High-capacity, Highly Reliable Core Router Type-X320/80

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Abstract

This article presents an overview of our high-capacity router, Type-X320/80, which is suitable for a carrier-grade network, and describes its features. It provides high reliability, excellent quality-of-service control, multiprotocol support, and good cost-performance. It can transfer up to 392/90 million IP packets per second.

1. Position of Type-X320/80

Although carriers need a multi-service network with high reliability and excellent quality-of-service (QoS) control functions, conventional routers have low reliability because many of them evolved from LAN service equipment. The core router Type-X320/80 that we have been developing has QoS control functions and high reliability suitable for the construction and operation of carrier-scale IP networks. The Type-X320 can be used as a core router that acts as a relay transfer and the Type-X80 as an edge router that accommodates the core routers and users. Combining the two leads to a flexibly constructed network that can meet the requirements. The key technologies for a carrier-grade service network are listed below. Type-X320/80 provides all these functions.

(1) High reliability
- Uninterrupted service switchover through fully duplicated and synchronized system operation
- Software hot-upgrading through duplicated memory
- MPLS (Multi-Protocol Label Switching) path protection using high-speed fault notification

(2) Excellent QoS control
- Traffic input control using traffic policing in each traffic flow
- QoS control and packet classification/discard based on a color code attached to packets using multiple-class queues

(3) Multi-protocol support
- Provision of service integrated backbone network using MPLS
- Smooth transition to IPv6 (IPv4/IPv6 dual stack & wire-speed forwarding)
- Inclusion of various IPv4/IPv6 routing protocols and MPLS signaling protocols
- ATM (Asynchronous Transfer Mode) emulation (Type-X320 only)

(4) Economy (Type-X series line-up)
- High-capacity (320 or 80 Gbit/s) transfer capability using one 19-inch rack-mountable unit
- Comprehensive line interfaces ranging from 100 Mbit/s to 10 Gbit/s (POS (Packet Over SONET), Ethernet, and ATM)
- High reliability and quality control equivalent to an exchange system for the price of a router.
- Economy gained from focusing upon core functions (Type-X320)

Table 1 shows the specifications of Type X320/80.

2. High reliability

Type-X320/80 provides carrier-grade reliability through a duplex configuration, i.e., common modules such as REB, IOC, CLK, and SWB are duplicated, and line circuit modules such as LINF can be either duplicated or stand-alone (Fig. 1). Forwarded packets are immune to routing fluctuation and network instability because the routing protocol processing module (REB) is separated from the packet transfer module (LINE).

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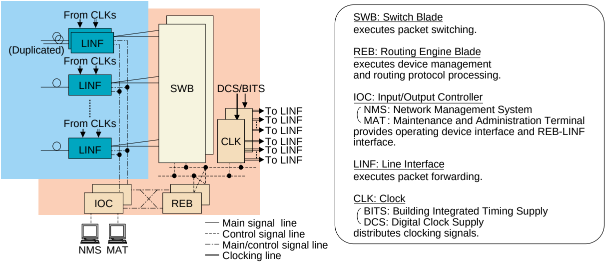
Table 1. Type-X series specifications.

		Type-X80	Type-X320
		Functions	
Switching capacity		80 Gbit/s	320 Gbit/s
IP packet processing capability		90 Mpps	392 Mpps
Number of line card slots		16 (can accommodate 2.4 Gbit/s × 16)	16 (can accommodate 10 Gbit/s × 16)
Line card types		OC-48c/STM-16 × 1 (POS) OC-12c/STM-4 × 4 (POS) OC-12c/STM-4 × 2 (ATM)* OC-3c/STM-1 × 8 (POS) OC-3c/STM-1 × 4 (ATM) Gigabit Ethernet × 2 100-Mbit/s Ethernet × 8	OC-192c/STM-64 × 1 (POS) OC-48c/STM-16 × 4 (POS) OC-48c/STM-16 × 1 (ATM) OC-12c/STM-4 (POS)* OC-12c/STM-4 × 4 (ATM) 10-Gbit/s Ethernet* Gigabit Ethernet × 8
IP protocols		IPv4, IPv6 (dual stack, hardware forwarding)	
Routing protocols		OSPFv2, OSPFv3, RIP2, RIPng, BGP4, BGP4+	
DiffServ		EF, AF × 4, BE	
MPLS	Signaling	Static, LDP, RSVP-TE	
	Path type	L3 MPLS, Ethernet/AAL5 over MPLS	L3 MPLS, ATM emulation
Traffic engineering		Load balancing	
Redundant configuration		Fully redundant configurable	
Non-interruption services		Software upgrades, Firmware upgrades*	
Power		DC-48V, AC-100/200V	
Dimensions		19-inch rack mount	

*: Support under consideration pps: packets per second



* Type-X80 and Type-X320 both have the same block configuration with different packages to be mounted.

Fig. 1. Block diagram of Type-X.

2.1 Fully duplicated and synchronized operation

The Type-X REB maintains main system information of protocol/hardware data in duplicated systems (main and standby) by constantly updating both sets of memories with the same content (Fig. 2). Even with redundantly configured routing engines, conventional routers must be rebooted to switch the system, which interrupts protocol sessions or causes traffic loss. However, fully duplicated and synchronized operation enables Type-X to maintain the protocol session with an adjacent router without losing any packets if the REB system is switched over in the event of a fault.

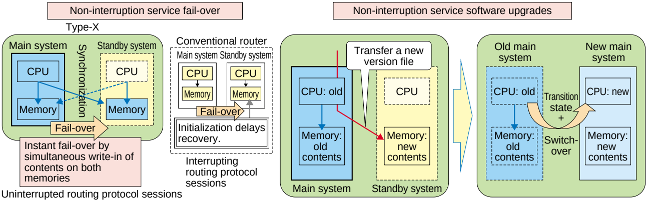


Fig. 2. Mechanism of Type-X duplicated routing engine.

2.2 Interruption-free service software upgrading

Running new and old files simultaneously to execute data transfer processing and initialization during the execution of call processing in an old file makes software upgrades equivalent to currently used switching equipment (Fig. 2).

2.3 High-speed MPLS path protection

The high reliability of the entire network also offers MPLS path protection. Normally, when an MPLS path fault occurs, each path sends switching request messages to upstream that sequentially process the requests from one to another. When requests reach terminating routers, traffic is switched to the standby path. However, if multiple-MPLS paths send switching requests simultaneously due to a link failure, congested processing may result in slow path switching. Type-X also solves this problem by grouping MPLS paths to shorten the time required. MPLS paths with the same path switching point (terminating router, etc.) are grouped together. Each group directly sends the switching request messages to the routers at the path-switching point so the switching time to the standby paths can be reduced.

3. QoS control functions

To forward mixed traffic of differing quality of Service, Type-X identifies the quality level of each traffic data stream (traffic policing) and executes QoS control (multiple-class queue control) to match the quality level. Type-X also links with X-OSS to manage the QoS of the entire network (Fig. 3). The traffic policing monitors the traffic volume input into the edge router on each IP flow classified by the combination of destination and source address and each

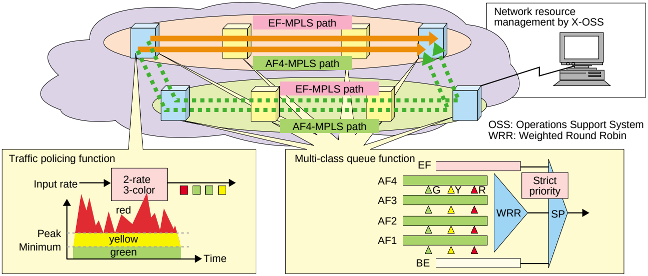


Fig. 3. Functions to meet different quality requirements in the same network.

MPLS path, colors the packets (setting the TOS (Type Of Service) field of the IP header and the Exp (Experimental) bit in MPLS packet headers) with monitored results and controls packet discard according to the color code.

The colored IP packets and MPLS traffic enter the queues in each transfer quality class at the core/edge router (Type-X has six class queues: EF, AF1-AF4, BE). The packets input to the queues are read depending upon the priority for each class. Packet color code and queue length according to input class are used to control packets discard in each transfer quality class and in each packet.

In this way, Type-X divides QoS classes per IP flow and MPLS path and controls the QoS using DiffServ (Differentiated Services) functions to execute QoS control. These advanced hardware functions produce various QoS levels, such as priority control and minimum bandwidth guarantee control.

4. Multiprotocol support

4.1 IPv6 functions

Type-X320/80 also supports IPv6 (for routing protocol, see Table 1). The interfaces support simultaneous forwarding of IPv4/IPv6 and MPLS packets. Since all packet types are forwarded by hardware, wire-speed forwarding is achieved regardless of the heavy load and arriving packet types (IPv4/IPv6 dual stack forwarding) (Fig. 4).

Since the same queue as for IPv4 is used, QoS using DiffServ functions is also provided in IPv6. This requires advanced QoS control to be implemented with hardware in IPv6.

4.2 ATM function (Type-X320 only)

The ATM function is one of the features of the Type-X320. This function not only transfers ATM cells (Fig. 5) but also emulates an ATM network using Type-X320 and also provides OAM (Operation, Administration and Maintenance) leading to enhanced operation. As shown in Fig. 6, this function also provides ATM emulation to ensure cooperation between the ATM and MPLS networks. It adds the MPLS header to the incoming ATM cells to encapsulate. The encapsulated MPLS packets arbitrarily choose the egress line and are transferred to the MPLS network as normal MPLS packets, whereas VCI/VPI (virtual channel/path identifier) information is mapped to the label field of the MPLS header. A number of ATM bearers types are achieved by MPLS DiffServ to ensure ATM QoS, e.g., by mapping CBR, VBR/GFR, and UBR to the EF, AF, and BE classes of MPLS, respectively. Thus, IP/ATM is integrated into the

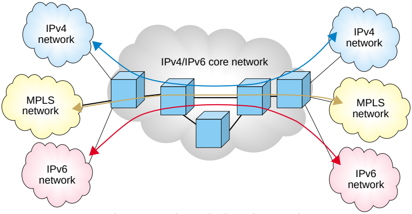


Fig. 4. IPv4/IPv6 dual stack network.

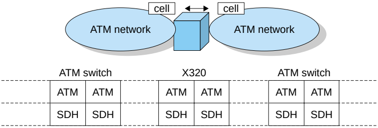


Fig. 5. ATM cell switching.

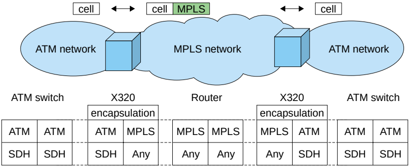


Fig. 6. ATM emulation.

MPLS network in the Type-X320. The current X320 ATM interfaces are OC-48c/STM-16 and OC-12c/STM-4 (Table 1).

5. Economy

Using a high-density switch and high-speed line card brought about economies of scale in the Type-X. The X320/80 router is more competitively priced than similar routers on the market.

6. Summary and prospects

We have been developing the Type-X series. This system provides high reliability and excellent quality-of-service control functions to support a carrier-grade multi-service network. Uninterrupted service and ATM emulation are distinctive features compared with features in other routers. This system has been installed in actual networks of NTT subsidiary companies since 2001. Type-X has excelled in terms of performance stability, and has been enhanced with even more functions for possible standardization. NTT hopes that with the addition of further functions the system will become the *de facto* standard in the future.

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