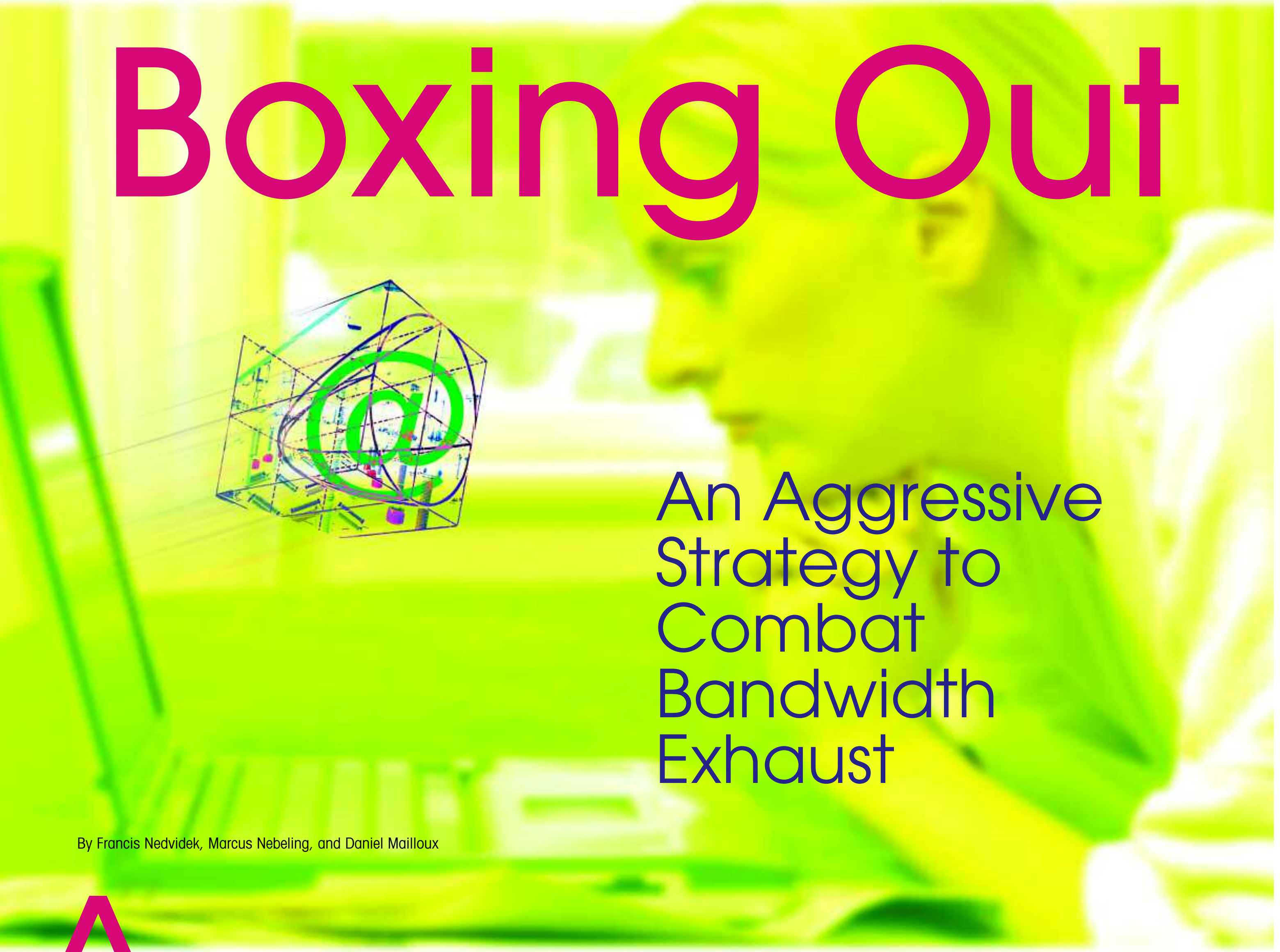

Boxing Out

An Aggressive Strategy to Combat Bandwidth Exhaust

By Francis Nedvidek, Marcus Nebeling, and Daniel Mailloux

Across North America, FTTH networks are being built using various PON architectures fed from a common backhaul. As networks grow in terms of geographic reach, subscriber counts and the scope and number of services offered, Coarse Wave Division Multiplexing (CWDM) has become a preferred method for increasing the bandwidth of these optical access networks quickly, simply and at a low cost.

Passive CWDM requires absolutely no electrical power, and yet the technology has proven itself to be sufficiently robust and reliable for installation in the most demanding environmental conditions. Products recently released to the market allow enhanced flexibility in terms of network planning and installation while preserving scalability to handle far higher data transmission volumes as bandwidth needs expand. And since CWDM is inherently transparent to protocol, coding and bit rate, it is ideally suited for aggregating bandwidth over fiber. It is fully compatible with Broadband PON (BPON ITU-TG.983.x), Gigabit capable PON (GPON ITU-TG.984.x), or Ethernet PON (EPON IEEE 802.3ah). Passive CWDM elements are interoperable with configurations applying ATM, TDM / TDMA, SONET / SDH, and accommodate 1310 nm and 1550/1490 nm analog modulation as well as digital modulation overlays.

Very important, of course, is the fact that passive CWDM is low cost, especially when compared with the cost of leasing dark fiber or laying additional fiber lines not to mention the expense of purchasing and maintaining active network equipment.

The Best Offense Is a Good Offense

As telecom FTTH deployment extends into less densely populated areas, it becomes essential to upgrade telecom access networks between the central office (CO) and the subscribers. The typical PON architecture depicted in Figure 1 uses an optical platform, traditionally located in the CO, known as an Optical Line Terminal (OLT) to transmit traffic to approximately 16 to 32

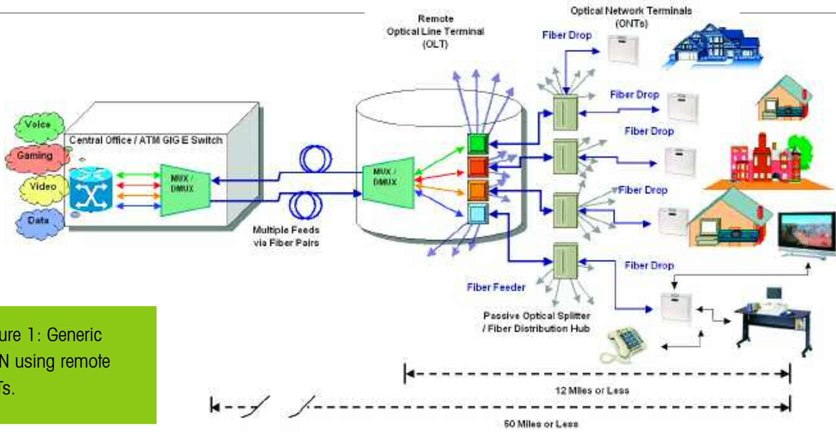

Figure 1: Generic PON using remote OLTs.

residential drop points. Passive optical devices called splitters / combiners are located at fiber distribution hubs between the OLTs and subscribers' Optical Network Terminals (ONTs). The ONT is normally the point where the access fiber line is converted to a twisted pair copper line.

The splitters/combiners divide a single downstream transmission into multiple fiber drop streams as well as aggregate upstream traffic from multiple ONTs into a common stream traveling back to the CO.

As fiber gradually penetrates deeper into the access edge, the OLT is moving into the wider subscriber territory. The reason for this shift out of the CO is to better extend the network to connect with more ONTs. Reaching more subscribers with higher bandwidths attains higher penetration densities and consequently greater revenue generation potential. Splitters /combiners promote high degrees of network utilization by enabling the price of one OLT port and laser transceiver to be shared across many drop points. The goal of the network operator is to provide even more subscribers with service while containing the cost to reach each additional customer. Today, it is becoming practicable and economically viable to extend fiber directly to the premises in some instances. With fiber moving into the home and office, the optical network termination effectively moves all the way to the customer location.

Although the diagram of Figure 1 shows an FTTH access network where a pair of fibers serves each remote OLT, bidirectional single fiber PON architectures are also common. Distance from the CO to the furthest ONT normally lies in the range between 12 miles and 60 miles. The fiber distribution points contain passive splitters / combiners that connect the fiber lines among approximately 32 drop points (subscribers). This fan-out number is highly dependent on the available signal power budget and the fiber attenuation accruing between the distribution points and the subscribers.

Figure 2 represents a situation where existing subscribers intend to upgrade to higher value-added bandwidth services. In order to satisfy customers attracted to buy IPTV, VoIP, Video on Demand (VoD), etc., the 622 Mb/s downstream capacity must increase between the CO and the OLT, that currently provides roughly 20 Mb/s to each subscriber.

The target bandwidth adequate to address the existing demand and also satisfy expected new subscriber and service expansion requires a downstream CO/ OLT link bandwidth of 2.5 Gb/s. Multiplying the number of bidirectional channels traveling between the CO and OLT by 4 corresponds to introducing 4 CWDM wavelengths. The passive CWDM enhancement relieves the fiber exhaust as shown in the upgraded network of Figure 3.

The upgrade - installing 4 CWDM channels at the original data rates - boosts the bandwidth of the CO / OLT link. The existing CO rack hardware, existing street cabinet OLT and the available fiber distribution panels all remain unaffected. The complete installation requires 4 channel-specific (color coded) transceivers plugging into the router / switch, the associated patch cables, the rack-mounted CWDM module, and the snap-in passive CWDM cassette located in the OLT. Service interruption is necessary at the CO to make the connection of the CWDM module to the router and at the OLT when the pre-packaged CWDM cassettes are mounted into the outdoor cabinet. The cassettes typically arrive ready for splicing although cassettes may be specified that include connectors. Only minimal training of the field service personnel is necessary. The passive CWDM modules may be installed in much the same way as any fiber management cassette used in distribution hubs or street cabinets.

Hard Court Press

PON systems come in many flavors. Nearly each equipment vendor offers a different variation in terms of performance / price tradeoffs, scalability, and network management capability. Network operators then add another layer of diversity when deploying PON networks depending upon the economics, expansion priorities and the market demographics of the particular situation. Designers and implementers of EPON (Ethernet PON) may benefit from using passive CWDM on the client side of the OLT. A simple EPON architecture is represented in Figure 4.

The EPON of Figure 4 was conceived

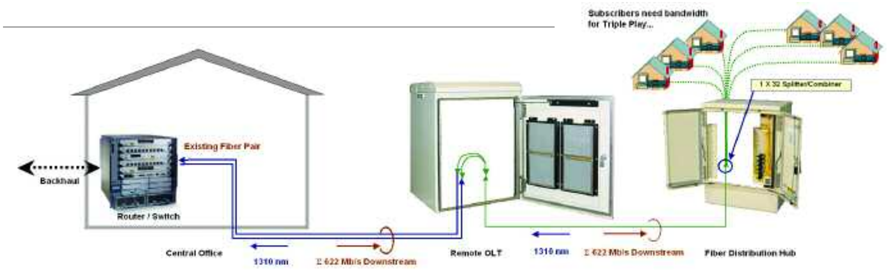

Figure 2: Limited fiber capacity – insufficient bandwidth for new subscribers and new services.

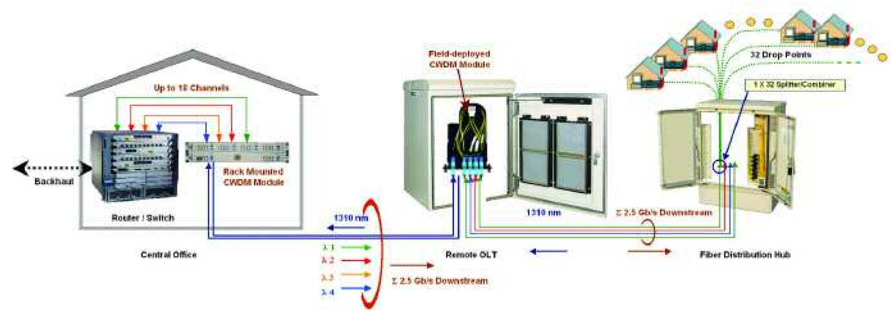

Figure 3: Passive CWDM adds capacity.

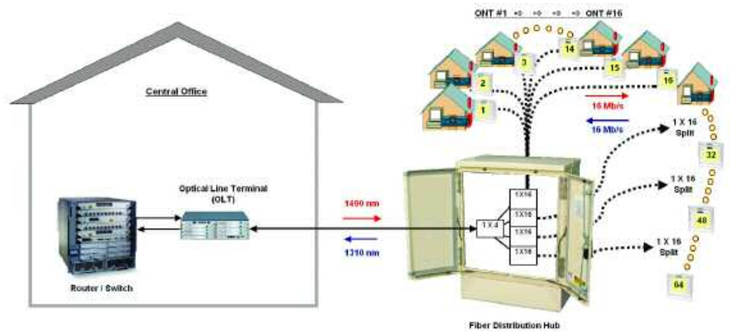

Figure 4: EPON deployment with bidirectional 1 Gb/s bandwidth capacity.

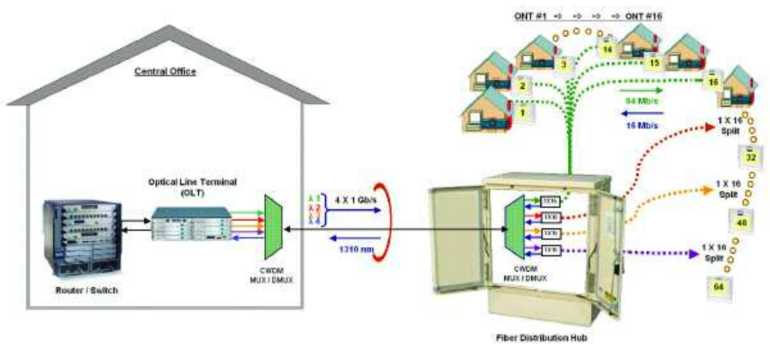

Figure 5: EPON deployment upgraded to 4 Gb/s bandwidth capacity.

to service up to 64 subscribers, all sharing a single 1.25 Gbps bidirectional optical Ethernet feed line; the upstream and downstream network speeds are symmetrical. The theoretical maximum sustainable data-rate for each subscriber is a little over 16 Mb/s. As subscriptions for IPTV, HDTV, and other higher bandwidth services become available, the 16 Mb/s downstream capacity will certainly prove insufficient.

Figure 5 shows the same network retrofitted with a 4-channel passive CWDM extension, which effectively multiplies the downstream capacity by a factor of 4 without affecting the upstream traffic. A rack-mounted CWDM unit in the CO and a miniature hardened CWDM module deployed in the fiber distribution hub increases the revenue earning potential of the feed line while minimizing OPEX and CAPEX. Compared to the cost of alternative upgrade scenarios, the passive CWDM solution wins by a very wide margin.

In this case, deploying a 4-channel CWDM upgrade augments the throughput of the downlink toward subscribers by a factor of 4 while requiring minimal modification of the existing infrastructure.

Never Passive on the Court

A passive CWDM approach offers the significant benefits of low CAPEX, minimal OPEX, and very simple and straightforward upgrade planning and implementation. Deployed in the field, passive CWDM preserves scalability and network flexibility as the network grows and the bandwidth demands change. Major advantages of upgrading access network bandwidth using passive CWDM include:

- **Predictably low equipment and operating cost.** The network solution and the equipment deployed must offer both low CAPEX and economical OPEX. Passive CWDM satisfies these requirements when upgrading bandwidth capacity on new or existing fiber lines.
- **Quick and efficient network upgrade.** Rapid response can pre-emptively or defensively capture and hold customers, and shorten the period to reap the ROI. In practical terms, installing the multiplex / demultiplex capability reduces to an exercise in modifying fiber cabling.
- **Simplicity of specification and simplicity of deployment.** An inherent attraction of passive CWDM solutions is the modest levels of technical expertise required to design, manage, and execute an upgrade or a greenfield deployment. A CWDM approach allows operators room to maneuver when rolling out additional geographical coverage or services as the demand, competitive landscape, and financial aspects dictate.
- **Open standards, nothing proprietary.** Standard CWDM technology operates unconstrained with any of the routers, switches, and DSLAMs available on the market. As a passive element, CWDM modules are functionally transparent to all data transmission protocols, and are immune to the incompatibility problems often encountered when connecting disparate equipment and accessories supplied by different vendors. The risk of becoming captive to any particular proprietary approach or attendant service agreement is small.

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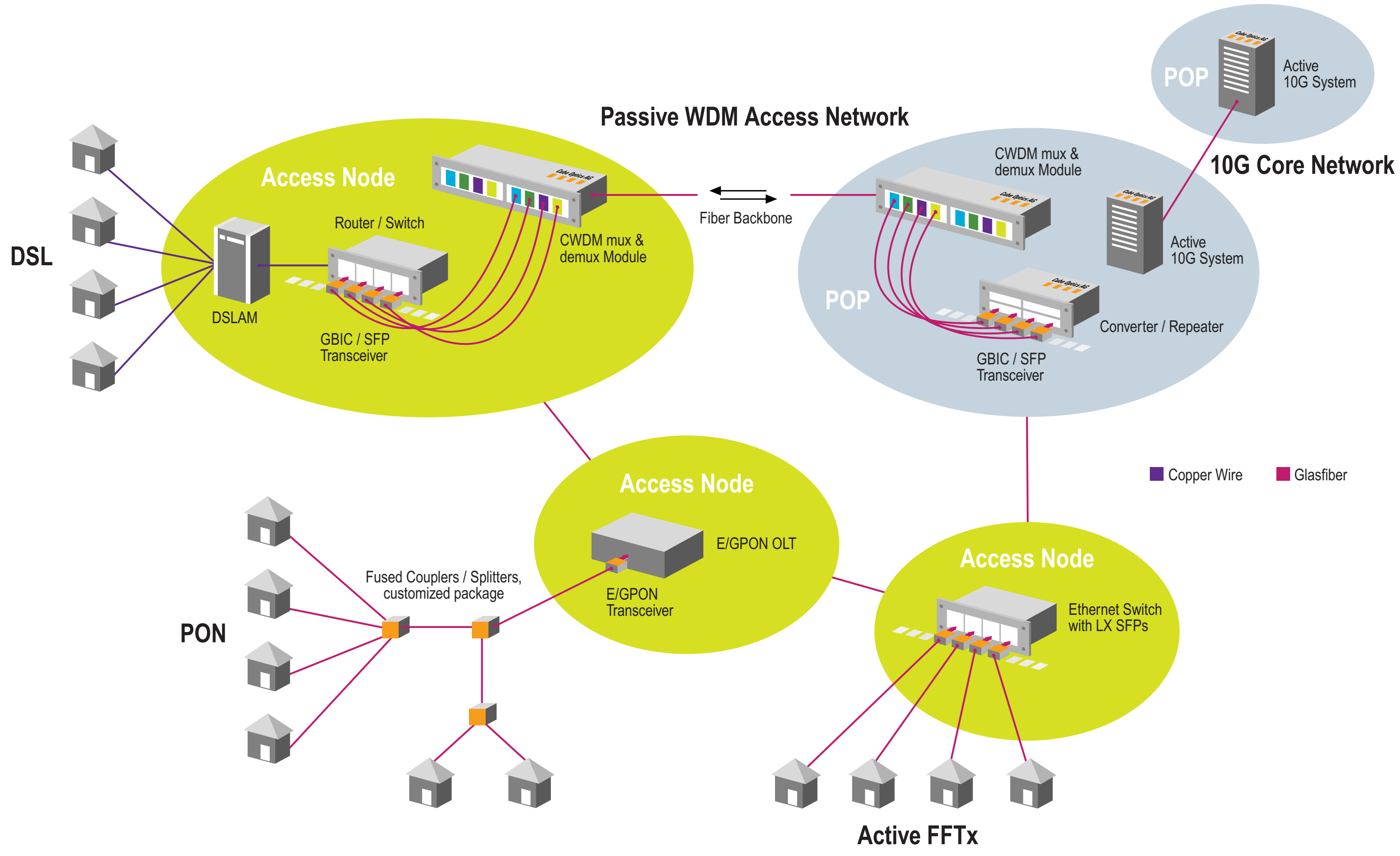

The ideal solution for metro access networks over dark fiber. The passive WDM set-up strongly reduces the equipment needed to build an access network. This not only cuts CAPEX by >50% but drives your operational expenses down, as there is less to plan, less to install, less to integrate, less to monitor and therefore less risk of network failures:

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