# Metro SONET System Supporting Optical Backbone Infrastructure: FLASHWAVE 4500

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**Driven by a rapid increase in broadband subscribers and strong demands for multiple services from broadband subscribers, carrier networks are dramatically migrating to the next-generation network. The metro network, which effectively transports user traffic from a variety of access networks, is evolving from a SONET/SDH-based network to an IP-based network. To keep up with the fast-paced network evolution, Fujitsu has developed the FLASHWAVE 4500 Multiservice Provisioning Platform (MSPP). This paper describes the goals of the FLASHWAVE 4500 development and the features of this platform that enable flexible adaptation to network changes. It also describes the future enhancements that will be made to converge metro-network and layer2 functionality in this platform to make it suitable for the future next-generation optical backbone infrastructure.**

## 1. Introduction

The recent shift to broadband Internet use has led to a dramatic increase in the amount of data traffic on communications networks. To deal with this increase, the use of networks has been reexamined to maximize their transmission efficiency. In particular, metro networks are being innovatively changed to access networks and are becoming cost-efficient, high-volume networks that integrate long-haul networks using Dense Wavelength Division Multiplexing (DWDM). To cope with these rapidly changing networks, Fujitsu has developed the FLASHWAVE 4500 system for metro SONET systems.

The FLASHWAVE 4500 is functionally equivalent to a conventional Metropolitan Area Network (MAN) that uses Time Division Multiplexing (TDM) technology suitable for present telephone services. It can also efficiently transfer packet signals such as those used by Ethernet and video services. This paper describes the FLASHWAVE 4500, which will support the next generation of fiber backbone infrastructures.

## 2. Development goals of FLASHWAVE 4500

Currently, there are three main types of networks: access, metro, and long-haul (**Figure 1**). Because of the various services access that networks provide and the enhancement of broadband, access networks have recently seen a major increase in IP traffic. Metro networks require the extensibility to flexibly adjust to expanding traffic and the reliability to support leased-line services as well as cost-efficient transmission for this IP traffic support. Long-haul networks use multiplexed DWDM devices that transmit data via fiber-optic cables. Therefore, in a metro network, seamless connectivity with DWDM devices and cost efficiency are required.

Based on these factors, the FLASHWAVE 4500 was developed to do the following:

1) Support existing Plesiochronous Digital Hierarchy (PDH) signals as well as SONET

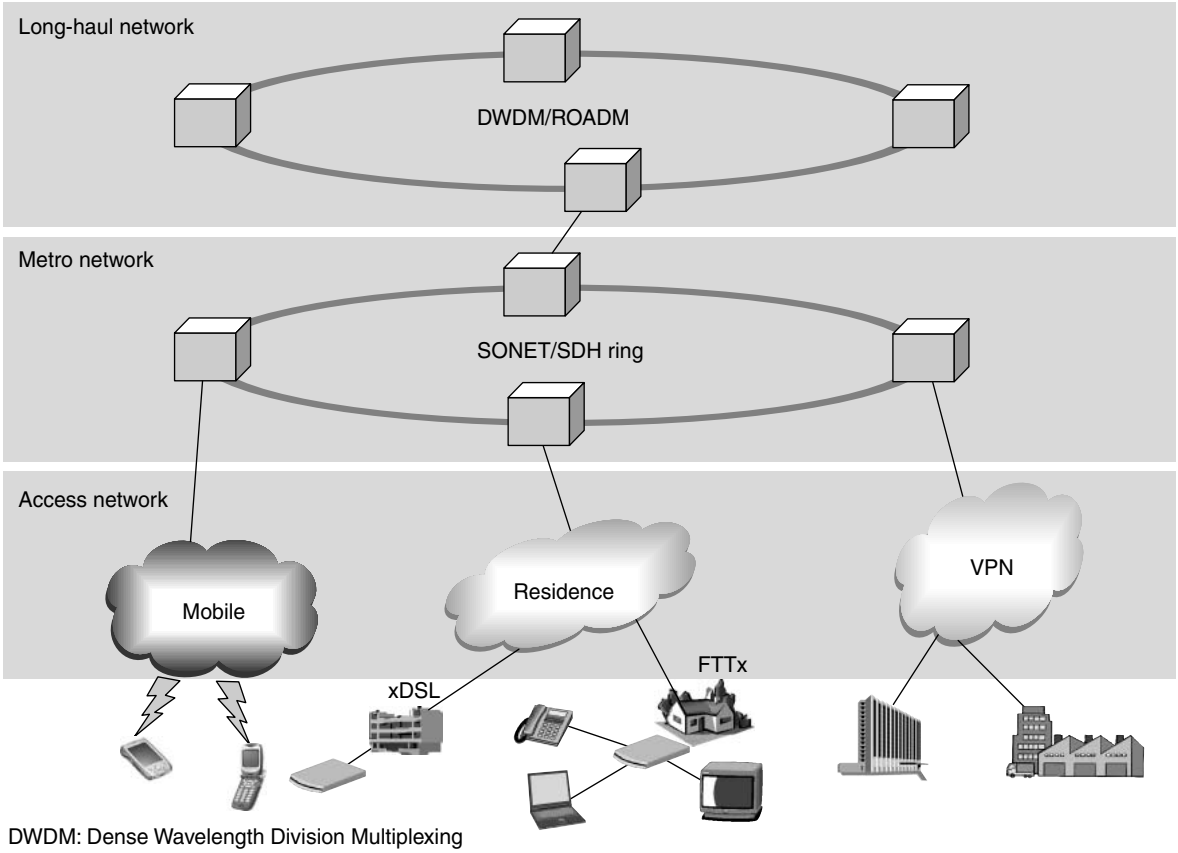



Figure 1
Network layer architecture.

Optical Carrier (OC)-3, OC-12, OC-48, and OC-192 so the FLASHWAVE 4500 can adapt to an expanding network.

2) Support IP signals using Ethernet over SONET (EoS: transmission in SONET format) for improved reliability and standardization of device implementation.
3) Mount a light source having the same wavelength as is used in DWDM by using OC-48 and OC-192 interfaces, thereby allowing direct connections to DWDM devices.
4) Enable flexible expandability by providing systems ranging from single-shelf stand-alone systems to three-shelf, single-system units that allow system management and multi-shelf systems compatible with cross connection transaction.

The FLASHWAVE 4500 is based on the SONET standard to ensure compatibility between present networks and also compatibility with new technologies such as 10-Gigabit Ethernet and DWDM. In addition, by allowing for flexibility and expandability, it allows carriers to reduce their initial costs and use an architecture that can be expanded when needed.

## 3. Special features of FLASHWAVE 4500

**Table 1** lists the technical specifications for the FLASHWAVE 4500, and **Figure 2** shows a photograph of its appearance. The concept of the FLASHWAVE 4500 was realized through the following:

1) Operation of universal slots

The FLASHWAVE 4500 provides a wide variety of interfaces that support SONET, PDH,

Table 1
Specifications of FLASHWAVE 4500.

| | |
|---|---|
| Network operation configuration | • Point-to-point: Terminal, Linear ADM (1+1)<br>• Ring: UPSR, 2F_BLSR, 4F_BLSR, RPR |
| Interface unit type | • DS1, DS3, EC1<br>• OC-3/STM-1, OC-12/STM-4 (1.3 nm, 1.5 nm)<br>• OC-48/STM16, OC192/STM64 (1.3 nm, 1.5 nm, colored)<br>• Ether/RPR (10/100 BaseT, GbE)<br>• DVB-ASI |
| Cross-connect capacity | • STS: 1344 × 1344 ~ 5760 × 5760<br>• VT: 5376 × 5376 ~ 10 752 × 10 752 |
| Clock synchronization | • Internal Stratum 3 timing source<br>• Synchronous Status Messaging (SSM)<br>• BITS Primary and Secondary In/Out |
| Monitoring/control | • TL1 protocol over X.25, OSI/LCN<br>• TCP/IP and X.25 gateway function<br>• Software download<br>• Remote memory backup/restore<br>• Full suite of in service upgrades |
| Dimensions/weight | • Width × depth × height: 546 × 305 × 580 (mm)<br>• Weight: 60 kg |

EoS, as well as DWDM. These interfaces use the same form factor and have no limits regarding which devices they can contain (universal slots), so network designers can freely design systems. In carrier networks, in response to the increased traffic, bandwidth is often increased by adding a ring network using an overlay ring or by upgrading from an OC-3 ring to an OC-12 ring. The FLASHWAVE 4500 allows networks to be expanded through the addition of new units, without affecting network operation. Also, it allows units to be upgraded to higher capacity units, without any break in service, and the addition of new features. Therefore, by using the FLASHWAVE 4500, service administrators can easily modify their network configurations.

2) Data over SONET

This technology provides flexibility for applications that use packet transfers as well as data transfer, while allowing carriers to provide highly reliable data transfer based on SONET. By providing Ethernet over SONET, Resilient Packet Ring (RPR) over SONET, and Digital Video Broadcasting Asynchronous Serial Interface (DVB-ASI) over SONET technologies, services can be provided across a wide spectrum such as FTTx applications, LAN applications, and IPTV applications used for Internet video solutions.


Figure 2
FLASHWAVE 4500 appearance.

The merits of using the technology to map data transfer packets onto the SONET payload are as follows:

- Data can be transferred using redundant and highly reliable technologies such as Bi-direc-

tional Line Switched Ring (BLSR) and Unidirectional Path Switched Ring (UPSR) that are provided in the existing SONET network.

- Carrier operators can continue to use SONET's line settings and alert monitoring systems.
- Transmission bandwidth can be used effectively by utilizing virtual concatenation technology, which virtually concatenates timeslots according to the required bandwidth.
- Compatibility with redundant protocols of upper layers via the use of alert transfer can be ensured.
- Line status indicators such as packet loss counters and various error counters can be constantly monitored, and reports can be collected from between every 15 minutes to once a day.

3) Seamless connection with DWDM systems

Long-haul networks gain higher cost efficiency through the introduction of DWDM systems. DWDM systems are also being introduced to support the ever-increasing demands placed on metro network resources. By using a light source having the same wavelength as used in DWDM systems, the FLASHWAVE 4500 can directly connect to DWDM networks without using transponders, which lowers network development cost.

The FLASHWAVE 4500 can also cover the entire DWDM band by using a single variable-wavelength light source.

4) Multi-shelf deployment

Up to three shelves of the FLASHWAVE 4500 can be deployed as a single system, allowing it to contain interfaces for up to 60 slots and a linear expansion of cross connections to 280 Gb/s. Until now, this was only possible through the use of expensive Digital Cross Connect (DXC) systems. The FLASHWAVE 4500 can be used to expand an existing facility and can be flexibly adjusted to accommodate changing network capacity needs at low cost (**Figure 3**).

5) Control and monitoring capabilities to reduce the burden of operator maintenance

The FLASHWAVE 4500 has new features for existing SONET-based networks and has Ethernet and DWDM capabilities. It also facilitates customer maintenance through ease of use and expandability and supports multiple monitoring interfaces for operation with different networks.

The FLASHWAVE 4500 has the following maintenance features:

- Ease of control and expandability

To mount the many different interfaces into a universal slot, the FLASHWAVE 4500 uses plug & play auto provisioning, so interface units can be automatically set up simply by inserting them into an open slot. In addition, by using the remote software download feature with a standard protocol, remote interface upgrades and software enhancements can be easily performed with no need to change the hardware infrastructure.

- Support for multiple monitoring interfaces

The FLASHWAVE 4500 not only supports 10-Gigabit Ethernet signals, it also allows remote TL1 base operation through traditional OSI and

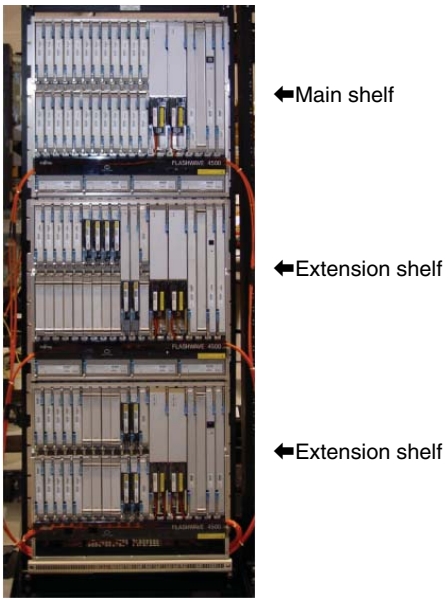



Figure 3
FLASHWAVE 4500 3-shelves extension.

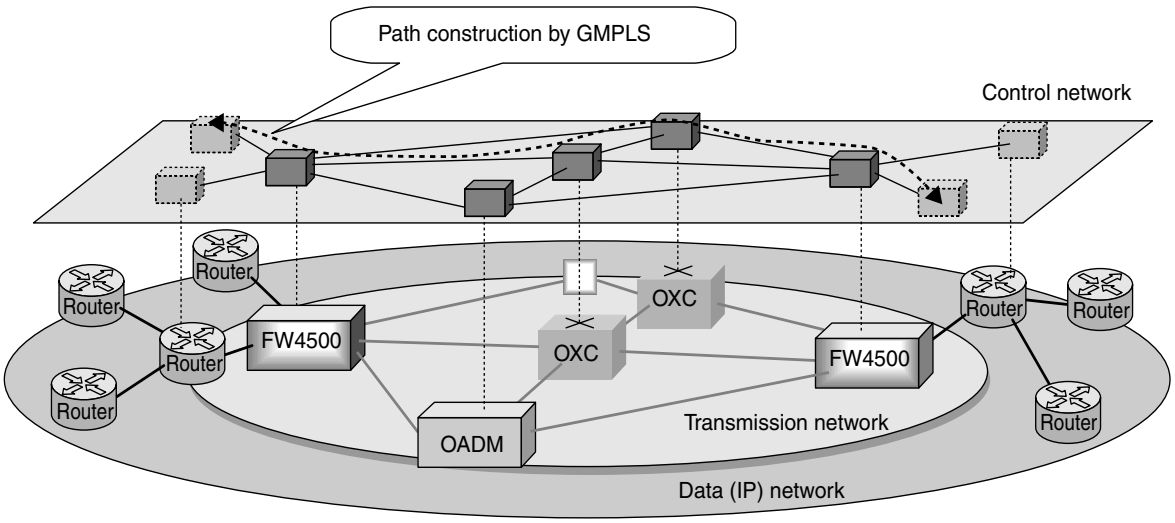
TCP/IP networks and has Simple Network Management Protocol (SNMP) monitoring features. Also, in addition to network operation using a specialized monitoring control device (Netsmart1500), it complies with the standard interface used by the standard operating systems of North American carriers and SNMP management.

## 4. Future plans

To support the upcoming expansion of metro networks, we plan to provide a wide range of expansions for the FLASHWAVE 4500. To support this expandability, there are plans to increase Layer 2 support to optimize the subscriber service signal efficiently and also plans to deploy Generalized Multi-Protocol Label Switching (GMPLS) control, which will reduce operation costs as follows:

1) Expansion of data functions

As communication needs increase, so does the need to expand the internal data functions of equipment to facilitate the expansion. Therefore, Ethernet services in various forms, including Virtual Private Networks (VPNs), will be supported by offering support for QinQ Type 2 layer routes (QinQ is a VLAN technology for which a provider tag is granted). In addition, we aim to expand the offered functions and operation of the standard core network through the use of Multi-Protocol Label Switching (MPLS) to allow routing and QoS. To be precise, it enables the control at each flow of each current class to be further subdivided. It meets the service demands of the end users by offering polishing, scheduling, and other added functions at each flow. Therefore, services that have different bandwidth and quality requirements, for example, Internet access, file transfer, voice (VoIP), broadcast quality image delivery, and video on demand, can be provided via the same network. Also, by accommodating a high-level-layer protocol within the system, the necessary bandwidth can automatically be allocated or the preliminary routes can be set while reserving the required bandwidth. As a result, a highly reliable network can be built at a lower cost. In addition, the time between reception of the




GMPLS: Generalized Multi-Protocol Label Switching
OXC: Optical cross Connect
OADM: Optical Add Drop Multiplexer
FW4500: FLASHWAVE 4500

Figure 4
Example of network management by GMPLS.

service order from the end user to deployment can be greatly reduced, thus allowing for a service with a higher competitive edge. By using MPLS technology and applying Pseudo Wire (PW) technology that accommodates non-packet signals such as frame relay, ATM, and Time Division Multiplexing (TDM) signals using packet transfer technology, a network with a true multi-protocol environment can be achieved. The FLASHWAVE 4500 allows this technology and Layer 2 technology to be used together, thereby enabling highly efficient use of a metro network. With this improvement in the efficiency of bandwidth usage for metro networks and port usage of provider edge switch routers, the cost of facilities and operations can be dramatically reduced.

2) Compatibility with GMPLS

Currently, because IP, TDM, and DWDM networks are operated via their own dedicated control devices, networks modifications require individual networks to be separately set up. Required modifications must be completed on demand and as quickly as possible, and at present, GMPLS is considered to be the best technology for achieving these needs. To implement universal slot operation in the FLASHWAVE 4500, we installed an unlimited routing mechanism in its control overhead path. Therefore, by making a partial modification, it can support GMPLS. In the future, the standardized control planes that determine how to change the routing of an independent network in response to network demand fluctuations will be built onto the device, thereby implementing GMPLS control (**Figure 4**).

## 5. Conclusion

This paper described the ideas behind the development of the FLASHWAVE 4500, the features of the system, and its future development. Now that many subscribers have switched to broadband, metro networks have rapidly progressed from the present SONET-based system to an IP-packet-based system. Fujitsu will continue to revolutionize its services, allowing for changes in networking, and is planning to expand the FLASHWAVE 4500 as a metro transfer system to support the fiber-optic backbone network infrastructure.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