The Low Latency Network - Design Considerations

Applications Affected by Latency

Finance

- Automatic/Algorithmic Trading
- Securities/Market Analysis

Service Providers

- ECN Access
- Inter-Exchange Connectivity

Storage

- Fibre Channel Transmission

Video

- Interactive Conferencing
- Distribution
- Online Gaming

The latency requirements for applications like algorithmic trading and derivative pricing are much stricter than for traditional web applications like VoIP and network gaming. While traditional applications can tolerate more than 100 milliseconds of latency, algorithmic trading and other financial applications are sensitive to milliseconds or microseconds delays. Market demand for ultra low latency networking is growing rapidly. It is important to understand there are various latency definitions; host latency or the time to process messages from the sending and receiving hosts and network latency which defines the delays which occur inside the network. For purposes of this paper, we will limit our discussion to network latency.

If low latency is a critical requirement of the network, there are several factors that must be considered when designing the network and assigning services to that network.

Media

Signal propagation speed through a transparent material such as a fiber optic cable, are lower than the speed of light in a vacuum due to the refractive index of the fiber. Similarly, when an electrical signal travels in a copper cable, it travels at a speed lower than speed of light due to the effects of inductance, capacitance, and resistance of the cable. Today, long distance signal transmission is more efficient and economical using fiber cables.

One of the factors that limits the maximum reachable distance in fiber optic communications and must be considered in network design is chromatic dispersion. There are different ways to correct this; one is by using dispersion compensation fiber (DCF). This is used to optically compensate chromatic dispersion in spans exceeding 80km. DCF will, however, introduce almost the same delay as the fiber it compensates (latency of 100km of fiber is about 500 microseconds) resulting in a significant source of excess latency in the network. Alternatively, dispersion compensation can be done using other technologies which do not introduce any delay and due to smaller size can be directly integrated into WDM systems.

Distance

The fundamental contributor to total network latency is the refractive property of the fiber itself which adds about 5 (rounded from 4.76) microseconds of delay per kilometer. Therefore, any optical transmission has an inherent latency of 5 microseconds per kilometer. For example a 100Km span will have a 0.5 millisecond delay prior to any processing delay.

Since all networks are constrained by the physics of the speed of light, in applications such as algorithmic trading which are sensitive to millisecond or microsecond delays, location of the trading system in relation to the exchange is a critical part of the network design

Network Components

Layer 2 or 3 Switches typically add more latency than Layer 1 transport systems due to inherent router and switch delays as a result of processing packets from an ingress port to egress port. This paper will only address Layer 1 transport platforms and the effect of various components on network latency.

When considering system components or modules, differentiation must be made between optical and electrical media. In general, passive optical components (MUX/DEMUX, OADM) or amplifiers (EDFA or Raman) do not introduce any significant delay.

On the other hand Optical-Electrical-Optical (OEO) modules introduce some amount of latency depending on the type and therefore their use should be minimized in the design of a low-latency network. This also makes sense from an economic standpoint as OEO components are typically more expensive.

When running long distances, each 70-80km span will need to compensate for chromatic dispersion (and for power loss). The use of Dispersion Compensation Modules (DCM) does not introduce any delay when compensating for chromatic dispersion. Using DCM in place of Dispersion Compensation Fiber will create enormous latency differences between two approaches especially over long distances.

In addition to passive optical components, each WDM transport system uses transponders for wavelength conversion and muxponders for service aggregation into higher data rates. It is important to evaluate the functionality against the latency of each when low latency is the objective. Generally, the simplicity of the module design is relative to the amount of latency it will create in a network. If a transponder provides only optical conversion or repeating with little processing the latency will be the lowest.

Higher level of transponders, one with Forward Error Correction (FEC) for example, provide much better optical performance due to error correction and much higher level of performance monitoring (a network management advantage). These transponders, however, incorporate more signal processing and therefore introduce higher latency values than regular transponders. Trade off between performance accuracy and latency level must be evaluated in the network design.

Muxponders due to the processing for service aggregation also introduce higher latency than a simple transparent transponder.

Ultra-low Latency Network Design

In summary, the lowest latency networks use fiber optic media, passive components, non-FEC transponders and dispersion compensation modules. To further reduce latency values, choose the shortest fiber paths and minimize or eliminate the use of OEO repeater nodes.The latency specifications of network modules vary greatly from vendor to vendor. Most vendors will tout system bandwidth capacities, but keep latency figures close to their vest. The latency data, however, is important in comparing network designs.

MRV has more than 50 offices throughout the world. Addresses, phone numbers and fax numbers are listed at www.mrv.com.
Please e-mail us at **info@mrv.com** or call us for assistance.

MRV Los Angeles
20415 Nordhoff St.
Chatsworth, CA 91311
800-338-5316
818-773-0900

MRV Boston
300 Apollo Drive
Chelmsford, MA 10824
800-338-5316
978-674-6800

MRV International
Business Park Moerfelden
Waldeckerstrasse 13
64546 Moerfelden-Walldorf
Germany
Tel. (49) 6105/2070
Fax (49) 6105/207-100