Research on RPR Technology and Its Application in Nuclear Power Plant

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Keywords: RPR technology, Data operation, Topology discovery, Fault response, Nuclear power plant.

Abstract. With the development of enterprise information construction, Ethernet technology for the effective solution of some problems more and more powerless. In order to solve the these problems, the optical transmission system based on RPR (Resilient Packet Ring) technology is designed and constructed in nuclear power enterprises. This paper introduces the technical characteristics of RPR from the aspects of RPR network structure, data operation, topology discovery and fault response, and then summarizes the technical characteristics of RPR. At The same time introduces the practical application of RPR technology in the field of nuclear power plants.

Introduction

RPR (Resilient Packet Ring) is a packet-based ring network technology, which employs a reciprocal dual-loop topology. Each optical path in the ring works at the same rate. It combines the advantages of SDH and Ethernet technology, realizes the sharing and protection of network bandwidth through bidirectional topology ring structure, fault self-healing and fair algorithm, and becomes a new technology for constructing metropolitan area network.

RPR Principles

Network Structure of RPR

RPR (Resilient Packet Ring) is a new MAC layer technology standardized by IEEE 802.17 workgroup. It is a medium access control (MAC) protocol working in the second layer of OSI stack. It is independent of physical layer and can run on SONET/SDH, Ethernet and DWDM. RPR technology combines the advantages of SDH fault self-healing with the economy, bandwidth, flexibility and scalability of Ethernet. RPR provides data optimized bandwidth management and high performance multi-service transmission solutions based on loop topology.

The network structure of RPR is shown in the following figure:

![Figure 1. Schematic diagram of RPR ring network structure.](image)

RPR is a reciprocal dual-loop topology. Each optical path in the ring works at the same rate. The dual-loop of RPR can transmit data and control messages. The RPR node uses the MAC address as
the identification and must ensure that all nodes MAC on the ring are different. RPR has two physical optical interfaces, but logically only one interface for both the network layer and the link layer.

**Data Manipulation of RPR**

In RPR ring network, nodes and ring cooperate to complete data operation. The operation includes four ways.

- Insert: The data frames outside the RPR ring network will be inserted into the data stream of the RPR ring network in the future.
- Transit: Nodes transmit the data frames passing through the node on the RPR ring network to the next node.
- Copy: A node copies a data frame from the data stream of the RPR ring network and delivers it to the upper layer of the node for processing. This operation will not terminate the forwarding of data frames on the RPR ring network.
- Strip: The node terminates the forwarding of data frames on the RPR ring network and strips it from the RPR ring network.

Each node uses the above basic data operations and their combinations to provide support for unicast, broadcast, multicast and unknown unicast.

**Topology Discovery**

RPR collects information about the number of ring nodes, ring states, and the order of nodes by topology discovery, and generates topology database. When the topology of the ring network is stable, the corresponding topological database will no longer change.

**Topological Database**

Each RPR node maintains a topology database, which holds the topology information of the entire RPR ring network and is the node generation ring selection. The main basis of the topological database contains three parts.

- Ring topology information, such as node number, loop state and available bandwidth.
- Topology information of the node, such as MAC address, protection type, node protection status, node name, topology information of the node. The checksum and neighbor node's topology information check and so on;
- Topology information of other nodes, such as MAC address, valid state, reachable state, protection type, node index, reserved bandwidth, and node name, etc.

**Topology discovery process**

In the process of RPR topology discovery, TP (Topology Protection) frame and ATD (Attribute) frame are used mainly. Discovery (Attribute Discovery) and TC (Topology Checksum) frames propagate topology information:

- TP frames are used to broadcast configuration and status information for each node, while other nodes update their topology numbers based on the received TP frames. Finally, every node in the loop has a consistent understanding of the topological information of the ring.
- ATD frames are used to transfer node's MAC address, name and other attribute information, which is also stored in the topology database.
- TC frames are used to transmit topology information checksum between adjacent nodes, and to check whether the topology database of the neighboring node and the local node is true or not. Match to determine whether the topology of RPR ring network is stable. The three frames are sent periodically, and the cycle lengths can be configured. Among them, TP frame and TC frame have two kinds of sending cycles: fast sending cycle and slow sending cycle:

  - When a node is initialized or a topology change is detected, the fast transmission of the TP frame is triggered and the fast transmission of the TP frame is triggered. Network topology information is spread throughout the network. After sending the TP frame in the fast cycle, it is sent in a slow cycle.
When the ring network topology is stable and convergent, it will trigger the fast transmission of TC frames, send TC frames in fast cycles, and then send them in slow cycles. No matter how the topology is, the ATD frames are sent periodically according to the cycle set by the user.

**Failure Response Mode**

RPR fault self-healing ability is very strong, its protection mechanism can achieve event detection, fast self-healing, and fast service recovery after fiber or node failure, so that the network can quickly detect the fault and make appropriate response to ensure rapid service recovery within 50 ms. RPR supports the following two ways of failure response:

**Passthrough**

The Passthrough mode is mainly used for node failure. When a node detects an internal fault, it can enter Passthrough mode. At this time, the node is similar to a relay, no local access to any services, any data frames arriving at the node are directly forwarded in a transparent manner, and the node is not visible in the ring network topology.

Protection switch

If the node no longer has the ability to forward data frames, such as power failure or fiber optic disconnection and other causes of failure, the node needs to enter the protection switching mode. Protection switching can be divided into two modes:

- Wrapping mode
- Steering mode

**Technical Characteristics of RPR**

The technical characteristics of RPR can be summarized as follows: (1) effective multiplexing of transmission bandwidth. (2) fast loop protection switching (50ms) function, which can provide self-healing time of 50ms on MAC layer. (3) automatic topology discovery. (4) access control and fairness algorithm. (5) provide reliable multilevel QoS services.

Obviously, RPR based on SBH can make the transmission of voice service and data service fit for each other. It not only ensures that voice service can be transmitted in its inherent way, but also makes the transmission of data service no longer completely confined to the limitations of SDH transmission mode, so that the utilization of transmission channel can be greatly improved, and LA can be achieved through the new MAC layer protocol. N extends to MAN / WAN, extending the many advantages of LAN to MAN / WAN. Compared with the WAN/LAN-based RPR, the bandwidth utilization rate of SDH-based RPR may be slightly lower (by using the key technologies of next-generation SDH such as VCAT and LCAS, the bandwidth utilization rate can be further improved), but the QoS of voice service transmission can be fully guaranteed and can be directly docked with existing network devices and switches, so it is even more effective. It can be used as a unified platform for voice and data transmission.

**Application of RPR Technology in Nuclear Power Plant**

The application of network services in nuclear power plants can be divided into the following categories: (1) voice services: dispatching telephone and administrative telephone; (2) data services: dispatching automation data, management information system and office automation system data, control system data; (3) video services: video conferencing, video surveillance and so on; (4) multimedia. Business: E-mail, Web applications, videotex, multimedia conferencing, video on demand, video broadcasting, etc.

For nuclear power enterprises, most of the initial enterprise network based on Ethernet technology construction, with the deepening of enterprise information construction, Ethernet technology for the
effective solution of some problems, more and more powerless. Specific as follows: (1) traffic control: Ethernet technology cannot form traffic localization, destined to affect the performance of the network; (2) delay: Ethernet technology leads to the access link in series equipment too much, resulting in delays multiplied, cannot achieve wire speed forwarding, network delay jitter uncontrollable; (3) quality of service (QOS) and Experience Quality Assurance: Ethernet technology is a network technology that tries its best to transmit, lacking quality of service and quality of experience assurance; (4) Reliability: Ethernet technology can only use spanning trees and link aggregation to improve the reliability of network links, providing up to 15 seconds of switching time for backbone networks. Speaking of a long time; (5) scalability: Ethernet technology leads to tight coupling of all parts of the network, network expansion is subject to too many constraints of the existing network, so-called pull and move the whole body.

In order to solve the above problems, the optical transmission system based on RPR (Resilient Packet Ring) technology is designed and constructed in nuclear power enterprises.

The optical transmission system of Nuclear Power Plant (6 generating units) uses 10G RPR resilient packet ring technology, each computer room is equipped with one RPR core equipment and integrated service access equipment, covering multimedia access services in corresponding areas, and network security devices such as hardware firewalls are configured at the interface of RPR ring network and external network or other private networks. Meet the needs of future multi service transmission. It can realize the access, processing and transmission of TDM, IP and other services at the same time, and provide a unified network management multi-service transmission platform. At the same time, optical transmission equipment has powerful networking capabilities, can support a single machine multi-ring, sub-ring, chain and point-to-point network topologies. RPR (Resilient Packet Ring) technology combines the practicability of Ethernet and the powerful function of optical transmission equipment. It uses spatial multiplexing to improve the utilization of bandwidth, minimize the protocol overhead, realize the fair utilization of network resources, and has the characteristics of effective reuse of transmission bandwidth and fast self-healing. The technology transforms the nuclear power plant LAN into a fast, simple, reliable broadband network that can provide rich value-added services in time. Without reducing the network performance and reliability, it provides a new, effective and more economical network solution.

Concluding Remarks

For the optical communication system of nuclear power plant, the problems of its transmission network will become more and more prominent with the increase of the scale of the nuclear power plant network and the development of the service. Optical transmission technology based on RPR is a very mature optical transmission technology. It provides a solid hardware foundation for the rapid development of distribution automation, power MIS, GIS and ERP in the future nuclear power plant system. It can also be predicted that with the maturity of the new generation optical network technology, the optical communication network of nuclear power plant will be transformed from static, non-intelligent, fixed bandwidth allocation to flexible, intelligent and dynamic bandwidth allocation. RPR technology will have a broader development space in the rapid development of the optical communication network of nuclear power plant. And good application prospects.

References

