2 环网保护的快速"Wrapping"机制

3 Proposed Distributed Implementation for Ring Protection Switching

Generally speaking, a general protection switching is concentrated in a core card, which is composed of ring APS FSM processor, protection group(PG) Table, data path switch, control management, OAM processor, the third label push/pop and host CPU. When Track Signal Fail(TSF) or Signal Degrade(SD) is detected or remote switching request is received from the R-APS packet, the ring APS FSM processor will act and switch data path from the working path to the protection path. The Ethernet traffic and MPLS-TP tunnel OAM are protected by pushing the third label and popping the third label. Of course, the protection switching is automated or manually operated by host CPU. At the same time, the ring APS FSM status will be reported to host CPU. The concentrated implementation of ring protection switching is depicted in Fig. 3. However, with increasing the volume of protection switching group, the implementation structure will show drawbacks such as consuming more FPGA or hardware resources, more load to CPU, and less reliability without proper redundant bandwidth. This will do harm to the telecommunication service.

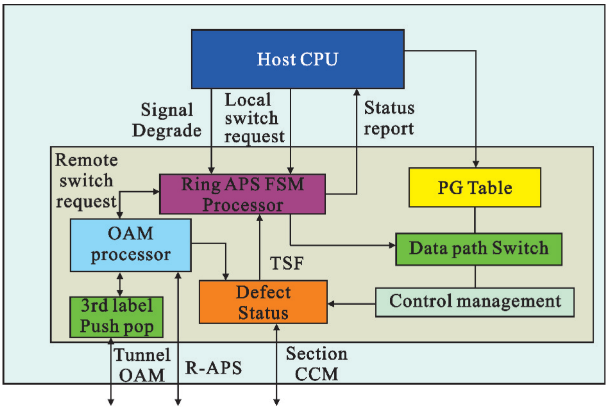


Fig. 3 Concentrated implementation for ring protection switching
图 3　环网保护倒换的集中式实现架构

Compared with traditional implementation of ring protection switching in a core card, one innovative distributed implementation for the ring protection switching has been proposed in this paper as shown in Fig. 4. The distributed implementation for ring protection switching is consisted of one ring protection switching master in core card and many ring protection switching slavers in IO cards. The proposed method shall increase the protection group volume of IO cards and support more IO cards, provide enough protection bandwidth by sharing ring protection tunnel of multiple working LSPs, simplify the network management to IO cards, relieve the host CPU load and enhance the equipment reliability. At the same time, the distributed implementation will reduce the cost of the network device and provide the high – quality telecommunication service for operator.

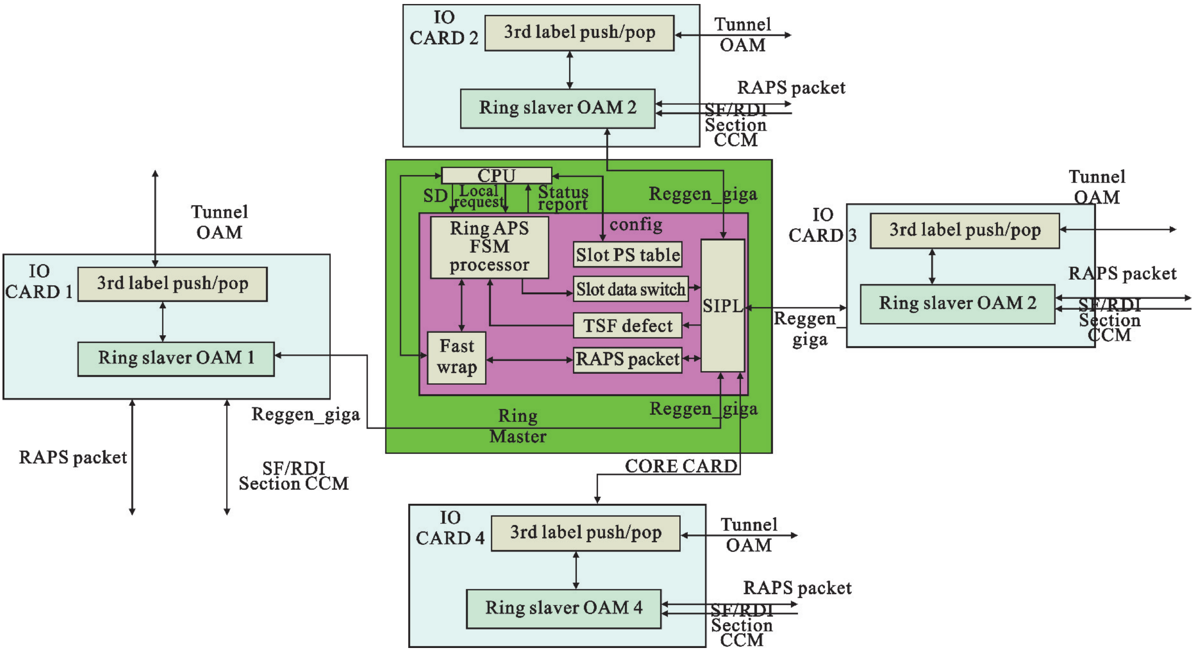


Fig. 4 Distributed implementation for ring protection switching
图 4　环网保护倒换的分布式实现架构

The architecture which is composed of a ring protection switching master and slavers is shown in Fig. 4. A ring protection switching Finite State Machine (FSM) is put on the core card as the master. The ring protection switching master consists of ring APS FSM processor, slot protection switch (PS) table, slot data switching, TSF defect, RAPS packet processor, fast Wrapping and SIPL protocol. The SIPL can wrap the slot PS table, slot data switching and RAPS packet and send the packet information to the related slot slavers in the IO cards. The SIPL can also receive the packet information, extract the RAPS packet /TSF defect and forward it to the ring APS FSM processor.

The Simple Internal Packet Link (SIPL) protocol is used to transfer the packet information through the reggen_giga bus. It is defined in Fig. 5.

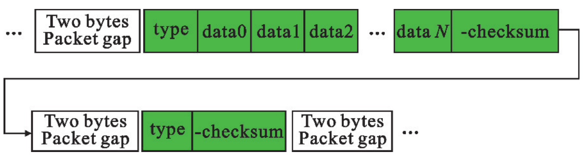


Fig. 5 SIPL protocol format
图 5　SIPL 协议格式

The minimal packet gap is two bytes. The first byte of type field is used to indicate the packet type. The last byte of checksum is used to validate the packet. The data 0 to data N is the packet content, the length can be from 0 to 2048. The SIPL protocol shortens the deliver time of packet information between core card and IO card. Hence it is a valid way for the distributed ring protection switching to ensure the protection switching time. Most importantly, the "Fast Wrapping" function can in advance announce the signal failing message in the ring related node network elements.

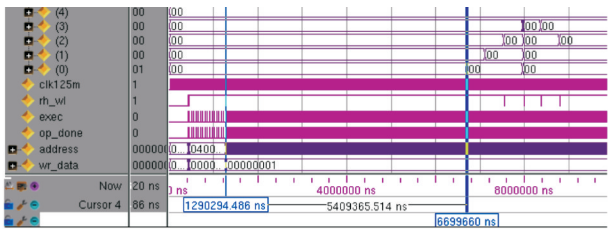
The ring protection switching slavers are put on the IO cards as the slavers. The slaver can receive the RAPS packet or send out it in the IO card. The slavers also detect Signal Fail(SF) or Remote Defect Indication(RDI) from the remote device. The third label push/pop module is used to fast modify the protected MPLS-TP tunnel OAM packets and traffic label processing when ring protection switching status changes.

For instance, there are four ring protection switching slavers in IO card 1, IO card 2, IO card 3 and IO card 4. Between IO card and core card, there is a link of reggen_giga bus, which is related to the slot number. In the example there are 4 reggen_giga buses for IO card 1, IO card 2, IO card 3 and IO card 4. The distributed architecture of ring protection switching provides the extendible space and flexibility of protection switching in one IO card or multi-IO cards.

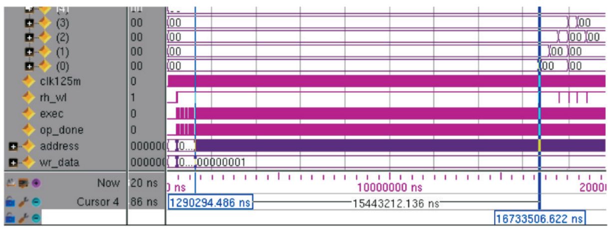
4 Simulation Results

The distributed implementation method for "Fast Wrapping" ring protection has been realized in FPGA. In the simulation, we use the simplified ring model with 2 nodes. One working ring path is composed of port 0 in node 1 and port 1 in node 2. The other protection ring path is composed of port 3 in node 1 and port 2 in node 2. When SF is detected by port 0 of node 1 or port 1 of node 2 in the working path, the traffic will be switched to the protection path. The fast wrapping mechanism can be verified and compared with normal "wrapping" in the simulation.

The simulation results are shown as Fig. 6. From the simulation, on detecting SF by software, "Fast Wrapping" mechanism may take 5.4 ms to finish the protection switching as shown in Fig. 6(a). While, as shown in Fig. 6(b), normal "Wrapping" mechanism needs 15.4 ms to do that. According to protocol[1], MPLS-TP must provide mechanisms to guarantee 50 ms recovery time from the moment of fault detection in networks with spans less than 1200 km. "Fast Wrapping" mechanism can get better performance to meet the requirement of protocol. Considering line delay time, it has enough margins in the real ring network.



(a) Simulation for "Fast Wrapping" mechanism



(b) Simulation for "Wrapping" mechanism

Fig. 6 Simulation results
图 6　仿真结果

5 Conclusions

Ring protection switching is one of the key technologies of MPLS-TP network which confirms high performance network services with high level survivability. In this paper, based on investigating existing MPLS-TP ring protection schemes, a novel "Fast Wrapping" ring protection switching mechanism and corresponding distributed implementation for it has been proposed. Using the "Fast Wrapping" switching mechanism and corresponding distributed implementation method, the protection switching time is much faster than that of traditional methods, so that the data loss due to signal fail or signal degrade can be decreased during the protection switching. At the same time, the protection group volume can be easily increased, the operator of network management can be simplified and the equipment reliability can be improved due to the distributed implementation. As one contributor to RFC5317[7], our network elements (NEs) are compatible with the related standards while we have proposed a new ring protection algorithm that can be privately applied in our NEs. After the improved performance has been evaluated in communication fields by the users, we will promote the private protocols to standardize with the related customers.

References:

[1] IETF RFC 5654, Requirements of an MPLS Transport Profile[S].

[2] Cheng W, Wang L, Helvoort H, et al. MPLS-TP Shared-Ring protection (MSRP) mechanism for ring topology [EB/OL]. [2015-04-06]. http://datatracker.ietf.org/doc/draft-cheng-mpls-tp-shared-ring-protection.

[3] van Helvoort H. MPLS-TP ring protection switching (MRPS)[EB/OL]. 2011-08-27[2015-04-06]. http://tools.ietf.org/html/draft-helvoort-mpls-tp-shared-ring-protection-switching-01.

[4] Nanjing University of Posts and Telecommunications. A fast ring protection method based on MPLS-TP: China, 201010230442.7[P]. 2010-11-24. (in Chinese)

[5] SUN Jie, JIANG Jie, YANG Daiyun. A method of MPLS-TP shared ring protection in PTN[J]. Optical Communication Technology, 2014(3): 21-23. (in Chinese)

[6] Xie W J, Huang S G, Gu W Y. An improved ring protection method in MPLS-TP network[C]//Proceediss of 2010 IC-NIDC. Beijing: IEEE, 2010: 1056-1060.

[7] IETF RFC5317, Joint Working Team (JWT) Report on MPLS Architectural Considerations for a Transport Profile[S].

[8] ITU-T Rec G. 8032/Y. 1344, Ethernet Ring Protection Switching[S].

[9] ITU-T Rec G. 8031/Y. 1342, Ethernet Linear Protection Switching[S].

[10] ITU-T G. 8131/Y. 1382, Linear Protection Switching for MPLS Transport Profile[S].

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