WHITE PAPER

A Sensible Low-Latency Strategy for Optical Transport Networks

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Sources of Latency in Optical Networks

Latency in optical networks has been getting a lot of attention recently. This is especially seen in financial and trading firms which depend on the speed of transactions. The delay of a fraction of a second in trading can translate into millions of dollars in losses or lost opportunity.

An understanding of the latency added by various network elements and technologies, and the potential tradeoffs and limitations to achieve a low latency network, is essential in developing a sensible low latency network strategy.

The sources of latency in an optical network and their approximate values are shown below:

Network Element	Approximate Latency
Transparent transponder or regenerator	A few ns
Optical Mux/Demux, WSS, or FBG-based DCM	5 to 50 ns
EDFA	50 to 200 ns
Muxponder or SONET/SDH/OTN ADM	10 to 100 µs
Forward error correction (FEC)	15 to 150 µs
DCF-based DCM	40 to 120 µs
Optical fiber	500 µs/100 km
Layer 2 or higher switch/router	up to a few ms

Transparent transponders and regenerators simply perform clock and data recovery (CDR) and use the recovered signal to drive a modulator. These devices do not buffer or manipulate bits and, therefore, have inherently low latency, mainly driven by cumulative circuit board track lengths and spliced fiber segments (if present).

Optical components, such as an optical multiplexer, demultiplexer wavelength selective switch (WSS) or fiber Bragg grating (FBG) dispersion compensation module (DCM) also have inherently low latency, mainly determined by the length of spliced fiber segments within a circuit pack.

The latency added by an Erbium doped fiber amplifier (EDFA) is low, determined by the length of doped fiber and spliced fiber segments, which can be up to a few tens of meters.

Transport equipment, such as muxponders, OTN/SONET/SDH ADMs, etc., must perform mapping, framing and adaptation operations on the signal, i.e., buffer and manipulate bits, which adds latency to the transported signal. If forward error correction (FEC) is used, the latency will necessarily be increased further due to FEC encoding and decoding. In general, stronger FEC results in higher latency.

DCMs that use dispersion compensating fiber (DCF) can increase latency significantly, as the length of DCF required is approximately 20% the length of fiber being compensated when working with standard singlemode fiber.

The optical transmission fiber itself can be among the largest contributors to latency in an optical transport network, as some optical circuits may span hundreds of miles.

Finally, Layer 2 or higher (L2+) switches and routers can add significant latency, as they must make routing and forwarding decisions based on information contained in the transported signal. In many cases header information may need to be manipulated, such as a checksum that is calculated or recalculated and reinserted into a frame before it can be forwarded to a destination port on a switching or routing element. In some cases, a frame may be significantly delayed, or even dropped, due to congestion control. Latency, however, through such network elements can be improved significantly by priority queuing and/or cut-through forwarding, whereby the bits in a frame are transported out a destination port based on processing a part of the header only, i.e., before the entire frame is received.

A Low Latency Strategy

A strategy for providing the lowest latency possible must consider the latency of individual network elements and avoid using high latency elements on end-to-end optical paths that have critical delay requirements:

1. Where possible, avoid L2+ transport infrastructure that adds significant latency to the signal.
2. Use a physical route between the circuit end points that minimizes the total transmission fiber length, and avoid using long patch cables when inter-connecting equipment and facilities.
3. Use DCMs based on lower latency technologies such as FBG instead of DCF.
4. Use standard G.709 FEC over superFEC where the additional link budget is not needed, or consider disabling FEC altogether.
5. Minimize the number of network elements that perform multiplexing, mapping and framing functions, such as muxponders and OTN/SONET/SDH ADMs.
6. Consider using OTN wrapping at circuit end points only, and use transparent regenerators at any intermediate regenerator locations. This would provide the benefits of end-to-end trace and signal quality monitoring without incurring additional latency at intermediate regeneration locations.
7. Consider using transparent transponders when low latency is considered more important than signal quality and trace monitoring within the transport network, or when such monitoring on the client equipment itself is sufficient.

Optelian provides technologies and products that meet the above objectives, such as FBG-based DCMs, transparent transponders and regenerators, and OTN-based products that can be user-configured for either standard FEC or strong FEC, or have FEC disabled.

Conclusions

A service provider's optical network will generally not introduce latency that is detrimental to voice or data services. However, for some services, such as those to support algorithmic trading, a low latency transport network becomes critical. The choice of network elements and technologies used in deriving the path for such services will have a major impact on the latency of the transport network.

In summary there are several well-advised and readily available choices network operators can make in order to minimize latency in the network where it is a critical service requirement.

About Optelian

Optelian provides Intuitive Packet Optical Networking™ to deliver next generation services. Our solutions are powered by the modular Optelian FLEX Architecture™ to deliver services from access to long-haul, passive to packet, and 100M to 100G. Intuitive Packet Optical Networking enables Service Driven Networking, allowing operators to rapidly deliver services while optimizing network capacity. We empower intuitive service management through a simplified infrastructure that virtualizes network and technology complexity.

With agile design capabilities and North American manufacturing, Optelian can meet custom requirements to suit any network. Combined with professional services to ensure your network is optimally planned and deployed, along with world-class customer support, Optelian delivers the technology and services that enable intuitive next generation networks.

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