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A Multivendor Multiservice Local Network Based on Wavelength-division Multiplexing and Subcarrier Multiplexing

Soung C. Liew, Bellcore, 445 South St., Morristown, NJ 07960

In a future multiservice broadband network, it will be desirable to have multiple service vendors in order to provide telecommunications subscribers with maximum choice at lowest possible cost. Many local broadband networks have been proposed recently, prompted by the pace at which optical and electronic technologies are progressing. This paper proposes a novel optical network based on wavelength-division multiplexing (WDM) and subcarrier multiplexing (SCM) technologies that allows support of multiple service vendors on a common distribution infrastructure. The optical network is, moreover, compatible with emerging broadband standards directions.

For simplicity, we first consider a particular network structure consisting of both two-way switched service and one-way broadcast video service. To keep things simple, we concentrate on service delivery from the central office (CO) to the subscriber, since the bulk of the information flow is expected to be in that direction. Figure 1(a) shows the CO and feeder portions of the subscriber loop. At the CO, wavelengths λ_1 to λ_8, which carry switched information streams to eight separate subscribers, are multiplexed optically onto one optical fiber. Another eight distinct wavelengths, λ_9 to λ_{16}, are used to carry the broadcast video channels of eight video vendors to the subscribers. For this discussion, we assume each switched wavelength carries a 622 Mbps baseband NRZ data stream, and each video wavelength contains 10 FM-NTSC video channels subcarrier-multiplexed between 0.95 GHz and 1.45 GHz. Thus, each service type is allocated a spectrum of electronic frequencies, and carriers of the same service type are distinguished by their optical wavelengths.

The signals on the eight video wavelengths are combined and split 128 ways using an 8×128 asymmetric star coupler. Each of the 128 outputs is associated with a set of eight subscribers, and each output is combined with the output of an associated WDM device through a coupler. Thus, each video source supports a total of $128 \times 8 = 1024$ subscribers. An optical amplifier [1] is used to boost the combined signals. To make sure that the switched signals do not overwhelm and saturate the shared optical amplifier, the coupler should have an asymmetric splitting ratio, say 100 : 1, in favor of the video signals so that the preamplified wavelengths have equal power.

After amplification, the signals travel over a feeder fiber before they come to a remote node (RN). At the RN, the signals are split into eight more paths, each leading over a distribution fiber to a subscriber site. As shown in Fig. 1(b), at the subscriber premises, an acousto-optic tunable filter (AOTF) is used to select the subscriber's wavelength for switched services, plus one of the broadcast video vendor wavelengths. To date, simultaneous selection of up to five wavelengths with channel spacings of 2.0 nm in the 1.5μm region have been demonstrated for the AOTF [2].

The wavelengths selected by the AOTF are a function of the electronic control signals, which are radio frequencies (RF) typically lying between tens of MHs to hundreds of MHs. Each wavelength is matched to one distinct control RF and will be selected if that RF is on. For our network, the control RF corresponding to the subscriber's switched data is provided through a fixed RF generator. In addition, a tunable signal generator that tunes over the control RFs of the video wavelengths is used to select one of the video wavelengths; the tunable signal generator can be designed so that only the RFs of the vendors that have been subscribed to are available to the subscriber. The output of the AOTF is detected by a broadband receiver, and the signal is then split. Thereafter, an electronic filter is used on each branch to filter out the electronic signal of the desired service.

Table 1 shows a power budget which indicates that this system is feasible using current technologies. The component power loss and the receiver sensitivity are extracted from other experimental demonstrations [1,2,3]. The power margin of 3dB should be sufficient to circumvent power penalties associated with the use of the optical amplifier and AOTF.

The multivendor concept can be generalised to more than two service types [4]; different service types are simply allocated non-overlapping sets of subcarrier frequencies. With the multiwavelength selection capability of the AOTF, one wavelength out of each service type can be selected for detection. The postdetection signals of different service types are distinguishable, since they are carried on non-overlapping subcarriers in the electronic domain.

References

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Table 1: Power Budget Estimate

component	*power budget*
laser output power	0 dBm
WDM loss, 8 × 128 coupler loss	(4 dB), (24 dB)
2 × 1 combiner loss for switched signals, for video signals (1.0 dB connector loss and 100:1 splitting ratio)	(21 dB), (1dB)
net gain of optical amplifier	20 dB
loss of feeder (≈ 10km)	(7 dB)
loss of 1 × 8 RN splitter	(7 dB)
loss of distribution fiber (≈ 2km)	(3 dB)
loss of AOTF	(5 dB)
receiver sensitivity	−30 dBm
power margin	3 dB

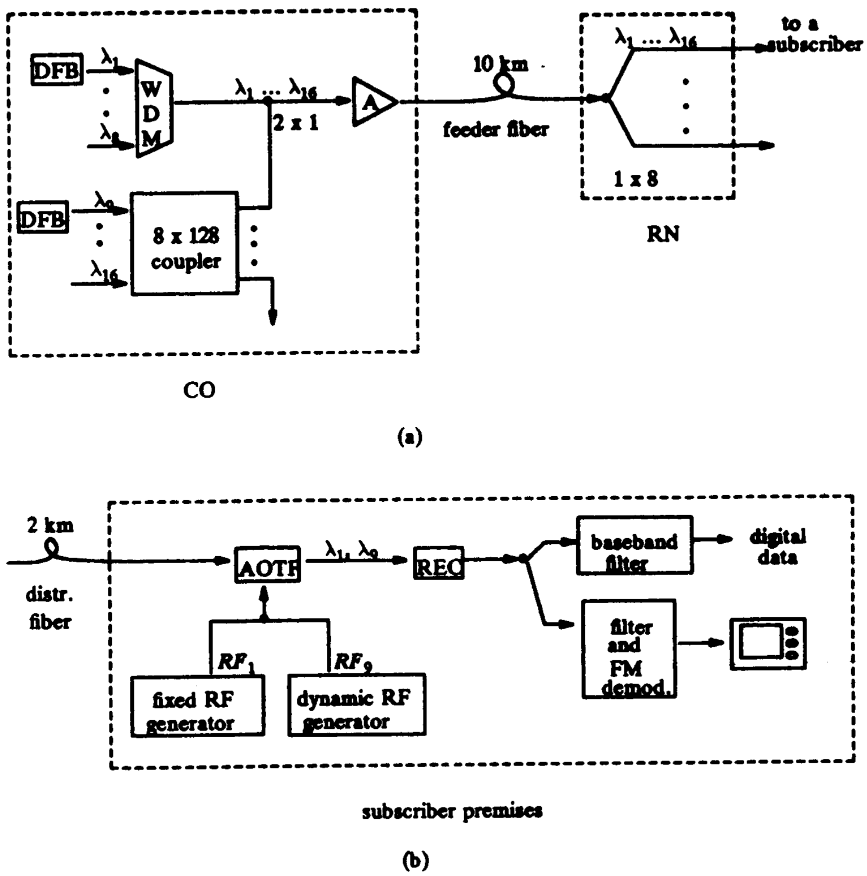

Fig. 1. Basic Network Structure (a) CO, Feeder, and RN; (b) Distribution and Subscriber Premises