COMPANY BRIEF

Matisse Networks
Company Brief
July 20, 2009

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Company Overview

Matisse Networks was founded in 2001 and launched its EtherBurst commercial product in September of 2006 after a successful beta test at Lawrence Livermore Labs. Since 2008 Matisse has shipped products to both Enterprise and Service Provider customers worldwide. The Company's products are designed to enable customers to build highly scalable metro aggregation networks by delivering the best features and advantages of optical DWDM and Ethernet technologies in an integrated system while simultaneously driving down the total cost of ownership. Matisse targets both Service Provider customers and Enterprise customers with its unique approach.

EtherBurst fundamentally changes the economics of optical networking through its optical packet switching technology and by its ability to dynamically allocate bandwidth capacity based upon traffic demand. The fusion of Ethernet packet switching with DWDM optical packet switching technologies allows statistical multiplexing at the optical layer and real-time sharing of network capacity among connections eliminating the stranded bandwidth that is wasted on under-utilized wavelengths in traditional ROADM based optical transport networks.

Matisse Networks EtherBurst® is the first commercially available Ring Optical Burst Switch (Ring OBS) system and the only such system in production today. EtherBurst switches individual optical packets rather than entire optical wavelengths making it an ideal technology choice for building highly scalable metro optical aggregation networks to support the growing needs of packet-based Carrier Ethernet, IPTV and mobile broadband services.

Highlights

- Matisse Networks is the first company to ship a commercial Optical Packet Transport system based upon ring optical burst technology (Ring OBS). Matisse Networks' innovative research and development has resulted in the award of numerous patents covering breakthroughs in packet optical networking.
- The Metro DWDM market was $3.8B in 2008 and is expected to grow to $5.4B by 2011. This market is dominated by Service Providers deploying optical transport for their rapidly growing IP/Ethernet based services. For example, the demand for Carrier Ethernet services is growing at a CAGR of 43%. Service Providers are being challenged to maintain margin as subscriber port and service revenue grows at a lower ARPU per Megabit thereby creating the need for more efficient transport solutions for their IP/Ethernet based services.
- The competitive landscape primarily consists of solutions attempting to incrementally adapt circuit-based optical technology to accommodate packet services. These competitive approaches include transporting Ethernet over SONET/SDH, transporting Ethernet over DWDM equipment using ROADMs and integrated Ethernet grooming in the Packet Optical Transport Platforms (POTP).
- With its breakthrough Ring OBS products and technology, Matisse Networks blends Ethernet and DWDM into a single platform that provides packet switching granularity in the DWDM domain significantly reducing CAPEX for Network Operators.
- EtherBurst eliminates the need for optical engineering, wavelength planning and configuration through its optical flowthrough provisioning capability significantly reducing OPEX for Network Operators.

- Matisse Networks has been shipping EtherBurst systems for revenue since 2008. Matisse has developed a sound go-to-market strategy that will enable the company to capitalize on its early successes and continue to grow its revenues.

Experienced Leadership

Matisse Networks is led by a team of experienced telecommunications industry professionals with over 200 years of combined experience. This proven leadership team has had key leadership roles at a number of well known startups in Silicon Valley including Ascend Communications (acquired by Alcatel-Lucent/ALU); Amber Networks (acquired by Nokia Siemens Networks/NSN); TiMetra Networks (also acquired by Alcatel-Lucent/ALU); Bay Networks (acquired by Nortel); Terayon (acquired by Motorola) and Extreme Networks (EXTR).

Led by Sam Mathan Chairman and CEO, the leadership team includes: Claude Hamou, Founder and COO; Craig Easley, VP of Marketing; Doug Stewart, VP of Sales; Prabhat Mishra, VP of Engineering; Jerry Lovatt, VP Finance and Hank Zoeller VP of Manufacturing Operations.

Management Team

Sam Mathan	Chairman and CEO
Claude Hamou	Founder and COO
Jerry Lovatt	Vice President of Finance
Prabhat Mishra	Vice President of Engineering
Craig Easley	Vice President Marketing
Doug Stewart	Vice President North America and EMEA Sales
Hank Zoeller	Vice President of Manufacturing Operations

Board of Directors

Sam Mathan	Chairman and CEO
Claude Hamou	Founder and COO
John Jarve	Director, Menlo Ventures
Andrew Kau	Director, Walden International
Vincent Occhipinti	Director, Woodside Fund
Ross Ireland	Former Senior Executive VP of Services and CTO at SBC (now AT&T)

Delivering the Next Generation of Optical Packet Transport Systems

Matisse Networks' business strategy is to develop innovative products that provide game changing economic advantages for its customers. The Company's technical approach leverages commercially available "off-the-shelf" components combined with patented intellectual property and engineering innovation. This strategy has been critical in enabling the company to achieve its business milestones at uncharacteristically low investment levels for an optical systems company. By avoiding the significant expense of developing its own proprietary optical components, Matisse was able to bring the EtherBurst product to market with $35M of capital. This is a fraction of the capital required by other optical innovators, like Infinera, who have required in excess of $200M of capital to bring their products to market.

Through focused execution and significant technology and business achievements, the team has successfully created significant momentum in the Ring OBS market category, resulting in recognition of its technology and market leadership. In a recently published report titled "The Optical Switching Revival – Rebuilding Optical Networks for Packets", Heavy Reading Senior Analyst Sterling Perrin pointed out that while there are only "two viable players in the optical burst switching space – Matisse Networks and InTune Networks, Matisse Networks is further along with products that are shipping today". Perrin goes on to report that OBS represents the next generation of optical packet transport systems.

Timeline of Corporate Milestones

2003 – Matisse Networks receives $21M of initial venture funding.

2006 – EtherBurst product is commercially launched.

2007 – EtherBurst Optical Packet Transport systems begin lab trials with several Service Providers. The company closes an additional $45M of funding.

2008 – Matisse begins revenue shipments of its products to both Enterprise and Service Provider customers.

2009 – EtherBurst is deployed by Time Warner Telecom, the third largest provider of Ethernet Services in the US.

Go To Market Strategy

Matisse Networks' EtherBurst Ring OBS switch addresses the fastest growing segment of the metro optical equipment market, Metro DWDM. Matisse Networks' sales and distribution model is to introduce EtherBurst products and technologies directly to early adopters in both Service Provider and Enterprise market segments worldwide. Once customer traction is established in a region we expand our sales coverage with direct and reseller relationships in the region. Matisse will continue to expand its reseller channel of highly skilled value added partners to provide the reach necessary to fully capitalize on the market opportunity for Metro Optical Packet Transport Systems.

Value Added Distribution Partners

European Reseller Partners

Xantaro - Germany
DeltaNet - Switzerland

Japan Reseller Partner

Nissho Electronics

Korean Reseller Partners

iCraft
MegaCraft

Current Revenue Customers and Customer Trials

Developing a product that is applicable for both Enterprise and Service Provider networks allows Matisse to generate revenue in the short term in the Enterprise market while investing to secure Service Provider network project wins. These Service Provider projects are networks of size and scale and will accelerate revenues in the mid-term and beyond. Matisse first began shipping its products for revenue in 2008 and is now poised to grow its customer and revenue base. The following is a list of our customer engagements:

North America

Time Warner Telecom – Revenue customer
Verizon – Lab trial
Cablevision/Optimum Light Patch – Lab trial
US Government – Revenue customer (details classified)

Europe

British Telecom – Lab trial successfully completed
Swisscom – Proof of Concept trial completed
Telefonica – Lab trial scheduled for November 2009

Asia

KDDI Labs, Japan – Revenue customer
KT, Korea – Proof of Concept trial completed
CAT, Thailand – Network trial

EtherBurst Market Opportunity

Market Drivers Fueling the Growth in the DWDM Metro Market Segment

The shift in services from circuit oriented TDM services to IP/Ethernet services like Business Ethernet has continued to accelerate even during the global economic downturn. Business Ethernet services are the dominant source of packet traffic in Service Provider networks today representing $8B of service revenue worldwide in 2008 according to a recent report published by Vertical Systems Group, an industry research firm who has been tracking the Carrier Ethernet market since its inception. In their latest Ethernet Network Services (ENS) report, published in December 2008, they forecast double-digit market growth over the upcoming 5 years and predict that the global market for Carrier Ethernet services will approach $40B in annual revenue by 2013 (Figure 1).

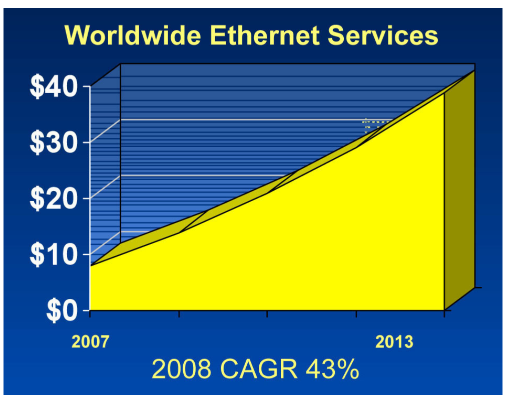

Figure 1 Source: Vertical Systems Group

While subscriber growth continues at a brisk pace, competition for those subscribers in the market is creating price pressure that is reducing the price per bit and threatening service margins. A recent study by Cisco's Internet Business Services Group (IBSG) documents the margin erosion and points to the importance of efficiency measures to reduce the cost of delivering these services in order to preserve service margins (Figure 2). The study goes on to suggest that while core networks are operating fairly efficiently and costs are largely fixed in the access network due to the capital costs associated with deploying

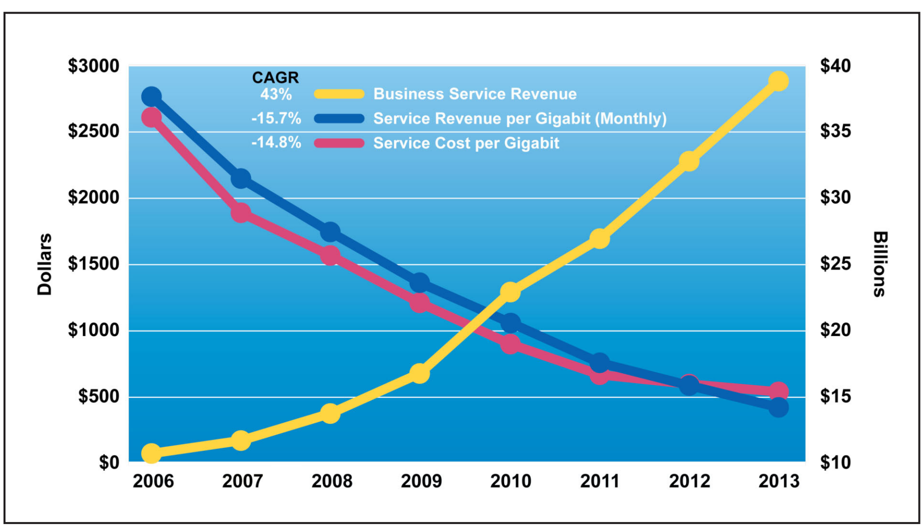

Figure 2 Source: Cisco IBSG and Vertical Systems

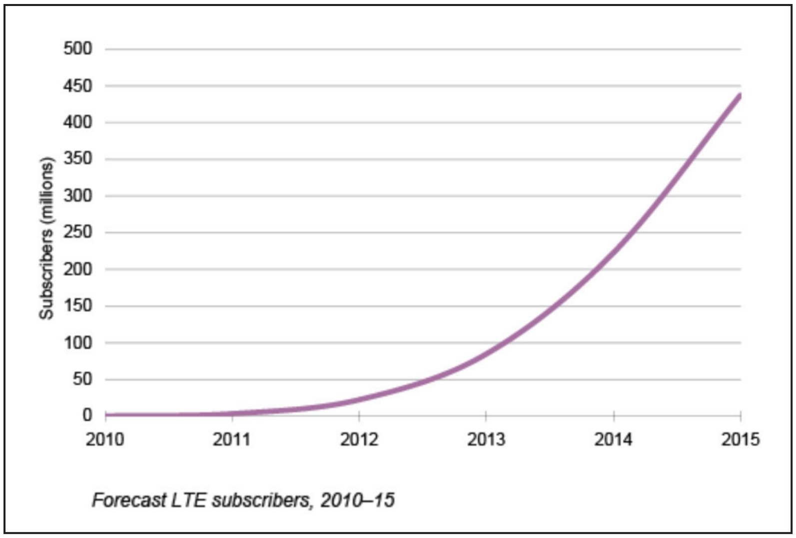

Figure 3 Source: Analysys Research Limited

fiber access lines and customer premise equipment, there is significant opportunity for both capital and operational cost reduction in the metro optical transport network.

The rising demand for packet transport systems will be fueled not only by the continued acceleration of the adoption of business-class Carrier Ethernet services but also by bandwidth intensive IPTV and emerging LTE mobile broadband applications. According to Media Research Group (MRG) IPTV subscriber rates are forecast to double each year over the next 5 years growing from 20 million subscribers in 2008 to nearly 100 million subscribers by 2012. ABI Research forecasts an aggressive ramp up for LTE subscribers predicting that adoption will go from 0 in 2010 to 32 million in 2013. Analysys Research Limited forecasts an even more aggressive ramp for LTE subscribers, projecting 450 million LTE subscribers by 2015 (Figure 3).

The primary driver for growth in capital expenditures for metro DWDM equipment is a need for Service Providers to drive new service revenues from bandwidth intensive packet-based services such Carrier Ethernet, Internet Protocol Television (IPTV), and mobile broadband.

Targeting the Growing DWDM Segment within the $9 Billion Optical Metro Market

Optical hardware used by Service Providers to build metro networks is based on either SONET/SDH or DWDM technology and is currently a $9B dollar market. DWDM technology continues to gain share versus SONET/SDH in Service Provider networks and according to Infonetics' Optical Network Hardware Market Size and Forecast released in January of 2009, is expected to achieve 50% of the total metro market by 2011 (Figure 4).

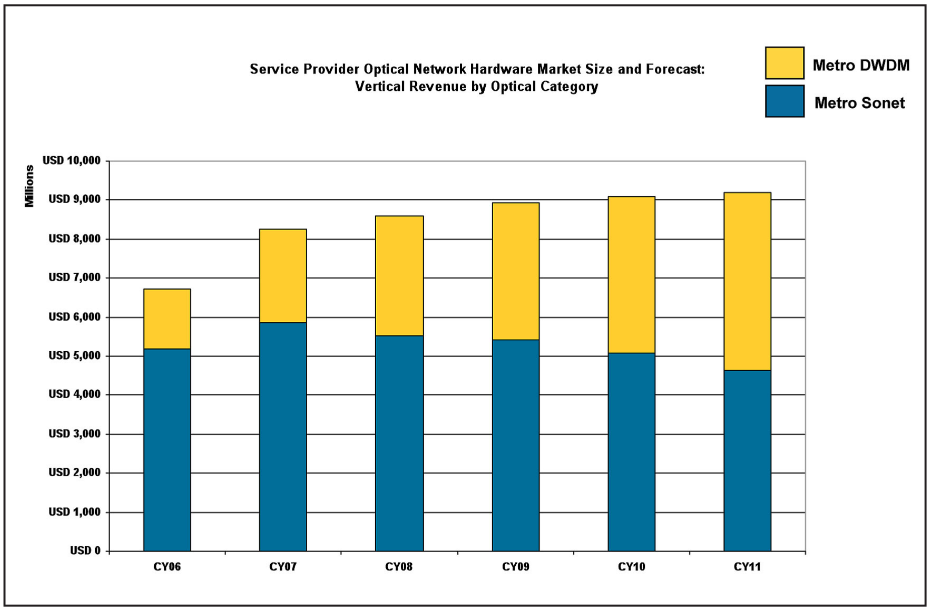

Figure 4 Source: Infonetics Research

The erosion of the SONET metro market will continue as packet-based services continue their strong growth. SONET, the 1st generation of optical networking technology was designed and optimized to carry fixed bandwidth services like TDM over fixed bandwidth circuits. Packet services such as IP/Ethernet are dynamic in nature and cannot be carried efficiently over SONET optical transport networks. Carrying Ethernet packet services over SONET also requires encapsulating the Ethernet packets prior to transmission over the SONET network, further reducing the efficiency due to the additional overhead required by encapsulation protocols. SONET has been a popular optical networking technology and according to Infonetics Research, has an enormous installed base of over 475,000 SONET rings worldwide. These large number of installed fiber rings will be eventually upgraded to carry high bandwidth Ethernet traffic and represent a major market opportunity for our products over the life of the networks.

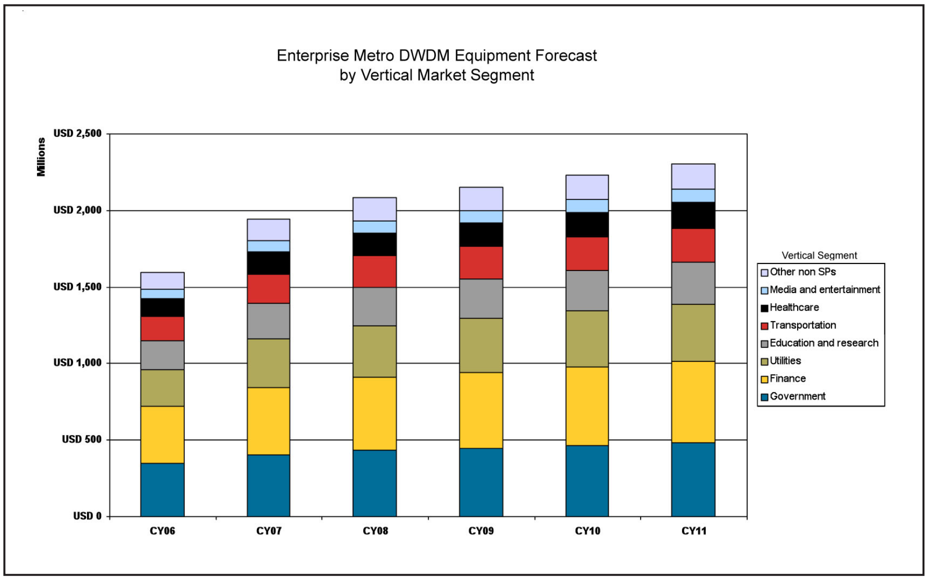

Figure 5 Source: Infonetics Research

Despite current economic conditions, the Metro DWDM equipment market grew from $3B to $3.7B (23.3%) in 2008 and is forecast to continue this growth increasing to $4.2B (13.7%) in 2009. According to Infonetics Research, double-digit growth is expected to continue through 2011 when the market is expected to reach $5.3B as metro DWDM continues to replace SONET/SDH spending.

Enterprises have also witnessed the rise in packet applications brought about by the convergence of their voice, video, storage and data networks on a single IP/Ethernet network. As bandwidth demands for new applications continue to push Enterprise networks for more and more capacity, optical transport has become a crucial element in most large Enterprise networks. DWDM equipment is being deployed in private Enterprise networks to provide high bandwidth capacity and efficient multi-location connectivity. IT organizations are facing the same challenges as Service Providers are seeking to upgrade their networks and optimize them for Ethernet data traffic and packet based applications like Voice over IP (VoIP), IP video conferencing and IP storage networks.

According to research performed by Infonetics Research, in 2008 the Enterprise DWDM market was over $2B and is expected to grow by another quarter of a billion dollars to $2.2B by 2011. Government networks makeup the largest segment of the market along with finance, education and utility companies. A smaller segment that is growing fast is health care where medical imaging applications and patient record keeping requirements are creating a large demand for high bandwidth (Figure 5).

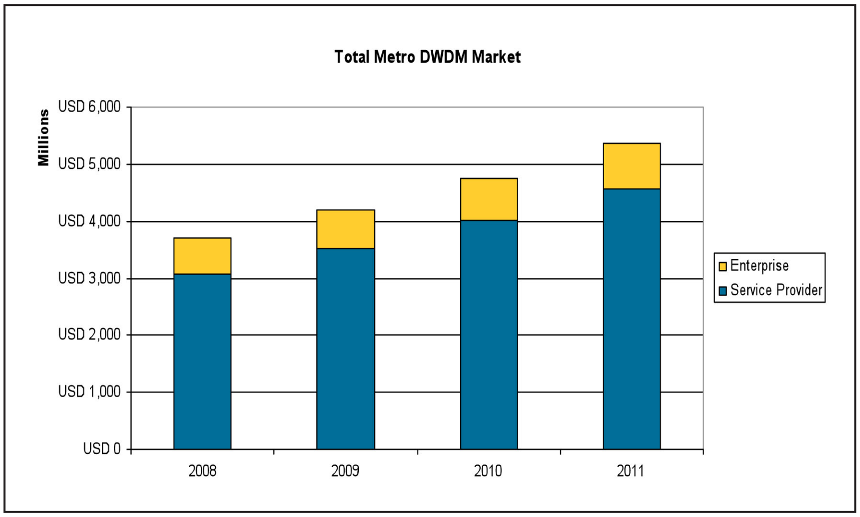

Figure 6 Source: Infonetics Research

The Total Addressable Market for Matisse Networks is a combination of the Enterprise Metro DWDM along with the Service Provider Metro DWDM equipment markets. According to Infonetics Research, the total Metro DWDM equipment market was $3.8B in 2008 growing to $5.4B in 2011 (13.1% CAGR) and is dominated by Service Providers who are deploying optical transport technology in the metro as a means to carry Ethernet and other packet services like IPTV and Mobile Broadband between Ethernet access networks. Though relatively smaller when compared to the Service Provider market, there is a significant opportunity within the Enterprise market for Metro Optical DWDM equipment as well (Figure 6).

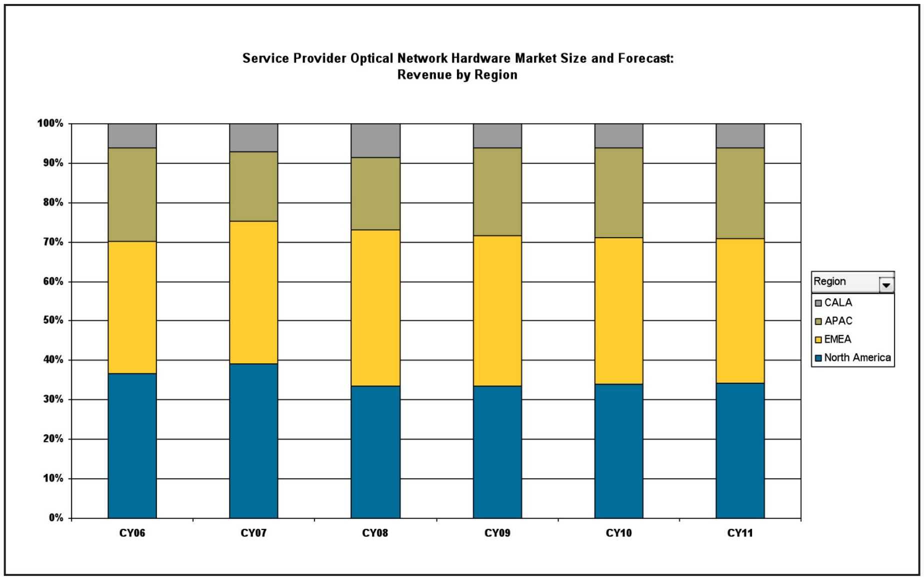

Figure 7 Source: Infonetics Research

Worldwide Market by Region

Asia, North America and Europe each account for approximately one third of the worldwide market for DWDM equipment. This is consistent with the profile for regional adoption of Carrier Ethernet business services and the early deployments of IPTV. The benefits of delivering packet services are being seen globally, although the applications driving the adoption vary by region (Figure 7).

Growing Demand for Carrier Ethernet and other Packet Services is Creating an Opportunity for Transformation in the Metro Optical Network

According to Infonetics Research in the recently published Optical Network Hardware Forecast Report, Service Providers around the world are in various stages of network transformation. These networks are being redesigned from primarily serving TDM services to networks that will primarily carry packet services.

Carrier Ethernet Switch/Routers (CESRs) provide layer 2-3-4 functionality in these transformation projects. A variety of other protocols are being considered for inclusion to make up for the capability gaps with Carrier Ethernet in terms of resiliency, vis-à-vis SDH/SONET, that tend to be IP-MPLS-Ethernet with Ethernet-DWDM metro optical transport. The most efficient network design results in a network that connects the service delivery layer to an Ethernet-DWDM fused network. This enables the eventual Convergence of IP/Ethernet networks to a 2-layer model with an IP-MPLS-Ethernet data service layer over an Ethernet-DWDM optical transport layer, as shown in Figure 8.

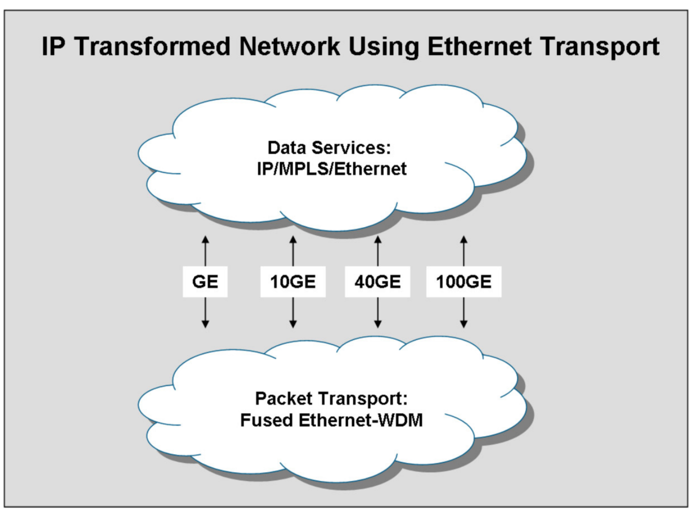

Figure 8 Source: Infonetics Research

Optical Packet Networks – Solutions Landscape

The prolific growth of packet-services including Carrier Ethernet, Voice over IP, and IPTV is creating a challenge for the circuit based optical transport networks. Originally designed and optimized for traditional circuit oriented (TDM) services, optical networks lack the fundamental capabilities that are required to transport this new generation of services effectively.

As reported by key industry analysts, Carrier Ethernet services have grown at a fast pace due in large part to Ethernet's inherent ability to dynamically assign switch/router capacity to support demand rather than "nailing-up" capacity between switch/router pairs. Ethernet enables carriers to oversubscribe the capacity of switch/router elements to take advantage of the "bursty" nature of IP data applications. Transporting Ethernet Services over optical networks using traditional static DWDM systems requires Ethernet services to be mapped to circuits, eliminating the benefits of Ethernet's statistical multiplexing in the optical network and stranding precious capacity (capital) in the network.

Several approaches are used to carry Ethernet services on optical transport, ranging from deploying Ethernet directly on dark fiber, to encapsulating it for transport over existing SONET and DWDM optical systems. The inefficient fiber usage characteristic of the native Ethernet over dark fiber approach, and the protocol inefficiency of carrying Ethernet over SONET/SDH (due to the encapsulation complexity and overhead requirement) and its limited 10G bandwidth have set the stage for Ethernet over DWDM to become the preferred solution for transporting IP/Ethernet services.

However, the current DWDM systems use static wavelength paths. The Reconfigurable Optical Add Drop Multiplexer (ROADM) systems being deployed today simply add and drop traffic on optical wavelengths on fiber and have no flexibility for switching or re-routing traffic on a packet-by-packet basis. This network architecture requires a router interface per transponder (location) in order to route traffic onto the DWDM optical network. Worse still, reconfigurations of the optical circuits connecting the locations require reconfiguring the transponders (or adding new ones) to accommodate changes in the network. So the problem of not being able to efficiently accommodate the dynamic traffic patterns of Ethernet packet-based services in the optical domain remains with ROADM metro optical transport.

The latest products from the large incumbent equipment providers to address this issue is the advent of Packet Optical Transport Platform (POTP), which integrates a packet (Ethernet) switch fabric along with the existing TDM switch fabric in the same optical transport platform. While this integration does enable switching Ethernet traffic directly onto DWDM wavelengths, it still requires dedicating an entire wavelength to location pairs and does not provide the flexibility to allocate unused capacity in the wavelength to other location pairs. The POTP equipment remains unaware of the traffic volume on the individual circuits and cannot re-use available bandwidth on under-utilized transponders, which is therefore inefficient and costly. POTP does not address the fundamental problem of inflexible dedicated "nailed-up" circuits to transport Ethernet over the optical metro. The integrated switching function of POTPs does enable one router interface to effectively switch to multiple transponders, which provides some incremental benefit over the OADM and ROADM approaches.

Matisse Networks EtherBurst Ring Optical Burst Switch is designed to meet the challenge of lowering the cost per bit transported with a fundamental technology innovation that enables switching individual packets in the optical domain rather than entire wavelengths. EtherBurst provides the flexibility and dynamical bandwidth allocation of Ethernet in the optical domain. EtherBurst eliminates stranded bandwidth on under utilized circuits by eliminating the circuits themselves.

Competitive Products

There are a number of equipment vendors with products in the three categories described above vying for market share in the metro optical DWDM transport network market. The large incumbent vendors have circuit oriented DWDM platforms based upon legacy Optical Add Drop Multiplexer (OADM) or Reconfigurable Optical Add Drop Multiplexer (ROADM) technology. This category has greater than 80% of the metro DWDM market and is the most vulnerable to new innovators in the market.

The second category is the Packet Optical Transport Platforms (POTP), which are still relatively new and have only been deployed by a few Service Providers. While POTP has been widely heralded as the next generation of optical transport, the cost and complexity of the systems has resulted in only a small number of Service Provider installations.

The final category is Ring Optical Burst Switches, a category defined recently by Heavy Reading Senior Analyst Sterling Perrin in his March 2009 research report on optical transport systems titled: "Optical Switching Revival: Re-Building Optical Networks for Packets". The report names two companies actively working on Ring Optical Burst Switches – InTune Networks and Matisse Networks. At present only Matisse Networks is shipping product.

Circuit Oriented DWDM (OADM / ROADM)

The following companies are providers of circuit oriented metro DWDM equipment:
Ciena – CN 4200
ADVA – FSP 3000
Cisco – 15454
Fujitsu – Flashwave 7500

Packet Optical Transport Platform (POTP)

The following companies are providers of packet optical transport platforms:
Alcatel-Lucent – 1850 TSS
Ericsson – SPT 2700
Fujitsu – Flashwave 9500
Tellabs – 7100

Ring Optical Burst Switches (Ring OBS)

The following companies are providers of Ring Optical Burst Switching products:
InTune Networks
Matisse Networks

EtherBurst Ring Optical Burst Switch – EtherBurst Innovations

Three important innovations comprise the technical foundation of Matisse Networks' EtherBurst Ring OBS transport system – the eBurst™ module, a 10 Gbps optical burst transponder, the MeshWave™ traffic aware packet processor and the eWave™ EDFA optical amplifier.

eBurst™ Optical Burst Transponder Module

eBurst is Matisse Networks' innovative 10 Gbps optical burst module. eBurst integrates off-the-shelf silicon and optical components along with Matisse Networks' intellectual property to create the first commercially available 10 Gbps optical burst switching transponder module. eBurst's tunable laser tunes and locks to any wavelength in the ITU C-band in nanoseconds. This enables packets to be transmitted as colored bursts of light. The burst receiver recovers data in nanoseconds from any other eBurst optical burst module in the network. The eBurst module creates a shared pool of optical bandwidth capacity that can be shared by any service to reach any location in a single optical hop. The dynamic allocation of bandwidth by the eBurst module is the key to efficiently transporting Ethernet and packet-based services in the optical network.

MeshWave™ Packet Processor

Matisse Networks' MeshWave is a high-performance packet processor that is integrated with the eBurst optical burst transponder module. MeshWave is responsible for scheduling, collision avoidance, protection switching and quality of service enforcement. The MeshWave packet processor ensures that there are no collisions of optical bursts on the fiber and provides sub 50ms network protection.

eWave™ EDFA Amplifier

The eWave EDFA amplifier makes the EtherBurst system deployable in a wide variety of network topologies. The eWave module is available in two- and four-wavelength models and is deployed in PX-1000 Photonic Nodes in the EtherBurst domain performing optical burst amplification along with drop filtering. An integrated optical multiplexing function allows the EtherBurst Packet Optical Transport system to share the same fiber facility with existing optical transport equipment.

EtherBurst Ring Optical Burst Switch Product Line

PX-1000 Photonic Nodes

The PX-1000 Photonic Node is the optical element of the EtherBurst system providing amplification and wavelength add/drop capability. The PX-1000 leverages EDFA optical technology to amplify optical burst traffic, extending the effective coverage area for EtherBurst networks. The PX-1000 supports either eWave-2 channel modules or eWave-4 channel modules, supporting up to four SX-1000 connections. The PX-1000 supports integrated multiplexing of EtherBurst and existing optical transport network signals onto a single fiber providing seamless coexistence for both legacy and EtherBurst services on the existing fiber facility. Up to eight PX-1000 Photonic Nodes can be deployed in a network, providing support for a large variety of network topologies and amplification for 320Gbps of optical capacity.

SX-1000 Ethernet Service Nodes

The SX-1000 Ethernet Service Node provides the Ethernet and optical burst switching functionality of the EtherBurst system. The SX-1000 Ethernet Service Node supports two Ethernet service (tributary) modules and two eBurst optical burst switching (trunk) modules, each providing 10 Gbps of shared optical bandwidth. The eBurst optical burst module represents the latest innovation in optical switching, mapping Ethernet packets onto ITU wavelength packets and employing optical burst switching to deliver them anywhere in the network in a single optical hop. Up to sixteen SX-1000 Ethernet Service Nodes may be connected to a ring of up to eight PX-1000 Photonic Nodes to build scalable optical packet transport networks.

MatisseView Element Management System

The MatisseView management system provides unified access to EtherBurst's optical and packet network services through Simple Network Management Protocol (SNMP), web Graphic User Interface (GUI) or Command Line Interface (CLI). From a single station, network operators can securely log in to any PX-1000 or SX-1000 and obtain visibility and control of all EtherBurst network elements in the domain.

Support for northbound Operational Support Systems (OSS) using SNMP enables seamless integration with existing network management systems. Via secure RADIUS or TACACS+ access control, the web-based GUI enables point-and-click provisioning and maintenance of both packet and optical network service parameters including such details as power levels, span loss and optical burst forward error correction (FEC) statistics for the photonic layer. The CLI provides network operators with a familiar look and feel that lets them move quickly through configuration, provisioning and maintenance operations. Flow-through provisioning of services across the optical transport network is also provided by a simple point-and-click operation. EtherBurst's zero-touch optical transport automatically establishes the optical connectivity between the end points, eliminating the need to provision underlying optical circuits typically required to establish the service across a metro network.

EtherBurst Ring Optical Burst Switch Value Proposition

Rather than employing a connection based network design model, the Matisse Networks EtherBurst changes the network design model to bandwidth by blending the flexibility of Ethernet and high-bandwidth scalability of DWDM in a single platform. EtherBurst combines optical burst switching with advanced Ethernet switching to deliver greater transport efficiency, operational simplicity and network transparency. Matisse Networks' EtherBurst is designed to extend the statistical multiplexing gains of Ethernet packet switching into the optical domain, providing a much-needed performance and efficiency uplift to optical transport networks (Figure 9).

The fundamental difference between the EtherBurst product and the other DWDM products is that instead of dedicating a pair of transponders to a static connection that transmits information from a single source to a single destination, each optical burst transponder can transmit to any other optical burst transponder in the network. An EtherBurst transponder is essentially a shared pool of bandwidth that can be accessed by any service and between all locations. This bandwidth-oriented design eliminates stranded bandwidth on under-utilized transponders providing the most efficient optical transport for IP/Ethernet services.

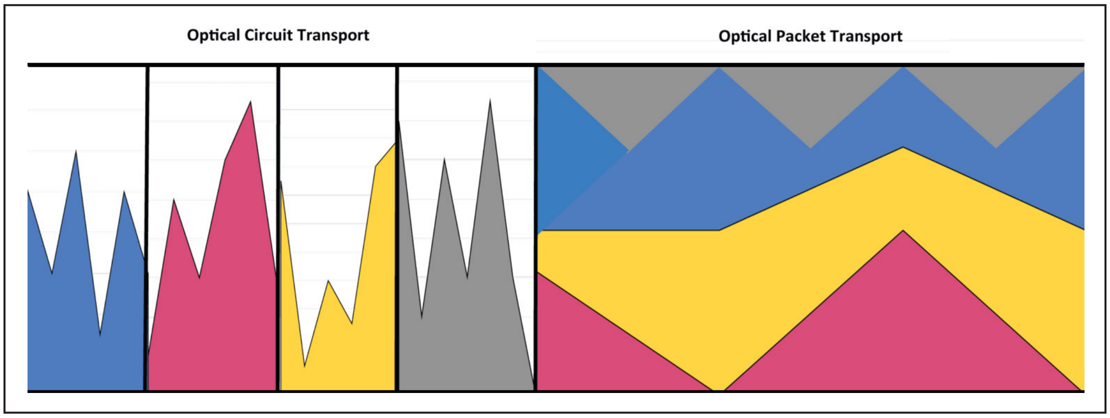

Figure 9 Source: Matisse Networks

The EtherBurst optical burst switch is a fusion of Ethernet switching and DWDM technology in a single platform enabling the service convergence and network transformation required to enhance the Service Provider margins. EtherBurst utilizes the Ethernet control plane to perform packet switching in the optical domain. The use of Ethernet, the industry's standard and ubiquitous control plane, enables rapid and transparent network deployment of EtherBurst in deployed IP/Ethernet service networks, facilitating a transparent metro bandwidth upgrade to already deployed packet service networks.

EtherBurst is the only metro optical transport system available capable of collapsing the service and transport layers and in so doing provides the most efficient method for deploying Ethernet services.

EtherBurst Supports a Variety of Deployment Scenarios

Due to differences in network architecture, type of service offerings and the amount of existing Ethernet services, Service Providers will deploy the EtherBurst Ring OBS differently in their networks. Tier 1 Service Providers typically have networks with network architectures that consist of hierarchical layers for access, aggregation and core. Tier 1 Service Providers with existing SONET and DWDM networks originally built for legacy voice and circuit-oriented private line data services need a transport solution to efficiently aggregate packet services in the metro. Features, like efficient capacity utilization, service architecture transparency, network protection, and support for multiple service topologies tend to be more important to this set of customers.

Tier 2/3 Service Providers typically have flatter network architectures that collapse the aggregation layer and connect the access edge directly to their network backbones using Ethernet over dark fiber. These Service Providers will rely on both service delivery and DWDM transport capabilities of the EtherBurst platform. The Ethernet service delivery capabilities of EtherBurst coupled with the plug-and-play optical transport provided by the use of the industry standard Ethernet control plane by the EtherBurst switch make it the ideal choice for smaller Service Providers looking for economical solutions to meet the growing demand for Ethernet services.

Efficient Packet Transport for Tier 1 Service Providers

Tier 1 Service Providers have been operating optical transport networks for over 20 years, using a variety of optical networking technologies including SONET/SDH and Optical Add Drop Multiplexers (OADM) or Reconfigurable OADMs (ROADM) transport equipment to provide the capacity required to carry the volume of traffic present in the network. Originally built to carry voice traffic and circuit-oriented private line data services, these optical networks are circuit oriented and are built in very structured hierarchies to enable traffic grooming at each level. These structured legacy hierarchical networks do not provide the dynamic bandwidth allocation and connectivity necessary to efficiently transport IP/Ethernet services, making them a poor choice for transporting the fast growing new services.

When Tier 1 Service Providers introduced Ethernet services, they were carried natively at the access edge and encapsulated for transport over the existing legacy aggregation and backbone networks. Ethernet access services are typically groomed using aggregation routers which then encapsulate the Ethernet traffic in a SONET/SDH payload over OADM or ROADM transport equipment. While Ethernet over SONET/SDH encapsulation provided a means for transporting Ethernet services over available OADM and ROADM optical network infrastructure, the inefficiencies and cost premiums increase as service volume grows leading to the erosion of service margins. As the adoption of Ethernet services continues its double-digit growth year over year, Service Providers need solutions for transporting the services more efficiently in order to enhance service margins. Tier 1 Service Providers typically have extensive Ethernet access networks that are responsible for delivering the Ethernet services that support business applications including both Ethernet Private Line and Ethernet Transparent LAN services. These access networks contain the Carrier Ethernet service delivery platforms, so most Tier 1 Service Providers would prefer to maintain these network elements while addressing the inefficiencies of circuit-oriented transport networks.

In response to Service Provider demands for improved efficiency in transporting packet services, the large incumbent vendors developed the Packet Optimized Transport Platform (POTP). The idea behind POTP is to integrate a packet switch fabric and provide grooming of Ethernet and packet services onto an optical circuit in a single platform. While this approach provides the incremental benefit of reducing the number of router interfaces it does not address the fundamental inefficiency that is created by transporting dynamic bandwidth packet services over fixed capacity optical transport circuits.

EtherBurst Ring OBS provides an ideal aggregation platform between the Ethernet access network and the regional metro and long haul optical transport networks. With its high capacity 10 Gigabit Ethernet NNI interfaces acting as tributary connections to the Ethernet access network, EtherBurst provides a native Ethernet hand-off with no encapsulation or protocol overhead to transport the Ethernet payload over the optical metro network. The EtherBurst Ring OBS system, with its optical packet switching capability addresses the fundamental inefficiencies of transporting Ethernet over circuit-oriented optical transport, while at the same time meeting the resiliency requirement for optical transport equipment.

With over 475,000 deployed SONET rings already in existence, EtherBurst Ring OBS technology is uniquely suited to provide the much-needed uplift to these networks without changing the fiber plant (as is typically required to accommodate mesh DWDM network topologies).

Combining Service Delivery and Transport for Tier2/3 Service Providers

Tier 2/3 Service Providers are also profiting from the growing demand for Ethernet services. Many of these Service Providers have built Ethernet service portfolios delivering business Ethernet services to support a variety of applications including Dedicated Internet Access, Voice over IP, and Transparent LAN services.

Tier 2/3 Service Providers have generally used the Ethernet over dark fiber approach to deliver Ethernet services, however this architecture does not provide the scalability necessary to keep up with growing demand as it is very fiber intensive and growth from successful uptake of Ethernet services quickly leads to fiber exhaustion in the network. Facing the expensive alternative of deploying additional fiber in the network, Tier 2/3 providers are evaluating alternative solutions to overcome the fiber exhaustion challenge and deliver Ethernet services on a single platform. EtherBurst, with its fused Ethernet switching and packet DWDM capabilities, provides a solution that addresses fiber relief and service delivery in a single product.

The EtherBurst Ring Optical Burst Switch is an ideal solution to the fiber exhaustion challenge. Ring OBS DWDM is the most efficient solution for providing high bandwidth packet services. Using EtherBurst Ring OBS, Service Providers can aggregate up to 320 Gigabits of capacity over a single fiber ring and achieve fiber relief.

The EtherBurst switch offers a full set of Ethernet service delivery features that provide the quality of service, subscriber management and resiliency needed to deliver SLA-backed Ethernet services. EtherBurst's Carrier Ethernet capabilities have been certified compliant with the MEF 9 and MEF 14 standards and give Service Providers the features they need to deliver Ethernet services directly to subscribers. Each individual port on the EtherBurst switch can be provisioned as a User Network Interface (UNI) or as Network to Network Interface(NNI), providing the ability to connect subscribers directly to the EtherBurst switch on a UNI, or alternatively it can be used to connect an entire access network on an NNI port and serve as an aggregation switch, similar to how it is typically deployed in larger more hierarchical networks.

Tier 1 and Tier 2/3 Service Provider Use Case Examples

The following two use cases illustrate how Service Providers and network operators can leverage the value of the EtherBurst system in the deployment scenarios described earlier. These two use cases highlight the value that EtherBurst Ring OBS brings in two very different types of network deployments. The first use case looks at an opportunity for a Tier1 Service Provider to increase the efficiency of their optical core by more efficiently aggregating Ethernet and packet-service in the metro. The second use case demonstrates the simplicity with which EtherBurst enables a Tier 2/3 Business Ethernet Service Provider to expand their Ethernet services while concurrently providing fiber relief and avoiding the cost and complexity of deploying a separate DWDM transport network.

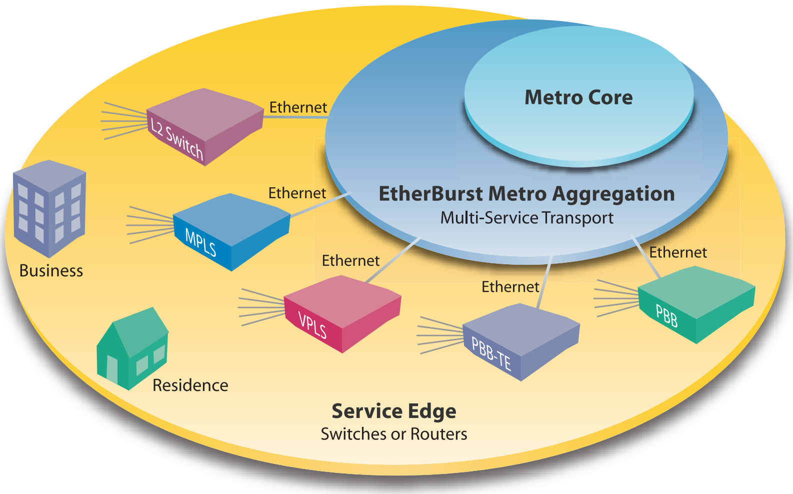

Figure 10 Source: Matisse Networks

Tier 1 – Efficient Metro Aggregation for Ethernet Packets Services (Figure 10)

The Tier 1 Service Provider can increase the efficiency of their optical core networks by more efficiently aggregating Ethernet and packet services using the EtherBurst Ring OBS systems in the metro. EtherBurst provides any-to-any connectivity in the metro enabling traffic from multiple services to be efficiently transported on a single converged metro transport network. EtherBurst's ability to dynamically allocate bandwidth to services as needed ensures that no bandwidth is wasted lowers the cost to deliver Ethernet services.

Tier 2/3 – Extending Business Ethernet Services over the Optical Metro Transport Network (Figure 11)

This is for Tier 2/3 Service Providers looking for ways to scale not only their capacity, but also to complete their Business Ethernet service portfolios with fractional 10GE and SLA-backed differentiated services. Tier 2/3 Service Providers can rely on EtherBurst's service delivery capabilities to connect subscribers directly to Ethernet service ports. EtherBurst provides advanced support for delivering a differentiated service portfolio of guaranteed and reserved bandwidth services as well as prioritized full-rate and sub-rate best effort Ethernet services. EtherBurst's use of the ubiquitous Ethernet control plane and proven interoperability with the L2/L3 products from Cisco, Alcatel-Lucent and Juniper that are deployed in networks today, enables a seamless aggregation bandwidth upgrade.

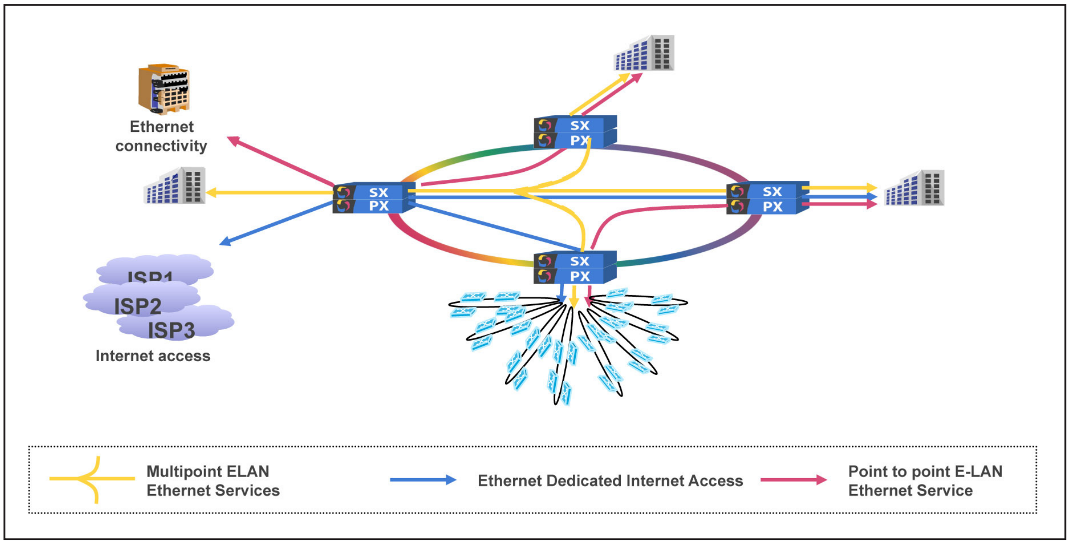

Figure 11 Source: Matisse Networks

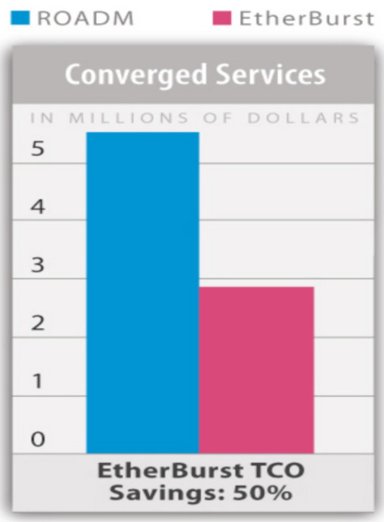

Figure 12 Source: Network Strategy Partners

Total Cost of Ownership

Enhancing Service Provider Margin

Matisse Networks' EtherBurst offers significant economic advantages through use of patented technology innovations in the field of Optical Burst Switching. Since EtherBurst is traffic aware and able to switch individual packets onto wavelengths, available transponder capacity in the network is effectively shared among all destinations and services. This network efficiency reduces capital and operational costs since it uses less transponders, less router ports and eliminates the complex optical engineering and wavelength planning needed by ROADM/POTP systems. These fundamental capabilities provided by the EtherBurst Ring Optical Burst Switch enables Service Providers to reduce the cost per bit to transport Ethernet services in the metro thereby increasing their service margins.

Lower Capital Expenses

EtherBurst deployments require significantly fewer transponders than legacy DWDM systems because EtherBurst's optical burst transponders transmit and receive data from every other transponder on the ring without any photonic layer reconfiguration.

As Ethernet services continue to become the dominant traffic type in Service Provider networks, the any-to-any connectivity model of Ethernet needs to be extended across the optical transport network. Using legacy circuit-oriented network architectures requires deploying a full mesh of optical transponders. The number of transponders required to grow a mesh circuit DWDM network scales with N^2 (where N is the number of nodes); whereas the number of transponders required to grow the EtherBurst optical burst network scales with N. This fundamental architectural shift results in a dramatic reduction of capital expenditures when comparing optical burst switching to circuit DWDM.

In-Service Network Upgrades

EtherBurst has been designed for incremental growth and expansion. The network can easily be expanded by adding PX-1000 Photonic nodes and additional SX-1000 Ethernet Service Nodes to existing deployments without wavelength planning or photonic provisioning. Using the traffic engineering features of EtherBurst, even network upgrades requiring the insertion of new nodes in the ring can be completed in-service without service disruption.

Circuit-based DWDM networks require expensive Reconfigurable Optical Add Drop Multiplexers (ROADMs) and a skilled network engineer to design or re-design the optical circuit, and then to implement the design change by issuing commands to the network elements to re-tune the transponders to different wavelengths. Optical circuit networks can take from hours to days to reconfigure.

Lower Operational Expenses

PROVISIONING: MatisseView is a metro-wide element management system that simplifies moves, adds, and changes which can be completed with simple point-and-click actions. MatisseView manages both the Ethernet and Optical domains to accelerate service velocity by simplifying the assignment of Ethernet ports to create Metro Ethernet Forum (MEF) compliant services across the optical domain. With EtherBurst, packet service delivery no longer requires optical circuit provisioning to connect Ethernet service ports.

MONITORING & MAINTENANCE: EtherBurst converges optical and Ethernet alarms, enabling the network operator to monitor the health of the network without cumbersome multi-layer alarm correlation procedures. With EtherBurst, packet service monitoring no longer requires separate alarming and monitoring of optical circuits. Since EtherBurst integrates both Ethernet and the DWDM layer, packet service troubleshooting no longer requires separately testing both the optical layer and packet layer.

Summary

Matisse Networks' EtherBurst Ring Optical Burst Switch is revolutionizing optical networks for IP/Ethernet packet services. Until now, transporting Ethernet traffic required deploying an expensive and inefficient circuit-based optical transport network. By combining Ethernet and optical burst switching in a single platform, made possible by a number of patented innovative breakthroughs, Matisse Networks' EtherBurst increases the efficiency of optical transport and improves the operational simplicity to deliver the lowest total cost of ownership for transporting packet services.

Management Team Biographies

Mr. Sam Mathan

Mr. Mathan serves as Matisse's Chairman and CEO. Previously, as President and CEO of Amber Networks, he developed the company into the leader in fault tolerant routing, resulting in the sale of Amber to Nokia for $421 million in July of 2001. Prior to Amber Networks, as Senior Vice President of Telco Marketing and Sales, Mr. Mathan helped establish Ascend Communications as the dominant supplier of dial access, frame and cell switching equipment. Subsequent to the acquisition of Ascend by Lucent Technologies he steered the merger of the two sales forces and served as Senior Vice President, Telco marketing and sales of the resulting Lucent Technologies Internetworking Systems division. Prior to Ascend, Mr. Mathan directed the product management and marketing team responsible for Pacific Bell's first series of network integration products and services. Mr. Mathan has a BSc and BE from Osmania University, Hyderabad, India, an MSEE from North Carolina State University, and an MBA from Southern Methodist University. Born in Hyderabad, India, Mr. Mathan moved to the USA in 1970.

Mr. Claude Hamou

Mr. Hamou is Matisse's President and COO. With over 20 years in various management roles he brings a wealth of experience from a variety of backgrounds. In addition to having founded Matisse, Mr. Hamou is currently responsible for all engineering and operational activities for the company. Previously, Mr. Hamou was Executive VP and General Manager of Terayon Communications' Data Cable Division. Prior to Terayon, he was VP of Engineering and Operations at Apache Systems and Director of Engineering with Adaptec. Mr. Hamou holds a BSc from the Technion Israel Institute of Technology in Haifa, Israel, and an MS in Management from Santa Clara University, California.

Mr. Jerry Lovatt

Mr. Lovatt, Vice President of Finance for Matisse, is a California Certified Public Accountant (CPA) with over 17 years of experience. His career has centered on high technology companies, including software, EDA, ERM, telecommunications and others. This includes growing start-ups internationally to take them into the IPO process. Most recently he served as Corporate Controller at Sylantro Systems Corporation, a telecommunications software provider. Mr. Lovatt's experience also includes management positions at various Silicon Valley CPA firms with clients including Apple Computer, Exodus Communications, Macrovision, Travel Zoo and others. Mr. Lovatt launched his career at the international CPA firm of KPMG, LLP. He holds an MS in Taxation and a BS in Accounting from San Jose State University.

Mr. Prabhat Mishra

Mr. Mishra, Matisse's Vice President of Engineering, has over 20 years of engineering management experience developing and bringing to market networking and computer systems products. Mr. Mishra was most recently Senior Vice President of Engineering with Nevis Networks. Previous positions have included Vice President of Engineering at Caspian Networks and Vice President of Engineering at Alteon WebSystems (acquired by Nortel Networks). Mr. Mishra also held senior management positions at Sun Microsystems where he was responsible for the development of the SPARCstation product line. He holds an MSEE from Virginia Polytechnic Institute and State University, and a BSEE, IIT Kanpur, India.

Mr. Craig Easley

Mr. Easley serves as Vice President of Marketing for Matisse. He has 18 years of experience in the information technology and telecommunications industries with such notable companies Nortel Networks, Bay Networks, Extreme Networks, Atmosphere and Network General. Mr. Easley has served 5 terms on the Metro Ethernet Forum's (MEF) Board of Directors. Currently serving as Co-Chair of the MEF Marketing Committee, he is a visible leader within the Carrier Ethernet industry. He has also been a long-time participant in the IEEE and has contributed to the development of numerous telecommunications standards. He earned an MS in Computer Science from the University of Maryland where he graduated Summa Cum Laude.

Mr. Doug Stewart

Mr. Stewart is Vice President of North America and EMEA Sales. He has over 26 years of experience selling optical transport and Layer 2/3 equipment into the Enterprise and global Service Provider market. Mr. Stewart oversees Matisse's regional sales forces and reseller relationships. Prior to joining Matisse, Mr. Stewart served as Vice President of Worldwide Sales at Mintera Corporation, a manufacturer of 40 Gigabit optical terminals, selling optical transport equipment into Asia, North America, and Europe. Prior to joining Mintera, Mr. Stewart was Vice President of Worldwide Sales at TiMetra Networks, a manufacturer of multi-service edge routers used at the provider "edge"; offering Ethernet, VPN's and routing capabilities for Service Providers and large Enterprise customers which was acquired by Alcatel-Lucent. Before joining TiMetra, Mr. Stewart held positions as Vice President of Sales at Amber Networks, Assistant Vice President (AVP) Sales at Ascend Communications and AVP of Sales at Newbridge Networks. Mr. Stewart holds a BA in Economics from Hobart College, an MBA from the Rochester Institute of Technology and an MS in Telecommunications from George Washington University.

Mr. Hank Zoeller

Mr. Zoeller serves as Vice President of Manufacturing Operations for Matisse Networks. He has over 25 years of extensive operations management experience with companies in high technology, bio technology, and medical devices, such as Nellcor, Molecular Devices, Network Appliance, and Cacheflow. He most recently co-founded and served as Vice President of Operations at Cardiva Medical, Inc. In addition, at each company Mr. Zoeller was involved as a cross-functional team member transitioning new products from R&D/Engineering to manufacturing and commercialization establishing a manufacturing strategy resulting in substantial cost savings, on-time deliveries, inventory reduction, quality and process improvements. Mr. Zoeller is a Certified Fellow in Production Inventory Management, (CFPIM), Certified Purchasing Manager (CPM), and is Certified as a Six Sigma Black Belt (CSSBB). He is currently President of the Mission Peak Chapter of APICS.

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