Driven by a never-ending appetite for bandwidth from businesses and consumers, service providers are in the process of upgrading their backbone and core networks to 40G and 100G. Over the past year, there’s been no shortage of deployments by a number of large traditional telcos, R&E providers and CLECs, a list that includes Verizon Communications, Internet2, and XO Communications, in addition to a growing base of international carriers.

But even as service providers begin to migrate their core networks to 100G, they are looking at what lies ahead. Already, a number of trials have been conducted by AT&T and Verizon, with the latter conducting a 21.7 Tbps trial on over 1,503 kilometers (934 miles) of standard single mode field fiber.

To build the foundation for what lies beyond 100G, the IEEE, the Optical Internetworking Forum (OIF), and the International Telecommunications Union (ITU) are looking at emerging techniques to provide greater speeds of 400 G and even terabit speeds:

- **ITU:** Having developed the basis for the Optical Transport Network (OTN) standard in 2001, which was later refined to become ITU-T G.709 version 3 in 2010, OTN enables service providers to groom multiple client services onto a smaller number of high capacity wavelengths. Later, the ITU devised the Optical Data Unitflex (ODUflex). ODUflex includes two main elements: Circuit ODUflex and Packet ODUflex. Circuit ODUflex supports any possible client bit rate as a service in circuit transport networks, while Packet ODUflex creates variable size packet trunks (containing GFP-F mapped packet data) for transporting packet flows using L1 switching of a low order (LO) ODU.

- **IEEE:** The IEEE is focused on developing standards for Ethernet. In August, the IEEE formed the 802.3 Industry Connections Higher Speed Ethernet Consensus group with the goal of building a new Terabit Ethernet standard.

- **OIF:** OIF has been tasked with developing many of the interconnections between devices and modules and the multi-source agreements (MSAs) for the modules themselves. Inside the OIF, the Physical and Link Layer (PLL) working group’s Multi-Link Gearbox 2.0 project, for example, is focused on how to synchronize data rates of 4x10G lanes with 4x25G lanes. Part of that project includes how to process link technology with optical interfaces as bandwidth grows to 400G data rates.

Jim Jones, President of the Optical Internetworking Forum, believes that the coalescence between standards bodies has provided the clarity that the telecom industry needs to deploy 100G systems. “One of the drivers is the clarity around the industry standards where, of course, we have the ITU defining the optical transport hierarchy (OTH); we have the IEEE defining the Ethernet side of things; and the OIF defining many of the interconnections between devices and modules and the multi-source agreements (MSAs) for the modules themselves,” Jones said. “What that has allowed is consensus among the industry where you have the ecosystem building up underneath that.”

In this eBook we’ll discuss the strategies, emerging standards and technological advancements that lie beyond 100G optical transport for vendors and their service provider customers.
Networks Will Deliver Terabit Speeds Someday; When it Happens is Harder to Say
BY JIM BARTHOLD

Bandwidth demand being what it is—insatiable—there is no question that vendors will produce and carriers will consume 400 gigabit and 1 terabit network equipment. But considering the fact that 100G gear is barely denting today’s networks and that new modulation approaches developed with 10 gigabit gear can mash those 100G circuits into multi-hundred gig superchannels, the logical question is when, not if, demand will push the need beyond 100G.

“If you look at the number of units being sold today, only about 1 percent are 100G units going out the door; about 85 percent to 90 percent are 10G units and the remaining are 40G.”

RANDY EISENACH, DWDM PRODUCT MARKETING MANAGER FOR FUJITSU NETWORK COMMUNICATIONS

10G units and the remaining are 40G,” said Randy Eisenach, DWDM product marketing manager for Fujitsu Network Communications. That leaves a lot of room for ‘100G to infiltrate the market. And that leaves a lot of room for economics to improve so that one piece of 100G gear worth is worth 10 bundled 10 gig circuits. That’s why, to some, it’s still not economical to go to 100G, let alone look beyond it.

“The initial 100 gig optics would be 16 or 17 times the cost of 10 gig optics,” said Doug Junkins, CTO of NTT America. “Those prices are coming down so the model we’ve been using is once they reach 10 or 11 times the cost of 10 gig then it starts to make sense to deploy those from the operational simplification perspective.”

In the meantime, he said, NTT answers its bandwidth needs by bundling 10 gig circuits and will continue to do so when 100G enters the market. “We have paths that we have 16 or more 10 gig circuits (so) we’re going to be doubling up 100 gig circuits as soon as we deploy them too,” Junkins said. “There’s a lot of bundling going on today and there will continue to be a lot of bundling.”

Bundling 10 or 100 gig circuits to create so-called superchannels buys time as standards bodies thrash out the specifications of 400 gig and terabit gear. There’s not even consensus that a 400G tier will even happen; that step could just be skipped as it was, in a way, when 10G went to 40G.

“The entire AT&T backbone is 40 gig and the entire China Telecom backbone is 40 gig so saying that it didn’t take off isn’t really true in the sense that there’s a significant amount of deployments out there,” said Eve Griliches, vice president of optical networking for analyst firm ACG. “But most of those people realize that this isn’t going to be fairly temporary.”

The big move for carriers will be the jump to 100 gig. “I think we’re going to see 100 gig deployed for a while,” she continued. The next and most viable move, she suggested, is building a superchannel out of those 100G circuits “and I believe the market has settled in the next three to five years that doing it via a superchannel is pretty much the way to go.”

That leaves plenty of time to debate whether the next move is to 400G or a terabit. “400 gig and 1 terabit are so far in the future that it’s very hard to pin down any specifics on what’s going to win and what’s not going to win,” said Andrew Schmitt, principal analyst, optical, for Infonetics Research. “The one thing that is clear is that 100 gig WDM as well as short range optical interfaces are going to be successful. There’s going to be a very high bar that whatever follows next is going to need to clear.”

In some quarters that would be called backward compatibility; the ability to leverage what’s already there as you move to the next step. “There are two fundamental things within an optical domain. One is capacity versus reach and that basically drives the decision whether you would do 400 gig or a terabit. The other is spectral efficiency, how good your performance is at a certain distance,” said Sanjeev Mervana, service provider marketing director for Cisco.

Operators and their vendors must consider existing network infrastructure before determining what step is next “because as you move towards 400 gig and a terabit, you’re going to use the existing infrastructure just as we are leveraging the 10 gig infrastructure today,” he said.

The complexity, along with the slow development of standards, gives vendors the opportunity to look at speeds beyond 100 gigs while simultaneously feeling out customers as what should happen next—400 gig or a terabit. In some of these equations, it helps to look into the past for answers about the future, said Eisenach. “A lot of the data networking industry did not want to stop at 40 because they’re used to increases in speeds on routers and physical ports in orders of 10. In the carrier community we have those intermediate steps because they match capacity to actual requirements and there’s always been a difference in price,” he explained. “What caught a lot of people on the data side by surprise was the cost of 100G optics—especially DWDM line side optics—is still very, very high and because of that the 40G optics, particularly the 40G muxponder cards, had quite a lifespan and will continue to have that. I see the same thing going on with the debate of 400G and 1 terabit.”

Mike Adams, vice president of product and technical marketing at Ciena agreed that 400G makes sense because “100 gig is still going through an integration cycle where they’re trying to make it simpler and more cost-effective to hit this mass adoption rate and … folks can see how those will apply to a 400 gig.”

Those looking at a timeline to
Case Study: Verizon Looks Beyond 100G
BY JIM BARTHOLD

With video demand devouring bandwidth in its backbone, Verizon is probably one step ahead of its fellow carriers in looking beyond 100 gigabit while trying to preserve as much infrastructure as possible.

Bandwidth demand comes at Verizon from multiple directions. There’s video, of course, and Verizon’s FiOS network plays a part there. There’s an increasing amount of machine-to-machine and sensor networks. Even cell backhaul, with the explosion of broadband demand, is playing a part in consuming existing bandwidth on both the backbone and metro networks. And finally, there’s just the increase in users sending and receiving globs of data from the cloud, along with the natural need to backup all network operations.

For Verizon, it’s not a matter of if it will go beyond 100G, it’s when and how to do it, with the notion that even an early carrier-conceived solution will eventually need to work with emerging standards.

As early as April 2001, Verizon and NEC completed a field trial where they pushed speeds to 450 gigabits—and then to a terabit—over 2,212 miles of fiber field in the Dallas area. That trial served as a laboratory for a number of methods that Verizon and its vendors can use to squeeze higher bitrates from the equipment in Verizon’s long haul networks. Today, every new piece of equipment in Verizon’s long haul network is 100g. Because prices haven’t quite reached satisfactory levels, the carrier’s metro networks (generally 500-600 kilometers in circumference) are still running various levels of 10G gear. But the plan is to standardize even those networks at 100G by 2014. As it rolls new equipment into the field, the carrier is replacing equipment that is two generations old. For instance, the existing 10G-optimized platforms running 80 channels at 10 gigabits are only about 10 years old. With an effective lifespan of 20 years, these networks are still reliable, manufacturer-supported and work well for the customers they serve. They remain in place as Verizon adds 100G infrastructure.

The earlier generation of networks ran mostly 32 wavelength systems. That equipment is older and, for the most part, no longer supported by manufacturers, so it’s being taken out as the 100G gear is put in. While the carrier anticipates customer disruptions as the older equipment is phased out and new equipment phased in, the counterpart is that if the equipment breaks, it will take longer to fix a

Beyond 100G
RANDY EISENACH, WDM PRODUCT & TECHNOLOGY MARKETING AT FUJITSU NETWORK COMMUNICATIONS, INC.

With 100G development efforts largely complete, Fujitsu is turning its R&D focus to 400G optical interfaces and WDM networks. Although still early in the industry standards efforts, one leading candidate is DP-16QAM utilizing two subcarriers. Rest assured, Fujitsu is leading the industry efforts to higher speed, more spectrally efficient optical interfaces and WDM networks.

400G DP-16QAM 4.6 bits/Hz
87.5 GHz

Along with coherent receivers, these more advanced modulation techniques enable much higher data rates and improved compensation for optical impairments such as chromatic dispersion (CD) and polarization mode dispersion (PMD). The trade-off with these advanced modulation techniques is they require higher Optical to Signal Noise Ratios (OSNR). OSNR translates directly into the optical environment is 100G. Because prices haven’t quite reached satisfactory levels, the carrier’s metro networks (generally 500-600 kilometers in circumference) are still running various levels of 10G gear. But the plan is to standardize even those networks at 100G by 2014. As it rolls new equipment into the field, the carrier is replacing equipment that is two generations old. For instance, the existing 10G-optimized platforms running 80 channels at 10 gigabits are only about 10 years old. With an effective lifespan of 20 years, these networks are still reliable, manufacturer-supported and work well for the customers they serve. They remain in place as Verizon adds 100G infrastructure.

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Economics Dictate Next Standards Stop Will Be 400G

BY JIM BARTHOLOM

Cost, not the need-for-speed, will drive the next high-speed data transport standard to 400 gigabits, not a terabit. The new standard could be on hand within three years as part of a process that will be faster but also more economically focused on than ever before.

It’s a big change for an industry that, even when developing its current 100G level, clamored for speed over anything else. That’s why, in many instances, the 40G interim step was forgotten as carriers and vendors alike pushed ahead to 100G. The economy has changed all that and, in turn, has changed the focus of standards bodies, said John D’Ambrosia, chair of the IEEE 802.3 Ethernet Bandwidth Assessment Ad Hoc and IEEE 802.3 Industry Connections and Higher Speed Ethernet consensus group.

D’Ambrosia is charged with helping the two groups build consensus for a next standardized Ethernet speed. The ad hoc group was formed in late August of this year, so D’Ambrosia has no timeline for when work will commence towards the next step in the process, a “call for interest” on a standards specification.

D’Ambrosia is wont to speculate as that organization developed 10G and 100G standards, he has a pretty good idea going in what’s will be coming out. “A lot of people I’m talking to from the supplier base are looking at 400 gigs as a realistic option. When you look at it from terabit, you’re looking at the bandwidth numbers … and you’re not necessarily considering how it’s going to be solved or what the cost of that solution is going to be,” he said.

Mathematically, a new standard can accomplish 400 gigs by combining 10 40 gig lambdas “and there is work under way right now on a project (with alternative evaluations) in the IEEE where you could possibly do a 4x100,” D’Ambrosia said.

The math for a terabit, he said, “gets a little scary.” The most widely discussed solution there would be 40 different pairs running bi-directionally at 25 gigabits.

“That is not a very attractive solution. Imagine with all those pairs what the cost is going to be and then the layer counts to route all that stuff would make it a very expensive proposition,” he said. “Even if you move up to x50 you’re still looking at a x20 interface and that’s (50 gig serial) just starting in development.”

Whatever speed is determined to be the right one, it probably won’t be fast enough or happen soon enough for some in the industry. That’s the nature of standards: everybody complains about them, but everybody wants them. “There are things we can do as vendors in developing the underlying Layer 0 technology and some vendors may come to market with a proprietary system, but I think most vendors are going to wait to have full standard support in the industry,” said Randy Eisenach, DWDM product marketing manager for Fujitsu Network Communications.

Even after the standard is developed, there will be added layers of complexity and testing to make sure those who use it actually interoperate. That’s where the University of New Hampshire Interoperability Lab (UNH-IOL) joins the party. “Folks at the IEEE call us the third leg of the Ethernet marketplace,” said Jeff Lapak, senior manager of Ethernet technologies at UNH-IOL. “Standards get generated by them; product vendors are on the other side; and we’re just off to the left providing services for the people who make the products but also feeding that information back into the standards body process as well.”

Lapak takes issue, to an extent, with vendors and others who claim that the standards process slows development of new products. In his mind, standards bodies “are moving faster; they’re starting to realize market need. They’re not actually speeding up their process but they’re getting involved in the next generation of technology earlier. As soon as one generation is finished, before waiting around and hoping they see a trend, they instantly start working on the next generation.”

On top of that, they’re making certain that one generation plays nicely with a new Ethernet speed and the Ethernet community has to move on making some decisions.”

JEFF LAPAK, SENIOR MANAGER OF ETHERNET TECHNOLOGIES AT UNH-IOL

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Q&A: Jim Jones, President of the Optical Internetworking Forum (OIF)

The Optical Internetworking Forum (OIF), a group dedicated to creating Implementation Agreements (IAs) for optical networking products, network processing elements, and component technologies, is constantly looking ahead to see how they can help members of the optical ecosystem prepare for what’s coming next. One of the trends that the OIF is helping to shape is how the optical community can coalesce around the emerging 100G optical trend and envision what lies beyond 100G. Jones said that what has helped drive more deployments of 100G is the cohesion on the standards and technologies that enable 100G. Sean Buckley, Senior Editor for FierceTelecom, caught up with Jim Jones, President of the OIF recently, to talk about current 100G trends and what lies ahead.

FierceTelecom: There have been a lot of 40G and 100G optical networking deployments over the past year. Can you talk about what’s driving that trend?

Jim Jones: There are a number of things. One of them is the clarity around the industry standards where, of course, we have the ITU defining the optical transport hierarchy (OTIH); we have the IEEE defining the Ethernet side of things; and the OIF defining many of the interconnections between devices and modules and the multi-source agreements (MSAs) for the modules themselves. What has allowed is consensus among the industry so that you have the ecosystem building up underneath that. I think you didn’t quite see that in 40G because of the fragmentation and the number of different options, but you see a lot more cohesion on 100G. That’s no pun intended between that and coherent optical technology. I think that has helped make the business case for both the vendors and the device manufacturers to make the considerable investments they need to bring that technology to market. I think you’re seeing more and more maturity in the products and solutions and certainly over time and you’re going to see or you are already seeing, the economics kick in and the costs come down. I think it’s inevitable as you get more and more of a critical mass of the industry behind it you are going to see more adoption of these technologies? How important are they to drive present and future deployments of 100G and beyond?

Jim Jones: In a lot of ways I see control plane and SDN as complementary technologies; they do overlap in some ways. I see really both of them as having a pivotal role in the development of 100G and higher speed technologies. Control plane has, of course, been around for a number of years, beginning with IP MPLS and more recently in the GMPLS control plane. SDN is relatively newer and a little bit more abstract. It’s sometimes difficult to grasp exactly what SDN is, but it’s a hot topic and you see it everywhere in publications and conferences. The way I look at it is that both are indirectly driving the growth of 100G. I say indirectly because both control plane and SDN are tools that enable service providers to virtualize and automate some of the delivery of the applications and services over different types of network infrastructures, but I think what you need is a mature, efficient way to handle huge capacity you get from 100G and beyond. One of the critical technologies there is OTN. I see OTN as a building block that helps bring it together along with control plane and SDN.

FierceTelecom: OTN continues to emerge in the optical domain as well. How has the concept of the dynamic OTN network progressed?

Jim Jones: An Infonetics report back in April talked about Optical Transport Network (OTN) deployments and control plane. In that report it was revealed that 96 percent of service providers polled were looking at control plane for both regional and long-haul OTN deployments. I think the OIF plays a big part in that. We’ve been able to get a good number of vendors and good number of service providers to prove what we have done over the past five or six years. I think besides control plane-based provisioning, I believe the second and third place options for service providers were control plane-based restoration and multi-layer control, and the OIF is currently very active in all three project areas. We have projects that are near completion. One good reason to call out the Infonetics report is that it’s not just OIF leadership telling you the reports of these things, but it’s also a third-party data point.

FierceTelecom: You mentioned three control plane projects. What do those consist of and how are they progressing?

Jim Jones: The main work projects that have come out of the OIF having to do with control plane are related to the External Network-to-Network Interface (E-NNI) and the User-Network Interface (UNI). The E-NNI is what you use to connect different domains, which often might be different vendor domains, while the UNI is what the client or user would use to connect to the network. We have the 1.0 and 2.0 versions of them that were ratified several years ago. I think we have done more recently is a multilayer project that continues on page 11.
that has defined the architecture, routing, and signaling extensions needed to allow E-NNI to function in a multilayer role, and that amendment is technology agnostic. It could go for a different type of layer technology in any arbitrary number of layers. To go along with that we also have a project on OTN that is taking the latest extensions that take advantage of the OTN V.3 that was ratified by the ITU in 2010. That includes things like Optical channel Data Unitflex (ODUflex), ODU0, and ODU4, which is the 100G container. Now, the Internet Engineering Task Force (IETF) has defined many of the base protocol mechanisms like 1+1 protection, for standalone to recover service after a failure. You have to use the control plane either way. The Multi-Link Gearbox is an important project because the nature of different parallel interfaces can be different; that is you may have, in the case of 100G, a 10x10 interface on one side of a device and a 4x25 on another. You have to have a very reliable way to ensure both data and timing transparency as you make that transition.

Which technologies will be role of Ethernet-over-OTN? Is that continuing to progress as well? What lies beyond 100G – Keeping pace with high-speed anywhere, anytime connectivity demands of consumers and businesses alike

HELEN XENOS, DIRECTOR, PRODUCT AND TECHNOLOGY MARKETING

FT: When we start looking beyond 40G and 100G to 400G, the OIF has been developing various elements like Multi-Link Gearbox 2.0. How are those efforts progressing in the OIF?

JJ: The projects that we have ongoing right now are exploring the boundaries of available and soon-to-be-available technology, for higher speed interconnects or whatever the next rate is and next sub rates for the parallel interfaces inside of a box. It would require possibly optical interconnect as well as electrical technologies inside the box. It may require some advanced techniques for heat dissipation. We completed a project recently that provided some guidelines, since the thermals are increasingly going to be a limiting factor as you put higher speed components into smaller spaces. The Multi-Link Gearbox is an important project because the nature of different parallel interfaces can be different; that is you may have, in the case of 100G, a 10x10 interface on one side of a device and a 4x25 on another. You have to have a very reliable way to ensure both data and timing transparency as you make that transition.

Over the past 4 years, significant technology shifts in optical networking, namely coherent optical technology, have enabled operators to achieve speeds of up to 100 Gigabits per second per wavelength on a single fiber. A key operational benefit of these new optical technologies is the ability to increase bandwidth capacity by 4 to 10 times over existing network and fiber assets, lowering deployment costs and accelerating time-to-service. In 2012, large service and cable providers, as well as research and government municipal network operators, are moving from early adoption to mainstream 100G deployment because of economic and efficiency benefits associated with high speed coherent technology.

To keep pace with the ever relentless growth in bandwidth demand from consumers and businesses alike, operators are already looking at the next wave of technologies required to carry them forward to 400G and Terabit networking speeds. New levels of flexibility and application-aware intelligence are required to cost effectively scale the network moving forward.

Innovative technology advances, such as integration of DSP in the transmitter, enable software-programmable coherent technology that helps service providers accelerate the move to dynamic, software-defined Terabit networking while improving network economics. Beyond scaling bandwidth and lowering costs, these networks can be programmed to quickly respond and adapt to changing requirements for capacity, reach and latency. The optical layer is becoming more intelligent and responsive to application needs—an increasingly critical requirement in today’s dynamic and cloud-centric networks, providing the opportunity to more quickly respond to new service demands. Software-programmable coherent technology can scale to 400G using existing photonic infrastructure in place today.

Directionless and colorless photonic architectures allow wavelengths to originate and terminate anywhere in the network and are currently being considered to increase wavelength efficiencies as well as further enhance service path flexibility and the ability to dynamically respond to new service demands. Flexible grid architectures are being considered, predominantly in core backbone networks, to prepare for Terabit transmission. It is expected that Terabit transmission, or the transmission of one thousand billion bits per second, will require more than the typical channel size of 50GHz or 100GHz of optical spectrum. The network needs to be able to appropriately select minimal adequate spectrum for each wavelength being transmitted. The additional flexibility brought by new photonic architectures can easily lead to operational complexity. Software intelligence is key in transforming the network into an intelligent dynamic resource; an intelligent distributed control plane can simply rearrange network connectivity will become increasingly useful as cloud networking becomes more pervasive, allowing dynamic assignment of capacity between data centers on an as-needed basis.

“In a lot of ways I see control plane and SDN as complementary technologies; they do overlap in some ways.”

JIM JONES, PRESIDENT OF THE OIF

FT: Staying on the OTN path, what will be role of Ethernet-over-OTN? Is that continuing to progress as well?

JJ: Yes, it is. It’s got quite a lot of energy. I think on one hand if you look at Ethernet, it’s really the pervasive interconnect technology particularly in the LAN, enterprise, and access environments. OTN is becoming much more dominant in the core and the backbone part of the network as well as regional parts of the network, and to some extent the metro network as well. That makes Ethernet over OTN a somewhat natural combination.

What will be role of Ethernet-over-OTN? Is that continuing to progress as well?
faster speeds might use Ciena’s history. The vendor introduced its 100 gig product at the end of 2009 and Adams predicted “the end of this year is going to be big for us and 2013 certainly is going to be a big year for 100 gig.”

It’s difficult to say carriers don’t care what’s next, when it will happen and what it will cost; they do. They’re faced with bandwidth demands being driven on the consumer and commercial side by heavy flows of increasingly rich video.

“From our perspective, we’re certainly looking forward to terabit,” said Rob Vietzke, vice president of network services for Internet2. “You’ll run out of 100s sooner or later and people will want a single carrier terabit in a few years. There’s no question that we will. Everyone would love to go times ten and skip right to terabit but I imagine there will be 400 along the way.”

Craig Drinkhall, vice president of product management and engineering for Lumos Networks sees an immediate future of mix-and-match.

“Whether we need to (go beyond 100G) is kind of a hard question to answer,” he explained. “You can take two fibers (now) and put 40 10-gig waves as a classic vendor implementation and then sell two or three or four to a customer. If you turn it into 100 gig now you have some of those 100 waves mixed in with 40 gig waves,” he said. At Level 3 it comes down to economics.

“We are not yet at a point where the cost benefit of 100 gig is great enough that we are deploying broadly for all of our backbone services,” said Paul Savill, senior vice president of core product management at Level 3. “We could use 100 gig today if it was cost-effective on our network. We load balance traffic across 56 10-gig ports (and) we would much rather have six 100 gig ports to load balance across. But we need it to be cost-effective and it’s just not cost-effective today.”

Because 100G, which is available and standardized, is not cost-effective yet, it’s pretty easy to determine a timeline for what comes next.

“I think for now and the next couple of years 100 gig should suffice,” said Cisco’s Mervana. “Beyond that, 2015-16 you’ll start seeing the need in some places for 400 gig.”

“The entire AT&T backbone is 40 gig and the entire China Telecom backbone is 40 gig so saying that it didn’t take off isn’t really true in the sense that there’s a significant amount of deployment out there.”

EVE GRILICHES, VICE PRESIDENT OF OPTICAL NETWORKING FOR ANALYST FIRM AGC.

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problem than with newer gear.

THE SHORT TERM FIX

While unilaterally installing 100G equipment, Verizon is also looking at getting more than 100G of speed. To do this, the carrier is removing 50 GHz fixed filters and replacing them with wavelength-selectable switches in the ROADMs to separate wavelengths without filters. That change lets the carrier lump together spectrum and stack wavelengths into superchannels that can, for instance, be built by using four 100G entities switched through the ROADM layer as a single entity and delivered as a 400G network.

"From 10 times 10 gig to 1 times 100 is much more economical, easier to manage and certainly higher throughput."

GLENN WELLBROCK DIRECTOR OF OPTICAL TRANSPORT NETWORK ARCHITECTURE AND DESIGN FOR VERIZON

This so-called superchannel approach, in trials, efficiently delivered bandwidth of either 400G, 1T, or steps in between across the network backbone. The trick is to get rid of the fixed filters and use most of the wavelength-selectable switches—the key switching element in the ROADM—to lump together as much spectrum as possible. Removing the filters provides about a 33 percent improvement since a since a 50 GHz filter is really useful for only about 35 GHz because of the need to provide headroom in the channel. “Short term our goal is to put the pieces in place that will allow us to use the flexible grid and to eventually get rid of those fixed filters,” said Glenn Wellbrock, director of optical transport network architecture and design for Verizon. “In the short term that would allow us to move to superchannels and regardless of whether that bitrate becomes 400 or a terabit, we would be able to support that in a cost-effective fashion by getting more wavelengths per system and moving those channels as close together as possible.”

THE LONG-TERM FIX

Long-term, Verizon is taking care to adhere to emerging standardized technology and architectures from IEEE and ITU—including Quadrature Phase Shift Keying (QPSK) as opposed to Quadrature Amplitude Modulation (QAM) to improve distance. Even as the carrier builds its own superchannel infrastructure, it recognizes that a standardized 400G link will be more economical and dependable than four 100Gs mashed together.

“The big thing in the switch-router world is the MAC layer itself. If you can make that one contiguous 400 gig you’re going to get more capacity than if you had four individual 100 giga gigs because traffic can’t split across the different physical interfaces,” said Wellbrock. This, he said, is why the 100G standard is much more popular and widely accepted than 10G—even though with 10G there are superchannels built on that infrastructure that can reach and exceed 100G.

“It’s easier to manage, lower cost and higher throughput if you can make one interface instead of 10. From 10 times 10 gig to 1 times 100 is much more economical, easier to manage and certainly higher throughput,” he added.

Verizon continues to do field trials to see how fast it can go using existing gear but remains cognizant of the need for standards. “Standards have everything to do with it,” Wellbrock said. “Even if two companies got together and decided to do something proprietary, those are the only two vendors that use it. Others could sign on and you could get to a de facto standard in some fashion, but that would be extremely dangerous and frowned upon because you’re circumventing the process that would allow you to interoperate with a larger set of suppliers.”

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organizations like IEEE, which is developing the 400 gigE standard and ITU which is working on G.709. In the past the two organizations might have proceeded independently and, like two ends of a railroad built just off kilter, arrived at just slightly different, but still non-connectable, solutions.

“I think both organizations are under pressure from their individual members to move forward but both organizations recognize that they really do need to move forward together,” Lapak said. “The ITU doesn’t want to come up with a new carrier speed that doesn’t work very nicely with a new Ethernet speed and the Ethernet community has to move on making some decisions.”

With or without cooperation—and D’Ambrosia is certain the 100G-plus effort will be WITH in capital letters, there is no way the telecommunications industry will move forward without a standard.

“Standards are under pressure from their individual members to move forward but both organizations recognize that they really do need to move forward together,” Wellbrock said.

D’Ambrosia said. That debate must be short-lived “because they have a bandwidth problem and they realize they’re going to have to come to a decision point of choosing 400. It’s doable but not as exciting as a terabit,” he said.

The wild card is time. Wait too long and the industry will likely feel the pain it experienced when it moved from 10 giga into a “40/100 where it’s going to make sense to do both speeds again,” D’Ambrosia said.

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“There can always be more efficiencies in how the standards bodies move but to not have a standard for 400 gig or terabit is not acceptable,” said Sanjeev Mervana, service provider marketing director for Cisco. “You have to have standards because the majority of the networks are multi-vendor environments.”

So the apparent consensus that there must be a standard leaves only two questions: how fast will it happen and how fast will it go.

“Since the group hasn’t met yet, there is no official timeline. This current ad hoc that’s being formed has a 12-month life. I would like to see the study group go not as long as did for the 40/100 gig project, which was 18 months. I would like to see that come down into the eight month range,” said D’Ambrosia.

So about two years to get to the point where things start to work together and another year on top of that to make sure everything does. How fast is a bit more problematic; and that’s where the economics will probably rule the day.

“I see a consensus developing around 400 gig from people who are suppliers. People who are users are going back and forth between the two (400 and a terabit),” D’Ambrosia said.
Networks are evolving to support the rise of a global connected village. Coherent 100G technology offers 10x more traffic capacity on the existing network.

A connected world, a 100G village

Distance learning facilities are connecting students across the world to their chosen universities. The Open University in the Netherlands uses an electronic learning environment to connect 23,000 students and alumni from their homes.

As of 2009, high-frequency trading firms account for almost three-quarters of all US equity trading volume. In this space, a 1-in-100 advantage can equate to more than $110 million in financial transaction revenue per year.

In 2011, real-time entertainment accounts for about half of the bandwidth being consumed in the US.

A large chunk of investments in submarine networks are focused on the African continent (close to $3 billion in 2010-2013), helping to connect the global village.

By 2014, all elementary school messenger in Korea will be digitized and school children will replace paper books by touchboards.

Major sports events such as the Rugby World Cup can be broadcast in HD worldwide and watched in real-time by smartphone and tablet users. By 2015, video and streaming is expected to surpass web and internet traffic.

100G networks will drive connections in the coming years, with Dell-Oro Group predicting revenues of nearly $1 billion by 2013 and $2 billion two years later.

Data consumption is expected to grow by a factor of nearly 45 between 2009 and 2020.

Scientists from 34 countries are using data generated by the Large Hadron Collider to study the smallest known particles – the fundamental building blocks of all things. This gigantic instrument produces about 15 petabytes of data annually – enough to fill more than 1.7 million double-layer DVDs or 15 times the height of the Eiffel Tower.

More than 100,000 patients across the land are being monitored in China by remote health monitoring devices. That instantly record and share their health information with healthcare providers.

100G networks are transforming the world into a connected village.

Sources: BofA Merrill, Gartner, Dell-Oro Group, Merrill Lynch Capital Markets, J.P. Morgan, Dell, Gartner.