Broadband Optical Network Technology for Next Generation LAN and Access Systems

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We are witnessing tremendous progress in lightwave communications networks, both in the economical bandwidth they can provide as well as in the services that can be provisioned. Multimedia, internet, computer and other data applications are fueling the market pull for these new broadband networks, and that influences the technology and architectures that are called for. Several key technologies, architectures and protocols are currently emerging.

One important technology is wavelength division multiplexing (WDM). WDM systems send several wavelengths down a single fiber thereby increasing the utilization of the link bandwidth. Already several major long haul and local exchange carriers are upgrading there installed infrastructure to WDM point-to-point trunks. While WDM is used on the links, electronic switching is used to cross-connect or drop traffic at the nodes. In is currently an active area of research around the world to develop truly transparent optical WDM networks. The vision for these networks is that routing and switching of traffic within the network is accomplished without the necessity of undergoing optical-to-electrical and electrical-to-optical conversions. In addition to high capacity, this technology can be flexible and reconfigurable. One way this flexibility is manifest is in the compatibility of legacy and future networks on the same optical infrastructure.

To date most research has focused on physical layer capabilities of these types of networks. All-optical networks have been demonstrated that support high speed (user data rates from 10 Mbps to 10 Gbps), and high capacity (~Tbps) transparent optical communications. In these networks, user channels are designated by different colors of light. In addition, in contrast to today's electronic networks, no bandwidth-limiting electronic conversions are made within the network. In such networks, wavelength partitioning, wavelength routing, and active multi-wavelength cross-connect switches achieve a network that is scaleable in the number of users, data rates, and geographic span.

With the success of all-optical network research at the physical layer, the next logical question is what types of services an optical network can provide. Current network systems provision three types of *transport* services. These are circuit switching (T1, OC-3, OC-192, etc.), datagram (e.g. Internet), and virtual circuit services like ATM. While all three network transport services are available today, there is a clear trend away from circuit networks towards datagram and virtual circuit networks in order to accommodate the rapid growth of bursty data communications traffic.

In small and private networks when dedicated infrastructure can be provisioned, the network can be optimized for the specific service requirements of the users. However, when public infrastructures are needed to connect a variety of private networks or users together it is difficult for a single networking technology to provide all the services required. This leads to a

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layered network service architecture such as is illustrated below in Fig. 1. The figure indicates the still novel concept that the optical layer could support packet service directly.

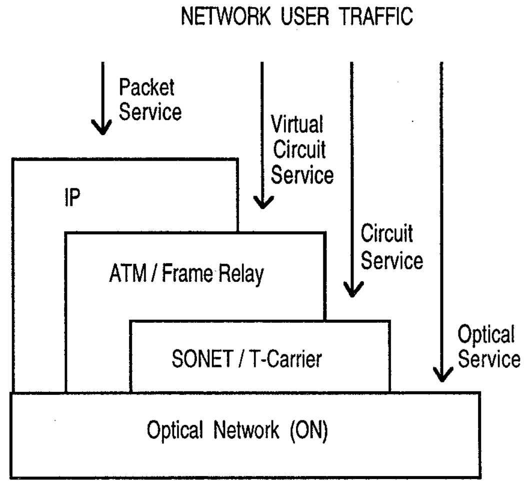

Figure 1. Service layers of an optical network

It is important to understand when and where network performance can be improved by bypassing network layers and providing services directly at the optical layer. For example, because of the proximity to the end-user, an access network is quite different from a backbone network. The relatively low-rate individual traffic flows need to be multiplexed into the higher-rate backbone trunks, thus requiring multiplexing equipment. In addition, the data traffic is quite bursty because it has not yet been sufficiently aggregated and could therefore benefit from statistical multiplexing. Complicating matters further, equipment must be cheaper in the access network than in the backbone or interoffice networks because equipment is shared over a smaller set of customers. WDM technology has emerged as the foremost solution to high-speed transmission and is beginning to dramatically change the underlying characteristics of backbone networks. While WDM is likely to soon dominate the backbone, architectural advancements in the access environment have not kept pace with that of the network core, preventing users from fully benefiting from the huge capacity of the optical technology. The architecture we will describe uses a low cost passive optical network for connecting the end-users to an access node, and a configurable optical network (e.g., WDM ring) for connecting the different access nodes to each other and to a backbone network.

For local and metropolitan area networks, some recently developed optical processing may be used for packet routing at data rates to 100 Gb/s and higher per user. These optical time-division multiplexed (OTDM) single channel local or metropolitan area network may have the same capacity as a number of WDM lower rate channels. However, OTDM networks can provide potential improvements in terms of user access time, delay, and throughput for bursty traffic. To compare and contrast OTDM with WDM we describe architecture and technology for single-stream 100 Gb/s local/metropolitan area shared media networks.

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