R&D Toward Cost Reduction and Quick Response to Increasing Demands for Optical Services

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Abstract

This article gives an overview of key technologies that will support the large-scale provision of optical services by simplifying optical fiber storage work through the use of connectors and modular products.

1. Issues surrounding the optical access network

The rapid growth in demand for broadband services has led to an urgent need for quick optical access network installation and simple, easy-to-use, and convenient optical fiber and cable technologies. In addition to lowering costs while maintaining functions and quality levels, we need new technologies that will enable us to respond quickly to increasing demands in the era of mass construction of the optical network. We must revolutionize the work of field engineers by simplifying techniques to lower the required skills and by making optical fiber easier to handle. The following issues are associated with the optical access network.

- Special skills are required for storing optical fiber in aerial optical closures and optical cabinets.
- Special skills are required for reconnecting optical fiber in aerial optical closures when the customer requests another service.
- Troubleshooting in aerial optical closures and optical cabinets is difficult.
- Special skills are required for handling optical cable and fiber inside a house.

If we could eliminate the troublesome work of storing bare optical fiber while ensuring that fiber is not bent tighter than the allowed bending radius, then we should be able to greatly reduce the work skills needed to handle optical fiber. And if optical fibers could be connected together using connectors, then the work of reconnecting fibers would become much simpler. To meet these needs, NTT is researching and developing technologies that do not require workers to have special skills and optical fiber that can be handled with the same ease as metallic cable (**Fig. 1**).

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2. Recent developments

This section gives an overview of some key technologies (**Fig. 2**) that have recently been developed to solve the problems of providing optical access facilities to 30 million subscribers by 2010, which is NTT's target. They have already been reported separately in NTT Technical Review, but this overview presents them together to give readers a clearer idea of how they fit together.

(1) FA connector [1]

Our field assembly (FA) connector has a structure that directly holds the outer sheath of an optical-fiber drop cable or indoor cable and prevents the optical fiber itself from being exposed. The interior of the FA connector includes a ferrule, an optical fiber with a polished tip, and a mechanical splice.

To assemble an FA connector, a worker fixes the outer sheath at the end of an optical-fiber drop cable or indoor cable using the sheath-holding part of the connector and then attaches the sheath-holding part to a larger holder. Then, using a stripper or fiber cutter, he or she cuts the optical fiber to a specified length and inserts that strand of fiber into the main

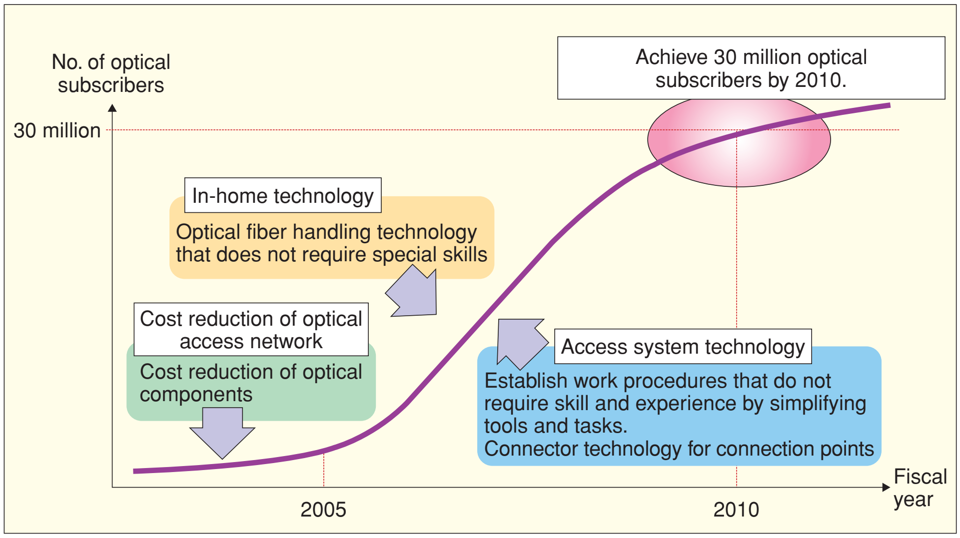
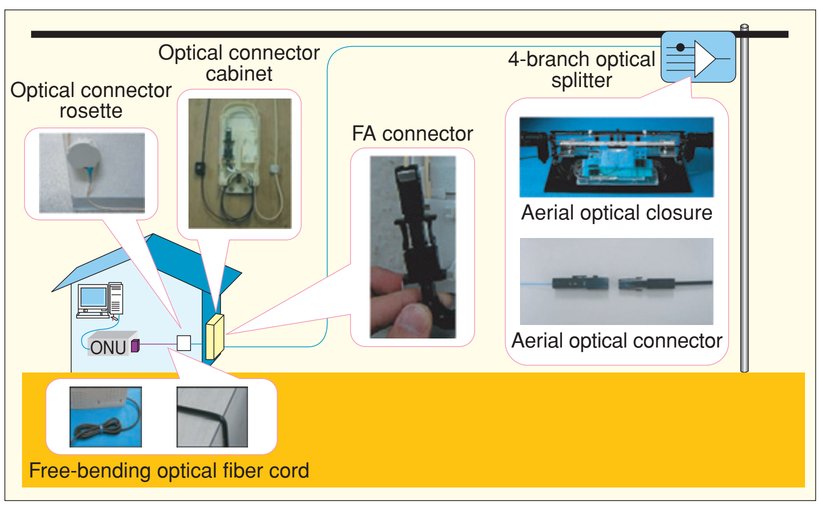


Fig. 1. Development path toward an era of mass optical network construction.



ONU: optical network unit

Fig. 2. Recently developed key technologies toward 30 million optical access subscribers.

unit of the FA connector. Finally, the worker connects the optical fiber using the mechanical splice inside the connector and fixes the sheath-holding part to the main unit of the FA connector to complete the assembly. Once the conventional mechanical splice technique has been applied, the unit can be easily and reliably assembled on the spot without the use of special tools. This method also achieves high reliability: it can achieve a connection loss of only about 0.3 dB and it satisfies the requirements for outdoor conditions in terms of temperature characteristics in prolonged high temperature and humidity.

The FA connector consists of a plug and a socket (FA connector plug and FA connector socket), as shown in **Fig. 3**. These can be connected directly to each other without the need for an adaptor. They are designed to be connected and disconnected many times. The FA connector socket can also be connected to (and disconnected from) an SC connector plug, which conforms to the JIS C 5973 standard. Moreover, because its structure is designed to change the output direction of an optical-fiber drop cable or indoor cable by 90º while reducing overall cable length, the FA connector socket will easily fit in the most commonly used outlet box (shallow-type switch box conforming to JIS C 8435), as shown in **Fig. 4**.

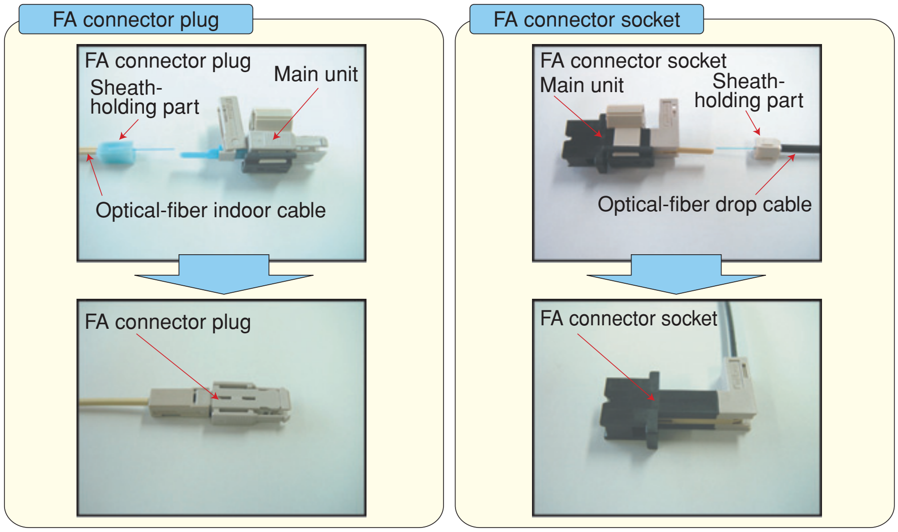


Fig. 3. Typical structures of FA connector plug and socket.

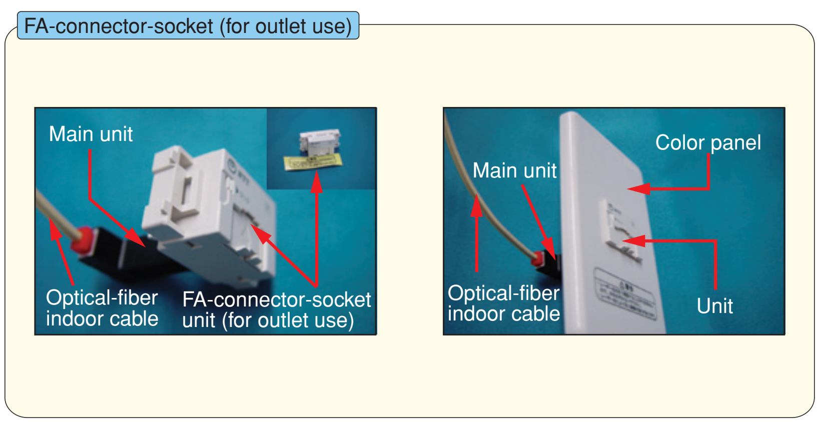


Fig. 4. Typical structures of FA connector socket (for outlet use).

(2) Optical cabinet [1]

In existing outdoor optical cabinets, optical fibers are connected by either fusion or mechanical splicing. Consequently, they must provide storage space for surplus fiber to allow repeated cutting and splicing. Storing this delicate reserve fiber after a connection has been made or after troubleshooting in the event of a failure takes time and skill. An optical cabinet that incorporates an FA connector as a connection point solves such problems in existing outdoor optical cabinets. It improves operability and also enables the cabinet size to be reduced because it improves maintainability (**Fig. 5**).

The FA connector has enabled a 40% reduction in the man-hours required to perform connecting and storing work in the cabinet and has enabled the volume to be reduced to only about 35% of that of existing products. The FA connector socket also allows connection and disconnection of an SC connector plug, which makes troubleshooting at connection points inside optical cabinets much simpler and streamlines maintenance operations. There is no need to store bare optical fiber, which reduces the number of components needed for storing optical fiber and improves the cost efficiency.

(3) Optical connector rosette [1]

The optical connector rosette, which is installed inside the user's home as shown in Fig. 2, uses an FA connector socket at the connection point inside the rosette, resulting in a smaller unit (**Fig. 6**). As in the case of the optical cabinet, the man-hours for connection and storage work in the rosette were reduced by

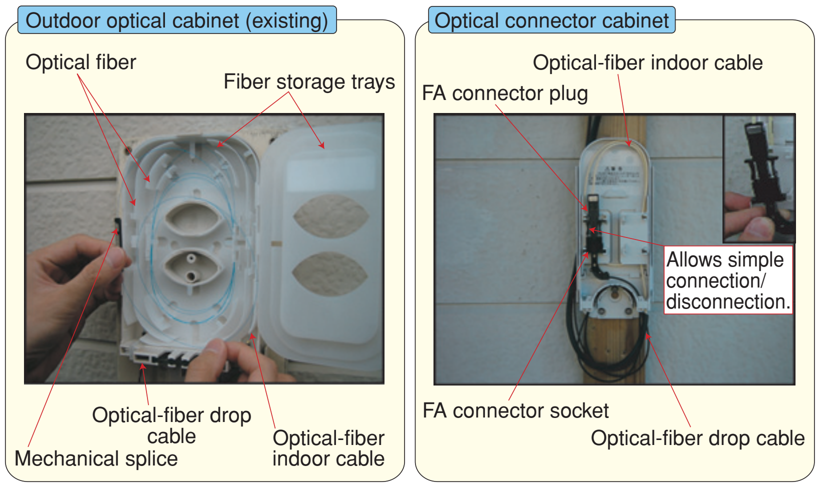


Fig. 5. Outdoor optical cabinet and optical connector cabinet.

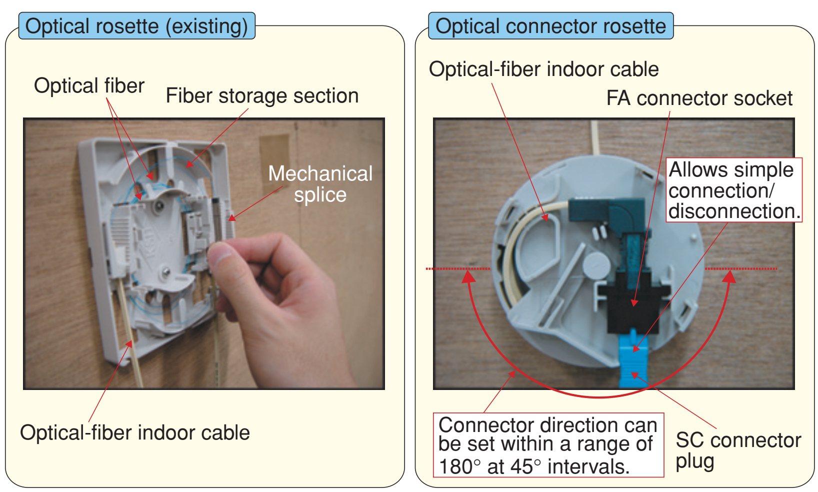


Fig. 6. Optical rosette and optical connector rosette.

about 40% through improved workability because there is no need to store bare optical fiber. The rosette allows a choice of five exit directions for the indoor optical fiber cable because the FA connector orientation in the optical rosette can be changed in 45º steps to suit the installation environment. Use of an FA connector here has enabled us to reduce the volume of the rosette by as much as 60% compared with existing products while simplifying troubleshooting at connection points inside optical rosettes and improving maintainability.

(4) Free-bending optical fiber cord [2]

Optical fiber that can be wired simply and neatly without special skills in much the same way as metallic cord will be an important factor in satisfying user needs as optical services are rapidly deployed on a large scale. To this end, we have developed a free-bending optical fiber cord that can be bent, folded, and tied as needed just like a metallic cord [2], [3]. It consists of holey fiber, a cord cover to protect the fiber, and a dustproof connector. The holey fiber is based on hole-assisted fiber (HAF), which has a highly refractive glass at its core and glass containing holes in its cladding. This design produces a strong light-confinement effect, which means that there is little bending loss even when the cord is bend with a very small bending radius. The cord cover has an outer diameter of 4 mm and a structure that reduces the load on the inner optical fiber when the cord is bent or stepped upon. It features a flexible material

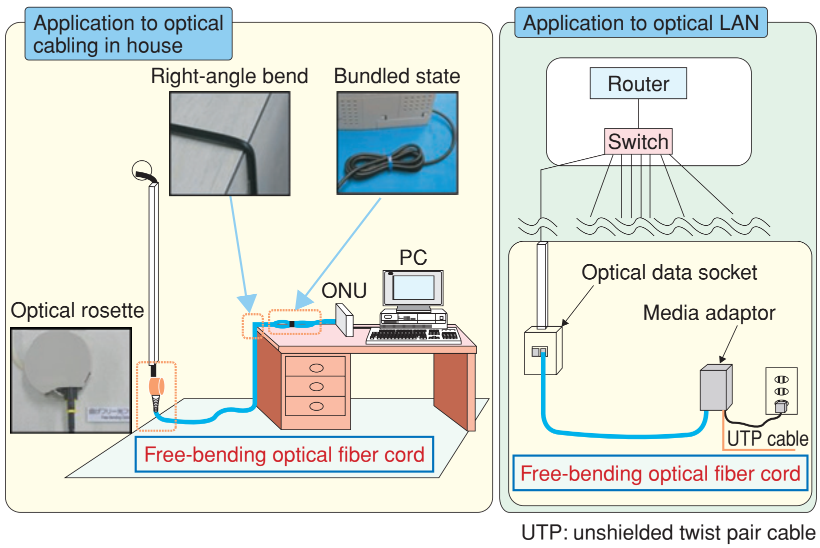


Fig. 7. Application examples of free-bending optical fiber cord.

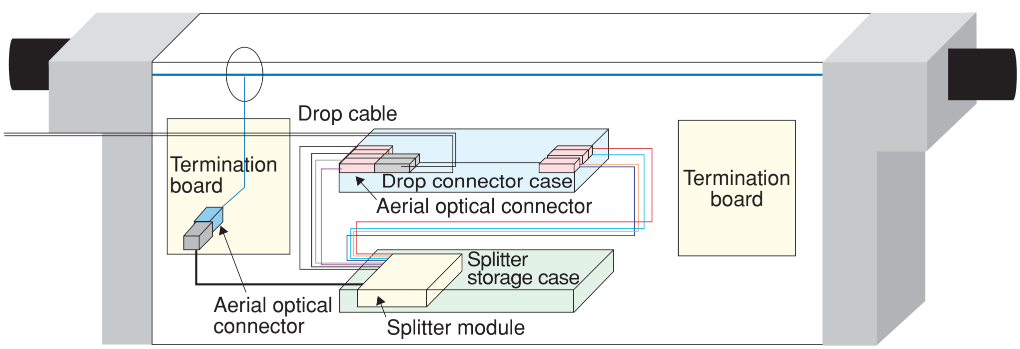


Fig. 8. Wiring format of new aerial optical closure.

conducive to bending to facilitate handling and to allow the tying or bundling of excess cord without affecting communications or leaving kinks after untying. The dustproof connector is compatible with SC connectors and features a shutter mechanism to protect the tip of the optical fiber from dust.

If a house is equipped with an optical socket like an optical connector rosette, this free-bending optical fiber cord can simplify home wiring of optical fiber, enabling home users without specialized knowledge to install it just like electrical or telephone wiring. Free-bending optical fiber cord can also be used for wiring optical local area networks (**Fig. 7**).

(5) Aerial optical closure [2]

Work in an aerial closure involves connecting optical fiber using a fusion or mechanical splice, so a long length of optical fiber must be stored in a tray. The optical fiber must be handled carefully during the storage work because it is thin and fragile. This storage work is also time consuming and thus poses an obstacle to large-scale optical service construction. Moreover, once a joint has been cut, it must be reconnected to a new optical fiber when the customer requests another service. To solve these problems, we have developed an aerial optical closure that uses connector-based connections [2], [4]. It has the following internal wiring format. An aerial optical connecter (described below and shown in Fig. 10) is attached to optical fiber wired from an optical cable, and it is wired to a terminal board and connected to the input side of a splitter module. Next, the optical fibers on the output side of the splitter module are wired to the drop connector case. These are connected to the drop-cable and run into a customer's residence (**Fig. 8**). Connectors are attached to input/output optical fibers of the splitter beforehand, and these

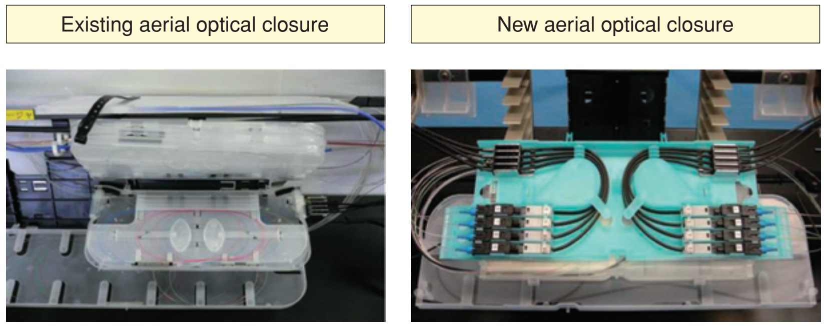


Fig. 9. Storage formats inside aerial optical closures.

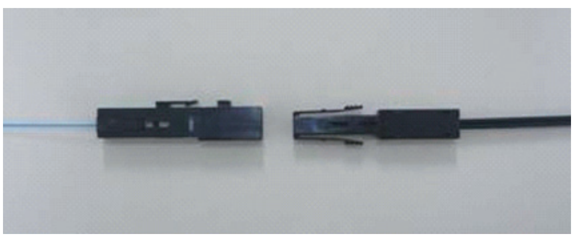


Fig. 10. Appearance of aerial optical connector.

fibers are protected. Therefore, storage work becomes very simple. This aerial optical closure:

- Reduces the need for storing bare optical fiber and hence simplifies the storage of optical fiber (**Fig. 9**)
- Makes connection work easy by using a connector
- Simplifies storage work by modularizing the splitter function
- Eliminates the need for special protection for optical fibers.

All in all, storage and connection work is greatly improved compared with the existing system. A change of service can be implemented just by disconnecting and reconnecting optical connectors and the optical fiber can be handled as easily as metallic cable. The above technical features are expected to make a great contribution to large-scale optical service construction and to simplify maintenance work in the future.

The connector discussed above is shown in **Fig. 10** [2], [5]. It is based on the FA connector (1). It is used for connecting fiber within an aerial optical closure in the aerial section of optical fiber cables running from an NTT switching station to customer houses and it is designed for assembly in the field by workers. It can be installed easily in a short time with no special tools and its use for making connections within an aerial optical closure enables the time required for connecting and storing optical fiber to be reduced by about 40%.

3. Conclusion

The technologies described in this report are extremely important for mass construction of the optical access network and are expected to simplify field work greatly. As optical services spread rapidly and become familiar to users, "ease of use" will become an even more important factor. To support the rapid construction of the optical network and reduce the total cost, we will continue our R&D efforts toward skill-free and low-cost optical products and technologies.

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