The Nebula PON FOIRL System

The Nebula PON (Passive Optical Network) FOIRL is the latest in a series of fiber optic repeaters, manufactured by Nebula, and used by service providers to extend Ethernet services that last mile from the CO to the customer. Earlier versions of the Nebula FOIRL (Fiber Optic Inter-Repeater Link) were used to provide up to 100 Mbps of full-duplex Ethernet service over a pair of single-mode outside plant fibers.

The Nebula PON FOIRL system provides for the transport of up to 1000 Mbps of full-duplex Ethernet traffic over one outside plant fiber as illustrated in Fig.1. The PON FOIRL has an internal WDM (Wave Division Multiplexing) filter to multiplex two Ethernet streams on to one fiber; the downstream wavelength (toward the customer) is 1490 nm, and the upstream wavelength (toward the CO) is 1310 nm.

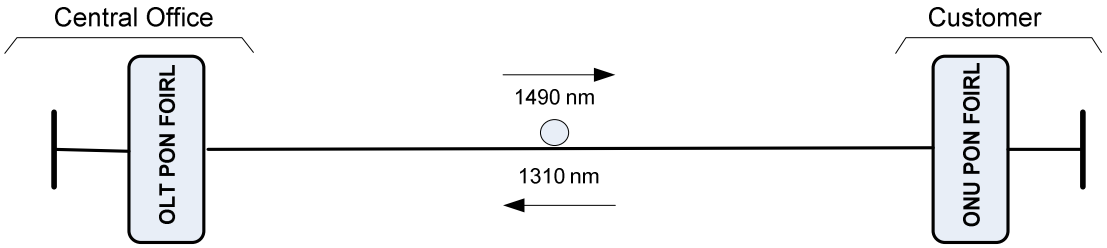


Fig. 1

When used in this fashion, the PON FOIRL system provides an economical way of offering a customer a 1000 Mbps connection to the service provider's network. The interfaces to both the service provider's network and customer's network are full-duplex Ethernet over the purchaser's choice of either copper or fiber. The service provider interface runs at 1000 Mbps, and the customer interface can auto-negotiate to any Ethernet speed up to 1000 Mbps. At the purchaser's option, either device can come with a secondary Ethernet interface, which provides an automatic fail-safe in the event that the equipment connected to the primary interface fails.

The Nebula PON FOIRL system can be used to serve a number of customers by using passive couplers to connect the different customers to the fiber that runs back to the CO.
This PON (Passive Optical Network) configuration of the Nebula PON FOIRL system is illustrated in Fig. 2.

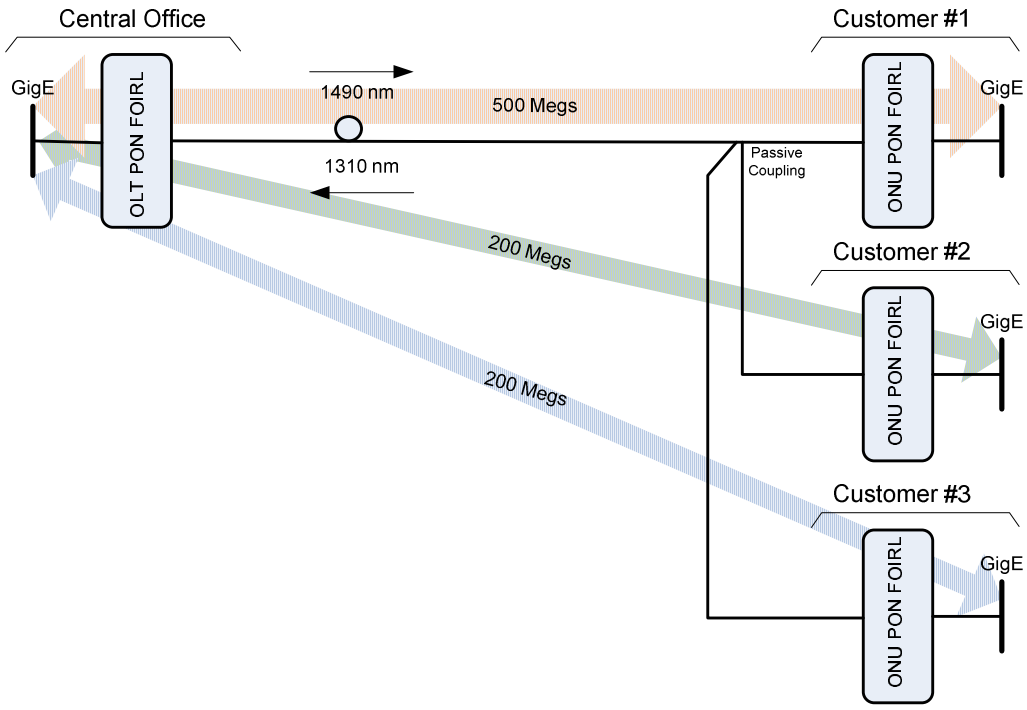


Fig. 2

The bandwidth assigned to each customer is a subscription-time variable. All traffic for each customer is classified and queued into a set of eight buffers (per customer) according to its QoS classification. For each QoS, the traffic received from the customer is at first shaped, and then policed to the subscribed bandwidth for that QoS once the buffer is full. This policing process employs early discard, enabling protocols such as TCP to converge to the full available bandwidth.

The shaper uses WWR (Weighted Round Robin) queue servicing, ensuring that the PON FOIRL network delivers high priority traffic immediately, without starving lower priority traffic. The eight queues and associated shapers and policers are implemented in hardware for maximum throughput and minimum latency. AES128 data encryption is used in both directions on the single mode fiber to make snooping the data next to impossible.

The downstream traffic is switched to the right customer based on an internal VLAN tag in each frame. The use of the upstream bandwidth is orchestrated by the OLT PON FOIRL, which allocates it in 6 kilobyte windows to each ONU PON FOIRL. The ONU PON FOIRL is capable of splitting customer frames across multiple windows, ensuring that all of the allocated bandwidth is usable.

QUALITY of SERVICE

Although the servicing algorithm WRR provides a guaranteed minimum bandwidth to each Class of Service, this minimum is only policed during periods of congestion. When the system is not congested any queue which is temporarily backed up can use bandwidth not being used by the other queues. Because of this sharing, it makes sense to configure all eight queues with a nominal amount of bandwidth, even if there is no traffic on the network which will use the queue right now. Since the queues are implemented in hardware the default configuration uses all eight and assigns a nominal amount of bandwidth to each. The default configuration will work in almost all networks, requiring only minor changes if a customer uses more than the nominal amount allocated to a particular high priority class.

Many different QoS configurations are possible. By turning off sharing on some of the queues it is easy to configure a scheduling system which has 4 WRR queues AND a low latency high priority queue for voice. A service provider might offer the ability for his customer to purchase a 200 megabits/second BEST EFFORT service, which would police his customer's TCP flows till they conform to that bandwidth, and a 200 kilobits/second HIGH PRIORITY service for voice, which receives immediate forwarding with low latency. The HIGH PRIORITY traffic could also be policed and frames dropped from VoIP conversations when one too many are carried at the same time.

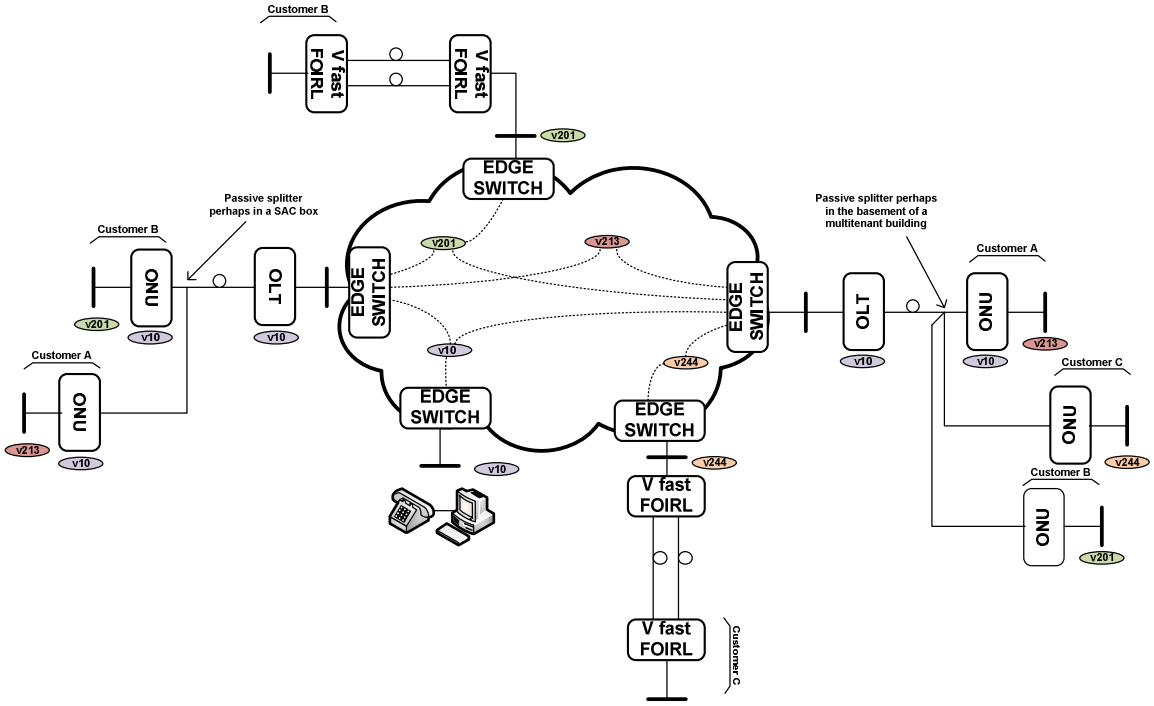
NETWORK MANAGEMENT

Within the PON FOIRL network, and on the service provider's interface, customer traffic is kept separate by virtue of being on different VLANs. The network management system in each PON FOIRL is reached by using a VLAN number on the service provider's interface.

The network management interface in the PON FOIRL provides a command prompt to a Telnet or SSH session which can be used to configure and query the unit. Configuration commands are provided to configure the QoS features and other network modes and parameters. For each of the 8 possible queues, the associated packet types, the bandwidth assigned, and the buffer depth before policing are configuration variables. There are commands to list statistics for each of the interfaces as well as stats detailing the operation of each one of the queues. The devices can be reconfigured while in operation, ensuring that changes to one customer's service do not cause downtime for others.

Both PON FOIRLs have sufficient flash memory to hold two copies of the system software. A remote software upgrade is as simple as sending the unit a new image file and then instructing it to reload from the new image, and this process is reliable even in the event of a power failure.

Typical Application



Features

Hardware implementation. All Features are implemented in an FPGA and run at line rate. Features can be easily added in the future.

All eight output queues can be configured at once which provides for an almost automatic QoS implementation with no degradation of throughput.

Inexpensive. Six hundred and eight customers can be served by 19 OLT PON FOIRLs mounted in a 3U mounting space enclosure at a power dissipation of less than 200 watts.

Easy integration into existing network management communication systems. Supports a Telnet or SSH accessible command line interface for configuration and testing and SNMP for supervision.

Uses transparent packet fragmenting so that 100% of the usable bandwidth is available to the customer with low latency and low jitter.

Standard queue servicing is Weighted Round Robin with bandwidth sharing (queues can lend output bandwidth not in use to other queues). Early Discard causes TCP/IP flow slowdown before the queue is actually full.

Uses AES128 encryption to prevent snooping on the fiber line.

Advantages

Very inexpensive upgrade path for Service Providers who use Nebula's V-FAST products currently.

Suitable for use as a service delivery system for large private business Data networks and as a commercial system to deliver Internet services to residences as an upgrade to ADSL.

Minimum investment involved to get started with PON technology and services.