# Development of an STM Transport System Accommodating Ethernet Signals

*Akira Hirama*†*, Kenji Sasajima, and Kazutaka Zaima*

**Abstract**

Existing network transport systems cannot carry Ethernet signals because they support only an interface for transporting STM (synchronous transfer mode) signals. The system described here was developed based on the broadband add-drop multiplexer (BB-ADM), which was originally conceived as an ultrahigh-speed leased circuit service node system capable of carrying STM signals. The new transport system employs generic framing procedure (GFP) and virtual concatenation (VCAT) technology to enable Ethernet to be used over an STM network.

## 1. Background

Routers and switches are enabling Ethernet-based networks to expand into wide area networks (WANs), which in turn is causing greater demand for technologies such as POS (packet over SONET (synchronous optical network)) to transport Ethernet signals directly over the network. Existing STM (synchronous transfer mode) transport systems cannot accommodate Ethernet signals directly, leaving no alternative but to build separate STM and Ethernet networks.

A recent project to upgrade the transmission links between Kagoshima and Okinawa was faced with the need to transport both STM and Ethernet signals. Building two separate networks over the more-than-2000-km route was not economically feasible. Instead, a way had to be found to accommodate Ethernet signals in the broadband add-drop multiplexer (BB-ADM).

## 2. Requirements and development concepts

To meet the first requirement of the development project (accommodating GbE (Gigabit Ethernet) signals in a BB-ADM), it was decided to make maximum use of the existing BB-ADM functionality for the operation, administration, management, and provisioning (OAM&P) of an STM network. This approach had the advantage of enabling Ethernet signals to be carried with minimal changes to the functionality already provided in the BB-ADM for STM network OAM&P. The specific technologies applied here are the highly touted generic framing procedure (GFP) and virtual concatenation (VCAT).

A second requirement was achieving interoperability with other systems in the existing network infrastructure. This was made necessary by economic considerations, because it would not have been feasible to build a brand new network stretching more than 2000 km, without making use of the network infrastructure already in place. One development requirement was therefore to make the new network interoperable with existing node systems and to use it as the public communication network for the areas served.

## 3. Accommodating Ethernet signals in an STM network

GFP and VCAT technologies were used to enable direct and efficient accommodation of Ethernet signals in an STM network. The role of GFP here is to map Ethernet signals incoming on the client side to STM frames. VCAT is used to divide up the signals into smaller channels suitable for client signals, thereby achieving highly efficient use of bandwidth.

Using GFP and VCAT, we developed two Ethernet packages, an FE (Fast Ethernet) package and a GbE package, based on an assessment of operational

† NTT Network Service Systems Laboratories
Musashino-shi, 180-8585 Japan
E-mail: hirama.akira@lab.ntt.co.jp

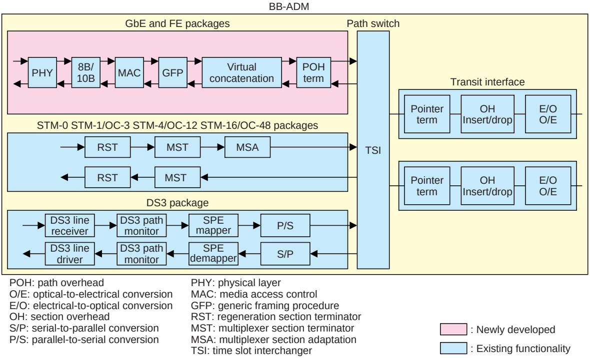


Fig. 1. Overview of BB-ADM.

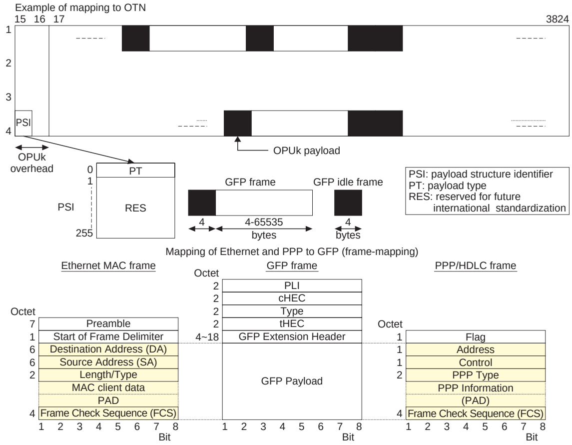


Fig. 2. Outline of GFP technology.

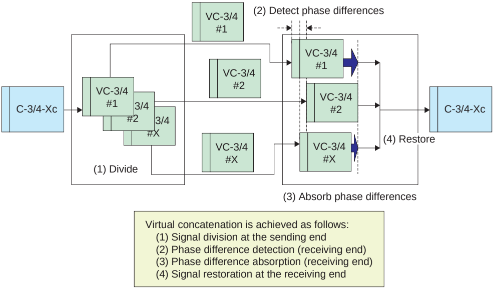


Fig. 3. Virtual concatenation.

needs. **Figure 1** shows the areas of new development in the overall BB-ADM system.

### 3.1 GFP

GFP is a technique for continuously mapping a byte-multiplexed variable-length payload onto an STM path or OTN (optical transport network) path. By defining how the client signals are mapped to GFP frames, it can hide the nature of the client signals from the path, which sees them simply as a payload of GFP frames.

Generally an STM path carrying GFP frames uses VCAT to create a virtual concatenation stream with suitable bandwidths for client signals. There are two kinds of GFP: i) frame-mapping (GFP-F) for Ethernet & PPP and ii) transparent-mapping (GFP-T) for fiber channels, ESCON, FICON, and GbE. This development makes use of GFP-F. **Figure 2** outlines the GFP technology.

### 3.2 VCAT

VCAT divides up signals for transmission on an STM network. It makes effective use of bandwidth by sending data on multiple channels while making them appear as one channel. VCAT is illustrated in **Fig. 3** and compared with more conventional technology in **Fig. 4**. As shown in Fig. 3, VCAT works as follows.

(1) Input signals at the sending end are divided into smaller units before they are sent to their destination. At the receiving end, (2) the differential delay between the individual VC-3 and VC-4 paths is detected and (3) compensated before (4) the original signal is restored. An advantage of this approach is that, by dividing up the signals for transmission, more effective use can be made of the available bandwidth. For example, when a GbE signal is sent as one signal, conventionally this must be done using a VC-4-16c (2.4 Gbit/s), which consists of 16 contiguously concatenated VC-4 paths, so the utilization rate is only 42% ((1) in Fig. 4). Using virtual concatenation, the same data can be sent on a VC-4-7v, which consists of seven virtually concatenated VC-4 paths. This uses only 1.05 Gbit/s, resulting in a utilization rate of 95% ((2) in Fig. 4).

The system uses virtual concatenation only for Ethernet signals. VCAT provides paths of various capacities with the granularity of VC-3 (50 Mbit/s) and VC-4 (150 Mbit/s). An arbitrary path capacity can be set, which enables an arbitrary path throughput to be set independent of the accommodating interface capacity. The path capacity that can be set with virtually concatenated paths ranges from VC-3-1v (52 Mbit/s) to VC-3-48v (2.4 Gbit/s) and from VC-4-1v (150 Mbit/s) to VC-4-16v (2.4 Gbit/s).

### 3.3 FE package development

The FE package implements the Fast Ethernet interface, which is a supplementary standard to the widely used 10- and 100-Mbit/s Ethernet. It supports Ethernet at the bottom two layers of the OSI reference model, and accommodates 8 or 16 IEEE802.3 Ethernet channels.

Of the Ethernet (10 and 100 Mbit/s) standards, it

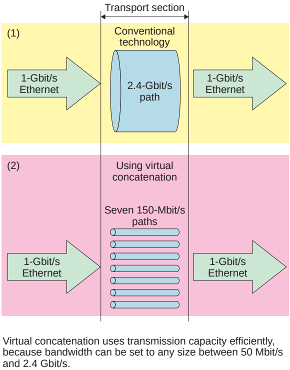


Fig. 4. Virtual concatenation compared to existing technology.

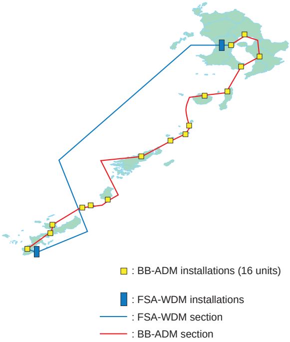


Fig. 5. Ring configuration.

supports 10Base-T and 100Base-TX. Auto-negotiation is used to select 10Base-T or 100Base-TX, half-duplex or full duplex mode, and whether or not flow control is used. An auto-MDI/MDI-X function prevents connection failure resulting from differences between straight and cross cables connecting visiting equipment to the BB-ADM.

### 3.4 GbE package development

The GbE package supports a 1000Base-LX/SX interface for BB-ADM use. The GbE package is a 100-fold extension of the popular 10-Mbit/s Ethernet interface. Introducing the GbE package is a low-cost way of upgrading an existing LAN or WAN to broadband speeds. The GbE package comes in two versions, LX and SX, designed for long- and short-distance applications, respectively. The only difference is in their optical interface, so we developed both types on a common main board, which improves development efficiency and eases operations and maintenance. The version is determined by which one of two SFPs (small form-factor pluggable modules) is installed. The package version can also be changed later by exchanging the SFP, which provides good stock flexibility.

## 4. Interoperability with existing infrastructure systems

The network system had to be designed for interoperability with nodes in the existing network infrastructure. Since the BB-ADM was originally developed as a leased circuit service node system, connection to existing infrastructure systems had never been tested. The BB-ADM interface specifications, however, already cover the specifications for existing infrastructure nodes, making it possible to complete interoperability testing by confirming the ability to connect and to transmit alarm signals. The verification results were good. Ten systems in all have been tested, including:

- FSA-WDM
- switchboard systems: ASM and SBM modules for an MHN-S
- SDH transmission systems: XCM/TCM
- ATM systems: ATM-SLT/ATM-XC/ATM-OLT
- leased circuit systems: DSM/DSM-L.

(FSA-WDM: fiber submarine transmission using in-line optical amplifiers with wavelength division multiplexing; ASM: architectural STM module; SBM: subscriber module; MHN-S: multimedia handling node for STM; XCM: cross-connect-module, TCM: termination converting module; SDH: synchronous digital hierarchy, ATM: asynchronous transfer mode; SLT: subscriber line terminal; XC: Xerox connect; OLT: optical line terminal; DSM: dedicated service handling module (–L: large type)).

## 5. Installed area

The network described here has a ring configuration consisting of two routes: one connecting Kagoshima and Okinawa directly and the other running through the islands in between them. The island-hopping route, connecting nine islands between Kagoshima and Okinawa, consists of 16 BB-ADM installations with a maximum separation of 130 km. The direct route, using FSA-WDM, is approximately 900 km long. Together the two routes make up a ring approximately 2200 km in total length (**Fig. 5**). The introduced equipment is currently operating stably.

## 6. Future work

In order to build long-distance rings over wider areas, we are continuing to develop an intra-office interface package to extend the transmission distance between BB-ADM installations.


**Akira Hirama**
Transmission Systems Development Project, Second Promotion Project, NTT Network Service Systems Laboratories.
He graduated from Tokyo Denki University high school. He joined NTT in 1986 and engaged in the maintenance and provisioning of SDH transmission systems and leased circuit service systems. He has been engaged in the development of SDH transmission systems and leased circuit service systems since 2001.

**Kenji Sasajima**
Transmission Systems Development Project, Second Promotion Project, NTT Network Service Systems Laboratories.
He received the B.E. and M.E. degrees in mechanical engineering from the Science University of Tokyo, Tokyo in 1994 and 1996, respectively. He joined NTT in 1996 and engaged in the maintenance and provisioning of leased circuit service systems. Since 1998, he has been engaged in the development of SDH transmission systems.

**Kazutaka Zaima**
Research Engineer, Transmission Systems Development Project, Second Promotion Project, NTT Network Service Systems Laboratories.
He received the B.E. and M.E. degrees in physics from Yamaguchi University, Yamaguchi in 1991 and 1993, respectively. He joined NTT in 1993 and engaged in development of the "ÉŒ-system" and "super-high-speed common carrier leased line". Currently he is engaged in the development of SDH transmission systems. He is a member of the Institute of Electronics, Information and Communication Engineers.