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Multidirectional Submarine Optical Branching Unit

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ABSTRACT

Submarine optical communication systems use branching units to connect branches of a cable to a main cable trunk. Typically, optic fibers from the trunk are branched to one of two branches, while inter-branch communication is nil. This disclosure describes an architecture for an optical branching unit that enables simultaneous inter-branch and trunk-branch connectivity. Connectivity between the trunks and branches is established using optical switches within the branching unit. The techniques enable greater and more effective use of expensive network infrastructure such as submarine optic fibers and optical branching units.

KEYWORDS

- Submarine branching unit
- Optic fiber
- Submarine optic fiber
- Branching unit
- Optical branching unit
- Multidirectional branching unit
- Submarine optic fiber
- Optical switching

BACKGROUND

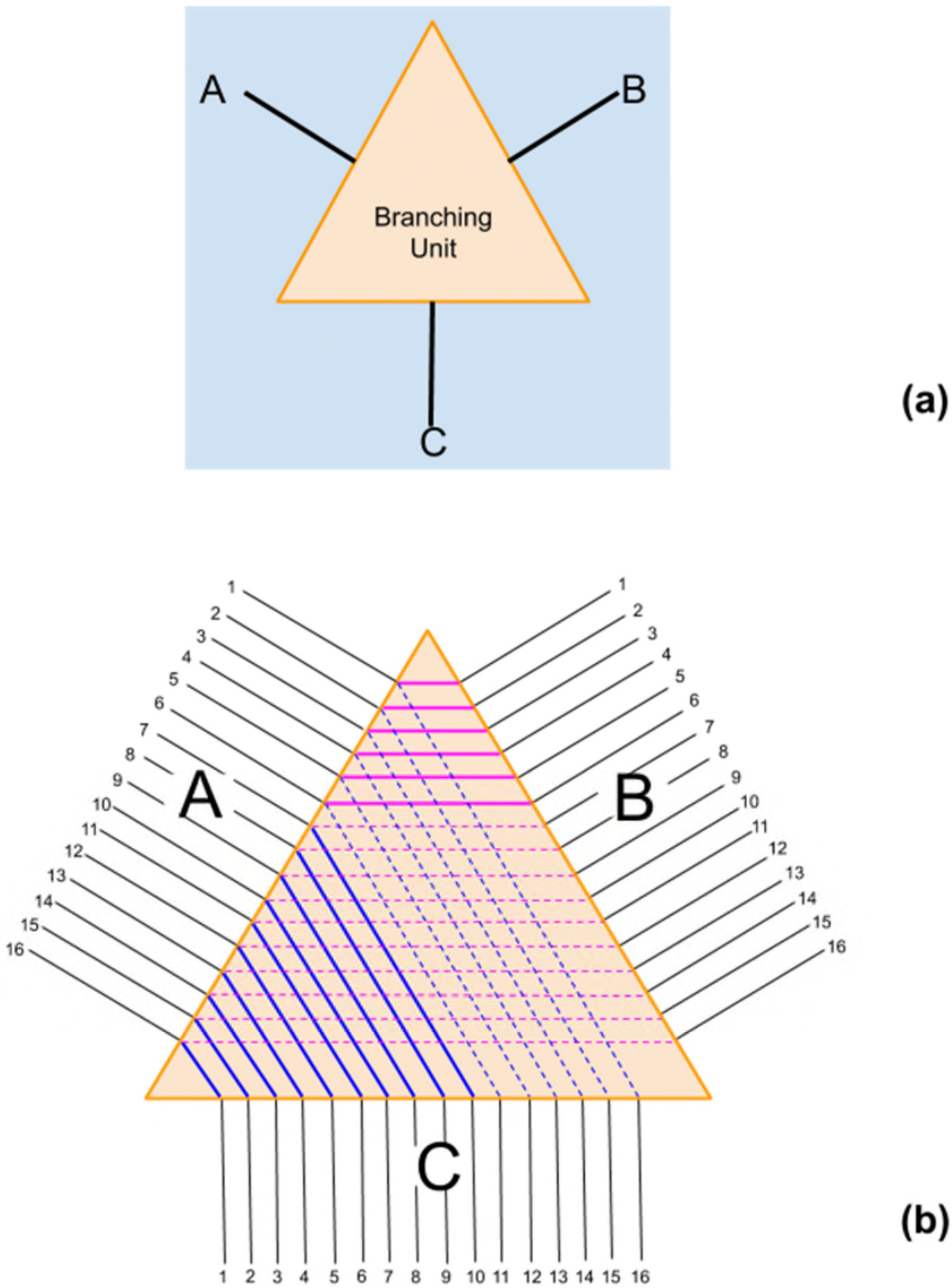

Fig. 1: A submarine optical branching unit (a) schematic (b) exploded view

Submarine optical communication systems use branching units to connect branches of a cable to a main cable trunk. Fig. 1 illustrates a submarine optical branching unit, which branches, or splits, optical fibers originating from a trunk A between branches B and C. The trunk A or branches B and C can connect to large geographical regions, e.g., countries or continents.

Fig. 1(b) illustrates an exploded view of the branching unit. In this example, there are sixteen incoming optical fiber pairs in trunk A. An optical fiber pair carries bi-directional communication. An incoming optical fiber pair can be connected to a port of branch B or of branch C. In this example, incoming fiber pairs 1 through 6 are connected to branch B, and incoming fiber pairs 7 through 16 are connected to branch C. Although the possibility exists for six optical fiber connections between branches B and C, this possibility remains unutilized. This is typical; while optic fibers from the trunk are branched to one or the other of two branches, inter-branch communication is nil.

Although existing branching units (BU) offer some within-BU optical switching, their capabilities are limited to the bi-directional branching (1×2) of trunk traffic from one trunk fiber-pair to two branch fiber-pairs, or the dropping of trunk traffic from one of two trunk fiber pairs to a bi-directional branch.

DESCRIPTION

This disclosure describes an architecture for an optical branching unit that enables simultaneous inter-branch and trunk-branch connectivity. Connectivity between the trunks and branches is established using optical switches within the branching unit. The optical switches enable directing traffic on a given fiber-pair to the trunk or to one or the other branch of the branching unit.

Denoting the total number of incoming trunk optical fiber pairs as NFP and the number of dynamic A-B connections as N, the number of dynamic A-C connections is NFP−N. Per the techniques of this disclosure, a certain number K of C-B (branch-to-branch) connections can be established, where K = min(N, NFP−N).

In the example of Fig. 1, NFP=16, and the number of A-B connections N=6; thus, the number of A-C connections is NFP−N=10. The number K of C-B (branch-to-branch) connections is min(N, NFP−N) = min(6, 10) = 6.

As another example, if NFP=16 and N=8, then K=8 as well. In this case, the number of A-B, A-C, and C-B connections are each equal to eight optical fiber pairs.

With the increased interconnectivity between the trunks and branches of a branching unit, a table of priority of connections is defined as follows:

Priority	Link	Branching unit configuration	Notes
1	A-B	0 to NFP	If the number of A-B connections is N, then the number of A-C connections is NFP−N
	A-C	0 to NFP	
2	C-B	0 to NFP/2	If the number of A-B connections is N, then the number of C-B connections is min(N, NFP−N).
3	C-B	0 to NFP	If the number of C-B connections is greater than NFP/2, then some A-C fiber pairs will be dark.

Table 1: Prioritization of the switching features of the branching unit

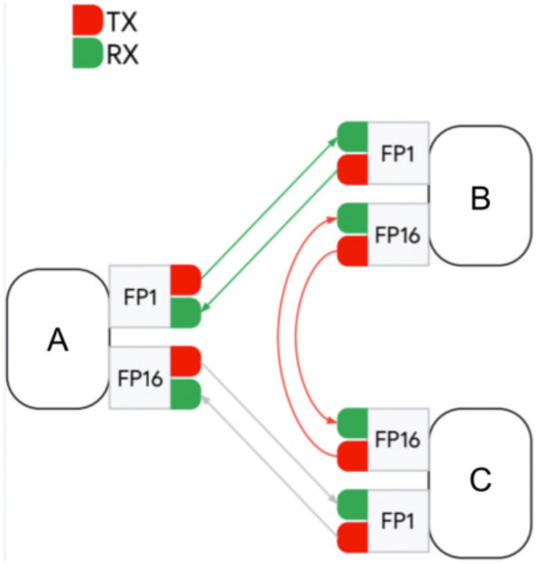

Fig. 2: Pairwise interconnect of fiber-optic pairs within a branching unit

Fig. 2 illustrates an example architecture that enables simultaneous trunk-branch or inter-branch connectivity within an optical branching unit. At a trunk or branch, fiber optic pairs (or their ports) are paired, e.g., fiber-pair 1 (FP) is paired with fiber-pair (FP) 16. In a similar manner, FP2 is paired with (for example) FP15; FP3 is paired with FP14; etc. At trunk A, one of the pairs (FP1) is bi-directionally connected to branch B, while the other (FP16) is bi-directionally connected to branch C. In a similar manner, branch B is connected to trunk A and branch C, and branch C is connected to trunk A and branch B. The architecture described in Fig. 2 enables the simultaneous connection of up to NFP A-to-B (or A-to-C) fiber pairs, N≤NFP A-to-C (or A-to-B) fiber pairs, and K = min(N, NFP−N) C-to-B (branch-to-branch) fiber pairs.

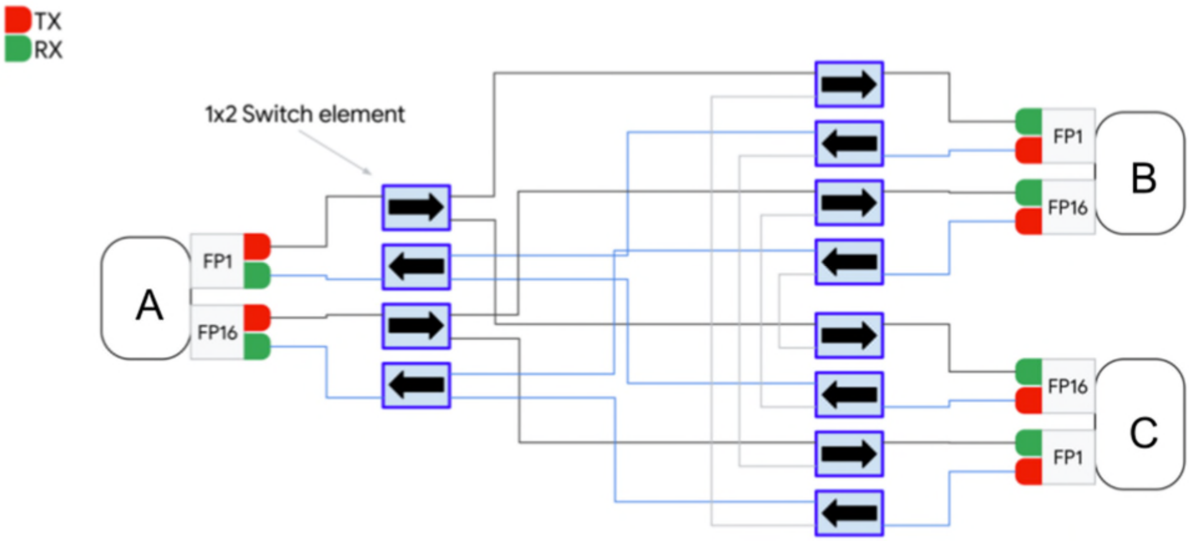

Fig. 3: An example implementation of pairwise interconnect of fiber-optic pairs within a branching unit

Fig. 3 illustrates an example implementation of pairwise interconnects of fiber-optic pairs within an optical branching unit to enable simultaneous trunk-branch or inter-branch connectivity within a branching unit. As illustrated, a single fiber-optic pair, e.g., FP1 at trunk A, can bi-directionally communicate with two branches using single-input-dual-output (1×2) switches. The number of switches is six times the number of the FP ports of the branching unit; for example, in a 24-port branching unit, the number of switches is 6×24 = 144.

In this manner, the techniques of this disclosure make greater and more effective use of expensive network infrastructures such as submarine optic fibers and optical branching units.

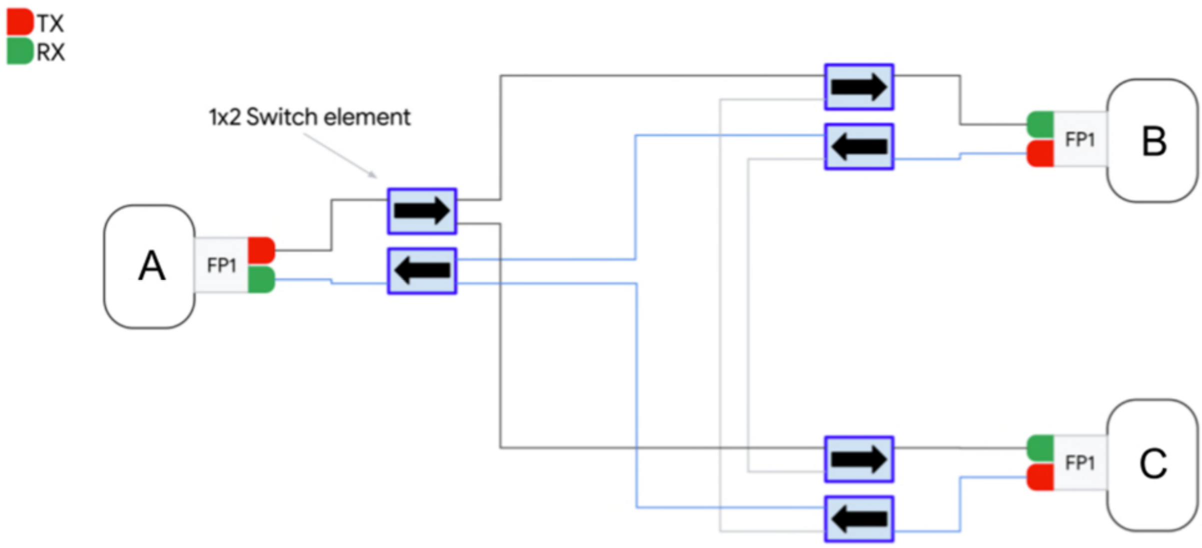

Fig. 4: An alternative implementation of fiber-optic interconnects within a branching unit

Fig. 4 illustrates an alternative implementation of fiber-optic interconnects within a branching unit. Although the implementation shown in Fig. 4 enables connectivity between any two of three nodes of a branching unit, it cannot implement prioritized connections, e.g., as specified in Table 1. For example, fiber-pair connections between branches B and C that are available after A-C and A-B connections are established can remain unused.

CONCLUSION

Submarine optical communication systems use branching units to connect branches of a cable to a main cable trunk. Typically, optic fibers from the trunk are branched to one of two branches, while inter-branch communication is nil. This disclosure describes an architecture for an optical branching unit that enables simultaneous inter-branch and trunk-branch connectivity. Connectivity between the trunks and branches is established using optical switches within the branching unit. The techniques enable greater and more effective use of expensive network infrastructure such as submarine optic fibers and optical branching units.