

# A dominant force in 100G

Since 2007, when Verizon first trialled 100G optical traffic on a live system, the company has played a leading role in the development of high speed networks. Now it is offering the benefits of this track record to other carriers and service providers to enable them to deliver a new generation of applications and services.

**SINCE 2007, VERIZON** has been making pioneering advances in 100G technology. These advances have helped to increase both the capacity and performance of its networks, with the potential to enrich the portfolios of its carrier and service provider customer base around the world.

Verizon's impressive run of innovation began with the successful conclusion of the industry's first field test of 100G optical transmission, on a live 312-mile network route between Tampa and Miami in Florida. The test demonstrated conclusively that by deploying advanced electronics, an existing network system could successfully be upgraded to 100G.

In 2009, Verizon became the first telecommunications company to successfully deploy a commercial 100G ultra-long-haul optical system for live traffic on its European optical core network between Paris and Frankfurt - the first time ultra-long-haul 100G had been deployed using a single channel on a production network.

The following year it deployed 100G between New York and Chicago, realising improved efficiencies and scalability for customers while still supporting high-performance services over Carrier Ethernet.

Ciena's 100G coherent optical transport solution was used, the same equipment Verizon used for its 100G deployment in Europe. Ciena is in fact continuing to work with Verizon on 100G solutions for network transport for both long-haul and metro applications.

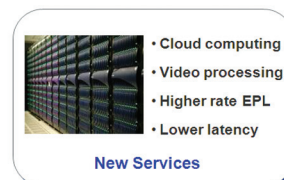
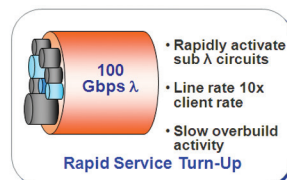
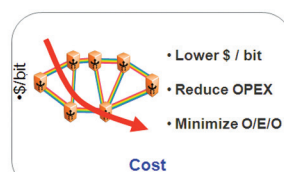
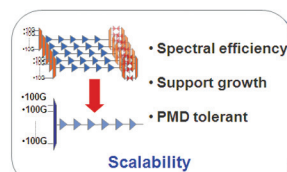
Now, to meet the increased demands created by video, mobile and cloud services, Verizon is upgrading its IP network backbone infrastructure in selected US markets, including Atlanta, Boston, Chicago, Dallas, Los Angeles, New York and Seattle.

Moving towards 100G has enabled Verizon to increase bandwidth efficiency on its existing fibre infrastructure. By installing new equipment on the network while retaining use of the current fibre system, it can now carry up to 10 times the amount of network traffic carried on a standard route. Optical efficiencies also are gained from carrying traffic on a single 100G wavelength as opposed to 10 wavelengths, each operating at 10G per second.

Verizon's 100G innovations now go beyond its major backbones, and it is working to deploy Cisco's CRS-3 Carrier Routing System platform to terminate high-speed connections closer to customer network facilities – the 'edge' of the network. Progress in this area will enable the network to seamlessly accommodate growth where traffic demand is the greatest.

"We're constantly seeking to improve the Verizon IP network to support traffic growth, improve performance and increase

## Applications and Benefits of 100G



functionality," said Ihab Tarazi, vice president of global IP and transport planning and technology for Verizon. "Upgrading the network using Cisco's CRS-3 platform provides better scale and expanded capabilities that support traffic growth areas such as broadband access and content delivery."

The result of all these innovations has been a substantial reduction in Verizon's network latency, as well as increased capacity per fibre, helping customers to control their costs as they move higher volumes of time-sensitive information more effectively between strategic business locations.

## A CRITICAL POINT

Verizon believes that a critical point in the evolution of 100G has now been reached whereby the technology is nearing deployment on a widespread scale, at the same time as making clear sense from a cost perspective.

"At this stage, 100G is not an everyday thing," says Michael Bettini, senior manager at Verizon. "We are one of only a few carriers to offer such a service commercially. With our 100G investments, we're considering the future needs of our wholesale customers, delivering on their high traffic demands, and their need for greater efficiency and lower latency. I truly believe 100G networks will be the superhighways of the 21st century, comparable in importance to past innovations in road and rail."

The company remains committed to meeting customer demand by further increasing the capacity, speed, resiliency and



efficiency of its global network, which stretches more than 670,000 route miles, including terrestrial and undersea cable, and spans six continents.

### WHY 100G?

Verizon's wholesale customers can now benefit from its 100G knowledge and investments by passing on a number of benefits to their enterprise and consumer customers, particularly those with critical traffic connectivity requirements.

All over the world, businesses are launching integrated solutions such as cloud computing services, unified communications as well as collaboration applications and consumers are eagerly adopting applications such as video streaming and online gaming. Verizon's advances in 100G technology will help to improve the overall efficiency of traffic to meet this increased demand.

Across a number of vertical sectors, there is demand for not only increased network capacity but also performance and speed – making 100G vital for communications services addressing markets like financial transactions, health care data exchange, energy services and entertainment on-the-go. With 100G, Verizon plays its part in helping meet those demands more efficiently and with better performance.

Independent confirmation of Verizon's 100G leadership has come in the form of a number of industry awards, recognising

the strength of its networking solutions. Last year, Verizon was positioned in the Leaders quadrant by industry analyst firm Gartner in the report *Magic Quadrant for Global Network Service Providers*. And for the third consecutive year, Verizon achieved the Metro Ethernet Forum's highest acclaim of 2011 Global Service Provider of the Year for the company's comprehensive, international Carrier Ethernet portfolio and ongoing service innovation.

### 100G - HERE AND NOW

Verizon has proved that 100G is a real world solution and not simply a technology at evaluation stage. In the UK for example, education and research network JANET has worked with Verizon to produce a networking solution to enable academic institutions to collaborate online over ultra-fast broadband. Now teachers and students at universities, colleges, schools and research councils can access and share information in the form of text, images and video on a daily basis. JANET now has a platform that can not only support the UK's educational needs today, but will provide a foundation on which future innovative educational services can be offered.

Its work with 100G is another example of Verizon's commitment to its customers, as it seeks to develop a network that embodies intelligence, efficiency and speed and delivers superior performance at competitive prices.

## Future development – beyond 100G

Verizon's pioneering advances in 100G do not represent the completion of its work in ultra-fast networking. The company continues to innovate and push boundaries.

In 2010 Verizon completed another industry first with a field trial transmitting high bit-rate technologies, including 100G, 450G and 1T (1 terabit or 1000G), all coexisting on the same fibre.

The trial, conducted with NEC Corporation, was performed on 2,212 miles of field fibre using Verizon's network in the Dallas area.

The trial used a novel approach that allowed for different modulation formats to be used to help ensure signal performance while carrying the highest total capacity. The two companies also specifically focussed on transmission performance over a significant fibre distance since other experiments in this area have only been performed in a lab environment.

"Verizon continues its research to find the scientific limits of high-capacity optical technology as we strive to offer the most advanced network technology that adds long-term value to our customers and is capable of sustaining the tremendous growth potential," said Ihab Tarazi, vice president of global IP and transport planning and technology for Verizon.

"This joint effort moves the industry towards a better understanding of the technology's challenges, differentiators and viability because the future will be shaped by what we learn now."

Network carriers, he says, are moving to higher and higher capacity rates to stay ahead of growing bandwidth demands from video services, wireless applications, real-time gaming, large-scale data storage and increased IP services.

"By increasing modulation levels and reducing optical carrier spacing using superchannels, the total capacity per fibre is increased by more than 100 percent as compared with the current standard 100G systems," adds Tarazi. "Superchannels" are the next evolution of optical technology that combines several optical carriers to create a signal with greater than 100G capacity. The ability to use current field fibre to carry higher

capacity rates enables carriers to avoid the need to deploy new fibre and, as a result, better utilise current network infrastructure."

"NEC has a proven commitment in delivering the most advanced optical networking technology to allow carriers to meet the growth in network traffic," said Masaaki Nakajima, senior vice president of NEC Corporation of America. "The success of the field trial with Verizon is an achievement that reaffirms our technology leadership and demonstrates the feasibility of delivering unmatched capacity over existing networks."

Previous experiments of this type had only been performed in a lab environment. Real network breakthroughs like this help to pave the way to a future when data rates will need to go beyond 100G, showing that Verizon will continue to be at the forefront of meeting customer data needs today, while setting the stage for future growth.

"I see a future where we offer our customers the ability to seamlessly transfer data from the US to Europe to Asia at high speeds," believes Bettini. "You'll be able to download a whole movie in Germany from the US in a matter of a few seconds. We'll see data of all sorts being able to transverse the globe, just like that. Networks like this will have applications in science and health. Vital data can be sent around the world with no more waiting. These networks need to be built now to support future needs. You can build multiples of 10G into efficient packages, but 100G is the next mature step. We've been hearing requests from our wholesale customers for 100G for a while now. Demand is already beginning to materialise."

"From local to global, Verizon's continued investment in networks and leading-edge technology is driving unsurpassed reliability and a superior consumer experience" says Tony Melone, chief technology officer for Verizon. "In addition, our world-class networks are enhancing, and even changing, business models for industries that use these networks. Our network strategy focusses on advancing technologies and expanding our network reach in a way that energises future innovations, as we have seen in areas such as 4G LTE and 100G optical."



# Verizon 100G Timeline

November 2007	September 2008	October 2008	December 2009
<b>Verizon completes industry's first 100G field trial</b>  Verizon concludes field test of 100G optical transmission on a live in-service route between Tampa and Miami in Florida. The test uses a live video feed from the company's national FiOS TV network as the payload. The transmission is conducted on an ultra-long-haul optical system carrying other live traffic at 10G, demonstrating that by deploying advanced electronics, an existing network can easily be upgraded to 100G.	<b>Verizon and Nokia Siemens Networks set new 100G record</b>  Commercial deployment of 100G takes a step forward with a new trial by Verizon and Nokia Siemens Networks. The test is on a single wavelength over 1,040km of field fibre, setting a new distance record and demonstrating improved performance over conventional transmission. The field trial, using Verizon's metro network in north Dallas, proves that 100G signals can be simultaneously transported with 10G and 40G signals on the same system with superior results by using advanced optical techniques.	<b>Verizon improves transmission quality</b>  In another field trial, this time with Nortel (now Ciena), Verizon achieves better tolerance for signal distortion than is possible with standard 10G transmission. Transporting data over 73km of field fibre in north eastern Texas at a 92G rate, the trial demonstrates twice the tolerance for signal distortion when compared with a regular 10G signal. Ciena's convergence platform is able to integrate advanced signal-processing techniques that maintain sustained signal integrity despite significant polarisation mode dispersion.	<b>Verizon deploys commercial 100G in Europe</b>  Verizon becomes the first carrier to successfully deploy a commercial 100G ultra-long-haul optical system for live traffic. The system is deployed on the company's European optical core network between Paris and Frankfurt. The accomplishment marks the first time for deployment of ultra-long-haul 100G using a single channel on a production network.
March 2010	June 2010	March 2011	September 2011
<b>First real traffic end-to-end transmission</b>  Verizon, Juniper Networks, NEC and Finisar announce the completion of the first real traffic 100G optical fibre transmission field trial applying standards-based optics end-to-end and using the latest in 100G native router interfaces. This accomplishment used emerging network technology to transmit data over a 1,520km optically-amplified section of the Verizon network in the north Dallas area.	<b>Verizon completes 100G Ethernet field trial</b>  Verizon's latest test involves carrying 100G Ethernet traffic on metropolitan Ethernet infrastructure. Using Alcatel-Lucent equipment deployed in the company's Switched Ethernet Services network, the trial transmits data over 12.7km of field fibre in the company's Dallas area network.	<b>Verizon deploys standards-based 100G Ethernet on long-haul IP backbone</b>  Verizon deploys the first standards-based, multivendor 100G Ethernet link for an IP backbone on a portion of its European long-haul network, increasing capacity and performance for customers. The deployment marks Verizon's latest step in advancing 100G technology by implementing 100G Ethernet connections between routers on its IP network. Using Juniper Networks routers and Ciena's 100G Ethernet coherent optical transport solution, Verizon implements 100G Ethernet connections between Paris and Frankfurt, a distance of 893km.	<b>Verizon deploys 100G on US long-haul network</b>  Verizon deploys 100G technology on an ultra-long-haul optical system on a portion of the company's US domestic backbone network. By the end of the year, Verizon uses this next-generation technology on more than 10 routes, significantly reducing latency as well as providing greater capacity per fibre and helping control costs. Using Ciena's 100G coherent optical transport solution – the same equipment Verizon used for its 100G deployment in Europe earlier this year – this high-capacity, ultra-long-haul system helps customers move time-sensitive information more effectively between strategic business locations.
March 2012	May 2012		
<b>Verizon further extends 100G in the US and Europe</b>  To meet growing network demands, Verizon continues to expand its 100G network by enabling additional kilometres on its ultra-long-haul optical routes in the US and Europe. In Europe, Verizon expanded its 100G network with two routes between London and Paris, and London and Frankfurt. These two new routes, along with the original Frankfurt to Paris 100G route deployed in 2009, create a 100G ring on Verizon's European production network. Providing significant latency improvements and increased capacity, these additional 100G routes in Europe and the US help meet the increased bandwidth demands from video services, wireless applications, real-time gaming, large-scale data storage and increased IP services.	<b>Staying ahead in the race for 100G</b>  Verizon is committed to extending 100G into the metro during 2013 which will provide even broader access coverage for key government and enterprise customers. The Verizon Network Technology engineers are also busy expanding Verizon's global mesh network which will improve the scalability and functionality for enterprise customers that require high-speed transparent wavelength services. Verizon will continue its leadership position by pushing network technology boundaries to meet the needs of its customers around the world.		