WHITE PAPER

Optelian

Making the move to 100G

Choosing the right strategy

SEPTEMBER 2013

It's not big news that new applications, services and exponential uptake in mobile devices are driving explosive bandwidth growth. Clearly, existing networks need to scale to meet these demands. However, it's not just about building bigger networks: it's about scaling these networks in a way that delivers the required capacity in the most efficient manner, where services can be rapidly deployed and are simple to manage.

The standard currency in today's DWDM networks is 10 Gb/s connections, carrying either line rate, or an aggregation of lower rate services. These networks are rapidly consumed by service demand, driving expensive overbuilds at an increasing frequency. What is required is a means to maximize the potential of available fiber capacity, and allow this newly enhanced capability to be used as flexibly as possible.

Next-generation 100G provides the solution. It has the ability to transform networks, significantly extending the revenue-generating potential of existing 10G DWDM infrastructure, while allowing for a simple transition to new high-capacity services when required.

So how can providers evolve their existing networks to reap the rewards of 100G technology? The key to opening up previously unavailable fiber capacity on existing networks is advanced modulation.

Overview of advanced modulation

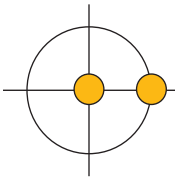
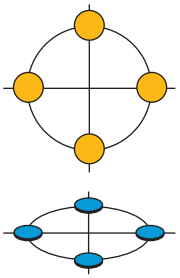
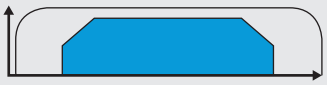
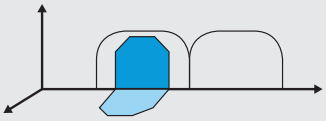
Most DWDM networks employ optical filters and reconfigurable optical add/drop multiplexers (ROADMs) using standard 100GHz or 50GHz channel spacing. At 10 Gb/s, simple on/off keying (OOK) modulation is sufficient for transmission through cascaded filter elements without significant penalty. OOK encodes one bit per symbol, so the symbol rate is equal to the bit rate (i.e 10 GBaud).

This modulation format cannot support 100G transmission for a number of reasons:

- The spectral width of a 100G OOK signal is ten times larger than that of an equivalent 10G OOK signal, making it too wide to pass through DWDM filters without excessive penalties
- The necessary modulator, driver and receiver electronics to attempt 100G OOK transmission are difficult to fabricate, making them hard to source and prohibitively expensive
- Noise tolerance, chromatic dispersion, polarisation mode dispersion and non-linear impairments all limit transmission reach to a few kilometers before regeneration is required, rendering the solution uneconomical

Instead, 100G transmission uses coherent dual polarization quadrature phase shift keying (DP-QPSK) to provide the required optical reach in a spectral width that is compatible with existing DWDM technology. DP-QPSK codes four bits per symbol using in-phase and quadrature-phase components of two polarization states (Figure 1), which reduces a bit rate of 127 Gb/s to a symbol rate of 31 GBaud, enabling transmission through many cascaded DWDM 50GHz or 100GHz filters or ROADMs.

Figure 1: Comparison of on/off keying and DP-QPSK modulation for 100 Gb/s

Modulation Format	OOK	DP-QPSK
Constellation		 Y-Polarization X-Polarization
DWDM Grid	200 GHz 	50 GHz 
Symbol Rate	127 Gbd	31 Gbd
Spectral Efficiency (bits/s/Hz)	0.5	2

Building on existing 10G networks

One of the key requirements for any 100G solution is the ability to operate seamlessly within an existing 10G network infrastructure, avoiding the need for additional optical amplifiers, dispersion compensators or regenerators. Without this capability, 100G becomes a niche technology that would only be deployable in expensive, new network builds.

DP-QPSK modulation with coherent detection enables transmission of 100G wavelengths over networking infrastructure designed for 10G engineering rules. This is possible for the following reasons:

(i) The DP-QPSK modulation strategy allows the ~30 GBaud signal to be transmitted through currently deployed DWDM filters and ROADMs with minimal performance penalty. An accurately wave-locked tunable laser on the DWDM line interface makes the solution more robust and less susceptible to wavelength drift within the filter band.

(ii) A local oscillator tuned to the same wavelength at the receiver provides coherent detection, which preserves both amplitude and phase information from the optical signal. This allows a powerful digital signal processor to compensate for chromatic dispersion and polarization mode dispersion, and deliver performance in excess of current 10G capabilities.

(iii) The 100G DWDM line signal is OTU4 encapsulated, which provides strong forward error correction schemes capable of achieving better than 9dB of coding gain.

Table 1 compares the typical optical performance specification for 10 Gb/s DWDM wavelengths based on XFP technology to what is achievable for 100 Gb/s using DP-QPSK with coherent detection:

Table 1: Comparison of 10G and 100G optical performance specifications

	10G (on/off keying)	100G (DP-QPSK coherent)
OSNR Tolerance (dB)	16	13
Chromatic Dispersion Tolerance (ps/nm)	1,600	40,000
Polarization Mode Dispersion Tolerance (ps)	9	30

Clearly, a DP-QPSK coherent 100G DWDM wavelength can match – and often exceed – the performance of a typical 10G OOK wavelength based on DWDM XFP technology.

That said, the impact of non-linear impairments also needs to be considered. 10G wavelengths are amplitude modulated, so the 1 to 0 transitions in the signal generate cross-phase modulation within the transmission fiber. The 100G wavelengths are phase modulated and will incur some performance penalty as a result. This must be addressed without defining guard bands in the DWDM spectrum, as that would reduce the traffic-carrying capacity of the fiber.

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Where 10G and 100G wavelengths exist on the same network, the use of Fiber Bragg Grating dispersion compensators reduces this non-linear penalty by up to 5dB compared to dispersion compensating fiber strategies. Fiber Bragg Grating compensators also provide less latency and intrinsic loss than compensating fibers, increasing achievable un-regenerated reach.

100G is the right choice

100G implementations offer an effective means to evolve existing 10G-based networks to deliver 10 times the capacity per wavelength. The use of DP-QPSK coherent technology permits simple integration of 100 Gb/s wavelengths onto the same infrastructure, without re-engineering, and expands a network's lifespan significantly. 100G is today's choice to scale networks in a way that delivers the required capacity in the most efficient manner, readying the network for tomorrow's bandwidth crunch.

The Optelian solution

Optelian's MPX-9110 platform provides comprehensive capabilities to address 100 Gb/s networking and service delivery requirements. Configurable as a muxponder or transponder, the MPX-9110 aggregates and transports any mix of 10 Gb/s, 40 Gb/s, and 100 Gb/s services over a 100 Gb/s OTN connection. Its tunable 100 Gb/s integrated line interface enables simple network integration with any available wavelength within 40- and 80-channel DWDM wavelength plans.

Efficient 10 Gb/s service delivery

- 100G provides the optimal approach for delivering 10 Gb/s services across core network infrastructure, eliminating the requirement to use a single wavelength per service. The solution offers a ten-fold increase in service capacity and revenue potential.

High capacity services

- Providing a 40 Gb/s and 100 Gb/s service offering drives new revenue opportunities and ensures customer retention via simple upgrades from 10 Gb/s. The MPX-9110 provides muxponder and transponder functionality to address both service rate requests with one service delivery platform.

Maximize existing network potential

- Deploying 100G solutions on even the last five channels of a 40-wavelength DWDM system provides significant capacity enhancements, extending the life—and revenue potential—of existing networks.

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