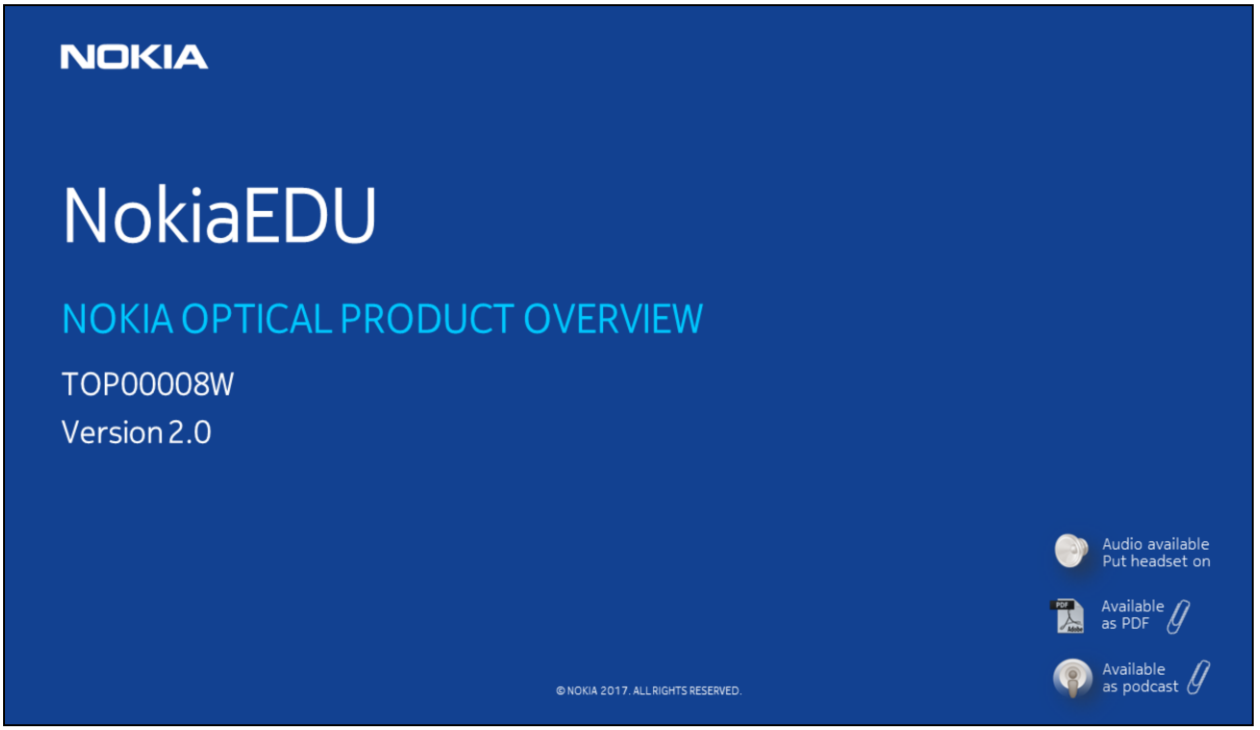
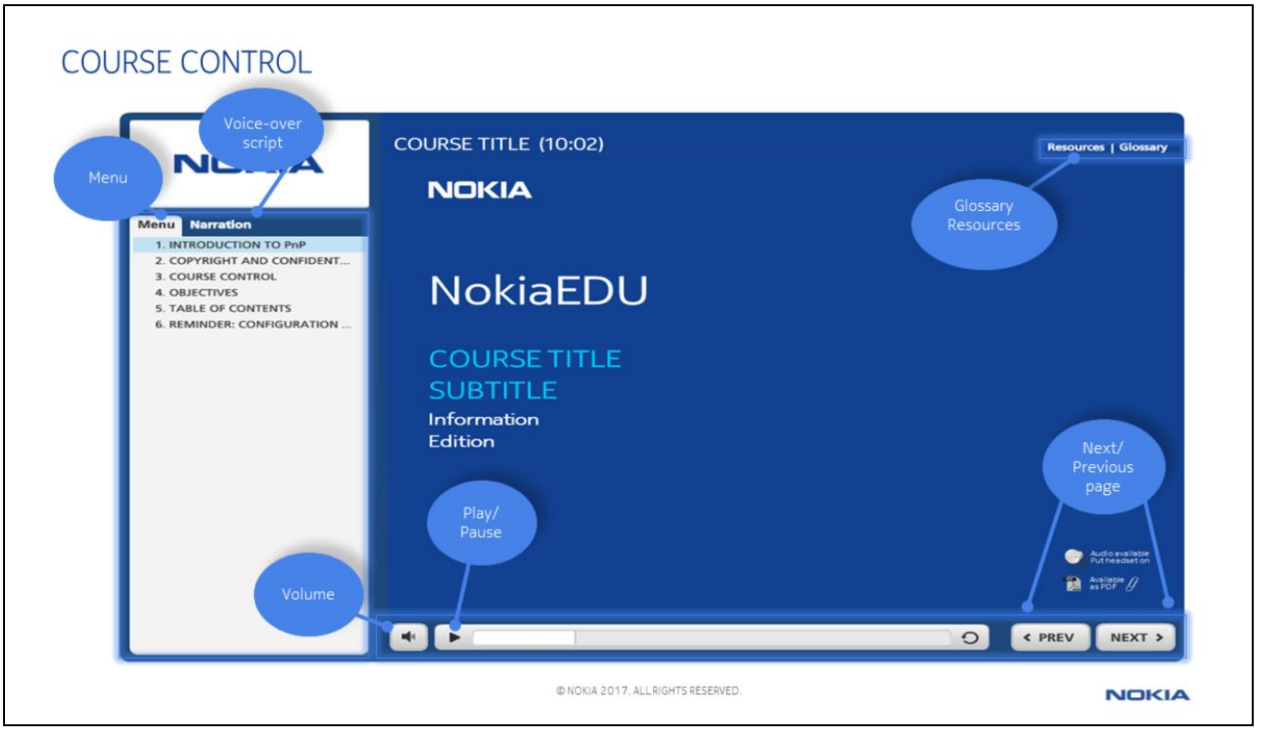


Welcome to the course, Nokia Optical Product Overview.

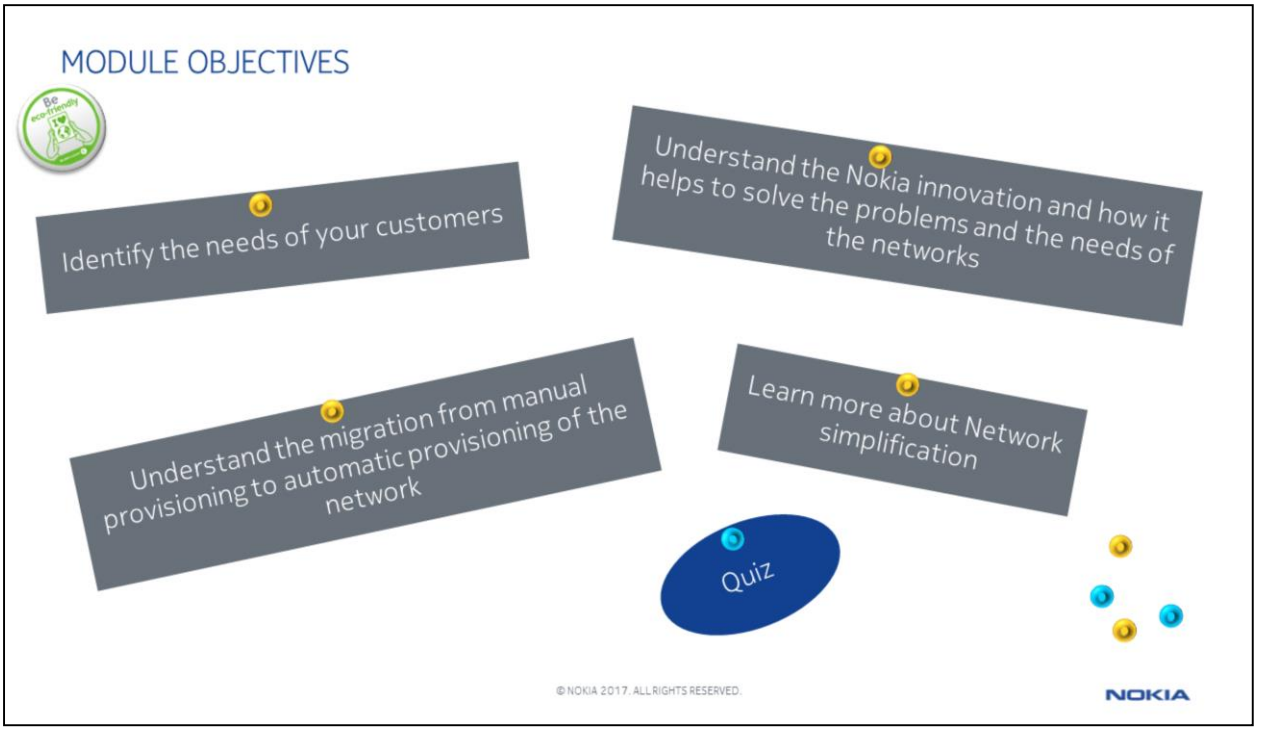


Before we get started, please have a quick look at the controls of this web-based training.

The side panel allows you to see the menu and view the voice-over script.

The control bar along the bottom allows you to play or pause, adjust volume, or go to the next or previous page. Glossary and Resources, like a PDF or podcast version of this course, are options.

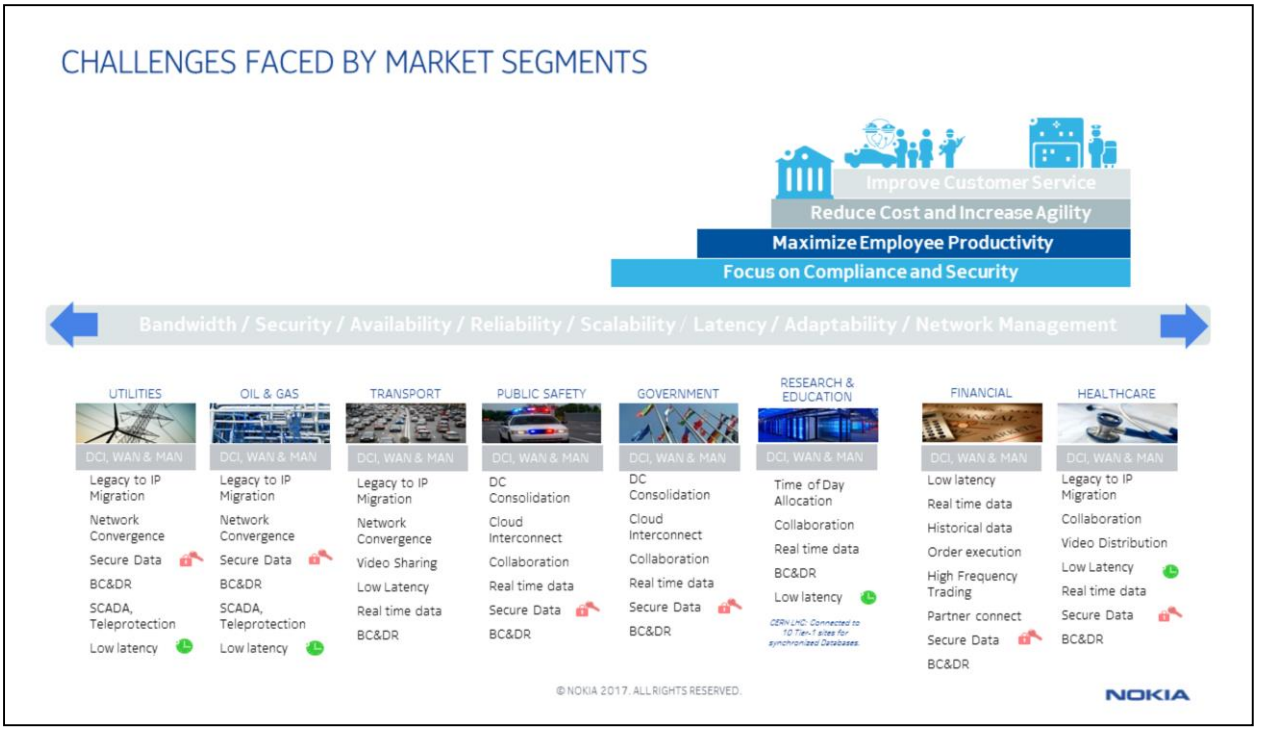
When you are ready, select the “Next” page button from below to continue.



Upon completion of this module, you should be able to:

- Identify the needs of your customers,
- Understand the Nokia innovation and how it helps to solve the problems and the needs of the networks,
- Understand the migration from manual provisioning to automatic provisioning of the network, and
- Learn more about Network simplification

In the end, you will need to pass a quiz to successfully complete this course. Please click Next to continue.



It is important to understand the challenges faced by the markets that you're going to be serving. Looking at the utility market, there have been some major changes. Utility markets communicate one-way, basically from the network operational center out to the substation. The increasing consumer demand of data access is driving a significant change in the way service providers do business. Service providers have to make sure that consumers can only get into their records and can't see the rest of the network and do any manipulation of the network. Service providers are relying heavily upon security. There are various types of securities. They can do IPsec across it. They can do layer one encryption. Layer one encryption is probably the fastest way to do encryption. It's on the fly and it's hardware-based, so it makes it very quick. It does not rely upon software algorithms, but it relies purely upon gating processes within hardware silica to allow very quick encryption because in the utilities segment when there is a power outage or a short of a transformer, you need to reroute around that very quickly to maintain public safety.

The oil and gas industry is very similar to the utility industry. They have to maintain public safety. In case of a rupture in a pipeline, They need to be able to turn that pipeline off very, very quickly. The main difference between a utility and an oil and gas is distance between monitoring points. Looking at the oil and gas, the pipelines are nationwide. Distribution areas are regionalized, which means that we have to go very, very long distances between monitoring stations. To get these long distances, WDM is a very good technology with its amplification.

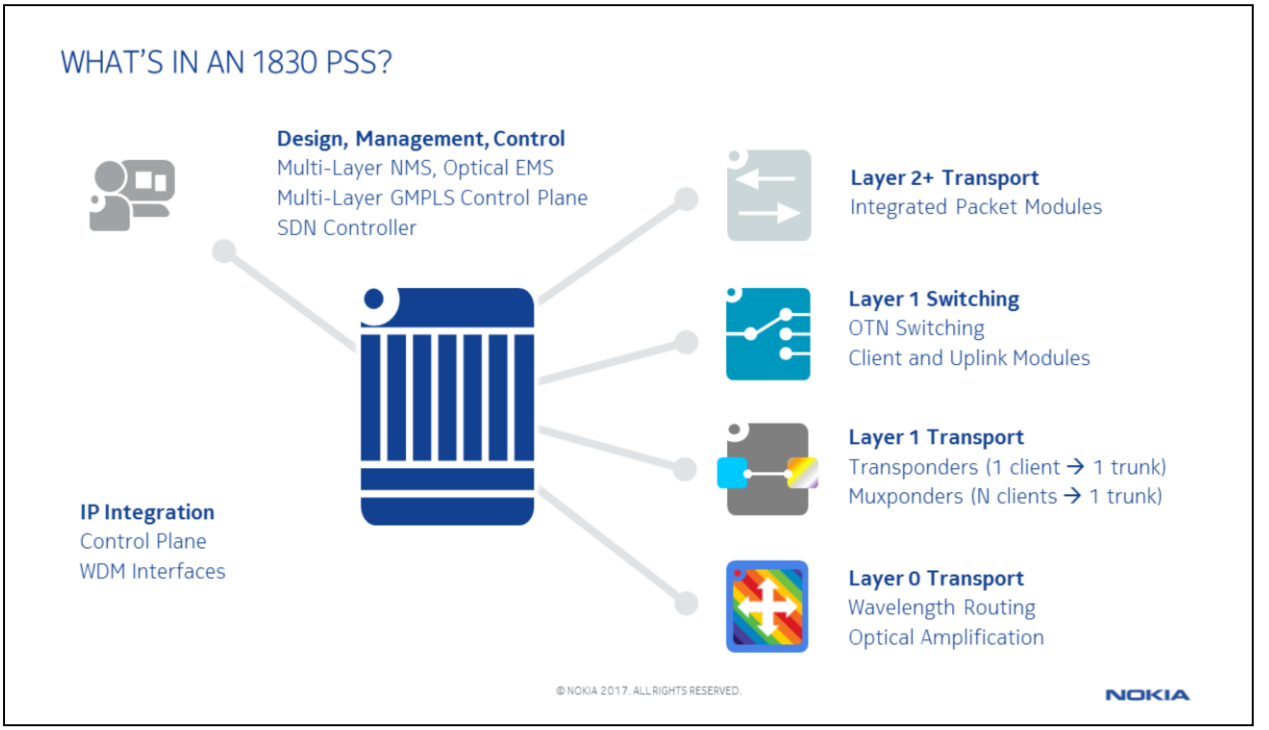
Transport is the backbone of the cities. Secure and connected industry can carry goods and people more efficiently.

Looking at the public safety as well as the government, the more wired and connected the government infrastructure is, the more industry you are going to attract to your particular city.

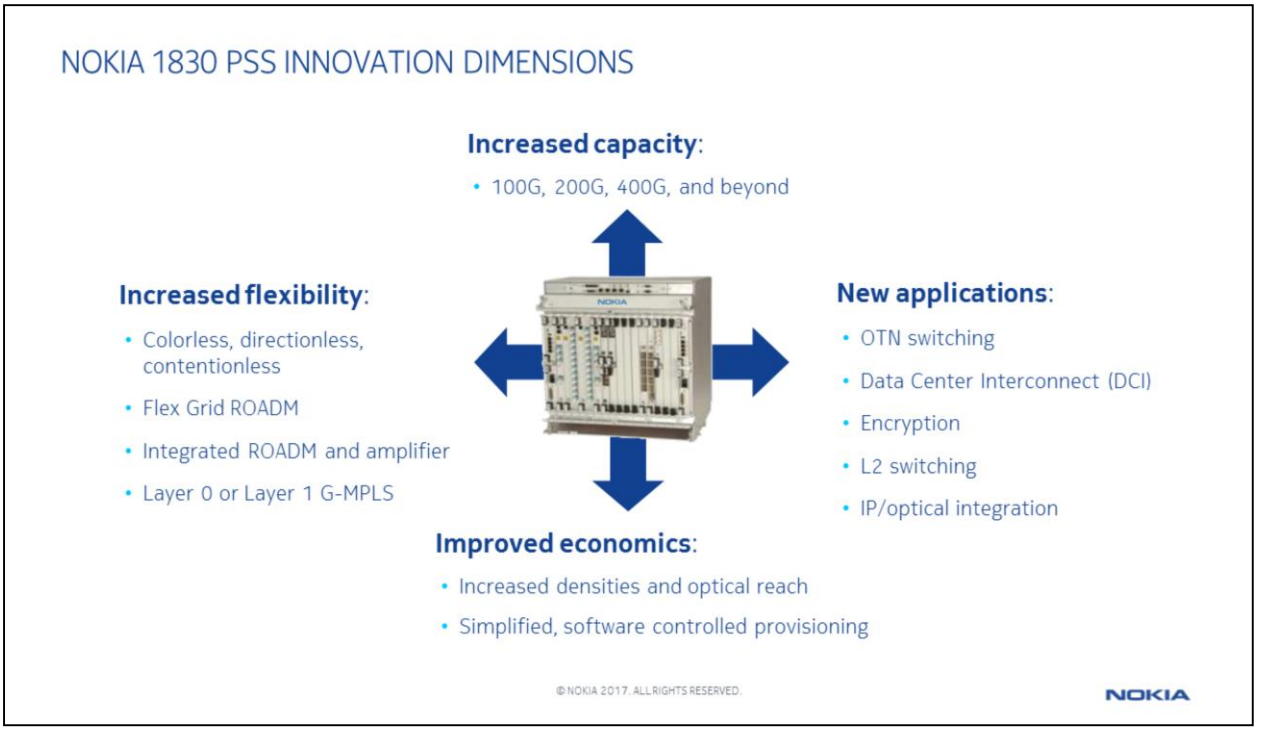
Research and education is totally different than the three or four industries that we just looked at. As universities become more wired, more connected, and have super computer capabilities, they're now moving to the public sector to sell those extra compute cycles. They need massive amounts of bandwidth to do so, to connect from that super computer to the first point of presence. We work with several universities and some of them are running upwards of 400 gigabits, again driving increased bandwidth across the network.

When we move on to the financial segment, it's a hybrid of everything we looked at. Much like the utility companies, now they have a very close touch-point to the consumer. So the financial institutes have to open up the network to allow users to access their record, but not anybody else's, to make the information secure, we connect the two data centers together with enough bandwidth in case of a total outage of one data center, possibly a power failure or a natural disaster so that the information that is in the other data center is synchronously replicated between them and that way there is no lag.

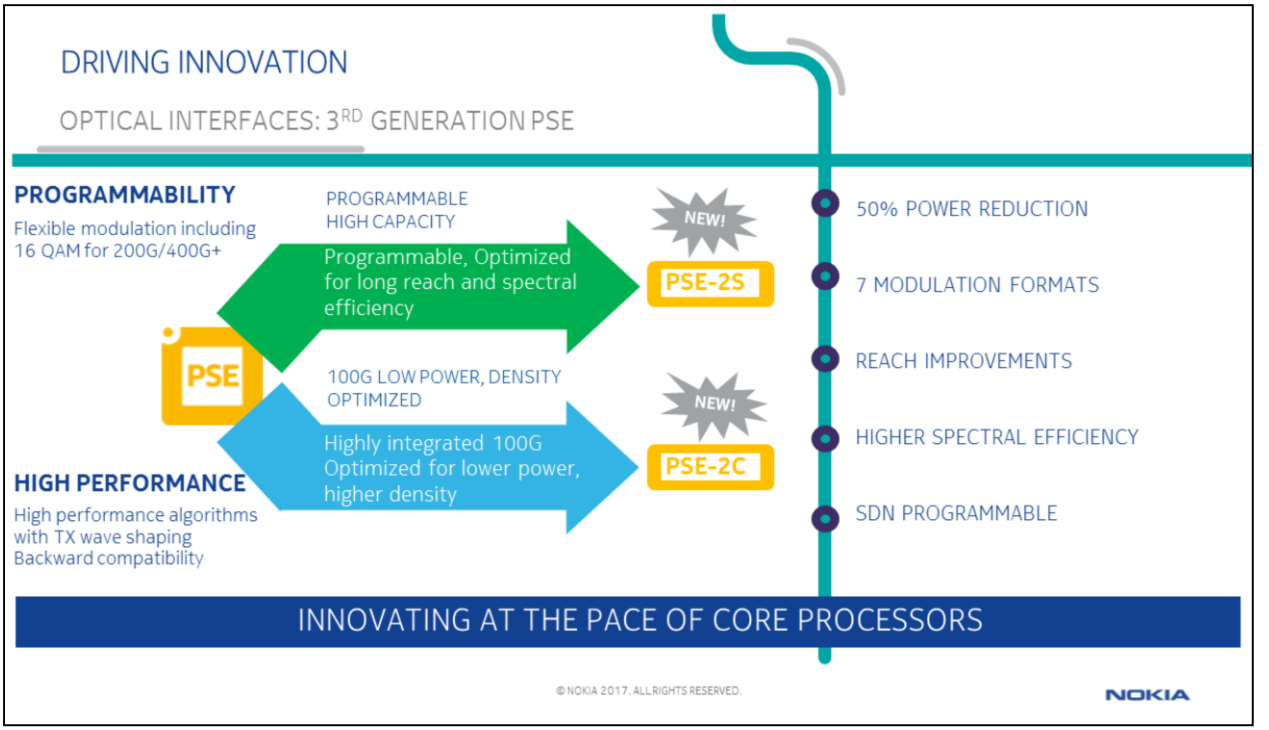
Healthcare has always been public-oriented, but today with the new healthcare laws, healthcare providers have to compete for business. Looking at the new equipment in the healthcare facilities, they can produce gigabits, hundreds of gigabits of data per minute, per second even. How do we get that from the machine to the data center to the doctor that's going to sit with me and tell me what he sees? How do we get that across? Today we need to have high bandwidth. We need to have security on that data due to the HIPAA requirements that the governments has placed on the healthcare organizations. Utilizing WDM in all of these applications provides the bandwidth. The technology that Nokia has put into their 1830 WDM platform allows them the security and the bandwidth to carry all of this data across. Again, to close out on this topic, all of these different segments that we've looked at, communications is not how they make money.



PSS can host a set of photonic boards and modules managing the light, acting at the layer 0 of the OSI stack. Then we have a full range of layer 1 transport items as transponders and muxponders, converting black and white client signals into OTN framed, colored lines. At the same layer, we also have boards capable of switching traffic at OTN level, for grooming at sub-lambda granularity. At layer 2, the portfolio of line cards offers Ethernet integrated packet modules as well, not as full blown as our IP assets in terms of features, but nevertheless enabling a finer level of aggregation and service control when needed. However all these hardware items would be of limited value, if there were no 'intelligence' to control them. This is why we offer powerful management systems, a multi-layer GMPLS control plane, and virtualization functions with an SDN controller. As an add-on, the control plane enables the IP and Optical integration, allowing the IP layer and the Optical transport layer to share information and fulfill automatically the service requests optimizing the usage of the resources. As a simple example of the optimization enabled by the IP and Optical integration, assume that we have a path that is already protected at the Optical transport level. In this case, you may not need to add protection for the same path also at IP level, thus saving expensive interfaces and making best use of the fiber infrastructure. The IP and Optical integration allows the automatic exchange of this information between the IP layer and the Optical layer.

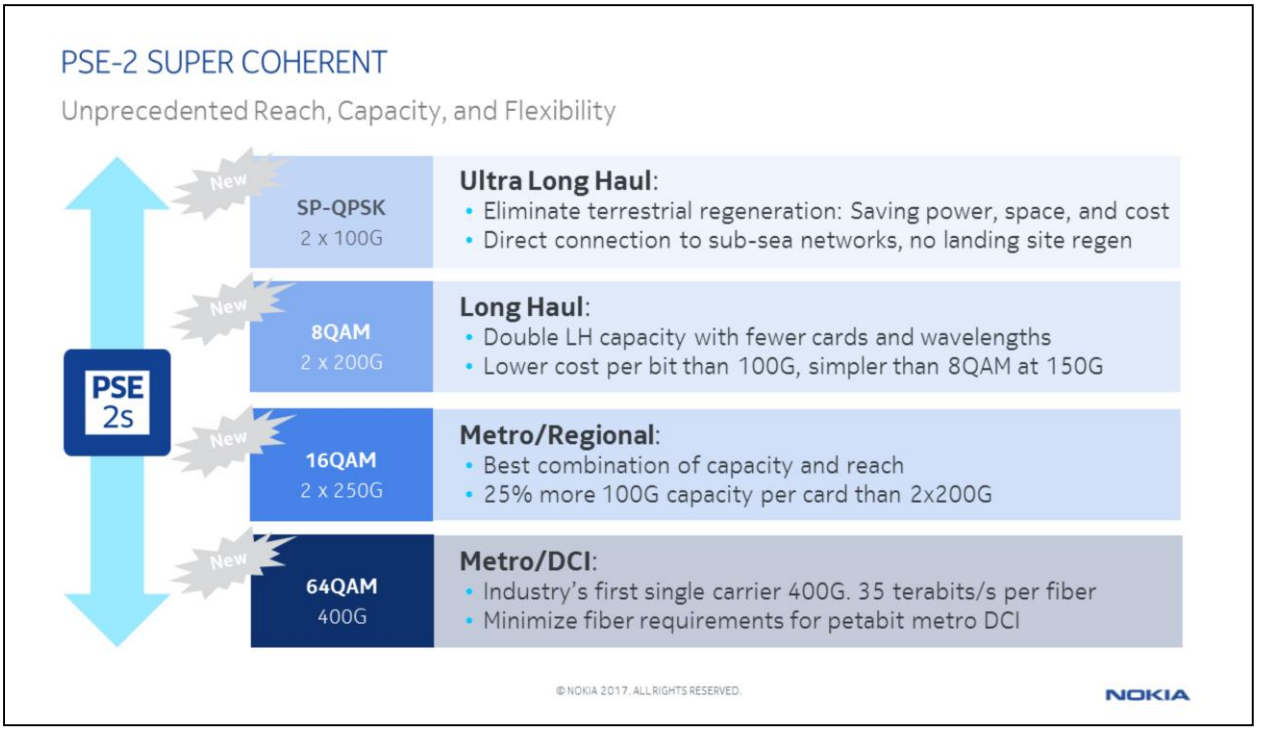


The 1830 PSS products are constantly evolving, setting the pace of the technology advancements. The lines of investment shown in the slide are already in action and will continue in the longer term to provide generating-value assets for our customers and ultimately for us. In a nutshell, on the 'north' direction, we have the constant strive for increased capacity, to squeeze more bits per second on a single fiber. In the 'west' direction, we work to make this capacity flexible as flexibility is the foundation block of intelligent networks, and the enabler for SDN and network virtualization or abstraction. In the 'east' direction, we work to support a wider range of applications, evolving the simple basic WDM and OTN switching to cover Data Center Interconnect (DCI) and Front-hauling needs, with security and encryption, L2 switching, IP and Optical integration. In the 'south' direction, we don't forget the cost improvements, both as capex and opex, with newer, denser network elements allowing at the same time simplified operations. We will now explore some of these lines of evolution in more detail.



This increased capacity is powered by our own in-house silicon. For this purpose, we evolved our second generation coherent 100G/200G Photonic Switching Engine (PSE) with two new versions, the PSE-2 Super Coherent (PSE-2S) and the PSE-2 Compact (PSE-2C). These third generation ICs are specialized for their tasks. The PSE-2S targets high-capacity, long reach, and flexibility. The PSE-2C is instead optimized for low-power, high density 100G applications. Both chips provide programmability, with the capability to change the modulation scheme and implement high-performance algorithms with transmission wave shaping to optimize the usage of the light spectrum as we'll see in a few slides from now.

Designing our own components gives us an edge over the competition, and allows us to be first on the market, keeping the technological leadership on the optical fiber photonics. The PSE-2S is an extremely complex device containing more than 2 billion transistors, and more than 100 Nokia patents are implemented inside the chip.

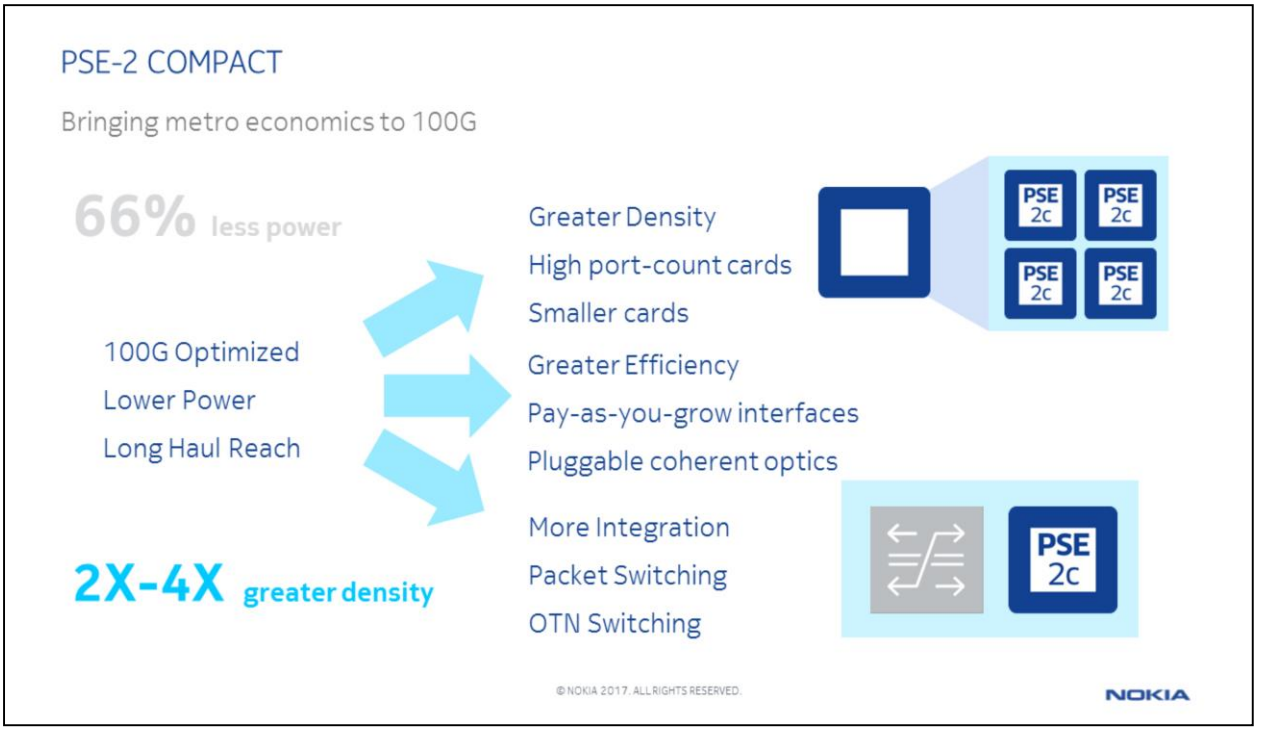


PSE-2 Super Coherent (PSE-2s) increases transport wavelength capacity, distance, and efficiency. It can be programmed to support optimal 100G to 500G transport wavelength capacities and distances for applications ranging from campus to ultra-long haul.

PSE-2s offers multiple modulation schemes like SP-QPSK for ultra-long haul transmission that is useful in eliminating terrestrial regeneration, which helps in saving power, space, and cost. It provides a direct connection to sub-sea networks and no landing site regeneration is needed. For long haul transmission, 8QAM for 2X200G, doubles the long haul capacity with fewer cards and wavelengths. It provides lower cost per bit than 100G and is simpler than 8QAM for 150G.

In addition to the standard 100G and 200G schemes it supports new, differentiated schemes optimized for specific applications.

16QAM for 2X250G and 64QAM for 400G are suitable for metro applications. 16QAM for 2X250G provides the best combination of capacity and reach along with 25% more 100G capacity per card than 2x200G. 64QAM for 400G is the industry's first single carrier 400G. It provides 35 terabits/s per fiber. It helps in minimizing the fiber requirements for petabit metro DCI. The PSE-2s powers the new D5X500 500G mux card.



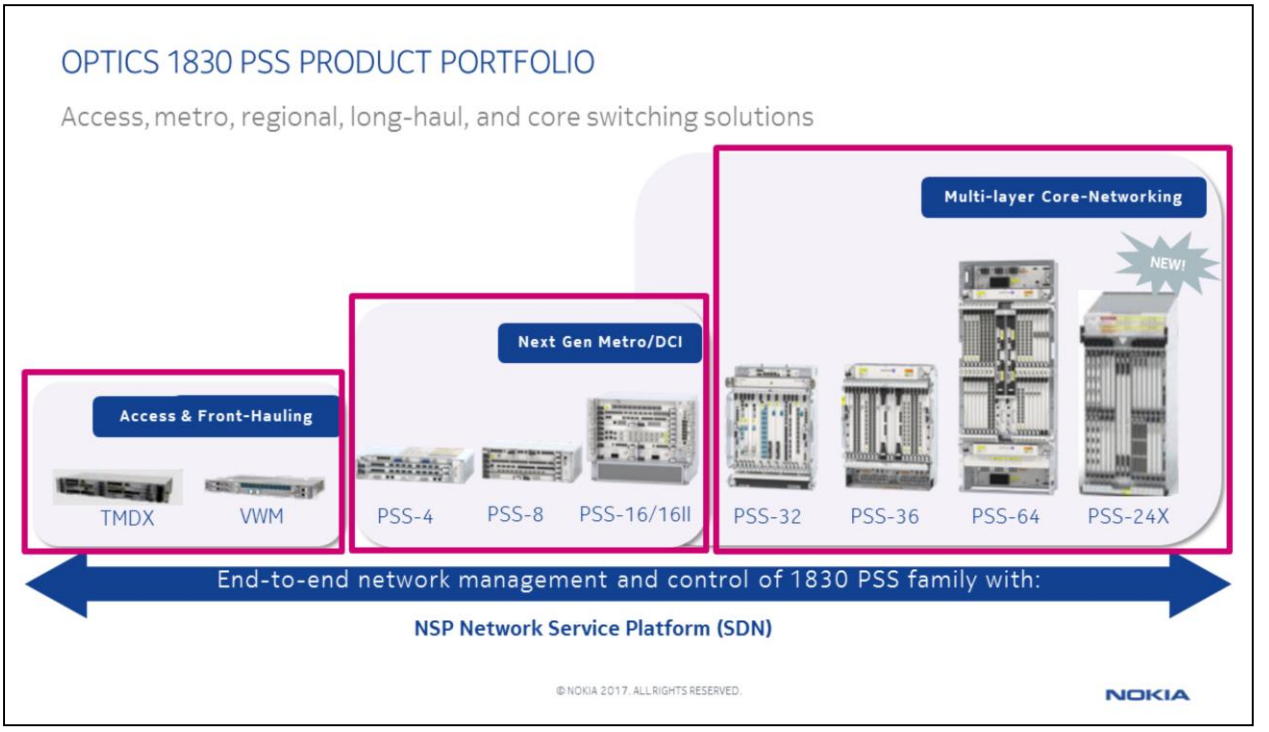
PSE-2c Compact or PSE-2c is optimized for delivering services over 100G transport wavelengths with a maximum 100G interface density and functional integration.

PSE-2c is optimized for 100G, which provides greater density, high port-count cards, and smaller cards.

With lower power consumption on PSE-2c, it provides greater efficiency, Pay-as-you-grow interfaces, and pluggable coherent optics.

PSE-2c is also optimized for long haul reach with more integration, packet switching, and OTN switching.

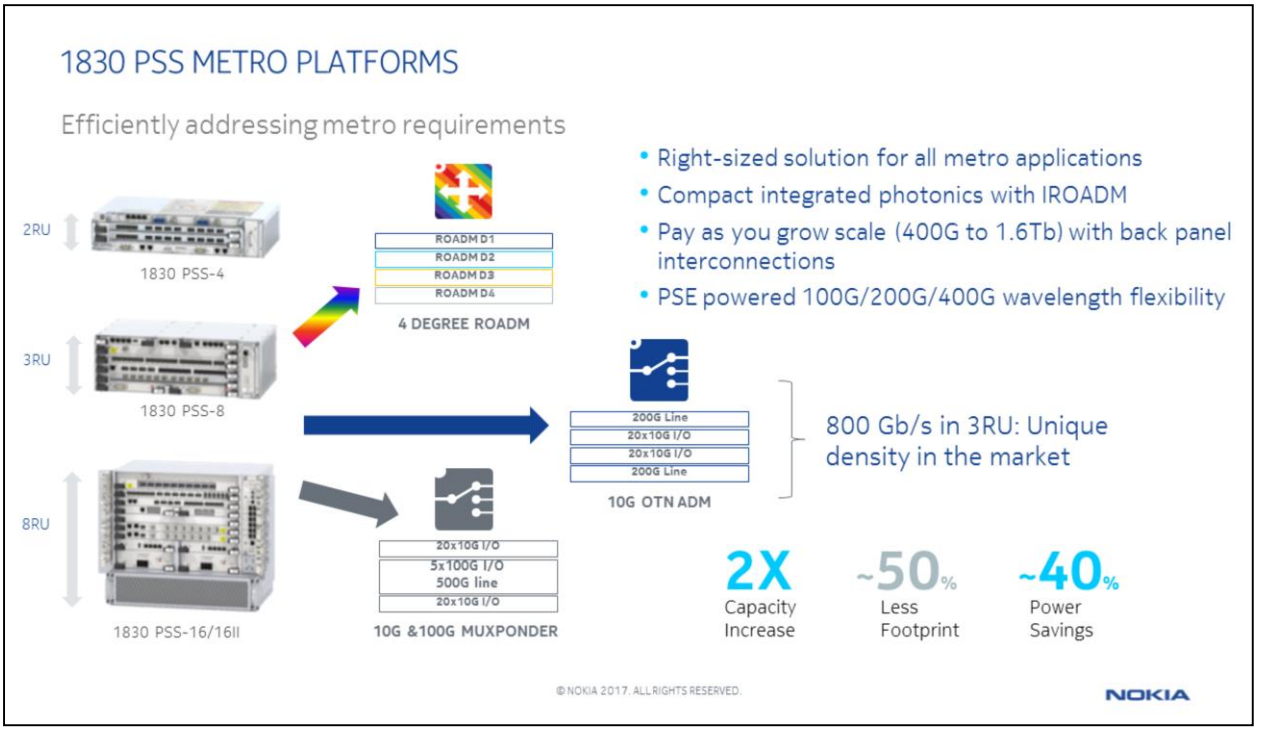
PSE-2c is perfect for metro applications. Network locations with an abundance of fiber may favor a lower start-up cost for 100G services with a “pay as you grow” cost model. By focusing on the essentials of 100G wavelength transport, power requirements can be significantly reduced, leading to the design of dense 100G cards with a high degree of functional integration in addition to supporting CFP2 ACO pluggables for cost-deferrable and field-replaceable coherent optics. The PSE-2c is key to the new S13X100 Universal 100G card.



This is the full 1830 PSS product portfolio, that spans from small boxes for Access and Front Hauling, up to the Long-Haul and Core platform with ultimate performances in terms of spans, reach, and throughput. The access and front-hauling boxes are called 1830 TDMX and 1830 VWM. The TDMX is a TDM eXtender, allowing to set up SDH switching capacity as well as large numbers of E1/T1 accesses to the 1830 PSS. The VWM, Versatile Wavelength Module, is a very compact fixed DWDM system that can be used either stand-alone or to provide mux/demux capability to other network elements, plus it forms the basis of our Front Hauling solution. In the middle, we have the Metro optimized network elements: PSS-4, PSS-8, and PSS-16II, suitable also for Data Center Interconnect (DCI). PSS-4 and PSS-8 are compact enough to be used as Customer Premises Equipments (CPEs), and in this respect crossing the boundary between Metro and Access. PSS-8 and PSS-16II are very flexible machines, converging multi-service capabilities in a single node while still allowing 100G, 200G, and even 400G+ uplinks. In the long-haul and core, we have then the Optical Transport Network (OTN) switching nodes PSS-36, PSS-64, and the brand new PSS-24X, and the photonic shelf PSS-32.

Note that most of the shelves can be arranged in single as well as in multi-shelf node configurations, allowing graceful growth as well as flexibility of function. For instance, you can stack multiple PSS-8 allowing pay-as-you-grow proposals, or you can mix PSS-24X and PSS-32 to achieve electrical - photonic compounds.

The 1830 PSS family can be managed by the NSP Network Service Platform for Software Defined Networks (SDN), as well as a powerful GMPLS control plane, called Multi-Reach Network (MRN), able to automatically coordinate the control of the photonic and electrical layers.



The Metro-optimized 1830 PSS platforms are the 1830 PSS-4, PSS-8 and PSS-16/16II. The form factor here is optimal for the Metro environment, where spaces are tight, and enable pay-as-you-grow scale.

The 1830 PSS-8 and PSS-16II are the newest members of the family in the Metro space and offer a scalable and future-proof metro platform for access and aggregation networks, supporting traditional photonic as well as multi-service, high-capacity Metro transport applications. To this goal, their line cards provide high-density photonics, OTN switching, and Packet switching in a very compact footprint.

Photonics in Metro have no ultimate reach requirements as Metro distances are smaller than the ones in the Long Haul / Core; so the Metro platform can support optimized photonics. For instance, we developed a compact integrated photonics ROADM card, called IROADM, with Metro performances in terms of span and reach, that provides one ROADM degree in one single slot.

These machines are pretty flexible. For instance, as you can see in the slide, PSS-8 can be fit with pure photonics Integrated ROADM (IROADM) cards, building a 4 degree ROADM system in 3RU; but the same shelf can also be configured as OTN Add-Drop Multiplexer (ADM) with a line at 200Gb/s, or as a 10G/100G muxponder, allowing 400G/s and even 500G/s on the line.

BUILDING SCALABLE SWITCHING

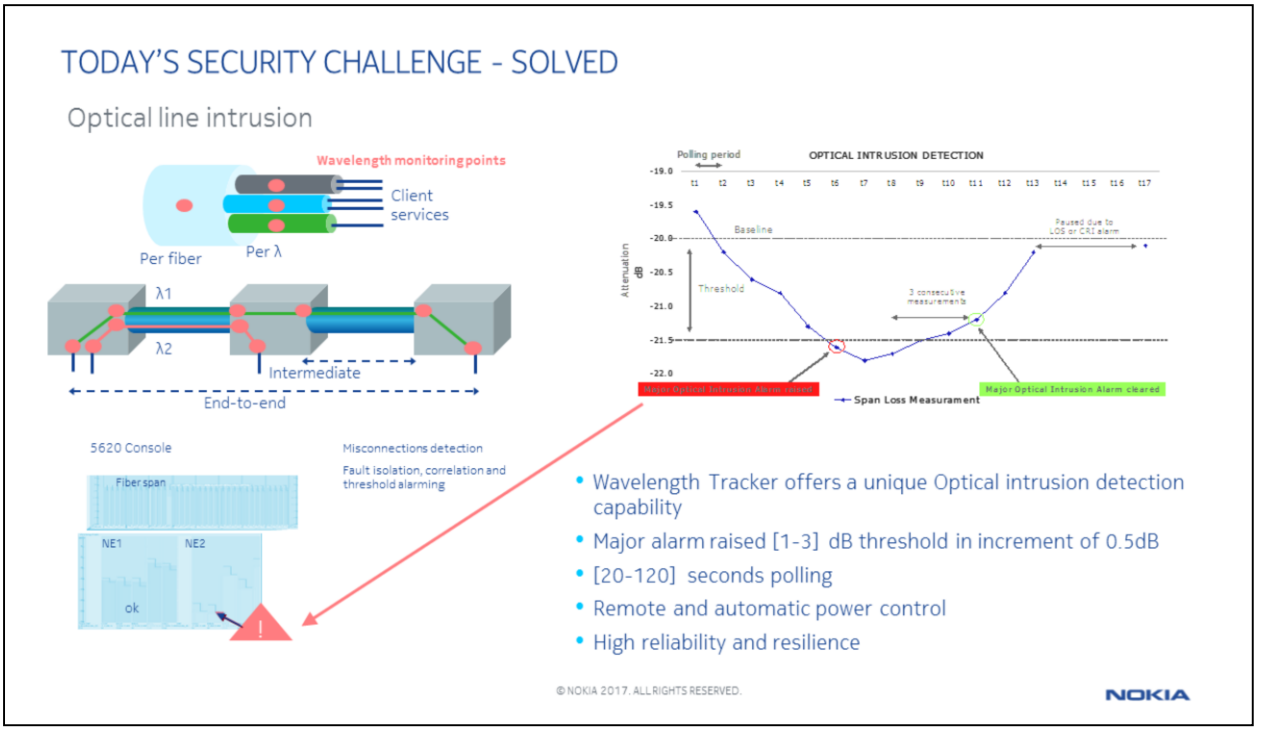
1830 PSS-24x – Introducing next generation core switching

LAUNCHED IN THE MARKET AT OFC 2016 IN MARCH

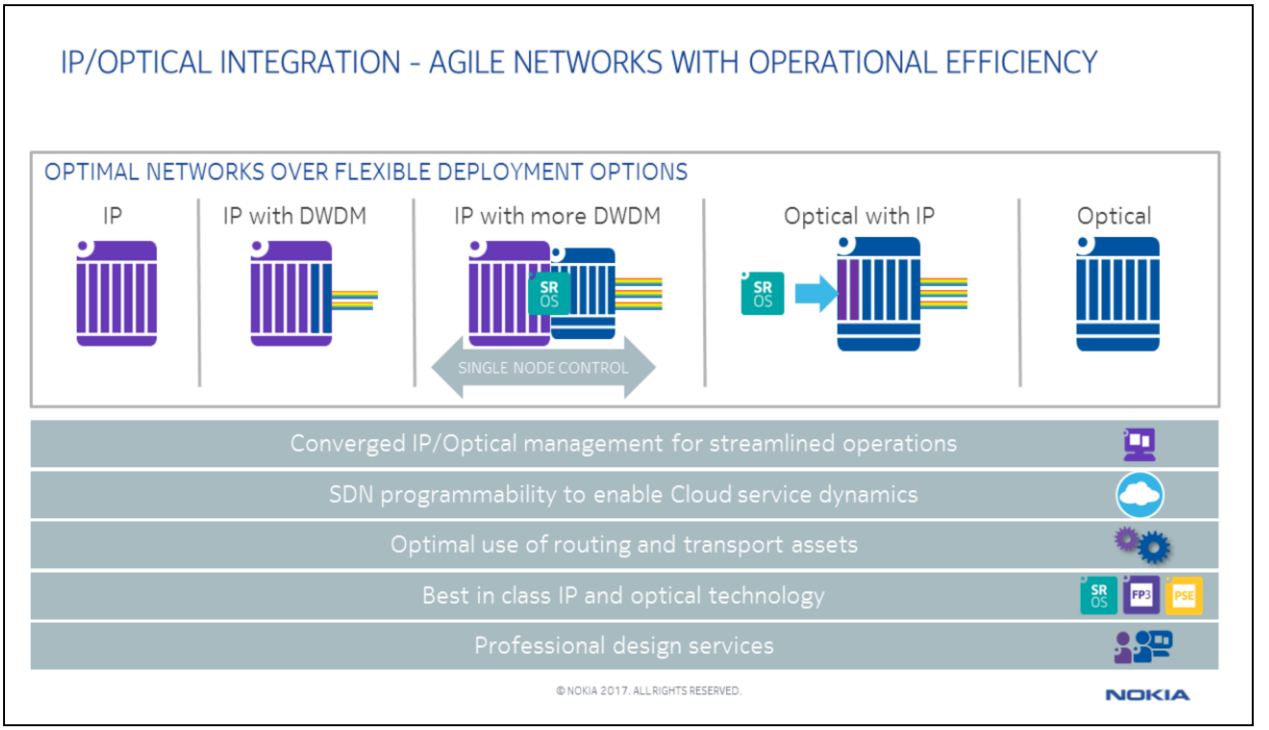
DENSITY	9.6T ➔ 24T per Shelf
CAPACITY	4x100G / 400G λ
LINE/CLIENT	10/40/100 ➔ 400 Gbps
SPECTRAL EFFICIENCY	35T per Line
GREEN	<0.8W/ Gbps

NOKIA

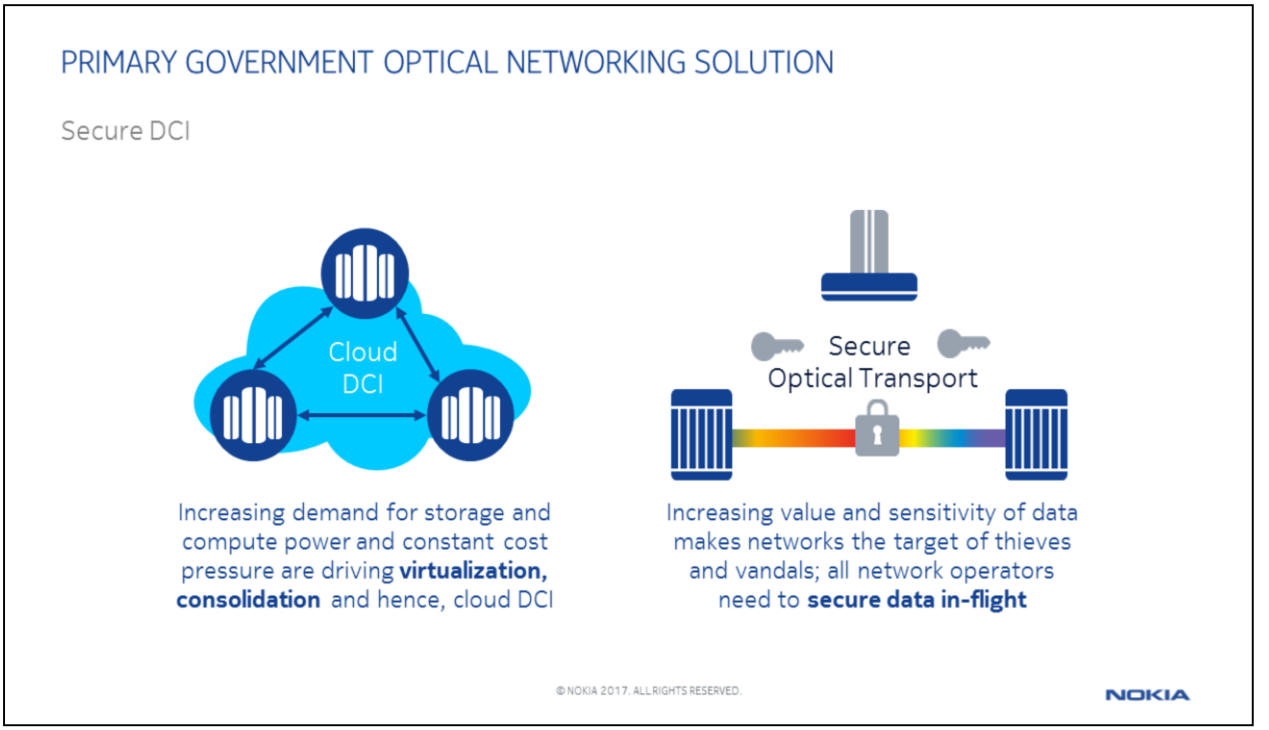
Among the Core network elements, we will have a spotlight on the 1830 PSS-24X as this is the newest member in the family. This network element is based on a large, scalable OTN switching shelf, capable of managing 9.6Tb/s of ODU traffic switching in the first release, with the possibility to grow in the same shelf up to 24Tb/s. The architecture is designed to support 400G wavelengths since day zero, enabling 35Tb/s per optical fiber, with a power consumption per Gigabit matching or exceeding the modern ECO green compatibility requirements.



When we look at every network today and the interaction between the regulators and the network, we're seeing that everyone now has security threats. You look at it from the edge of the network all the way through the core of the network. Today's technology makes monitoring very simple. There will be no outage when somebody slices into your network, there will be just a slight decrease in the signal level. Utilizing the technology in the 1830 platform, several technologies as a matter of fact, the wavelength routing engine and wave tracker, we can detect slight variations in power levels throughout the network and throughout the equipment. If someone were to try and tap into your optical fiber today, we have the ability to detect slight changes and we can set up monitoring points. We can detect that loss and point you to where it happened in your network, so you can quickly go out there and resolve the problem. Now if you're using the layer one on-the-fly encryption capabilities in the 1830 platform, you don't need to be concerned because what we do is full AES 256 encryption. The on-the-fly key rotation can automatically rotate new keys that change the encryption algorithm, which throws intruders off again. So the innovation on the 1830 platform not only allows for massive amounts of bandwidth, but also with the encryption capability and optical line intrusion detection, it allows you to ensure that your network is secure.



Looking at Nokia and the portfolio that we have available, you can look at other vendors and they may have a piece of the puzzle. They may have the IP piece, they may have the optical piece. But when we look at the innovations that have happened in networking in the past, where the combination of SONET/SDH and IP came together and SONET/SDH and WDM came together, the next logical progression is IP onto the WDM platform or WDM onto the IP platform. Nokia has very strong ties in both of these with the 7750 and the 7210 platforms. The 7950 along with the 1830, being under one management umbrella allows us to do intermixing of technologies. So you'll notice on the 1830, you're going to see very similar cards that you see in your 7750. Likewise, on your 7750, you're going to see very similar technologies that came from the 1830. Looking at this natural progression, ultimately you will have one platform that does IP directly over WDM from a common platform. Nokia has the pieces to put this together. In some cases that makes perfect sense. In other cases, we are looking for a single technology. Nokia can provide that, either IP or on the optical domain.

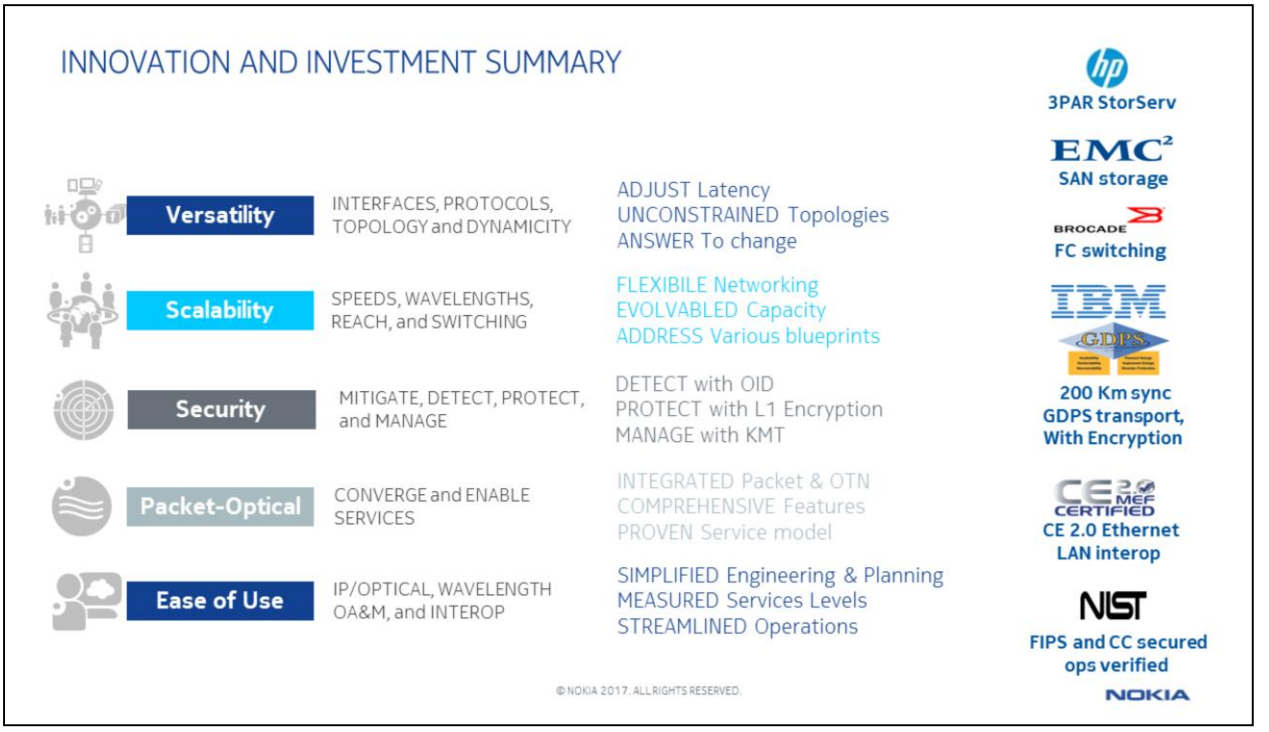


Increasing demand for storage and compute power and constant cost pressure are driving virtualization, consolidation and hence, cloud DCIL:

- Consolidating multiple, legacy systems and data centers into private, virtual private, and/or public cloud solutions
- Sharing IT resources across agencies

Increasing data capacity is the key for the market but also the security of the data exchanged will be a critical aspect of the future.

For this, Nokia has a full Secure Optical Transport solution with L0 encryption to secure the data in-flight.



From the slides that we looked at earlier, we've talked about versatility, scalability, security, packet-optical, as well as ease of use. Versatility: the 1830 allows for access, core aggregation layer, and the right-sized platform that fits into those applications. We talked about scalability from a single wavelength to terabits worth of bandwidth across the network. Security: layer one on-the-fly encryption, AES 256 certified, to make sure your customer's data is secure. Packet-optical: full layer two integration into the 1830 platform to allow for IP directly over WDM. And zero touch photonics make it very easy to provision A to B and also route around faults in the network. All of these innovations really wouldn't do us any good if we didn't meet certification standards of the equipment that's already in your network. If we were to look at HP, we are certified with the 3 PAR solution. EMC with their SAN storage switches. Likewise, with Brocade. Also, carrier Ethernet 2.0 certified. So you can be ensured when your customer picks a Nokia 1830 that we will interoperate with the equipment that's in their network.

With Nokia optical products, users do not have to compromise on the benefits of optical and IP networking.

- ○ True
- ○ False

What are the key benefits of Nokia zero-touch optical networking platforms?

- ○ Minimal preplanning
- ○ Service enablement
- ○ Service resiliency
- ○ All of the above

What is the key advantage of building SDN-based optical networks?

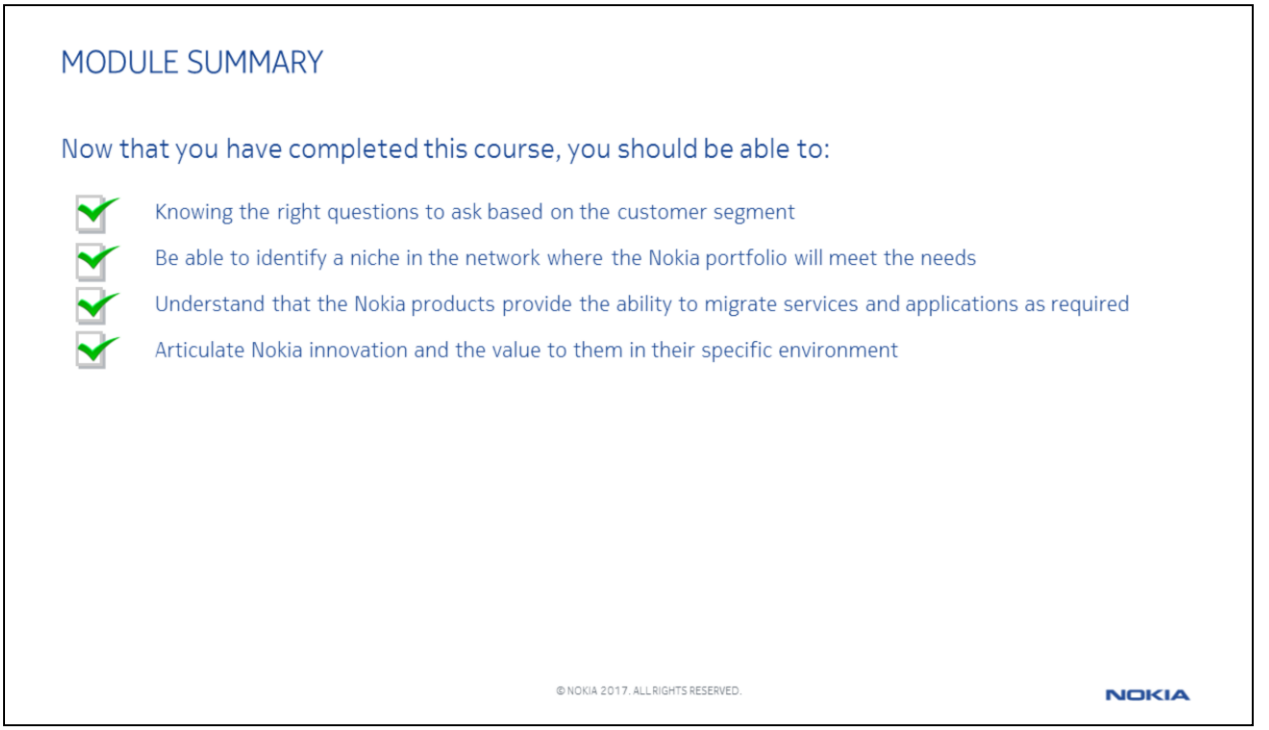
- ○ Dynamic networking
- ○ Agile networking
- ○ Integrated networking
- ○ All of the above

What is the key challenge that impacts most segments and is solved by Nokia optical networking products?

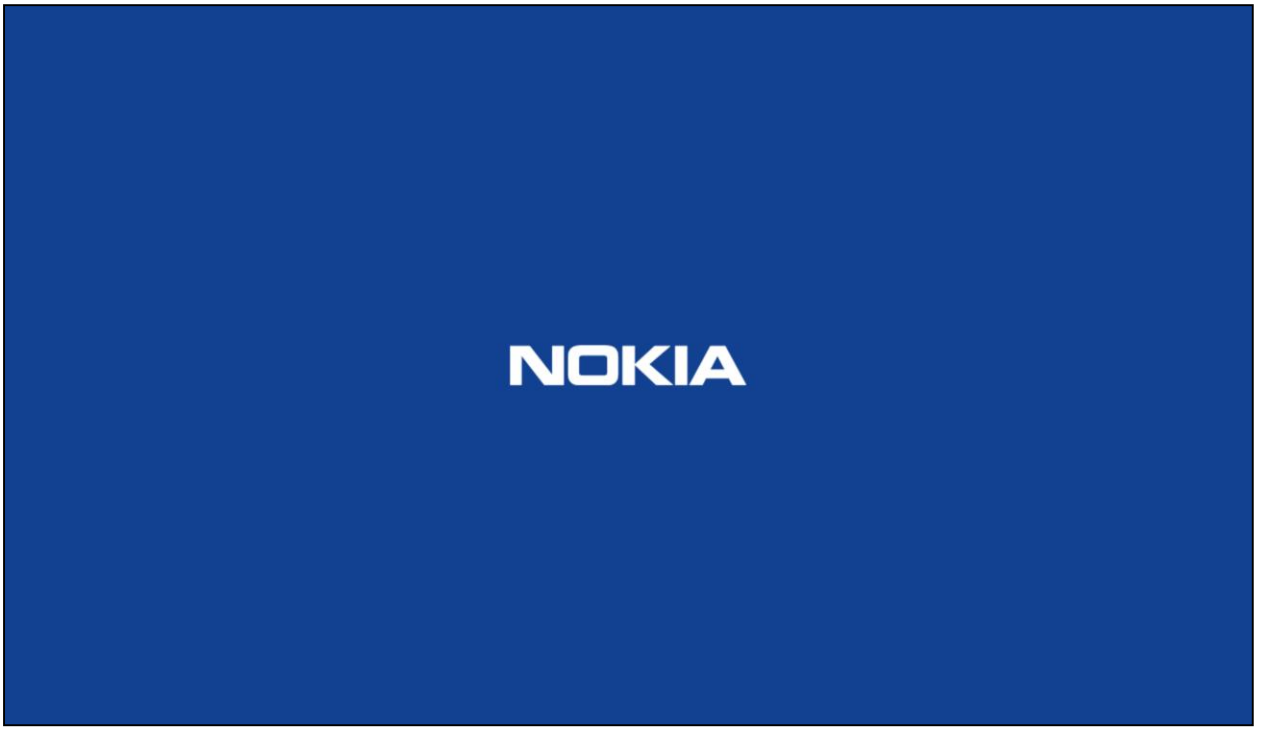
- ○ Partitioning
- ○ Single sign-on
- ○ Need for VPN
- ○ Low latency

Which recognition awards have been bestowed on the Nokia 1830 portfolio?

- ○ 2014 Asia Pacific ICT Awards
- ○ 2015 Lightwave Innovation Awards
- ○ 2013 IIR Next Gen Award
- ○ All of the above



To summarize, we have given you the information needed when you will talk to your customers, understanding the challenges they're seeing, and helping position how the Nokia products can fit to fill the voids and niches that they have. We hope you also understand how the Nokia products can provide the ability to provide your customers to migrate the services from where they are to where they need to be in the future, and lastly, also identify where the Nokia portfolio will innovate in your customers' networks and how they're going to be utilized.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