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CWDM — The Wave of the Future?

Making the most out of your metro fiber

Wavelength Division Multiplexing (WDM) is not exactly the latest in technology initiatives. It's been around for over two decades. And WDM in long-haul applications is nothing new in carrier networks.

So why the sudden renewed interest now? In short, because of Coarse Wavelength Division Multiplexing (CWDM). This less complex variation of WDM promises a much more cost-effective way to deliver speed and bandwidth over short distances to metro customers. Continuing technology advances combined with recent strides made in standards organizations, have led to a growing interest in CWDM.

But for CWDM to realize its potential as the "wave of the future," the remaining concerns of carriers and service providers about CWDM must be addressed, thereby removing the final barriers to adoption and proliferation of CWDM in the metro area.

This paper will provide an overview of the evolution of WDM technologies, current standards definitions and some of the benefits and shortfalls of today's CWDM implementations. And finally, we'll look at the ways in which technology innovators like Metrobility are meeting the challenge to make CWDM "ready for prime time" in metro core and access networks.

A white paper from Metrobility Optical Systems

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The Challenge

Transforming untapped infrastructure potential into profit. That's the goal of every service provider. And in the case of fiber networks, the challenge lies in finding ways to realize the full potential of infrastructure investment, accelerate revenue opportunities and provide scaleable and manageable end-to-end solutions that satisfy customers while creating profit and market expansion opportunities for the service provider.

WDM over the Years

During the last two decades, carriers, utilities and other entities began laying fiber. Originally, it was TDM-based technologies that were being used on this growing fiber infrastructure. But costs remained high, and applications didn't place sufficient pressure on existing, less-expensive physical infrastructures to cost-justify the widespread use of fiber that many had predicted.

So there is still a great deal of dark fiber out there, waiting for the convergence of applications requiring the speed and bandwidth of optical fiber and an affordable means of using that fiber strand. But with the evolution of Wavelength Division Multiplexing (WDM) technologies, fiber's day may well have come.

VARIATIONS ON A THEME

As WDM became increasingly popular over the last 20 years, a veritable "alphabet soup" of WDM acronyms have emerged: WDM, WWDM, BWDM, DWDM and CWDM.

WDM simply describes the methodology for sending multiple concurrent streams of data over the same optical fiber infrastructure, by placing the data on separate wavelengths or channels, which share the same fiber. This enables a more efficient use of the physical medium and is well suited to the transmission of voice, video and data streams.

BWDM, or Bidirectional Wavelength Division Multiplexing, allows for full duplex data transmission over a single fiber. This technique can be used in both DWDM and CWDM implementations and is a descriptive term, not an ITU-defined standard.

Wide Wavelength Division Multiplexing (WWDM) was originally defined as a LAN WDM operating in the 1310nm window, while early CWDM was also described as a LAN technology, but operational in the 850nm window.

Coarse Wavelength Division Multiplexing (CWDM) today has evolved from its LAN applications beginnings in the 850nm window to its current ITU-defined operations in the 1310nm window as a metro area networking technology. LAN WWDM is very similar to today's metro CWDM, and the standards for the two appear to be on a convergence course.

DWDM or Dense Wavelength Division Multiplexing is widely used by carriers for long-haul applications. Originally used primarily for voice traffic, today it supports a variety traffic types. It operates in the 1550nm window and supports a large number of high-speed channels over long distances and provides substantially increased bandwidth over installed fiber.

Catch the Wave: CWDM Today

THE BUILDING BLOCKS

There are three major components or building blocks in WDM-based products: amplifiers, multiplexer/demultiplexers and transceivers.

Amplifiers to boost signal and extend distances are not needed for CWDM deployments even up to 80-100km transmission distances.

Multiplexers and demultiplexers are used to combine and separate multiple channels or wavelengths. Optical Drop Add Multiplexers **(OADMs)** support drop/add and drop/pass capabilities on a per-wavelength basis. A DWDM multiplexer can cost 2 – 3 times more than its CWDM counterpart because of the expensive DWDM filters that are required.

CWDM Transceivers, with their lasers and OEOs (optical-electrical-optical converters), are far less expensive than the DWDM version, which are typically 4x to 5x more than CWDM equivalents – and they consume significantly more power.

Transceivers are typically packaged in SFP (small form-factor pluggable) and GBIC (gig interface converter) formats. ,

Application Drivers

But lower cost alone would not account for the interest in CWDM if there were not a growing number of applications for which CWDM is ideally suited and that are ready and waiting to take advantage of the operational advantages, as well as the cost savings afforded by CWDM technology.

The first applications that are always mentioned in a discussion of CWDM seem to be metro access, storage area networking (SAN) and high-bandwidth Ethernet. But there are a number of other services for which it is equally well-suited. For applications that require DS3/T3 or 100+Mbps data rates, CWDM shines.

Enterprise LAN connectivity, gigabit Ethernet and Fibre Channel SANs are now being joined by a number of other high-speed data, voice and video applications. CWDM is increasingly being considered for short-haul disaster recovery scenarios, as well as for voice, broadband access and cable MSO services, such as HDTV, video streaming, new digital services, high-speed Internet access, VPNs and VoIP.

Metro core and metro access connections are often best addressed by CWDM – CO to PoP and CO-CO links, as well as the cost-sensitive connection from the customer to the network core can be easily achieved with CWDM. Service providers serving the multi-unit property (MTU/MDU) marketplace benefit by being able to aggregate traffic generated by multiple co-located business or residential customers and offer cost-effective "last mile" connectivity.

There seems to be no end in sight as CWDM technology and the associated standards continue to evolve, while emerging bandwidth-hungry applications keep appearing on the scene.

CWDM vs. DWDM

The primary WDM technologies in use today, DWDM and CWDM, each has its advantages, but price/performance tradeoffs and the requirements of the application will ultimately determine which one a provider will deploy.

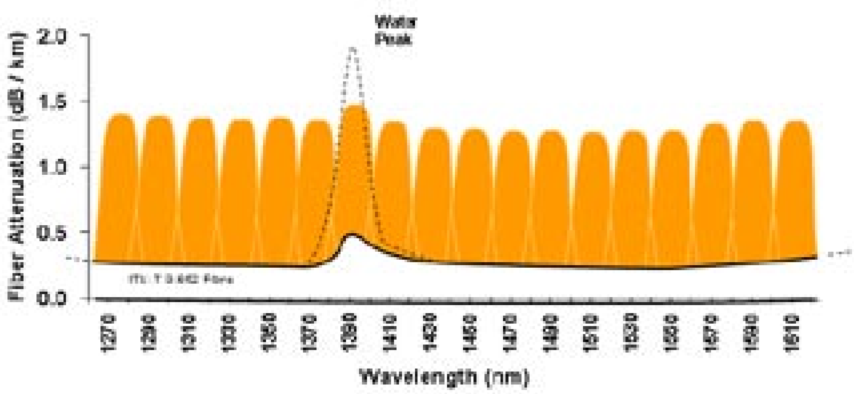
DWDM has been popular with carriers for some time. It was originally used to mitigate bandwidth issues in backbone long-haul voice applications, but is now used for a broader spectrum of applications, where high bandwidth is needed. Extended distances of up to 600km are supported, but require expensive EFDAs (Erbium Doped-Fiber Amplifiers) to boost power.

DWDM uses expensive narrow-bandwidth (.8nm) filters and requires specialized cooling to stabilize laser temperatures. The standard calls for up to 80 channels, but typical DWDM implementations support 16-40 wavelengths or channels, at speeds from 2.5 Gbps to 10Gbps per wavelength.

DWDM Upside: This technology is very efficient for long-haul networks. It not only supports long distances, a multitude of channels and high aggregate bandwidth, but it offers the sophisticated end-to-end management tools required in carrier networks. A far larger number of customers can be supported concurrently, spreading the infrastructure costs over a larger group of users.

DWDM Downside: This is a "hot" technology in every sense of the word. The high density of channels over a narrow frequency range from 1530 - 1620nm (spanning the C- and L-bands) requires expensive filters and cooling and consumes a lot of power. All this makes for larger engineering and manufacturing efforts bundled in a larger-than-optimum package. Complexity, cost, colossal equipment footprints combine to leave room for alternative WDM transmission facilities to emerge.

CWDM owes its emergence, in large part, to the growth of the metropolitan area network as carriers and service providers look for more cost-effective ways to deliver speed and bandwidth over shorter distances to their metro customers.



LIVING UP TO THE STANDARD

CWDM standards as defined in the fInternational Telecommunications Union (ITU) document ITU-T G.694.2.

Economic and market pressures, combined with technology advances and recent strides made in standards organizations, has led to a growing interest in CWDM. But while CWDM is a hot topic these days, some industry experts remain skeptical about its value to carriers, although both groups are intrigued by its promise of dramatically lower capital and operational expenses.

It is only in the last two years that CWDM has moved to center stage in the metro arena.

CWDM Upside: This technology is very "cool" in every way. Although originally designed for the short haul, today's CWDM implementations support distances up to 80km without amplification and up to 120km amplified. And although supported distances are much shorter than those found in DWDM implementations, CWDM can provide high-speed access and low-cost bandwidth without requiring expensive temperature-stabilization facilities. Deployable in a matter of hours versus days, CWDM is an ideal shared fiber "starter" transmission facility.

CWDM is less complex than DWDM, making it easier to engineer and manufacture in a far smaller footprint. Small form-factor pluggable (SFP) CWDM optics run cooler, require less power and support data rates from 100Mbps to 2.4Gbps per channel.

CWDM Downside: Many experts still contend that CWDM is only suited to niche markets like cable MSO and storage area networking applications and that the cost savings over DWDM come as a result of lower capacity, lower channel count with support for fewer concurrent customers, distance limitations and a lack of carrier-class management solutions. CWDM is also accused of lacking the capacity for scalability and manageability.

Riding the Wave - Moving forward with CWDM

Waving good-bye to the objections

Comparing both cost advantages and operational benefits of CWDM in the metropolitan network sheds light on the compelling arguments for wider spread adoption by carriers, service providers and their customers. But it's time to address their concerns about today's CWDM implementations, because those mostly-imagined objections have created an impediment to CWDM's wider deployment as the short-haul metro "technology of choice."

Debunking the myths

Many of the objections to deployment of CWDM that carriers and providers have raised over the years had a sound basis at the time they were initially raised. But the last two years have brought about so many advances, that it's worth another look to determine whether these objections are still valid or whether they should be relegated to the realm of WDM myths:

- **Lack of scalability**. With support for a limited number of channels (16 today), scaling up as capacity is outgrown requires a forklift upgrade to DWDM. This is no longer true, as hybrid CWDM- DWDM networks become more widely used.

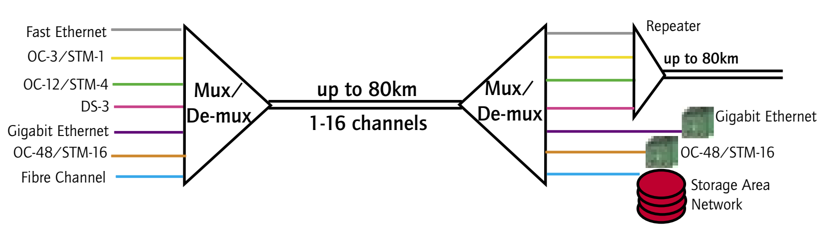
In fact, many providers are looking at the initial deployment of CWDM for cost and operational advantage, only adding DWDM as more bandwidth and channels are required. It is very easy to introduce new DWDM channels in the C-Band, where CWDM and DWDM wavelengths overlap, without any disruption to service. This is a far more cost-effective approach than installing all DWDM transmission facilities before they're really required.

- **Carrier-grade reliability and availability are lacking**. While there is some truth remaining in this statement, CWDM is making strides in terms of becoming more carrier-friendly. DWDM already supports innate failure recovery mechanisms and SONET-like failover in the 50 msec range. And although CWDM is still not quite as carrier-ready as DWDM. However, vendors are developing increasingly robust CWDM implementations. Metrobility, for example, already supports 200μsec failover and fully redundant configurations to ensure high availability and fast recovery and restoration in the event of failure.

- **Sophisticated carrier-class management tools are missing**. End-to-end management remains a challenge in passive optical networks. But again, vendors like Metrobility are making tremendous progress in this area, offering the option of intelligent, remotely manageable OEO devices for any wavelength at any given endpoint.

- **Distance limitations.** While DWDM will always be the preferred technique for long-haul applications, new CWDM technologies are already available to significantly extend distances over the original 50km limitations. New SOA developments are already extending the geographic span of CWDM to over 120km, and engineering advances like this will only continue as CWDM becomes more widely deployed.

- **CWDM is only suited to niche applications.** There is no single "killer app" driving CWDM, unless you consider the continually emerging bandwidth-devouring applications that are now ubiquitous. But the number of applications for which it can deliver a partial or complete answer is growing as the technology evolves and the standards proliferate. So, while this statement might once have been true, it is less accurate every day.



When configured with multi-rate CWDM optics, service providers can leverage existing fiber infrastructure to provision and manage multiple services over a single fiber pair by utilizing different CWDM lambdas.

Catching the Next Wave: The ongoing CWDM evolution

Recent analyst research suggests that 2004 will finally be the year of renewed network equipment growth. But Prudential Financial research on the network equipment market indicates that carriers will continue to take a hard look at all capital expenditures. That should bode well for CWDM, which offers both lower equipment and sparing costs, as well as the benefits of simplicity, faster deployment cycles and accelerated return on investment. And, not surprisingly, the Prudential report names CWDM as one of the top trends to watch for in 2004.

[Source: Singh, et al, "Communications & Data Networking Equipment," Prudential Equity Group, Inc. Research Report]

As more of the fiber infrastructure is lit up and its capacity is consumed, WDM technologies will gain increasing importance. That much is certain. And we can also surmise that as more broadband applications emerge and gobble up existing infrastructure bandwidth, CWDM's ability to make use of available fiber cost-effectively will ensure not only its survival, but also an increase in its popularity.

THE CRYSTAL BALL

Over the next 18 to 36 months, the need for carrier-grade availability (99.999%) will increase as CWDM is asked to support high-availability applications like disaster recovery.

Reliable line protection and restoration, along with fast (sub-50ms) failover will no longer be considered just a "nice-to-have" CDWM feature.

End-to-end management of the entire CWDM-based infrastructure will become more important if CWDM is to meet the expectations of carriers.

Further, CWDM equipment will have to be fully NEBS-compliant and available in indoor and outdoor enclosures.

And finally, it seems inevitable that higher speeds (up to 10Gbps) will have to be supported to meet growing applications demands.

Metrobility's CWDM Building Blocks

Metrobility® offers more than 100 CWDM-compatible options to support data rates from 10Mbps to 2.7Gbps. Pairing individual line cards with the Company's passive CWDM modules, network builders can build their CWDM network as their subscriber base grows. Metrobility's R4000 chassis-based modules support up to 16 channels over a passive optical network in point-to-point or ring network configurations.

THE MANAGEMENT ADVANTAGE

When CWDM uses only passive optical (PON) components, end-to-end management can prove challenging. But Metrobility's wide range of management solutions allows service providers and enterprises the ability to mix passive and active elements throughout the network as needed, so that users pay for only as much management as they need. This ability to place intelligent management components at critical points based on the needs of the user and the application enables providers to monitor and manage remote sites efficiently and cost-effectively.

Management options include both path and link fault management, in-service loopback, SNMP, PING and RMON Group 1 statistics, event logging and tracking, trends analysis and real-time analog data for measuring environmental conditions. And all management information is available in an easy-to-understand graphical display provided by Metrobility's NetBeacon® and WebBeacon™ software.

OUR COMMITMENT

Our ongoing commitment remains to empower the providers of network services to transform the potential of fiber optic networking into profit while better serving their customers.

Changes in emerging technology markets are not completely predictable, so we continue to create products based upon an open, standards-based architecture that allows us to adapt with agility as new technologies, protocols and standards appear and as applications and business practices evolve.

The Radiance product suite now supports CWDM standards. And we've anticipated next-generation requirements in the robust CWDM equipment and management feature sets that we're delivering today. The Radiance architecture is ideally suited to respond to evolving CWDM standards and technology advances as they appear, enabling us to continue to apply our vision to advancing the art in optical networking.

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