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Fiber to the Home-Shared Distribution Low Loss Network

Lekha Asnani

Electronics & Telecommunication Department Thadomal Shahani Engineering College, Mumbai University.

Abstract

A low-loss shared Fiber To The Home (FTTH) distribution network enables optical communications within a subscriber area, including optical fibers routed from a point of distribution to the subscriber area, a tap device including an optical tap which interfaces a downstream optical fiber with a first optical fiber, and a straight-through optical fiber which is routed straight through the tap device. The tap device includes a splitter which splits the downstream optical fiber into multiple downstream optical fibers, tap ports for the downstream optical fibers. Any number of straight-through optical fibers may be included which are routed straight through the tap device.

1. Introduction

A low-loss shared FTTH distribution network that enables reliable and cost effective optical communications to the home in a low-loss manner and also has an unlimited bandwidth.

Fiber To The Home (FTTH) is an attractive option that has received a significant amount of attention in recent years. Significant technological advances have been made in fiber optic communications. FTTH promises to deliver “true” broadband access compared to existing access technologies including network connections based on phone lines (DSL) or coaxial cable. The traditional Passive Optical Network (PON) approach to FTTH is to route a separate optical fiber to each subscriber location. This however, results in about 1,000 fibers on the average between each local node and the neighborhoods. This has proved to be an unwieldy architecture that is difficult to establish and prohibitively expensive to maintain. A low-loss shared FTTH distribution network according to an embodiment of the present invention includes a cable with optical fibers which is routed from the point of distribution into multiple subscriber zones, each subscriber zone including at least one subscriber location, a tap device

located within a first subscriber zone which includes an optical tap which taps a first one of the optical fibers with a downstream optical fiber providing at least a portion of an optical path provided to at least one first subscriber location within the first subscriber zone, and a straight-through optical fiber which is routed straight through the first subscriber zone and into a second subscriber zone.

The tap device may include ports (e.g., upstream and downstream ports) and the fibers may include fused connections and/or may be interfaced with fiber optic connectors. The tap device may further include a splitter which splits the downstream optical fiber into multiple downstream optical fibers. In this case of a splitter, the tap device may include tap ports for the downstream optical fibers. Each tap port may include a fused connection or a fiber optic connector. Also, any number of straight-through optical fibers may be included which are routed straight through first subscriber zone.

A low-loss shared optical plant according to an embodiment of the present invention includes a cable including optical fibers routed into multiple subscriber zones, each subscriber zone including at least one subscriber location, tap devices located within a first subscriber zone and including optical taps for interfacing downstream optical fibers with corresponding ones of the routed optical fibers, where each downstream optical fiber provides at least a portion of a corresponding one of multiple optical paths to first subscriber locations within the first subscriber zone, and at least one a straight-through optical fiber which is routed straight through the first subscriber zone and into a second subscriber zone. Multiple straight-through optical fibers may be included.

Table 1: Comparison between the Fiber To The Home and various Broadband technologies.

Technology	Spectrum Usage	Capacity	Max Range
HFC	7-860MHz	40Mbps	100km
ADSL	Upto 1.1MHz	1.5-12Mbps	5.4km
VDSL	Upto 1.1MHz	13-52Mbps	1.3km
AFSL2+	Upto 2.2MHz	7.5-26Mbps	2.7hm
BPL	1-30MHz	200Mbps	1.3km
FTTH	THz	1 Gbps	20km

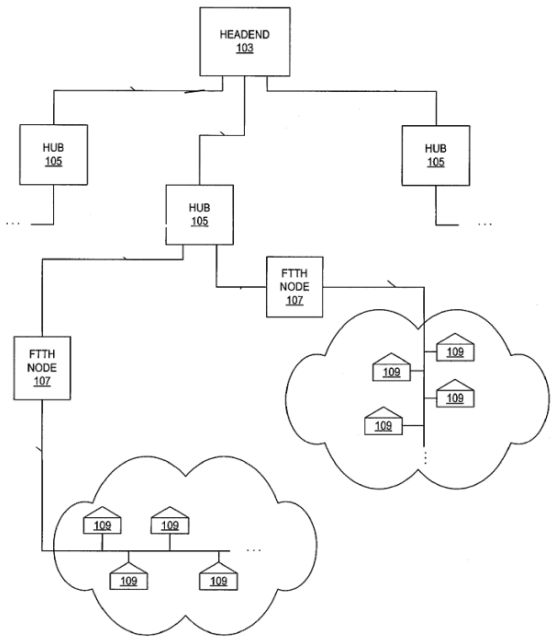

Fig. 1: Simplified block diagram of an exemplary low-loss shared Fiber To The Home (FTTH) distribution network.

One or more sources are coupled via appropriate communication links to deliver source information to a headend, which distributes the source information to one or more distribution hubs via respective communication links. Each distribution hub further distributes source information to one or more FTTH nodes via communication links, where each FTTH node in turn distributes the source information to one or more subscriber locations via neighborhood links routed to and throughout one or more zones. In the embodiment shown, bidirectional communication is supported in which subscriber information from any one or more of the subscriber locations is delivered to the corresponding distribution hub via the corresponding links and FTTH nodes. Depending upon the nature of the subscriber information and the network architecture, the subscriber information may be delivered to the headend or to an appropriate source by the corresponding distribution hub. The signals that provide source information from an “upstream” source, such as the headend and the hubs and the FTTH nodes, to the “downstream” subscriber locations are referred to as “forward” signals and signals sourced from subscriber locations towards the headend are referred to as “reverse” signals.

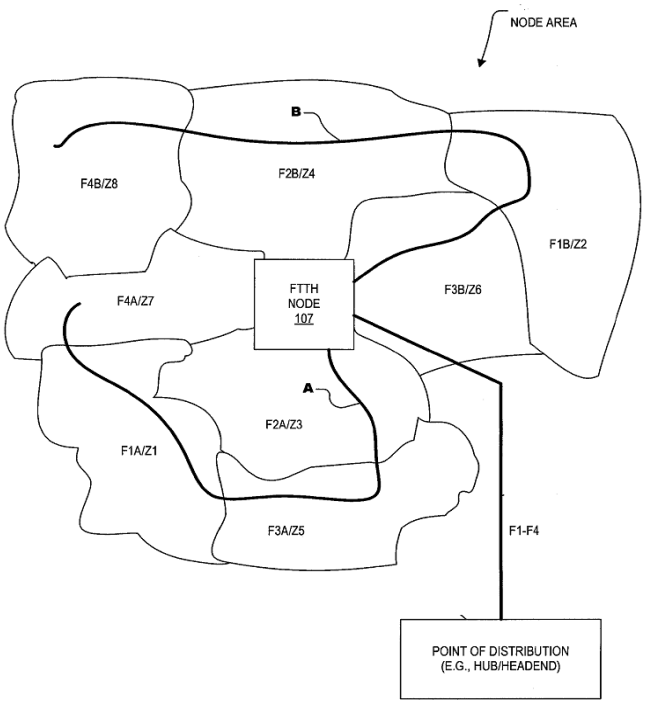

Fig. 2: FTTH node with multiple zones for servicing up to approximately 500 subscriber locations.

A fiber optic cable is routed between a point of distribution to the FTTH node of the node area. The point of distribution represents any hub or the headend or the like. In this configuration, the cable includes four Fibers and the FTTH node 107 is a transportation amplifier that splits forward signals and combines reverse signals to service up to 16 zones, although only 8 zones are shown. For the node area, each primary fiber is split into two separat fibers. In particular, the fiber F1 is divided into separate fibers F1A and F1B, the fiber F2 is divided into separate fibers F2A and F2B, and so on. The A fibers are grouped and routed via a cable labeled “A” and the B fibers are grouped and routed via a cable labeled “B”. Each zone is a logical group of subscriber locations that share forward and return path bandwidth, and typically pass (or support) up to 60 subscriber locations. As shown, the first cable A is routed from the FTTH node to four zones Z1, Z3, Z5 and Z7 and the second cable B is routed from the FTTH node to four zones Z2, Z4, Z6 and Z8, not necessarily in numeric order. The fibers F1A-F4A of cable A support zones Z1, Z3, Z5 and Z7, respectively, and the fibers F1B-F4B of cable B supports zones Z2, Z4, Z6 and Z8, respectively. If each zone Z1-Z8 represents up to 60 subscriber locations, then the node area 200 includes up to 480 subscriber locations. It is noted that each of the fibers may further be divided by two to support an additional 8 zones for up to a total of 16 total zones or up to about 960 subscriber locations.

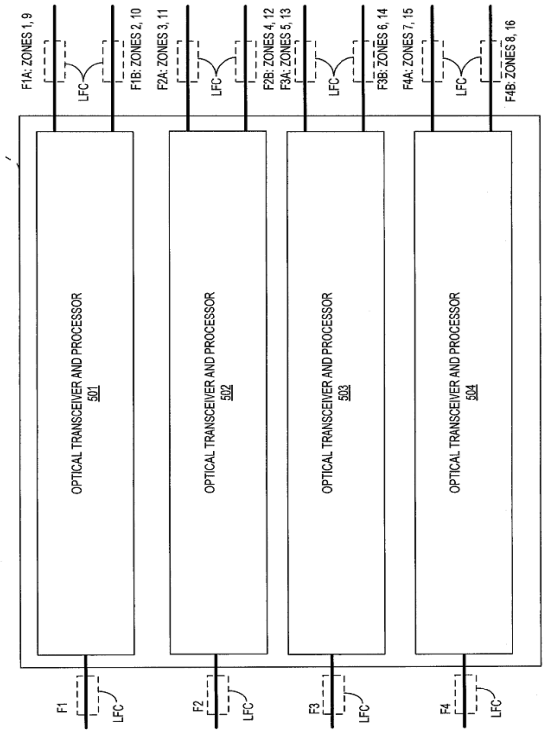

Fig. 3: logical block diagram of an exemplary embodiment of an FTTH node of Fig1.

Each of the optical transceiver and processors amplifies and splits the downstream red signal into two separate signals onto two separate downstream fibers via a corresponding fiber coupling LFC. As shown, the upstream fiber F1 is split into the two separate downstream physical fibers F1A and F1B by the optical transceiver and processor, the upstream fiber F2 is split into the two separate downstream physical fibers F2A and F2B by the optical transceiver and processor, the upstream fiber F3 is split into the two separate downstream physical fibers F3A and F3B by the optical transceiver and processor, and the upstream fiber F4 is split into the two separate downstream physical fibers F4A and F4B by the optical transceiver and processor. Each of the fibers F1A-F4A and F1B-F4B supports up to 2 zones each (e.g., F1A for zones 1 and 9, F2A for zones 2 and 10, F2A for zones 3 and 11, F2B for zones 2 and 12, F3A for zones 5 and 13, F3B for zones 6 and 14, F4A for zones 7 and 15, and F4B for zones 8 and 16). The node area previously described was shown supporting one zone per fiber F1A-F4A and F1B-F4B, where an additional zone per fiber could be supported in the illustrated embodiment.

2. Description

1. A low-loss shared FTTH distribution network, comprises of a cable including optical fibers routed from the point of distribution into subscriber zones, a tap device located within a first subscriber zone, said tap device comprising an optical tap which taps a first optical fiber with a downstream optical fiber providing at least a portion of an optical path.
2. The low-loss shared FTTH distribution network further comprises an upstream port and a downstream port, wherein a straight-through optical fiber is routed is routed straight through said upstream and downstream ports.
3. A first optical fiber comprises at least one fused connection at said tap device
4. A tap device comprises a splitter which splits downstream optical fiber into optical fibers, tap ports.
5. The downstream optical fibers are coupled via a fiber optic connector at one of the corresponding tap ports.
6. The tap device further comprises an upstream port and a downstream port, wherein said first optical fiber comprises a first fused connection at said upstream port and a second fused connection at said downstream port.
7. A low-loss shared optical plant comprises of a cable includes optical fibers routed into subscriber zones, each subscriber zones comprising at least one subscriber location; tap devices located within a first subscriber zone, each comprising an optical tap which taps of optical fibers with a corresponding downstream optical fiber; wherein each comprises at least a portion of optical paths provided to a first subscriber locations within the subscriber zone; and straight-through optical fibers which are routed straight through first subscriber zone and into a second subscriber zone.
8. The optical fibers comprise of at least one fused connection.
9. The low-loss shared optical plant has downstream optical fibers interfaced with corresponding tap devices via a fiber optic connector.
10. A method distributing optical fibers of a shared FTTH network comprises of routing a cable including a plurality of optical fibers into a plurality of subscriber zones; tapping at least one of the optical fibers with a tap device within a first subscriber zone to interface a downstream optical fiber which provides at least a portion of an optical path to a subscriber location within the first subscriber zone; and routing at least two of the optical fibers straight through the first subscriber zone and into a second subscriber zone.
11. Further interfacing the downstream optical fiber with a fiber optic connector is accomplished.
12. The optical transceiver and processors are configured in substantially identical manner and thus are not further shown or described. The fiber F1 from the point of distribution is coupled to a wavelength selective splitter of the optical transceiver and processor through a fiber coupling LFC. The red signal is provided to the input of an optical amplifier, having its output coupled to an input of an optical splitter. The splitter is a 1×2 splitter which evenly splits the

red signal power into two separate red signals RA and RB provided to respective inputs of first and second WDM filters. The first WDM filter passes the forward red signal RA to the downstream fiber run F1A for routing to and supporting zones 1 and 9. The fiber F1A is coupled to the WDM filter which provides respective reverse green and blue signals GA and BA to respective green and blue inputs of a processing circuit within the optical transceiver and processor. In a similar manner, the second WDM filter passes the forward red signal RB to the downstream fiber run F1B for routing to and supporting zones. The fiber F1B is coupled to the WDM filter, which provides reverse green and blue signals GB and BB to respective green and blue inputs of the processing circuit.

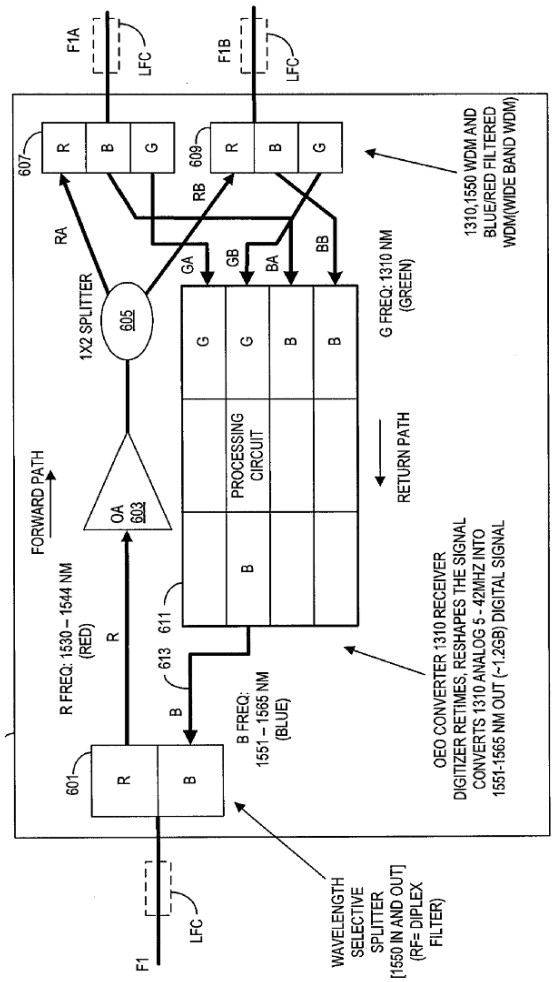

Fig. 5: detailed schematic and block diagram of the optical transceiver and processor.

In one embodiment, the reverse green signals are modulated with 5-42 MHz radio frequency (RF) signals. The processing circuit includes an Optical to Electrical to Optical (OEO) converter which re-times and re-shapes the signal for converting the green 1310 nm RF signal into a blue 1551-1565 nm digital output signal (approximately 1.2 gigabits). In this manner, the upstream analog green signals are converted to a blue digital signal which is combined with the reverse blue signals from the WDM filters to generate a single combined blue signal B on optical signal path at the output of the processing circuit. The combined blue signal on path is provided to the wavelength selective splitter for providing the blue signals upstream to the point of distribution. The subscriber locations in the zones and serviced by the FTTH node receive the red signal sourced from the point of distribution. The reverse signals generated by each and every subscriber location in zones are provided to the point of distribution via the FTTH node.

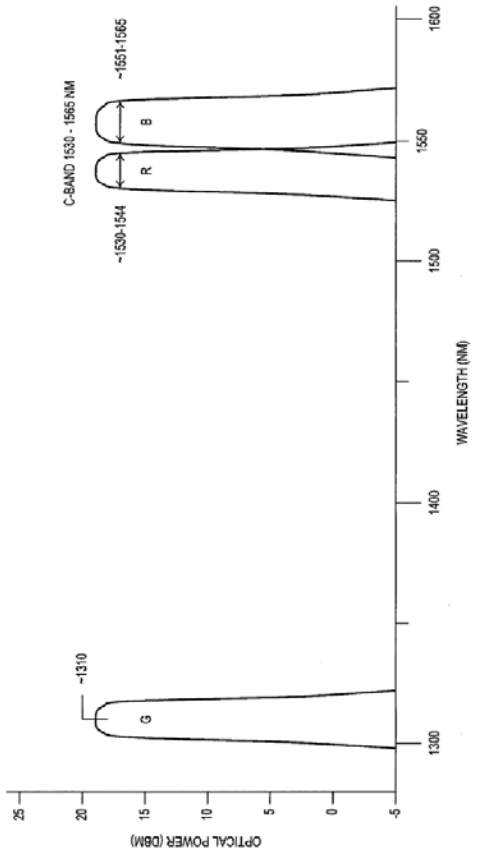

Fig. 8: graph diagram illustrating optical frequency plan employed by the distribution network of FIG. 1 in which optical signal power in decibels referenced to 1 milliwatt (dBm) versus optical signal wavelength in nanometers (nm).

3. Summary

A low-loss shared FTTH distribution network includes a cable with optical fibers which is routed from the point of distribution into multiple subscriber zones, each subscriber zone including at least one subscriber location, a tap device located within a first subscriber zone which includes an optical tap which taps a first one of the optical fibers with a downstream optical fiber providing at least a portion of an optical path provided to at least one first subscriber location within the first subscriber zone, and a straight-through optical fiber which is routed straight through the first subscriber zone and into a second subscriber zone. The FTTH has an extra advantage over the other broadband technologies as it has a relatively unlimited bandwidth.

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