



# Looking at the World Through Ethernet-Colored Glasses

The Rosy Promise of 10 Gigabit Ethernet



## Executive Summary

Increased efficiencies.

Tremendous capacity. Reduced

costs. Simpler, more fundamentally sound

networks. These were the advantages that Ethernet

brought to the LAN, and that Gigabit Ethernet began to offer entrepreneurial developers of metropolitan area networks (MAN).

Now, 10 Gigabit Ethernet (10GbE) promises to extend those benefits further into the MAN and out into the WAN environment. And not a moment too soon. Internet traffic is increasing by an order of magnitude every year. Yet the cost and complexity of building out the backbone to keep up with the runaway demand for bandwidth has resulted in network architecture and business models of equal vulnerability.

In 10GbE, however, carriers and service providers have a technology that not only offers extraordinary scalability and ease of provisioning, as well as the ability to interoperate with existing SONET-based networks at OC-192 rates, but that provides the first platform for unifying LAN, MAN and WAN over open-standard, Ethernet-Everywhere networks of unprecedented performance.

This paper begins to explore the rich potential of 10 Gigabit Ethernet and what's needed to make it happen.

## A View from the 10GbE Future

A Webcaster requests 100Mb more capacity for an event – that evening – and gets it without breaking a sweat.

A hotel provisions each room's bandwidth on a real-time, as-needed basis, so that guests don't have to subsidize maximum provisioning of all rooms all the time.

To better integrate a new international acquisition, a multinational corporation rolls out global, state-of-the-art, videoconferencing services the moment the acquisition is announced.

These are mere snapshots of what will be possible, and they barely scratch the surface. What makes them even imaginable is that, in the 10GbE future:


- Bandwidth provisioning will be virtually immediate with customized capacity and support services.
- Network development and management will be dramatically more cost-efficient and problem-free.
- Time will become a strategic ally in capitalizing on fast-breaking business developments and revenue-producing opportunities.

**10GbE is the Answer for Traditional Carriers** Traditional carriers are caught between a rock and a hard place. They are saddled with their existing networks: jury-rigged amalgams of fiber optics and antiquated voice-centric technology that are no match for the marketplace's insatiable demand for bandwidth. Yet they must somehow overcome the deadweight of this legacy infrastructure in order to remain competitive in a deregulated environment of ever-quickening and evolving demand.

With 10GbE, the traditional carrier stands to improve connectivity between LAN and WAN, at the points of presence as well as in the central office. They'll quicken the subsystems of their networks, e.g. server farms and storage area networks. They'll have a means for evolving to a much simpler and less costly network architecture.

**10GbE is the Answer for Alternative Carriers.** There is a tremendous barrier to entry for the CLECs, ILECs and non-legacy nationwide carriers: the capital costs of building out their networks. With 10GbE, the economic playing field will be radically transformed at both the regional and national level.

At minimum, alternative carriers are looking at three- to five-fold cost efficiencies in an Ethernet-Everywhere network that, at the same time, will allow them to deliver higher performance and differentiating services.



**10GbE is the Answer for Service Providers** The service provider landscape is rapidly evolving: once just a blip on the Web radar, ASPs will soon have equivalent stature with ISPs. But if “the network is the computer,” then the network has to scale radically from where it is today – with the accent on scalability.

Ethernet’s inherent ability to scale is the primary reason that the Dell’Oro Group predicts that 70% of 10GbE deployment will be by service providers (D’OG, August 2000). As bandwidth becomes a commodity, service providers will compete on the basis of responsiveness, customization and innovation. With 10GbE, service providers will be able to provision “bandwidth by the slice” in real-time, and offer such commodity-busting benefits as usage-based billing.

**10GbE is the Answer for e-businesses** This is almost a false distinction, for all businesses are on the road to either becoming e-businesses or ending up as road kill, and all e-business will eventually be just plain business. But if a business today is predominantly Web-centric, then it is disproportionately burdened with the need to maximize revenues, gain meaningful competitive advantage, and most important, show PTP – a path to profits.

Provisioned by a 10GbE service provider, the e-business is uniquely able to respond to their customers, to unexpected business opportunities, to the niche-positioning wars, to the challenges of the balance sheet – because they can depend on a high-performance network architected to respond to their needs.

**The Birth of “Bandwidth by the Slice”** The term “bandwidth by the slice” encapsulates the way the future of bandwidth provisioning is going to work: just-in-time, tailored to a specific need with exquisitely detailed service level agreements (SLAs), and billed on a usage basis. While it is true that customizable, get-what-you-need/pay-for-what-you-get bandwidth is available today through other means, the simplicity of Ethernet management will allow a much more refined tailoring of the SLAs, with multi-level hierarchies of mission-critical applications and situation-specific adaptations – after all, which data fits the definition of “delay-sensitive traffic” is likely to change numerous times in the course of a day, with finely honed shadings. Real-time, context-specific fluctuations in bandwidth management can enhance revenue streams across the company and around the clock.


## How Do You Get There From Here? – The Infrastructure

Ethernet dominates the LAN environment. By some measures, the LAN is already an Ethernet-Everywhere system: Ethernet accounts for 98% of LAN switches sold today, for instance. So today's networks feature Ethernet at each end, connected by a tangled, multi-layered complex of legacy architecture in the MAN and WAN. The speed and simplicity of 10GbE, however, finally allows the vision of native end-to-end Ethernet networks to be implemented. There are several factors to support this evolution.

**It's Everywhere You Want to Be** Ethernet has gained worldwide acceptance as an enterprise infrastructure technology due to its considerable advantages in scalability, simplicity, provisioning speed, and price/performance – and with 10GbE, the price/gigabit is projected to be 40% lower than for Gigabit Ethernet (Dell'Oro Group). As an open-standards-based, forward- and backward-compatible technology, Ethernet has bred years of familiarity among technicians around the globe. So instead of building out networks of increasing complexity, and face the increasingly more difficult task of finding engineers sufficiently trained to manage them, carriers and new-age service providers can work with an inherently simple infrastructure that is second nature to a large majority of network managers.

**Setting the Standards** The 10 Gigabit Ethernet Task Force of the Institute of Electrical and Electronics Engineers (IEEE) is presently at work developing 10GbE specifications that are an extension of the existing IEEE 802.3 Ethernet standards. Fully recognizing 10GbE's potential for unification of LAN, MAN and WAN over a single architecture, the task force has thus far established the following IEEE 802.3ae objectives (completion of the standards is anticipated for the first half of 2002):

- Preserve the Ethernet/802.3 frame format at the MAC Client Interface
- Preserve the minimum and maximum frame size of the current 802.3 standard
- Support full-duplex operation only
- Support star-wired local area networks using point-to-point links and structure cabling topologies
- Support 802.3ad link aggregation
- Support an optional media-independent interface (M11)
- Support a speed of 10,000 Mbs at the MAC/PLS service interface
- Define two families of PHYs:
  - a LAN PHY operating at a data rate of 10,000 Mbs
  - a WAN PHY operating at a data rate compatible with the payload rate of OC-192c/SDH VC-4-64c
- Define a mechanism to adapt the MCA/PLS data rate of the WAN PHY
- Support the following distances and fiber types:
  - at least 65m over multimode fiber
  - at least 300m over installed-base multimode fiber
  - at least 2km and up to 10km over single mode fiber
  - at least 2km over single mode fiber
  - at least 10km over single mode fiber



**Supporting Technologies**    *Wavelength Division Multiplexing (WDM)* – Commercially introduced in 1996, WDM greatly increases the carrying capacity of optical networks, by allowing a single optical fiber to carry many different wavelengths of light at the same time, each carrying a different data stream, e.g. voice, video, text. While a Course WDM (CWDM) system may only carry 4 to 8 signals on a fiber, Dense WDM (DWDM) typically carries 40 signals and new systems are in the works that will carry 100 wavelengths or more.

*Wire-Speed IP Routing* – This high-speed, high-bandwidth switch capability is necessary for quickly and appropriately responding to the unpredictable traffic patterns on data-dominant networks. Employing Ethernet, the Internet protocol and Layer 3 switching, wire-speed IP routers deliver enhanced performance, redundancy protocols for the network edge as well as the network core, and the scalability to keep up with volatile traffic growth.

*Policy-based QoS* – A next-generation approach to intelligent bandwidth management, policy-based QoS puts network performance at the service of strategic business objectives. Network managers merely define policies founded on the application priorities for the business, and QoS performance automatically follows those imperatives, thus simply protecting the primacy of mission-critical applications in the face of decentralized deployment and bandwidth-greedy but less vital applications.

## **How Do You Get There From Here? – The Migration Paths**

It is our firm belief at Extreme Networks that end-to-end-Ethernet-based, all-optical networks are inevitable. It is the only approach that makes sense to us, from a simple performance standpoint as well as the price/performance perspective. But the migration paths to a 10GbE Ethernet-Everywhere infrastructure, uniting the core networks with the edge networks, will take several different routes, depending on where you're coming from and how quickly you wish to push your migration.

**Migration Paths for the LAN**    As previously discussed, the enterprise is already an Ethernet-Everywhere environment. With 10GbE, however, enterprise managers will be able to leverage their existing Ethernet investment while increasing network performance. They'll have next-generation speed at their disposal, allowing them to scale everything up without having to change topologies or equipment. This is likely to be an increasingly vital advantage as LAN bandwidth requirements continue to soar with the increasing adoption of bandwidth-hungry applications like voice over IP and PC-based videoconferencing.

Initially, you will see 10Gbe used for providing high-speed connections between large-capacity switches on the LAN backbone, aggregating multiple flows of Gigabit Ethernet traffic. Eventually, however, 10GbE will be employed for many of the mission-critical areas of the network, including server farms and intra-campus connectivity.

**Migration Paths for the MAN** Broadband-gulping enterprise applications and the growth of the residential broadband market (via DSL and cable modem) have led to skyrocketing demand for broadband in the MAN. Pioneer Consulting expects the metro optical IP market to grow from an expected \$110 million in 2000, to \$1.08 billion by 2004 (PC, August 2000), due to its low-cost IP switching capabilities.


*Greenfield Networks* – There are two migration paths for the MAN. The simplest belongs to the greenfield ventures, which lease dark fiber and build their own networks from scratch, completely bypassing preexisting SONET and ATM infrastructures. With Layer 2, Layer 3 and Layer 4 switching, these 10GbE greenfield operations will enjoy several advantages right out of the gate:

- The ability to offer low-cost provisioning of Ethernet broadband services of up to a Gigabit.
- A solution for the “last-mile problem” that skirts the high cost of building a network to provide broadband to the home and SO/HO market.
- No interconnect issues since their network is entirely homegrown.
- The lower capital investment and operating costs of an Ethernet-based network, due in part to the smaller number of network elements required to run IP and data traffic over a voice-centric network architecture.

*SONET-based Networks* – The other, more complex migration path is for preexisting, SONET-based networks that require more bandwidth for data traffic. Theirs will be a staged migration. The first step will entail encapsulating Ethernet within a SONET wrapper for end-to-end communications via dark wavelengths over a DWDM system – not because it is necessary, but because these network managers are used to SONET providing the foundation for network operations.

The second step of the migration for preexisting networks, however, is to run native 10GbE over all-optical networks. With tens of thousands of fibers being laid into the trenches, it is a simple matter to light up a different fiber for each bitstream, with separate fibers for voice, text and video. Due to its order-of-magnitude speed over Gigabit Ethernet, 10GbE networks with WDM will readily co-exist with existing OC-192 network traffic

What’s more, once an IP network can demonstrate the same robustness as a circuit-switched network, SONET becomes doubly superfluous. Then it can become a significant competitive advantage to be able to eliminate the cost of upgrading every node in the ring and providing SONET muxes at every point as the network is further built out. These differentiating cost-efficiencies can be dramatic: as much as seventy times the speed of a T1 line for only three times the money.



*Migration Paths for the WAN* The most significant advance offered by 10GbE may be its speed parity with the OC-192 data rate. SONET's previous speed standard was OC-48, which was the equivalent of 2.5 gigabits, making interconnects between SONET and Gigabit Ethernet systems problematic. With 10GbE, however, the performance-edge argument for SONET goes away: 10GbE and OC-192 can be seamlessly interconnected. This SONET-compatible interface will allow 10GbE Ethernet switches and routers to interconnect with SONET-based backbone for Layer 1 transmission.

In fact, the network performance advantage swings firmly into Ethernet's corner with the introduction of 10GbE. While OC-192 is the fastest flavor of SONET, OC-48 is still the dominant version outside of the primary backbone network. This means that long-haul carriers who are continuing to build out their networks can gain both cost and performance advantages by working directly with 10GbE, which will provide more efficient and less costly connections between carrier-class switches and routers.

But ultimately, WAN managers are simply going to strip out the SONET layer, and the packet-over-SONET layer, and run Ethernet directly over the fiber. Network management will be handled by IP layer routing protocols, running on frame levels of Ethernet.

## A Look Behind the Curtain

**The Convergence of Ethernet and Optical Networking** It is important to demystify the popular notion that Ethernet/IP and optical networking are mutually exclusive technologies that require a carrier or network administrator to choose one or the other.

This misconception may stem from the perspective of "this is the way it's always been done." In today's networks, there are typically two switching boxes sitting next to each other at the point of presence (POP): one is for voice traffic, with its own ATM switch linked to the SONET ring; the other is for the data network, with another ATM switch linking the SONET ring to the routers. Separate industries have been built up around these different traffic technologies, so they have always been sold as separate solutions addressing separate needs – with separate and skyrocketing costs.

The reality, however, is that SONET does not stand side by side with the optical network across the wall from Ethernet. In actuality, SONET is the wall between Ethernet and the optical network. The SONET-based network is a complex of multiple layers: the fiber layer, the SONET layer, the packet-over-SONET layer, and finally Ethernet – each with their own management protocols and equipment needs.

What Ethernet allows a network manager to do is collapse all those layers separating Ethernet from the fiber and create a flat-hierarchy architecture: Ethernet, managed by IP layer routing protocols, running directly over the fiber layer. In effect, Ethernet and the optical network are complementary technologies whose bond is fully realized with the advent of 10GbE.

**The Provisioning Revolution** To fully appreciate the difference that 10GbE will make in the provisioning process, you need to look at how Ethernet provisioning compares to the predominant provisioning method over SONET-based networks today.

Ethernet offers software-controlled provisioning. It involves no truck rolls. No muxing. No translations to ATM or any other legacy technology that has to be worked around. No configuring countless SONET rings. Instead, it requires little more than pulling up a capacity inventory on the monitor and making a few mouse clicks to set the appropriate parameters. Provisioning takes minutes instead of weeks, which will have a dramatic impact on service providers' business models.

With 10GbE enabling the introduction of Ethernet beyond the local and regional networks, the economic and strategic benefits of software-controlled provisioning will be compounded as it begins to be implemented on a national scale.

**The Ethernet Evolution** Its simplicity of design and operation has led Ethernet to be thoroughly embraced as the foundation for LANs. The fact that Ethernet has managed to avoid becoming more complex as it has evolved over the years has only strengthened its appeal. Its relentless adherence to open standards, as established by the IEEE, has accelerated Ethernet's acceptance by supporting full interoperability and a variety of migration paths.

The eventual roll-out of 10GbE will profit not only from this constancy of design and mechanics, but also from the continual innovation that has allowed Ethernet to overcome its limitations without fundamentally changing. This is a technology, after all, that started out as a shared media, running at 10 Mbps, over coaxial cable. To overcome the deficiencies of being a shared media, it evolved into a hubbed 10Mbps network, running over copper wire. To ramp up its speed, it then developed into a switched 100Mbps network. Then came Gigabit Ethernet running over fiber optic cable to provide still higher speed & with full duplexing to overcome distance constraints.

Now we're entering the age of 10GbE and it, too, is just an interim stage. Already there have been projections of 40GbE to be market-ready by 2005, with 100GbE expected for roll-out in 2009. In truth, Ethernet isn't merely a technology – it's a movement.



## Why All This Matters

**The Case for Highly Scalable Broadband** On the one hand, a very quantifiable demand-acceleration case can be made. There have been staggering increases in:

- The number of network connections
- Connection speed as LANs scale up and dial-up users move to broadband, with even higher network speeds needed for aggregating these increasingly higher connection speeds
- Bandwidth-intensive applications – e.g. broadcast-quality video, VoIP, e-commerce, community-building – that are driving the increase in Internet traffic by an order of magnitude every year
- Web hosting and application service providers

**The Generational/Cultural Discontinuity** Of far greater import, however, is the under-the-radar demand curve that is being driven by what has been referred to as the Digital Generation: children and young people born since 1980, who have never known a world without personal computers and who have grown up with – and on – the Web.

For this generation – a generation also known as the Echo Boom because they are larger in number than even the Baby Boom generation – broadband is their birthright. They are arguably more comfortable with a broader range of technologies than anyone reading this paper, and their impact on technology – how it evolves, how it is used, the role it plays in their lives – will be profound.

Driven by the Digital Generation, home computers – or, more accurately, Internet-access devices – will exceed 90% penetration in the American home by 2010. And their users will be demanding the broadband networks to support them. Because, for this generation, the Internet won't be something they do – it will be a part of who they are.

Broadband entirely changes the way you think about how the world works – and how you live in that world. Broadband isn't merely a “thing” – it's a new way of thinking. And new ways of thinking tend to unleash disruptive technologies, not to mention discontinuities in demand.

## Perspectives For the Not-So-Distant Future

The market forecasts are instructive, but they are limiting. To see a prediction that, in 2004, 387,000 ports of 10GbE on Ethernet switches will ship for total revenues of nearly \$1.9 billion [Dell'Oro Group, August 2000], does little more than inform our production capacity planning. Our product development, on the other hand, is founded on a living-in-the-future perspective. We need to anticipate what comes after the next new thing.

**The Coast-to-Coast Ethernet Everywhere Provider** This is what we anticipate. Despite the fact that the IEEE 10GbE task force doesn't expect to publish its fully approved standards until the spring of 2002 at the earliest, we expect an entrepreneurial service provider to jump the gun and roll out their coast-to-coast Ethernet-Everywhere network, probably some time before the standards are set in stone. And it will be "game over" for any major carriers that haven't already been following this migration path for themselves.

That's why there is a tremendous need to plan now for Ethernet's continued evolution. Extreme's objective is to offer the most consistent Ethernet-based solution in the marketplace – built from the ground up, rather than cobbled together through mergers and acquisitions. We are the vanguard, not the old guard. Thus, unlike many other 10GbE vendors, we have no need to protect other lines of our business that are committed to non-Ethernet technologies. As a result, all our product lines work together to provide our customers with a native Ethernet solution for switch management, provisioning, and all related network functions.



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