400 Gb/s Ethernet: Why Now?

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Introduction

Bandwidth growth is unrelenting everywhere across Ethernet networking. Every day, *more* users are *more* quickly accessing the Internet in *more* ways, to utilize *more* applications and consume *more* content that demands *more* bandwidth every day. More, more, more.

Consequently, fundamental bottlenecks are appearing everywhere throughout the Ethernet ecosystem, and the future holds only more mobile, more video, more devices, more data and who knows what new unforeseen pressures that innovation in technologies and applications holds.

So, with no less than a bandwidth tsunami intensifying, the global Ethernet ecosystem is moving now to create a plan to evolve beyond today's 100 Gigabit per second (Gb/s) capabilities, in order to enable and provide solutions to the network and data-center operators.

Ethernet has undergone amazing changes since the concept was originally documented in 1973. The IEEE 802.3™ "Standard for Ethernet" initially was developed in order to standardize connectivity among personal computers, printers, servers and other devices inside a local area network (LAN), but the standard has steadily evolved to deliver increased capacities and connect more devices, users, media types and protocols across more types of networks. In only the last five years, the pace of change has accelerated substantially. The proliferation of smartphones, tablets, Wi-Fi®, 3G/4G/LTE mobile deployments, 10 Gb/s servers, Internet-enabled TV, the cloud and its associated applications, social media, video calling, online gaming and new database technologies has ratcheted up the bandwidth pressure on the Ethernet-interconnect space. Though data centers—the eye of the bandwidth storm—for years relied on 1 Gb/s server interconnections, the industry appears poised to rapidly leapfrog through the standardized 10 Gb/s, 40 Gb/s and 100 Gb/s Ethernet speed steps.

Approved in March 2013, the IEEE 802.3 400 Gb/s Ethernet Study Group was formed to explore development of a 400 Gb/s Ethernet standard to address market demand for efficient support of the exponential bandwidth growth. The launch of the study group—a recognition of the overwhelming industry support in moving forward with a new IEEE standards-development project to define Ethernet's next maximum signaling rate—built on two years of open efforts around inviting Ethernet's vast array of stakeholders into the work of assessing and tackling the market's emerging application requirements. In early 2011, the IEEE 802.3 Industry Connections Ethernet Bandwidth Assessment Ad Hoc (http://www.ieee802.org/3/ad_hoc/bwa/) gave the work an important head start by collecting input on bandwidth needs from across application spaces and geographic markets. Its findings precipitated August 2012

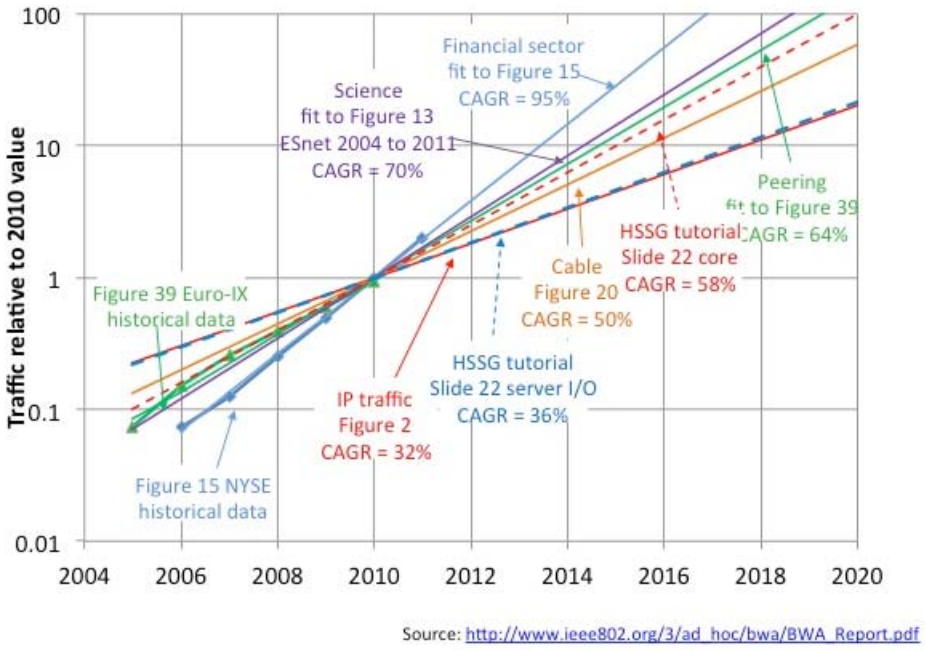
formation of the IEEE 802.3 Industry Connections Higher Speed Ethernet Consensus Ad Hoc (http://www.ieee802.org/3/ad_hoc/hse/index.html). And that effort led to the launch of a call for interest for an IEEE study group to explore development of a 400 Gb/s Ethernet standard.

With Ethernet celebrating its 40th anniversary this year, the evolution continues.

Understanding the Urgency

Deployment of Ethernet technology is pervasive worldwide. The needs of local area, data center, access and metropolitan area networks are constantly growing, and new application areas (such as automotive and industrial) seek to expand their reliance on Ethernet. As a result, bandwidth growth is being widely driven across numerous application spaces and markets by parallel surges in users, access methodologies, access rates and services.

Early in 2011, the IEEE 802.3 Industry Connections Ethernet Bandwidth Assessment Ad Hoc began collecting data on bandwidth trends impacting Ethernet wire-line applications toward the goal of jumpstarting future potential standards-development activities. The committee sought input from varied application spaces (including servers, data center networks, high-performance computing, financial markets, carrier and cable operators, Internet exchanges and the scientific community) and from users worldwide. The fruit of the committee's efforts was the 2012 IEEE 802.3 Ethernet Bandwidth Assessment (http://www.ieee802.org/3/ad_hoc/bwa/BWA_Report.pdf).



Findings of IEEE 802.3 BWA Ad Hoc

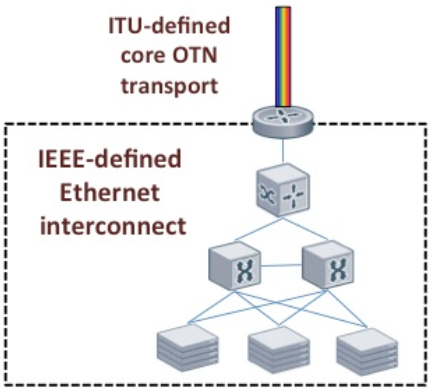
Based on the assumption that the trend of reducing the cost per bit continues, the report's findings included:

- bandwidth requirements of network-aggregation nodes were expanding more quickly than for end-station applications;
- networks would need to support an average 58-percent compound annual growth rate (CAGR), with the most aggressive CAGRs recorded in the financial sector and data-intensive science, and
- the bandwidth capacities of global networks would need to support 1 Terabit per second Tb/s by 2015 and 10 Tb/s by 2020.

Addressing the Problem

At its highest rates, Ethernet is clearly becoming the dominant traffic type for both "client" and "line" applications. However, while accommodating bandwidth growth in Ethernet interconnect and accommodating bandwidth growth in carrier transport are interdependent problems, they will *not* entail interchangeable solutions. The economics are different.

As different standards bodies, IEEE and the International Telecommunication Union-Telecommunication (ITU-T) cover different application areas. IEEE is looking at the Ethernet-interconnect space, such as within data centers and within service-provider central offices, inter-building links across a campus and links from the edge to the metro; the ITU-T is focused on the carrier-transport side. So, while there is close collaboration between the two entities to ensure seamless transmission of Ethernet traffic throughout the ecosystem, the actual specifications of the two areas are left to each respective body.



Line Versus Client

The exploding bandwidth requirements in the Ethernet-interconnect space clearly demand a higher interface speed, and the consensus of the industry is that 400 Gb/s Ethernet is the correct next speed step.

The technical feasibility of developing a solution—demonstrating system performance, proven technology with reasonable testing and confidence in reliability—is one important consideration in 400 Gb/s Ethernet's favor. Taking into account the cost targets of a solution also is important. It's not simply a matter of being able to implement a solution but implementing one at the right cost for the application. In the real-world global Ethernet marketplace, there is a never-ending balancing act to be struck between cost, power, density and bandwidth-demand providing many variables in assessing technology options. As an example, it is important to understand the impact of electrical interface width. Interface width is not just an optical-module consideration but an overall system issue. Wider interfaces entail more pins, and more pins mean more traces to route—translating into more power, most cost and more complexity.

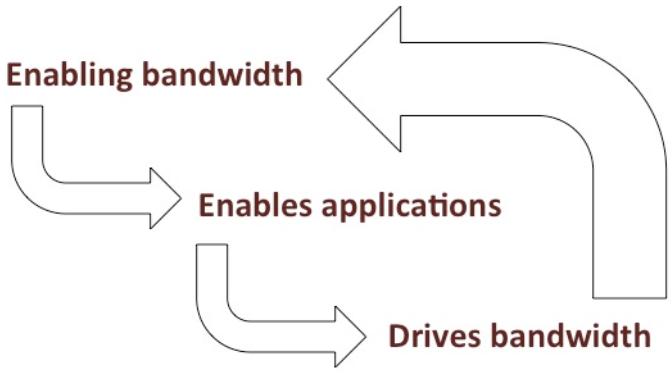
From this perspective of cost-effective higher-speed choices, 400 Gb/s Ethernet delivers the most effective use of bandwidth per square inch for IEEE-defined Ethernet applications.

There exist plausible implementations of 400 Gb/s Ethernet for today and next-

generation solutions. The building blocks of 100 Gb/s Ethernet can be leveraged. 400 Gb/s Ethernet fits in the dense 100 Gb/s system roadmap. And 400 Gb/s Ethernet's cost factors can be known and based on reliable data with regard to costs associated with both performance and installation.

Despite the obvious attraction to move to higher rates such as 1 Tb/s Ethernet, it generally has been accepted by the Ethernet ecosystem that interface rates beyond 400 Gb/s would require non-optimized cost implementations or, as some refer to it, "hero" implementations, resulting in higher research-and-development investment, longer time to market and non-competitive solutions. While aggregating lower-speed links to create a virtual higher-speed link is an effective method of addressing bandwidth requirements between releases of faster links, link aggregation is ultimately an interim solution between speed steps. The exponential bandwidth growth that the world is undergoing today implies exponential growth in the number of links, entailing significant management, operational and performance issues.

For IEEE-defined Ethernet applications, the conclusions of the IEEE 802.3 Industry Connections Higher Speed Ethernet Consensus Ad Hoc (and summarized in the 400 Gigabit Ethernet Call-for-Interest at the IEEE 802® Plenary in March) were that 400 Gb/s Ethernet strikes the correct balance among cost, power, density and bandwidth-demand factors at this time. As standards adoption paves the way for broad-scale implementation of cost-effective technologies, new applications are enabled, and, in turn, new bandwidth demand is spurred. The cycle of innovation, market growth and standards development accelerates.



Ethernet's Cycle of Innovation and Market Growth

Conclusion

Since its initial ratification in 1983, the success of the IEEE 802.3 Ethernet standard

has been rooted in its open and transparent development process. Through this process that invites the full swath of Ethernet's vast array of stakeholders, the standard is continually evolving to meet the needs of worldwide industry. In other words, it is the marketplace itself that has consistently driven the refinement and expansion of IEEE 802.3.

IEEE provides the forum for the global Ethernet ecosystem to come together to make such progress. Through the new IEEE 802.3 400 Gb/s Ethernet Study Group, individuals from end users, equipment vendors, chip vendors, optics vendors, cable suppliers, connector vendors, test-equipment vendors, printed circuit board (PCB) vendors and consultants from across all geographic regions worldwide are invited to participate in shaping the future of Ethernet's potential new higher-speed standards-development efforts. Once it determines the objectives, the study group will need to consider the broad market potential, technical feasibility and economic feasibility of a new standards project, as well as whether such a project would be compatible with but have a distinct identity from existing IEEE 802.3 specifications/solutions. Technical issues both internal and external to Ethernet devices must be considered—such as chip-to-chip and chip-to-module interfaces inside the box and copper twin-axial cabling and multi-mode and single-mode fiber relative to box-to-box communications. And the study group will need to determine the objectives of such a new project.

In addition, an Ethernet Alliance 400GbE Subcommittee is being launched to support the definition and development of the next speed of IEEE 802.3 Ethernet. This is another opportunity for the global Ethernet ecosystem to engage in helping shape and support the technology's ongoing evolution. Ethernet Alliance subcommittees help create and develop strategies that bring new standards-based products and services to market through tactics such as performing marketing studies, supporting new Ethernet technology incubation efforts, assessing technology costs, developing new standards frameworks and conducting studies on ways to further enhance Ethernet performance. Input from Ethernet's varied end users is essential to the work of such Ethernet Alliance subcommittees.

The world is changing rapidly with new bandwidth-generating applications constantly being introduced. Exponential bandwidth growth continues, with higher speed at lower cost per bit needed through the entire ecosystem. Past standards-development efforts (10 Gb/s Ethernet, Ethernet First Mile, 40 Gb/s Ethernet and 100 Gb/s Ethernet, for example) took three to four years to undertake and complete; today's intensifying bandwidth tsunami will not allow the global Ethernet ecosystem to take so long with the next speed step. In order to accommodate global industry's needed time frame for deployment, the global Ethernet ecosystem must begin the process of studying the problem now, as standards-based solutions are integral to maintaining business growth across the ecosystem.

Ethernet is well positioned for the long run—with proven technology, a huge installed base and incessant and multi-dimensional innovation. The work of the IEEE 802.3 400

Gb/s Ethernet Study Group, supported by the Ethernet Alliance 400GbE Subcommittee, in preparing for the leap to 400 Gb/s capabilities will help ensure that Ethernet's technological evolution and market expansion are never bridled.