Versatile Optical Fiber Cabling Technologies for Existing Buildings

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Abstract

We have developed a *single 8-core low-friction indoor optical cable* for high-precision cabling and a range of enhanced modules (*E modules*), which can be installed as demand requires. These versatile technologies overcome the problems encountered in the provision of optical fiber cabling to customers in small to medium-sized multi-dwelling units owing to the limited free space in existing conduits in customers' buildings. These technologies are also applicable for cabling in large buildings.

1. Introduction

In September 2011, the number of fiber-to-the-home contracts in Japan surpassed 21 million [1]. However, since approximately 42% of Japanese families live in multi-dwelling units (MDUs) [2], optical cabling systems for MDUs have become important. In contrast to FTTH cabling schemes for detached houses, which consist of a 4-branch optical splitter in the central office and 8-branch splitter module parts (SPs) installed on the user side (supporting 32 subscribers), schemes for MDUs and office buildings use 32-branch SPs (or a cascade of one 4-branch SP followed by four 8-branch SPs) [3].

As shown in **Fig. 1**, *small-diameter low-friction indoor optical cables* (hereinafter, narrow indoor cables) that enable multiple cable laying in conduits and *splitter module types suitable for dividable cabinets* (D cabinets) that can be installed in the empty spaces within facilities in MDUs and other buildings (telephone conduits, main distribution frame (MDF) boxes, and so on) have been developed [2]–[4] and implemented to expand the range of available cabling systems. These developments have contributed to a reduction in the number of small and medium-sized MDU buildings for which no optical fiber cabling systems exist; however, it is still not possible to provide optical services to all customers: as shown in Fig. 1, one reason is that customer telephone conduits (especially vertical conduits between floors) are not big enough to accommodate all of the cables required. Therefore, to provide services to even more customers, we need to provide products that enable a flexible response to demand in existing buildings.

2. Development concept

To overcome the cabling difficulties in small to medium-sized MDUs, conventional cabling techniques need to be substantially revised. Some specific cabling systems are shown in **Fig. 2**. Normally, narrow indoor cables are laid in a vertical conduit as customer demand arises, although this depends on the space available in the conduit: it is usually possible to lay one or two cables in a conduit, but it is often difficult to lay more once a conduit has three or more cables. There have also been problems with ensuring space to install distribution modules (module Ds) when laying 4-core indoor optical cables. To tackle these issues, we have developed a *single 8-core low-friction indoor optical cable* (8ST indoor cable). It can be inserted into a vertical conduit in advance and then branched on-demand using optical cables at the

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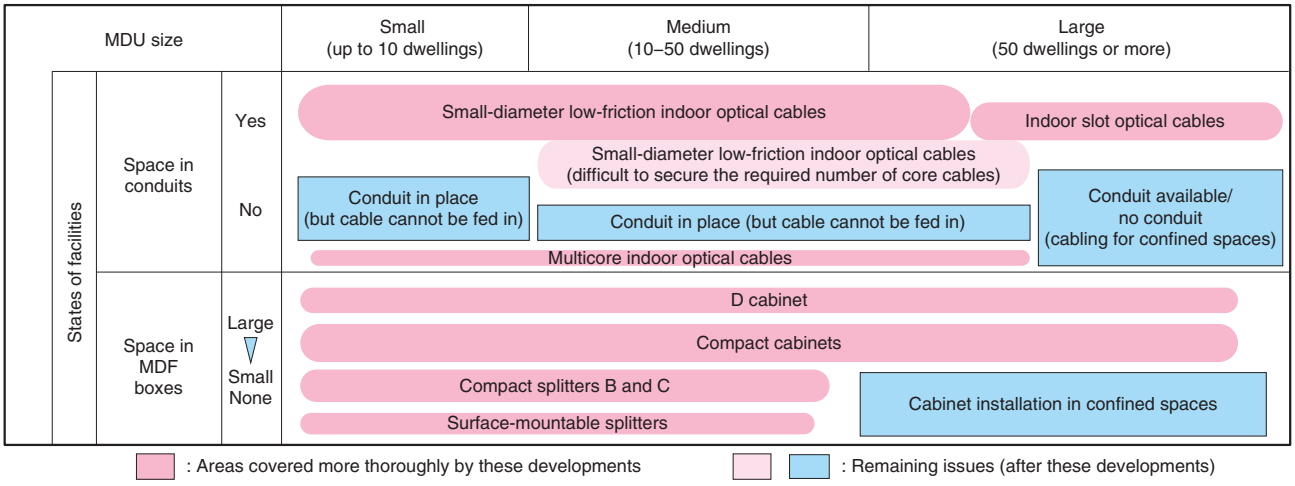


Fig. 1. Areas covered by the new developments and remaining issues.

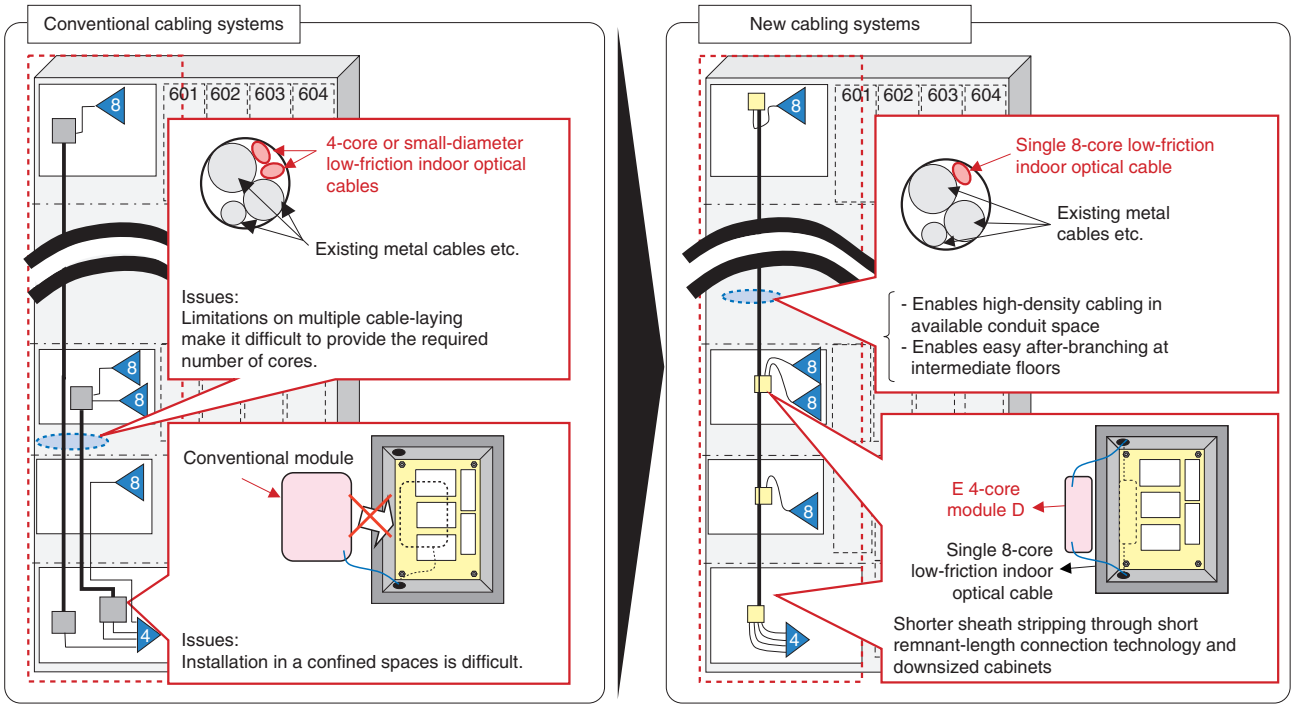


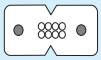
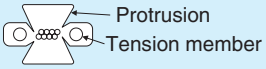
Fig. 2. Comparison of conventional and new cabling systems.

customer's floor and *space-saving enhanced modules* (E modules) to protect the connection point and the branched optical cables.

2.1 Single 8-core low-friction indoor optical cable

We aimed to create an 8-core indoor optical cable that can be laid in the space previously taken up by two narrow indoor cables in a narrow conduit and that can be worked with ordinary tools such as nippers for after-branching work. We chose eight cores because this enables service provision to all customers from an 8-branch splitter.

Table 1. Comparison of conventional and new cables.

	Conventional cable (8S-core indoor cable)	New cable (8ST indoor cable)
Shape		
Size	1	1
Friction comparison	1	1/5 Same as small-diameter low-friction indoor cable
Push-feed workability	×	○
After-branching workability	×	○

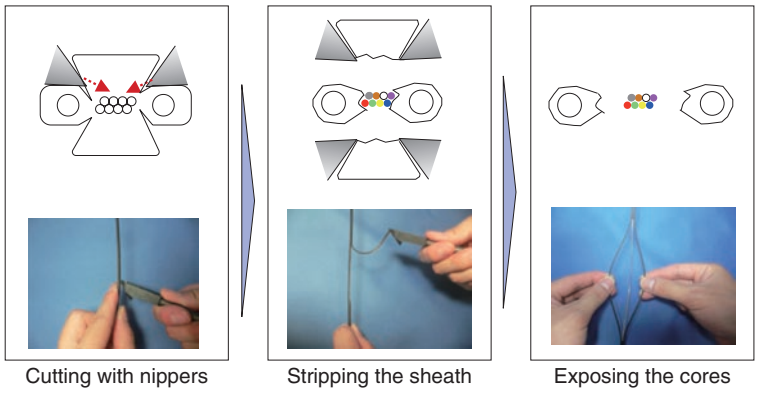


Fig. 3. Stripping the 8ST indoor cable.

The newly developed cable (8ST indoor cable) is compared with the conventional multicore indoor optical cable (8S-core) in **Table 1**. The 8ST cable consists of two tapes, each containing four single-core fibers (S: single-core; T: tape); the 8S cable consists of eight single-core fibers (S: single). The 8ST indoor cable has almost the same external dimensions as the 8S-core indoor cable, but is easier to lay in conduits: we have used a low friction outer sheathing material similar to that used for narrow indoor cables. This lowers the amount of force required to pull or push the cable through a conduit during cable laying work.

In the after-branching of conventional cables, pulling out the desired core from a multicore indoor cable was problematic on intermediate floors with lines in operation. Furthermore, specialized stripping and dividing tools were required to expose the core in aerial cables that can be after-branched. However, as shown in **Fig. 3**, our new cable can be stripped using ordinary tools that service personnel normally have at hand, which avoids the need to equip them with new specialized tools.

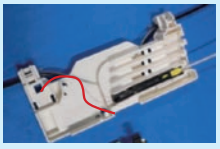
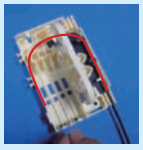
2.2 Enhanced modules (E modules)

With conventional modules, work is needed to pack wires into the module's housing. To reduce the amount of this work, and in consideration of maintenance, we also aimed to develop modules that can accommodate cable in non-looping lengths.

Our newly developed modules are compared with a conventional one in **Table 2**, where the red lines (guides for the eye) indicate the looped and non-looping storage configurations. As indoor modules for use in conjunction with the 8ST indoor cable, we have developed the enhanced 4-core distribution module (E 4-core module D) that enables up to four cores to be distributed and can be mounted on a post as required and the enhanced 8-core termination module (E 8-core module T) for installation at the cable ends.

To enable cable to be stored inside the module in non-looping lengths (all photographs for new modules except the leftmost (conventional module) in

Table 2. Comparison of conventional and new modules.

		Conventional module	New modules (E modules)		
Installation point		Indoors/outdoors	Indoors		Outdoors
Installation area ratio		1	1/2		1
Installation method		In advance	After installation	In advance	In advance
Cable stripping length		1	1/10 approx.		
	Cable packing	Looped cable storage inside the module 	Non-looping cable storage reduces cable packing work  E 4-core module D	 E 8-core module T	 E multicore storage tray (set)

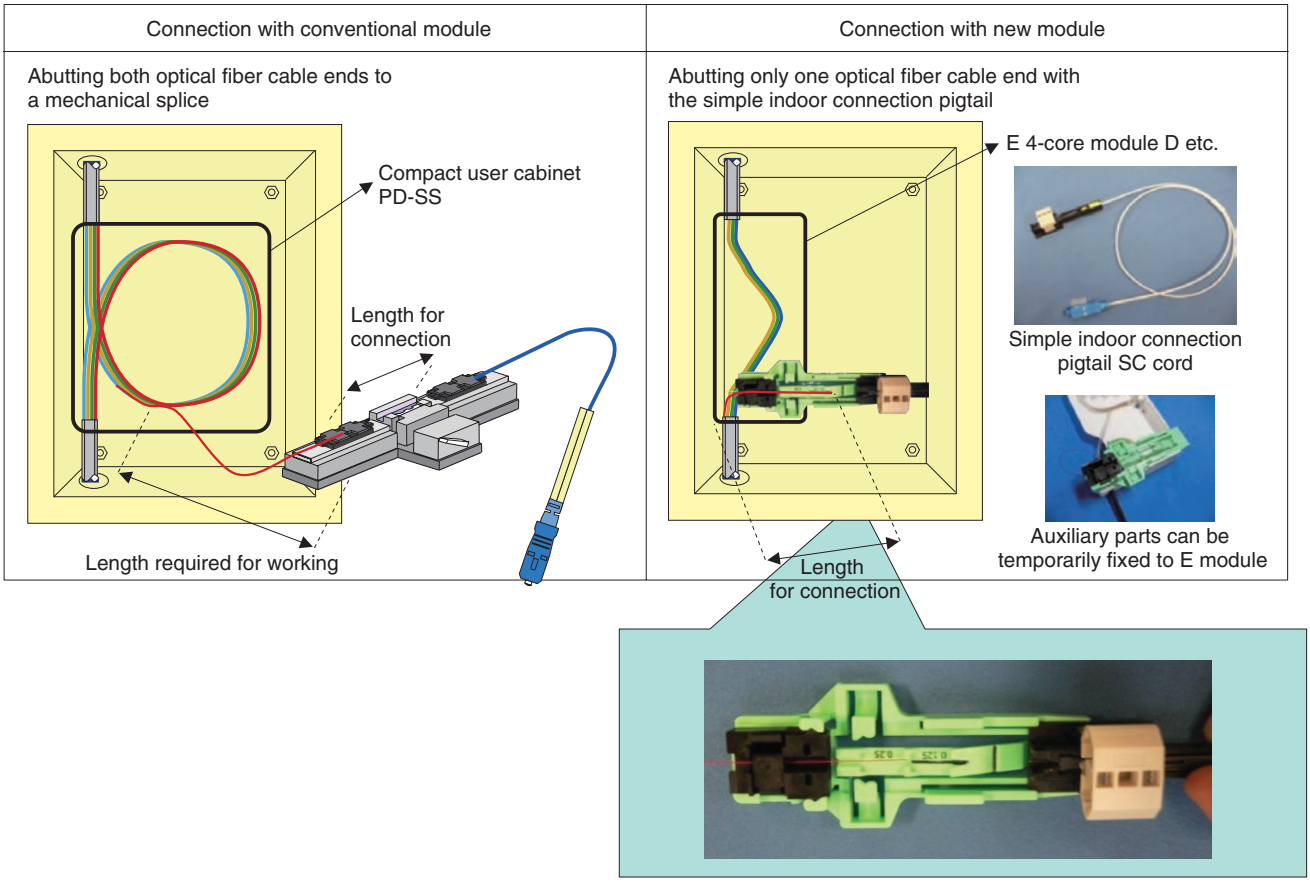


Fig. 4. Comparison of connection methods for conventional and new modules.

Table 2), it was necessary to revise the conventional connection methods. As a result, we developed a simple indoor connection pigtail in which an SC connector cord is attached to a mechanical splice made in advance, as shown in **Fig. 4**. With conventional modules, approximately 2 m of cable, consisting of the length for connection and the length for working, had to be stripped and packed inside the module. To store

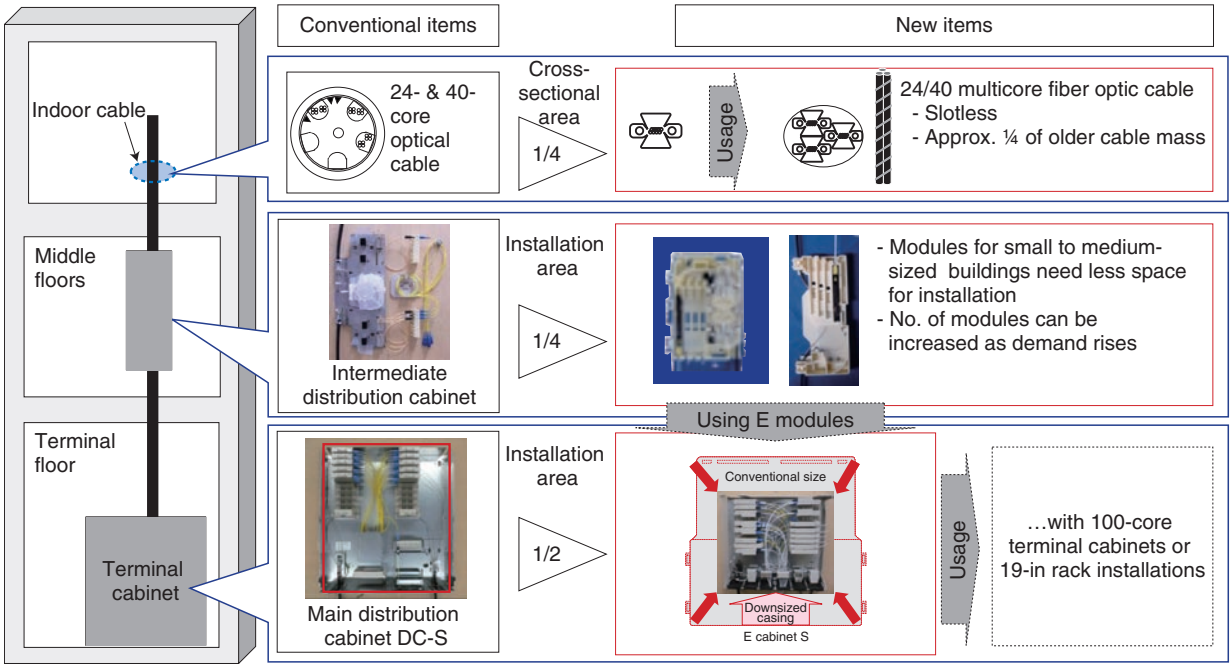


Fig. 5. Comparison of components for application to large buildings.

this fiber without bending it beyond its minimum bending radius, it was packed in a circular loop. With the new modules, on the other hand, the necessary length is only that required for connection; moreover, the length required for connection is shorter, so the length of cable that needs to be stripped is reduced by approximately 90%, enabling non-looping storage. Furthermore, the modules themselves are about 50% smaller than the older versions, so they can be installed in small MDFs and other places.

We have also developed a set of *enhanced multicore storage trays* (E multicore storage trays) for use in conjunction with these modules and cables that can be installed on external walls etc. The E 8-core module T can also be housed in a box that is resistant to ultraviolet light and rain for outdoor installation. Furthermore, wall-mounted splitter modules can be attached to the cover of an E multicore storage tray with screws.

3. Application to large buildings

Currently, slot cable-type cables with 24 or 40 cores and a main distribution cabinet type S (DC-S) are available for buildings that have a large broadband demand such as office blocks. However, the 24- and 40-core optical cables require long lengths to be stripped, and because of the large size of the DC-S, there have been cases where approval could not be obtained through negotiation with customers. To counter these issues, the new 8ST indoor cable and E modules offer improved workability and better installation potential in large buildings. The new and conventional structures are compared in **Fig. 5**.

The new 24- and 40-core multifiber cables consist of either three or five 8ST indoor cables bundled together and are approximately 75% lower in mass and smaller in diameter than the older versions. Used in conjunction with the E modules, these cables enable elemental termination or mid-cable connection as required. Moreover, while the older cables can be bent to a radius of 30 mm, the new version can tolerate being bent to a radius of 15 mm, which greatly improves cabling workability.

E cabinets house E modules in cases that are the same size as those used in the conventional cabinets (PT cabinets). In this way, the workability of the D cabinet is retained, while the area required for installation is reduced by 50%. We have made the connection method simpler with the simple indoor connection pigtail. Modules that can be installed in the E cabinet can also be installed on shelving in existing D cabinet racks. Moreover, the cable grippers in PT cabinets can be opened wider than usual, so these

newly developed items are compatible with existing systems. Moreover, with cabinets, we are considering ways to mount the items in trays for 19-inch rack installations designed to meet high demand.

4. Future plans

We will support the speedy deployment and expansion of services by improving workability in existing conduits between floors in MDUs through the introduction of the optical cabling technologies that we have developed. We intend to phase out existing cabinet products through the deployment of the cabinet products introduced in this article.

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