THE 400G PHOTONIC SERVICE ENGINE

LEAPING TOWARD A FUTURE OF FASTER SPEEDS AND HIGHER CAPACITY

STRATEGIC WHITE PAPER

Service providers around the world are moving quickly to accelerate their networks—making the jump from transport speeds of 10G and 40G to barrier-breaking 100 gigabits per second. Getting there is critical given the unrelenting rise in demand for high-speed, high-quality, always-on connectivity. With the introduction of the world's first commercial 400G electro-optical chip—the 400G Photonic Service Engine (PSE)—Alcatel-Lucent is already taking 100G to the next level of performance and paving the way for future 400G networks.

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BREAKING OUT OF THE COST-CAPACITY CRUNCH

Mobile data. Streaming video and social media. The proliferation of mobile devices, applications and interactive services. The list of bandwidth drivers is familiar—sometimes painfully so—to service providers striving to keep pace with demand that's doubling every two to three years[1]. While the world's appetite for bandwidth seems insatiable, network operators are keenly aware that the scalability of their current networks has its limits.

Not only is there an overall challenge associated with making sure today's networks are fast enough to handle their current and anticipated traffic demands, but the rate of growth is also putting providers in a cost-capacity crunch. The investments they're making in network upgrades and new builds to meet demand typically have a high price tag, and the revenues returned have not tended to be proportionate.

This cost-capacity crunch will only become more pronounced as cloud-based services further increase bandwidth demand and at the same time impose requirements for new content delivery and storage models.

Service providers need to ensure their networks—which cover a wide range of distances and topologies—can scale to meet the bandwidth demand. They have to monetize their networks by adopting the most efficient, flexible and cost-effective means of transporting traffic. And to further cut costs, they're also looking to reduce power consumption and their overall network equipment footprint.

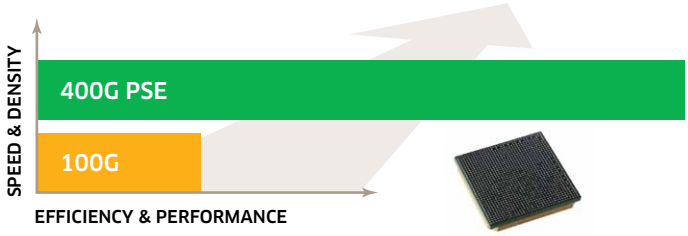
100G and beyond

Aware of the pressures facing service providers, Alcatel-Lucent started investigating 100 gigabit-per-second network technologies in 2005. (The reigning technology for years has been—and, given the incredible growth in bandwidth demand, to a surprising degree remains—10 Gb/s, with some networks having evolved to 40G in recent years.)

In 2007, Alcatel-Lucent conducted the industry's first field trial of 100 Gb/s optical transmission over a live, in-service 504-km portion of the Verizon® network between Tampa and Miami. That led to further refinements and, in 2009, the world's first single-carrier 100G field trial using a coherent receiver and the PDM-QPSK modulation format. In that case, a 112-Gb/s channel with commercial margins was transmitted with 40 Gb/s and 10 Gb/s channels on a 1,088-km span of Telefónica's network in Spain. A year later, Alcatel-Lucent brought to market the world's first complete, commercial 100G single carrier coherent solution.

The arrival of 100G promises huge relief for capacity-strapped service providers. But recognizing the relentlessness with which bandwidth demand will continue to climb, Alcatel-Lucent has continued its R&D efforts to: a) enhance the speed, performance and efficiency of 100G solutions; and b) create an evolutionary stepping-stone to the next major leap forward in network capacity—to 400G.

Figure 1. Taking 100G to the next level and beyond



[1] Telegeography: International Bandwidth Deployments - 2002-2016

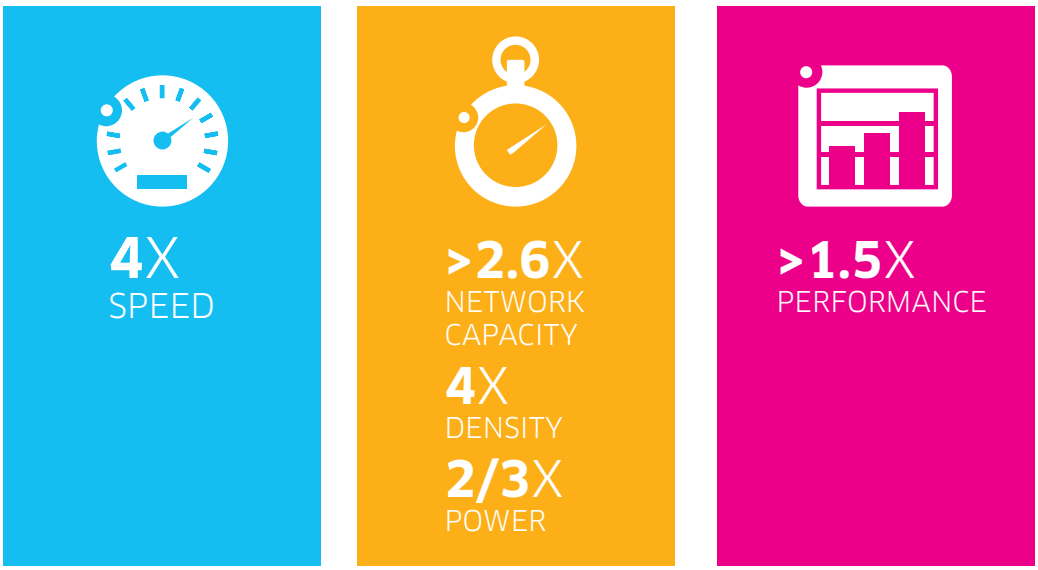
The result of that work is the 400G PSE chip, which has the ability to quadruple the speed of current 100G networks and lay the foundation for an upgrade to 400G. The first commercially available 400G chip, the 400G PSE is fully compatible with 100G networks, maximizing their capacity while optimizing space and power—extending 100G reach and performance.

BRINGING THE POWER OF TOMORROW TO TODAY'S NETWORKS

The 400G PSE builds on Alcatel-Lucent Bell Labs innovation and the real-world experience of Alcatel-Lucent with widely deployed 100G coherent solutions. It was developed for the Alcatel-Lucent 1830 Photonic Service Switch (PSS) platform, and can be utilized in a variety of ways depending on the service provider's requirements.

When configured for 100G transport, the 400G PSE can optimize performance, extending reach by greater than 50 percent (from 2,000 to greater than 3,000 kilometers) without the need for costly electrical regeneration and reducing power consumption and footprint by a third. It allows service providers to realize the full wavelength capacity of fiber of any quality, reducing the need to compromise on wavelengths or speed. In 400G applications, the PSE increases traffic capacity per fiber by greater than 2.6 times and reduces power consumption per gigabit by 33 percent.

Figure 2. 400G Photonic service engine – Industry's first 400G coherent optical chipset

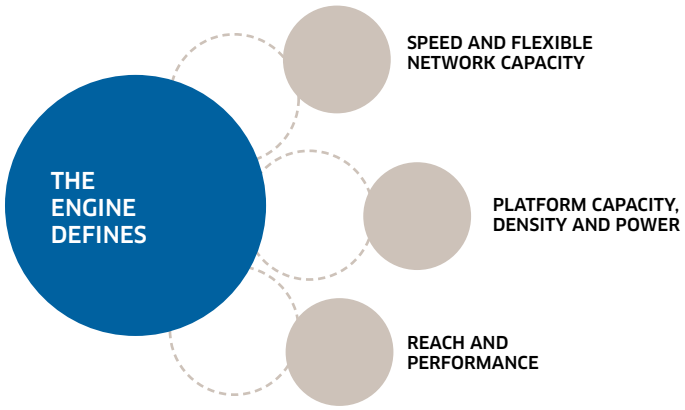


TRANSFORMING THE PERFORMANCE AND ECONOMICS OF OPTICAL NETWORKS AT 100G AND BEYOND

Inside the 400G Photonic Service Engine

An electro-optics engine defines the speed and capacity of a given network platform—and possesses its own innate characteristics with respect to capacity, density, carbon footprint, reach and performance as well. The 400G PSE concentrates on fundamentals: ensuring the extensibility of the 1830 PSS platform and delivering enhanced per slot capacity and a thermal envelope.

Figure 3. The role of a coherent engine – Executing on the fundamentals



The 400G PSE also includes more than 100 patented Alcatel-Lucent innovations. It combines new modulation formats with coherent technology and advanced digital signal processing (DSP) to pack more information into every optical transmission. The newly developed transmit DSP can shape wavelengths—allowing better spectral efficiency, better tolerance to non-linearity and improved noise reduction. It also features ultrafast digital-to-analog and analog-to-digital converters, powerful DSP-based forward-error correction (FEC) and a host of other advancements to deliver the best possible performance and versatility.

Implemented using 44 wavelengths at 400G, the PSE is fully compatible with the current ITU 50 GHz grid, eliminating the need to implement a flexible grid architecture.

Speed is built in

The 400G PSE supports BPSK, QPSK and 16-QAM modulation schemes and an innovative approach to demodulation. Whereas other chipsets demodulate signals in a fixed or static manner, the 400G PSE demodulates dynamically, with soft-decision FEC and higher symbol rates—increasing speed, improving optical signal-to-noise ratio, and providing better tolerance to fiber non-linearity.

Resilience and quality

The 400G PSE receiver includes significantly enhanced algorithms to compensate for chromatic dispersion as well as advanced frequency and phase recovery capabilities. This improves resiliency and optimizes burst error recovery while eliminating phase slips (sometimes called cycle slips) without penalty. The chipset also provides pre-compensation for chromatic dispersion, which further improves tolerance to non-linearity and increases reach.

Wavelength-shaping for greater capacity

Through filter configuration, the chipset's DSP can mold the transmit spectrum into almost any given shape, narrowing its spectra to achieve 37.5 GHz grid spacing at 100G. This amounts to a one-third increase in spectral efficiency and, when combined with the Alcatel-Lucent Flexible Grid Ready Optical Line, has the potential to increase 100G photonic line capacity to greater than 11.7 terabits. At 400G, photonic line capacity can be increased to more than 23 terabits.

Leveraging in-house innovation

The internally developed 400G PSE is optimized for 100G networks, for which third-party chips are just now becoming commercially available. With nearly two years of experience in 100G, Alcatel-Lucent has emerged as a leader in 100G optical deployments, putting Bell Labs' technology—and ongoing research—ahead of the curve.

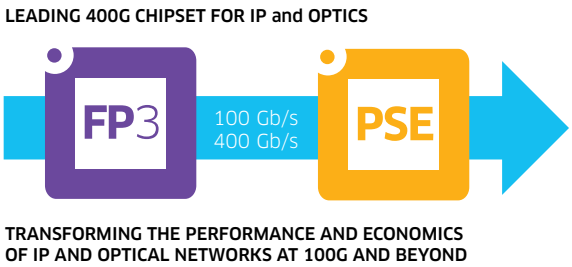
As mentioned, the 400G PSE is designed specifically for the 1830 PSS platform. While no third-party 400G chipsets are yet available, they will inevitably reach the market. Yet third-party chips are often engineered to meet a diverse range of potential applications, markets and products. They may deliver increased speed and density, or improve efficiency and performance, but often are not engineered to provide both simultaneously, whereas the 400G PSE, by virtue of its purpose-built design, can deliver complementary benefits of higher capacity, increased scalability, faster time to market and lower cost per bit.

Strengthening the Converged Backbone

The 400G PSE also represents a major step toward unlocking the full advantages of the Alcatel-Lucent Converged Backbone Transformation (CBT) solution, which tightly integrates the IP and optical layers of the network into a cohesive whole—cutting transport costs, reducing operational complexity and scaling bandwidth.

The 400G PSE and the Alcatel-Lucent 100G coherent optical solution contribute to the optical-side domain of the CBT equation. These are complemented in the electrical domain by technologies such as the Alcatel-Lucent FP3 chipset—the world's fastest network processor—which was the first commercial use of a 400 Gb/s network processor as the foundation for ultra-high performance public and private IP networks.

Figure 4. 400G for the entire network



Through cross-layer synergy in the data, management and control planes, CBT enhances overall network performance and efficiency. Drawing on best-of-breed products in both IP and optical domains, it offers advanced capabilities in cross-layer automation, grooming optimization, resiliency and management simplicity. Again, because the technologies share a common genesis and are designed for Alcatel-Lucent platforms specifically, they are able to deliver benefits beyond those available from mixed-vendor solutions.

Benefits of the 400G PSE

When planning 100G deployments, service providers must weigh a number of complex variables including fiber type, distance between sites, topology, placement of amplifiers, electrical regenerators and add-drop sites. Balancing elements often leads to compromise, with providers reducing line rates or wavelength capacity on some spans or installing additional regeneration sites—both of which diminish overall performance and undercut, to some degree, the value of the provider's technology investment. The 400G PSE was designed specifically to address these drawbacks.

Greater reach

In December of 2011, Alcatel-Lucent introduced the 100G XR, which substantially reduced these barriers, extending unregenerated reach from 1,500 kilometers to at least 2,000. The PSE further extends this reach to at least 3,000 kilometers, opening up new deployment scenarios and approaches. With the enhanced 100G performance enabled by the PSE, the addressable market in both ultra-long-haul and highly meshed regional applications is broadened, network capacity is increased and cost is significantly lowered.

Building a path forward

Current traffic demands can be met by 100G. However, the lesson of the last five years is that the next big thing can run its course quickly and providers—and the technology developers who support them—need to be continually looking farther out.

At the same time, given the cost of evolving the network, providers cannot afford to overhaul their infrastructures wholesale every half-dozen years to keep pace with traffic growth. Solutions have to be scalable, and they have to be backwards-compatible as well.

The 400G PSE provides a smooth evolutionary path on the 1830 PSS platform, allowing service providers to leverage their existing investment and migrate to higher rates at their convenience. 100G routes employing the 400G PSE will deliver unprecedented performance over virtually any fiber infrastructure or topology. Bandwidth can be scaled at any pace, even while power consumption and footprint are minimized.

A SOLUTION WITH A FUTURE

Bandwidth demands are skyrocketing. And with mobile devices becoming ubiquitous, video streaming increasing in popularity and social networks eating up more and more data, that's not going to change. Service providers are becoming increasingly challenged as their networks are strained without a proportional increase in revenue.

The 400G Photonic Service Engine provides instant relief by quadrupling the speed of 100G networks and multiplying capacity by 2.6—all while laying the foundation for the evolutionary leap to 400G. The engine creates a much smaller carbon footprint and drives a lower cost per managed transported bit, extending the 100G reach by more than 50 percent while enabling broader deployment in more use cases.

By dramatically increasing capacity and speed, the PSE enhances today's networks, while preparing for tomorrow's advances. It will be offered on the existing Alcatel-Lucent 1830 PSS platform, providing full backward compatibility and investment protection for service providers needing to scale transport bandwidth.

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