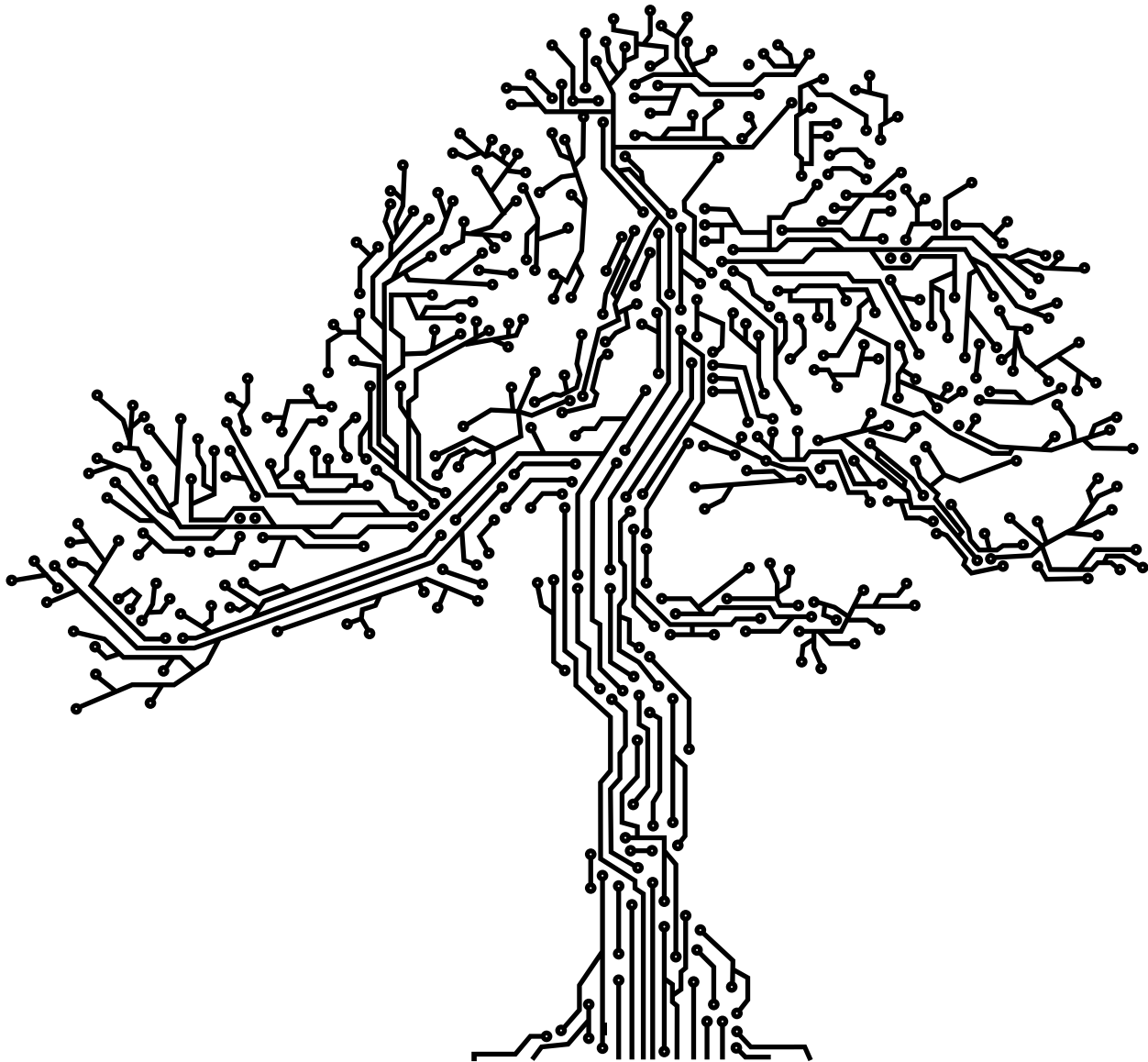# FIBRE
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END OF THE TUNNEL

Welcome to the winter edition of *Fibre Systems*. The first quarter of a new year is a time for reflection, as we look back over the last 12 months at the things we achieved and plan how we could improve. Just as the end of 2020 was undoubtedly a very abnormal way to finish a year, so too is the manner in which 2021 has begun.

Most of us experienced a very different type of Christmas, one that saw family and friends play charades via video link, not in our living rooms. In place of the usual festive television – due to filming delays and other Covid-related disruptions – household members gathered to watch the classic movies and shows via streaming services. Office Christmas parties took on a whole new form, with Zoom, Teams and Google Meet replacing the restaurant or bar.

We are fortunate to be in an age where all the above is possible. Imagine what the festive period could have looked like without that technology to meet – albeit virtually – with the people that matter the most. This is an all-too-real situation for many people living in 'connectivity-poor' areas of the world, and serves to significantly highlight the critical nature of optical communications, and its role in society.

The industry has undertaken some truly sterling work in these troubled times. Without it things would seem a whole lot more dark and dreary than they might already appear. If the pandemic did not prevent work taking place, then the festive 'lull' in December may as well not have even tried! Engineers were still busily working, potentially putting themselves at risk to ensure that the majority could enjoy all of the aforementioned activities.

As the first quarter of 2021 beds in, issues such as planning ahead will still prove a little tricky, particularly when it comes to events. This would usually be our OFC issue, and by the time you would be reading it, we would be around a month from the event opening its doors.

However, our industry has ably demonstrated it will take more than a pandemic to stop us showcasing products, learning from the experts and networking, and the online events are gathering momentum as a satisfactory – but temporary – alternative to face-to-face. Let's face it, of any industry, we are absolutely the best placed to achieve this.

I sincerely hope that it is not too long before we are all able to meet face-to-face once again. And, with vaccination programmes being rolled out in many countries, there is certainly hope, way on the horizon, dependent on individual governments and rollout plans. For me, the real light at the end of the tunnel is the one that bounces down the walls of the cable, keeping us as close to 'normal' as we can get, until we 'meet' again.

LATEST NEWS

OPENREACH STEPS ON ACCELERATOR WITH 5,000 JOBS FOR FIBRE NETWORK

Openreach is creating 5,300 UK-based engineering jobs this year.

The roles throughout the country will help the firm build, and connect customers to, its new full-fibre broadband network at an accelerated pace.

The expansion includes more than 2,500 full-time jobs in its service and network build divisions, as well as an estimated 2,800 positions in its UK supply chain, through partner companies Kellys Group, Instalcom, Kier, KN, MJ Quinn, Morrisons, Telent, John Henry Group and NMCN.

These subcontractor roles include 1,600 in service delivery, 700 in chief engineering, and 500 in fibre network and delivery.

The move comes as Openreach celebrates attaining a record build rate for its full-fibre broadband programme, which aims to reach 20 million homes and businesses by the mid-to-late 2020s.

The company says that engineers are now delivering to another 40,000 homes and businesses every week, or the equivalent of a home every 15 seconds.

Openreach CEO, Clive Selley, explained: 'As a major employer and infrastructure builder, we believe Openreach can play a leading role in helping the UK to build back better and greener.

'Our full-fibre network build is going faster than ever and we're now looking for thousands more people to build a career with Openreach and help us upgrade broadband connections and continue improving service levels.'

SURGE IN HOMES PASSED PREDICTED AT FTTH

There will be a significant surge to around 202 million homes passed for FTTH/B in 2026 in the European Union and UK combined, according to a market forecast revealed at the virtual FTTH Conference.

That compares to just 26.2 million home passed in 2012. Some markets are expected to experience an outstanding growth in the number of homes passed in 2026 compared to 2019, including Germany (+730 per cent), United Kingdom (+548 per cent) and Italy (+218 per cent).

The market forecast for 2020 to 2026 was revealed at the conference alongside a flash update of the 2020 FTTH Market Panorama. The figures were prepared by Idate with the FTTH Council Europe's market intelligence committee. The Market Panorama numbers were originally published last April, when the conference had been due to take place prior to pandemic restrictions. The numbers have been reviewed after the Covid-19 initial wave and were presented by Roland Montagne, of Idate DigiWorld.

The forecast covers 39 countries, providing individual analysis for 15 of them. In the country rankings, it is predicted that Russia will continue leading in terms of FTTH/B homes passed, with Germany next in the 2026 rankings.

In terms of subscribers, the forecast predicts a further increase to around 148 million in 2026 for the EU27+UK and approximately 208 million for EU38+UK. The FTTH/B take-up rate is likely to reach 73 per cent in 2026, demonstrating an upward trend compared with a recorded 23.4 per cent in 2012.

Looking at the drivers for this growth, and Covid-19 can partially explain it, having led to more data traffic and new broadband demands with people staying at home. But, according to the latest report, the pandemic was an accelerator that simply amplified the pre-existing trends.

In addition, said the report, FTTH/B deployments are intensifying across Europe, so it is worth noting a new digital divide for teleworking performance was revealed by the Covid-19 crisis. Beyond its impact on public policies, it is clear Covid-19 has changed public perception of broadband importance, and the willingness to accept premium for fibre. This trend is a key driver for the very high estimates for FTTH/B take-up. However, more measures by policy-makers to increase take-up are still crucial for the future of full-fibre, the report states.

LUNA INNOVATIONS ACQUISITION MAKES 'SENSE'

Optical technology vendor Luna Innovations has acquired OptaSense from parent company, QinetiQ for £29m.

OptaSense delivers fibre optic distributed monitoring solutions for pipelines, oilfield services, security, highways and railways, plus power and utilities monitoring systems. The acquisition aims to create a significantly larger combined optic sensing company, providing

Luna with distributed acoustic sensing (DAS) intellectual property, products and expertise.

It will also provide algorithm-development expertise, critical for AI and machine learning. OptaSense's research and development talent and salesforce, combined with more than 150 active and pending patents, will enhance Luna's existing team and broaden its IP portfolio.

OptaSense will become a subsidiary of Luna, while continuing to operate under its existing brand for the foreseeable future. OptaSense employees remain in the company, with offices in the UK, Dubai, the US and Canada.

Luna CEO Scott Graeff said: 'The acquisition marks an incredibly important milestone in Luna's history and will further support our growth trajectory. This allows Luna

to acquire a leader in fibre optic sensing solutions and distributed acoustic sensing systems of a global size and scale that will truly be transformative to our company.'

Steve Wadey, QinetiQ CEO, added: 'We are delighted to announce the sale of OptaSense to Luna, who will provide greater synergies and relevant market access to enable and accelerate their future growth.'

INFRASTRUCTURE AGREEMENT BRINGS FTTH TO 1.5M BELGIAN HOMES

Belgian operator Proximus has signed a partnership agreement with the EQT Infrastructure V fund. It will form a new joint venture to design, build and maintain an FTTH network in Flanders, Belgium.

The two companies identified opportunities in accelerating the build-out pace of the network in Belgium's Flemish Region, bringing the required connectivity to Flanders so that its residents and businesses can actively participate in the Gigabit Society.

The joint venture will benefit from the combination of EQT Infrastructure's experience of developing fibre companies in Europe and North America, and Proximus' expertise in the Belgian telecom market. The parties aim to efficiently build a fibre network, which will be open and accessible to all operators. The first customers will be connected this year, while the overall goal is to bring connectivity to at least 1.5 million households and businesses over the coming years.

The closing of the transaction is expected in the first quarter of this year. EQT Infrastructure will initially own 50.1 per cent of the venture and Proximus will hold 49.9 per cent.

LUMENTUM TO ACQUIRE COHERENT FOR $5.7BN

Lumentum is to acquire Coherent for $5.7bn, bringing the latter's photonics and lasers businesses into the former's telecom, datacom, and 3D sensing photonics businesses.

The combined company will be better positioned to serve the needs of a global customer-base increasingly dependent on photonics to enable important end-market transitions. This includes the shift to digital and virtual approaches to work and life, the transition to 5G in wireless networking, advanced bioinstrumentation, advanced microelectronics, and new materials for next generation consumer electronic devices, flat panel and OLED displays, communications equipment, electric and autonomous vehicles, and energy storage.

'The combination accelerates Lumentum's penetration of the more than $10bn market for lasers

and photonics outside of the communications and 3D sensing applications,' Lumentum said in a statement. 'The powerful R&D engine of the combined company will be primed to accelerate innovation in existing and future markets that need the unique capabilities that photonics bring.'

Alan Lowe, Lumentum president and CEO, said: 'We are thrilled to join forces with Coherent to create one of the world's largest and most diverse photonics technology companies with leading positions in the growing market for photonics.

'Coherent brings one of the most recognisable and respected brands in the photonics industry and a very talented and innovative team. By increasing our scale, expanding our portfolio, and bolstering our R&D capabilities at a time when global markets are increasingly relying on photonics products and technologies, we are

confident in our combined ability to pursue exciting new growth opportunities.'

He continued: 'Together, we expect to increase the pace of innovation, and to be at the forefront of the long-term market trends that are dependent on the capabilities of photonics. The combined company will also have a strong financial profile with a diversified revenue mix and significant synergy opportunities that will deliver enhanced value to our stockholders. The future is truly bright at Lumentum – and with the addition of Coherent, it is even brighter.'

Andy Mattes, Coherent president and CEO, added: 'We are excited to bring Coherent's strength in OLED display manufacturing, semiconductor wafer inspection and life science instrumentation to Lumentum's portfolio, to name but a few of the key applications we serve, and believe Lumentum's expertise and scale in world-class photonics components and systems will accelerate Coherent's vertical integration and addressable market expansion in several high growth areas. We anticipate the combined complementary product portfolio, breadth of customer application knowledge, and R&D capabilities, all based on photonics, will accelerate innovation and adoption of photonics across the many markets that we serve.'

Two members of the Coherent board will be appointed to the Lumentum board, which will be expanded to nine directors, at the closing of the transaction in the second half of the year.

BIDDING FOR BROADBAND: 10 MILLION RURAL AMERICANS TO RECEIVE HIGH-SPEED CONNECTION

More than 5.2 million homes in rural parts of the United States are to benefit from auction funding.

The Federal Communications Commission's Rural Digital Opportunity Fund Phase I auction formed part of a broader effort by the FCC to close the digital divide in rural America. It focused limited universal service funds on unserved areas that most need support.

Bidders won funding to deploy high-speed broadband to more than 5.2 million unserved homes and businesses, almost 99 per cent of the locations available.

CCO Holdings (Charter Communications) was assigned the most locations, at around 1.05 million. Some 180 bidders won auction support, to be distributed over the next 10 years. A broad range of providers successfully competed in the Phase I auction, including cable operators, electric co-operatives, incumbent telephone companies, satellite companies, and fixed wireless providers.

The other benefit of the auction, said the FCC, was that it unleashed robust price competition that resulted in more locations awarded at less cost to Americans who pay in to the Universal Service Fund. The 5.2 million locations assigned support had an initial reserve price of $26bn over the next decade; through vigorous competition among bidders, the final price tag to cover these locations is now just above $9bn.

FCC chairman Ajit Pai said: 'This auction was the single largest step ever taken to bridge the digital divide and is another key success for the commission in its ongoing commitment to universal service. I thank our staff for working so hard and so long to get this auction done on time, particularly during the pandemic.'

BOLIVIAN CITY TO REACH NEW HEIGHTS OF CONNECTIVITY

The highest city in the world is to benefit from deployment of a GPON broadband network.

Potosí, in Bolivia, is 4,090m above sea level, resting at the foot of the Cerro Rico mountain that rises up to 4,800m. The city was once one of the world's richest, with a population in the 1600s that rivalled that of London, Seville, Madrid, Rome or Paris. Today, it is home to Unesco's World Heritage site.

Iskratel, in collaboration with Teleserv Group Bolivia, will implement the optical broadband network for service provider Cotap. The deployment uses Iskratel's SI3000 Lumia GPON Optical Line Terminals (OLTs), along with Innbox G85 and Innbox G74 Optical Network Terminals (ONTs) at customer premises.

Juan Francisco Flores, Cotap's legal representative, said: 'In Potosí, a city with such a fascinating history, life has never been easy. The deployment of an optical broadband network not only delivers new connectivity to our residents and businesses, but opens up an array of business opportunities that the city and its people have not had before.'

Svjetlana Kalaba, director of business unit broadband at Iskratel, said: 'Bringing fibre connectivity to the people of Potosí, the highest city in the world, fills us with profound pride.'

EUROPEAN TELE-CONSOLIDATION COULD RETURN THIS YEAR, SAYS BLOOMBERG

Bloomberg Intelligence says consolidation could make a comeback in the European telecom market this year.

Their report, *Europe Telecommunications 2021 Outlook*, says that the sector could see the return of market consolidation, with carriers looking to test EU regulators following a court challenge to the EU's decision to block the Three-O2 deal.

With the current global crisis, some see chances that the previously strict merger and acquisition (M&A) regulation could be loosened a little. There are signs that the European Union's opposition to mergers could be cooling, after its antitrust chief in June called for more cross-border deals, especially in the telecom industry.

Mergers in the telecom sector could be looked upon 'more favorably' by regulators than before, Bloomberg Intelligence (BI) said, as the carriers suffer from lower roaming revenue and economic growth. The firm cited comments from Thomas Fitzgerald, fund manager at EdenTree Investment Management. He said 'the lure of 5G monetisation could continue to draw interest from the private sector'.

Before this activity, warned BI, the industry could face a sustained campaign to boost sentiment and, the firm added, there is limited scope for the Stoxx 600 European Telecom Index to significantly improve its 2021 relative-return performance in 2021. However, the European telecom sector should see its top lines recover during the year after what is referred to as a 'modest dent' caused by the pandemic, but capital spending and margin pressures will limit the scope of any sector re-rating.

The report was based on a survey conducted from 7 to 14 December, with participants naming 96 companies as potential targets, excluding those already in a formal takeover process.

According to the report, Spain and Sweden are the most likely countries for consolidation. In Spain, where five companies compete, there is regular speculation about tie-ups, with a recent joint-venture between Masmovil and Vodfaone.

In Sweden, Three is seen as a likely target for Tele2 or Telenor. Italy could also see consolidation in infrastructure with Telecom Italia eyeing Open Fiber, and in Belgium, cable operators could target regional company Voo.

Next year's most likely M&A targets, predicted by BI's mergers and acquisition desks, include KPN and BT Group, as a revival in dealmaking activity is set to favor the sector.

KPN, for example, was included in the M&A watch lists of eight out of 13 event-driven traders, analysts, brokers and fund managers surveyed by Bloomberg News. BT and network-equipment maker Nokia were included three times.

NEW YEAR, NEW QUALIFICATION STRUCTURE FOR UK NETWORK INFRASTRUCTURE

The UK network infrastructure industry's new occupational qualification structure has begun.

The structure leads to the Electrotechnical Certification Scheme (ECS), which is the ID and competence card scheme for operatives in the UK. ECS cards are designed to prove the holder's qualification status, main electrical occupation, identity, health and safety awareness, as well as any additional disciplines in which they are skilled.

All new (initial) applications must comply with the structure, and there are cards available that recognise all levels of occupations, such as network infrastructure assistant, which includes the requirement for a network infrastructure assessment, and network infrastructure installer Gold Card.

From 1 July card renewals will need to meet requirements of the new structure, which was developed by a working group of the Electrical Contractors' Association, the Joint Industry Board, Select, CNet Training and a large group of employers.

It follows the launch of the Network Cable Installer Apprenticeship Standard. Setting the benchmark for new entrants to the market at Level 3, it addresses the need to recognise professionals currently in the workforce that already benefit from hands-on experience, previous education and training, and industry-recognised qualifications.

Jay Parmar, chief executive of the JIB, explained: 'The new pathway clarifies the differences in education, training and experience for those already in the industry, and sets out a route for those entering the network cabling infrastructure industry.'

Martin Smith, international lead for network infrastructure at CNet Training, added: 'The introduction of the network cable installer apprenticeship means that the long-awaited defined educational routes for new starters and existing workforces are in place.

'A formidable collective effort has gone into this card structure. Its introduction will help to deliver the necessary skills and qualifications to lead the network infrastructure industry into a new era.'

GETTING CONNECTED: LONDON BROADBAND ROLLOUT BAGS £1BN FOLLOWING FUNDRAISE

G.Network, is investing more than £1bn to roll out connectivity in London following a successful fundraising initiative.

The funding includes an equity investment by UK private pension scheme, USS, with assets of up to £295m over six years, alongside debt secured from four banks of up to £745m.

In the next five years, the operator will dig around 4,500km of streets, reaching approximately 1.4 million London premises, including many in underserved areas.

The rollout is expected to create more than 1,250 new jobs.

Oliver Dowden, the Digital, Culture, Media and Sport minister, said: 'This fantastic investment in our capital is a welcome boost to the government's national mission to revolutionise Britain's digital infrastructure. It will give London a much-needed helping hand as we race to build back better from the impact of Covid and upgrade broadband speeds for well over a million premises, while also creating hundreds of new jobs.'

Sasho Veselinski, G.Network CEO, added: 'High speed, reliable connectivity is critical to the home and work lives of Londoners. We are rebuilding London's broadband from the fibre up, bringing first-class connectivity to residents and businesses, without expecting them to pay more.'

SEEKING A PATH BEYOND PLUGGABLE MODULES

ENABLING ON-BOARD AND CO-PACKAGED OPTICS REQUIRES PHOTONIC INTEGRATED CIRCUITS AND SILICON PHOTONICS, BUT THE EXACT FORMAT IS YET TO BE ESTABLISHED

ANDY EXTANCE

■ Ranovus' Odin IC has demonstrated operation with eight optical channels of 100Gbps per fibre pair, potentially enabling 25.6TbE switches

As the pandemic underlines the value of the internet more than ever, its underlying technology is making one of its biggest transitions for years. Companies are actively developing solutions that will enable the current 12.8TbE switching capacity of network switches to double every 18 months. This is because the powerful switch application specific integrated circuits (ASICs) doing their processing are speeding up rapidly.

Likewise, transceiver data rates are set to increase from 100 to 800Gb/s by 2022 and the number of transceivers per switch will grow from 32 to 64 or 128. The resulting density of components will be difficult to integrate, and will generate a lot of heat that is hard to dissipate.

Such advances will therefore require components that focus on energy efficiency, explained Erman Timurdogan, director of optical communications and process design kit development at Analog Photonics. That will reduce thermal losses enough for coolers to keep up, he said.

Multiple choice

To increase efficiency, advanced complementary metal-oxide-semiconductor (CMOS) nodes and multiple chiplets with different optimised functionalities, are being combined in multi-chip modules (MCM). 'However, transferring the data out is getting harder,' Timurdogan said. 'There are only two electrical solutions: increase socket size to allow more connections, or increase the communication data rate in each connection. A large socket increases cost and decreases manufacturability, and copper connections are lossy at high data rates.'

There is a solution that does not suffer from these drawbacks: place optical fibre connections close to switch ASICs. That idea has driven two slightly different concepts with slightly different application focuses: On-Board Optics (OBO) and Co-Packaged Optics (CPO). Both move away from the pluggable module standards to which the optical communication industry has become accustomed.

The challenge for the companies delivering the resulting products is finding the right technical strategy to realise these concepts. And while development is ongoing, the industry is

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PRODUCTION DEPLOYMENT OF CPO NEEDS SUBSTANTIAL INVESTMENT IN TECHNOLOGY AND FIELD TRIALS

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yet to agree on the necessary product formats.

In current module formats, electrical signals travel around 10 inches to the front plate for conversion to an optical signal. Hamid Arabzadeh, CEO of photonics developer Ranovus, explained this won't be possible once Ethernet switch ASICs reach 51.2TbE aggregate capacity. Density of retiming ICs or digital signal processors (DSPs) needed to recover signal loss in traces and connections can't keep up, while also meeting cost and power consumption requirements of the Ethernet switch systems.

Arabzadeh explained that OBO and CPO 'take the photonic and electronic components of the module and co-package them with the Ethernet switch ASIC, creating an optical input/output (I/O) using silicon technologies'. He adds that OBO can use Silicon Photonic (SiP) components. Alternatively, it can use PICs comprising two or more non-silicon-based photonic components in a single photonic device. But Arabzadeh argued that CPO can only use SiP due to density, cost, power consumption requirements, and reliability challenges of running in a hot environment.

Confidence boost
Ranovus' Odin IC is designed to contain electronics and SiP on a single die for module, OBO or CPO applications. These different applications exploit the same IP, Arabzadeh says, allowing companies to try Odin 'in a module form factor to gain confidence in the mass deployability of OBO and CPO'.

Odin includes several miniaturised, power-efficient and cost-effective components on a single CMOS chip. It has demonstrated operation with eight optical channels of 100Gb/s per fibre pair, potentially enabling 25.6TbE switches. Arabzadeh revealed that it will be in deployment for Ethernet CPO in the second half of 2022. Ranovus also has a strategic collaboration with IBM, TE Connectivity and Senko Advanced Components to create an ecosystem to design and manufacture multi-vendor solutions for CPO.

Currently, hyperscale data centre companies like Facebook and Microsoft lead CPO requirements, Arabzadeh said, but other sectors will use it when they have the same capacity requirements. 'Larger contract manufacturers need to enter into this space to develop their capabilities and reduce the cost of fabrication,' he added.

The integration of CPO on router and transport platforms allows the continued disaggregation of transport and switching, added Helen Xenos, senior director, portfolio marketing at Ciena. That separation allows each function to perform optimally. 'Because of the significant benefits of this approach, CPO can extend beyond the initial intended application of switch-to-switch or switch-to-router within the data centre,' Xenos said. 'At the same time, CPO is optimised for all interfaces to be of the same type. This is much more common in hyperscale data centre architectures than in service provider architectures, where there are multiple rates, reach and service types. As

a result, CPO offers the highest initial value for data centre deployments.'

Ciena is a member of the Optical Interconnect Forum, which launched the Co-Packaging Framework Implementation Agreement umbrella project. One of that project's objectives is, said Xenos, 'to identify the key co-packaged applications and their requirements, to widen the application space for CPO.'

Best of both worlds
In the first generation of the CPO implementation that the industry is working towards, the switch inputs/outputs remain electrical, Xenos noted. The lead switch interface proposal for traditional networking CPO applications is a 112G extra-short reach serialisation/deserialisation (Serdes) interface (XSR). 'For a future generation of CPO, one consideration is to replace the Serdes interface and move directly to an analogue interconnect between the optics and switch,' she said. 'This would further reduce power dissipation and enable scaling to higher bandwidth.'

With in-house experience in both SiP and also InP photonic integration, Ciena is able to produce and supply the optical engine for the CPO solution, she said. 'This development would reuse many of the building blocks that we already deploy in our coherent pluggable offering,' Xenos said.

Analog Photonics is also considering the shift from modules to CPO designs. 'To reduce the complexity of CPO, 51.2Tb aggregate switch bandwidth can be divided into 16 optical engines at 3.2TbE,' said Timurdogan. But scaling PIC chipsets to 3.2TbE at a 100G signalling rate needs 32 channels. Using single laser wavelength channels would require 32 fibres each carrying 100G, which would not increase bandwidth density per fibre. 'Instead, 32 laser wavelength

channels can be used in a single fibre,' observed Timurdogan. 'However, this solution will not offer any backwards compatibility with existing multi-source agreements and IEEE Standards. We decided to form an 800G building block that is compliant with these standards and can scale to 3.2TbE. That is why we decided to use eight fibres and four laser wavelengths using the 400G-FR4 format.'

Timurdogan also highlighted that electronic ICs for transceivers consume most power in enhancing signals and correct optical losses. The company therefore introduced ultra-low loss fibre-to-chip couplers to reduce signal degradation and minimised the drive voltage of transmit photonics to work with energy-efficient CMOS drivers. It also integrated an athermal, low-loss multiplexer and demultiplexer to mix and separate multiple wavelength channels integrated with SiP transceivers on the same platform, and increased the sensitivity of the receive photonics to reduce the optical power

> A LARGE SOCKET INCREASES COST AND DECREASES MANUFACTURABILITY, AND COPPER CONNECTIONS ARE LOSSY AT HIGH DATA RATES
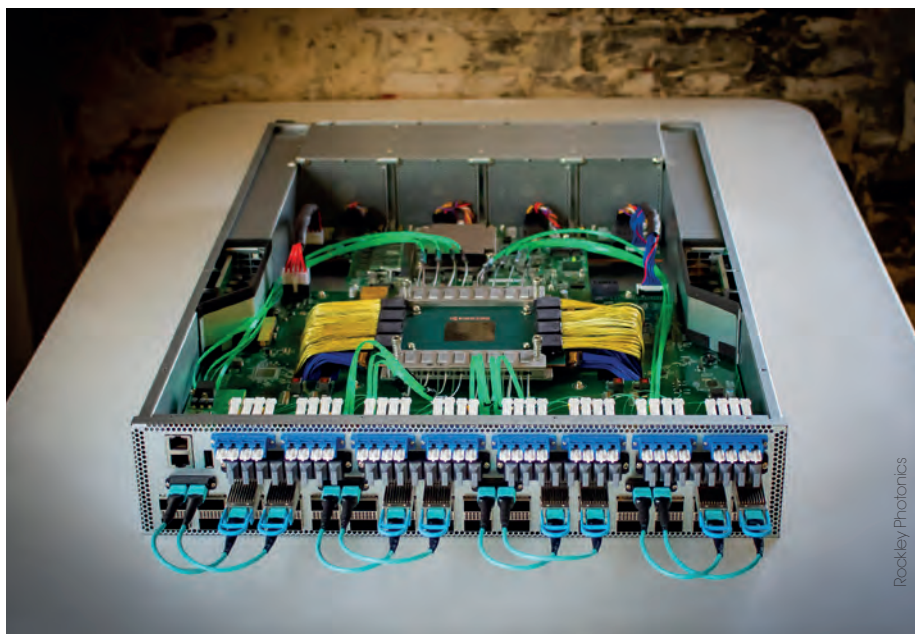
In 2020, Rockley Photonics demonstrated a 25.6Tbps OptoASIC switch

Analog Photonics

OSFP 800G

COBO 800G

CPO 4x 3.2T
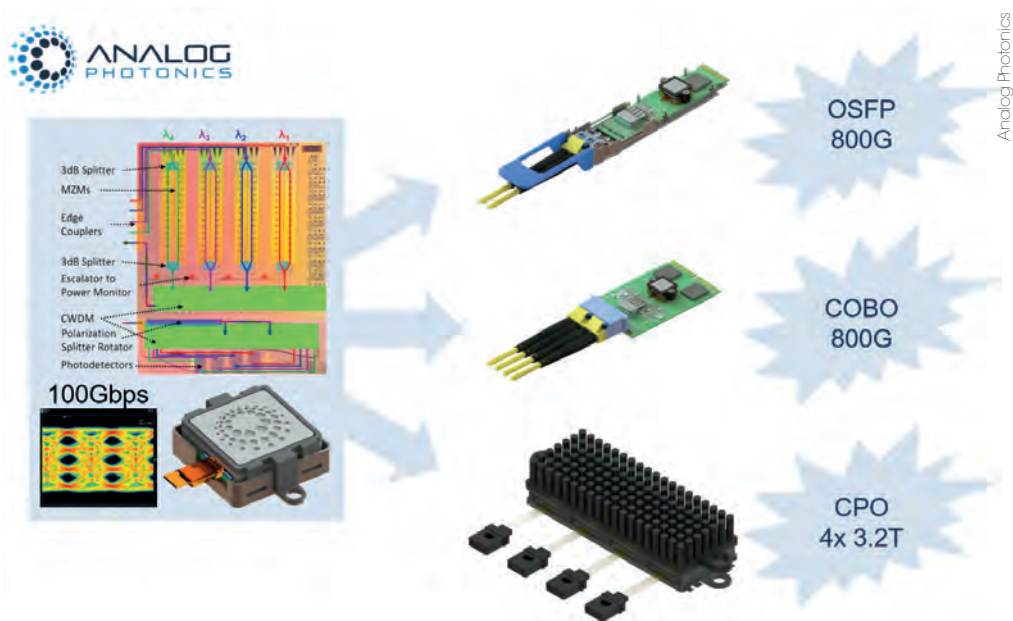
Analog Photonics demonstrated last year a reworkable 400G/fibre (100G/channel) SiP Engine that is scaling to 3.2Tb or more

needed. The company intends to have a 3.2Tb chipset ready by the fourth quarter of next year.

While many of the specifications are ready for OBO and CPO products, Timurdogan highlighted the many current unknowns. He noted that CPO products will be harder to reach once installed, and may need to be pre-configured and sold together with CPO transceivers. 'This makes the business model blurry, requiring switch maker, CPO transceiver and box companies to work closer than before'.

Good combination

Intel Corporation's Robert Blum agrees that 100Gb/s channels are likely to be part of co-packaged optics systems, but anticipates them being combined with 50TbE or 100TbE switches starting in late 2023 or 2024. 'That's where you can realise the benefits,' he said. 'When we did the analysis, we see about 30 per cent lower electrical power for the combined switch, and also similar improvements in cost.'

Intel's journey to this stage starts with 1.6Tb/s silicon PIC engines it has developed. 'We have hybrid lasers that are part InP, part silicon, and we use InP photodiodes,' Blum said. 'On the pluggable modules today, we use different modulators that are much larger. For the photonic engine, we made ring modulators that are much smaller and integrated everything onto a single chip.'

On the packaging side, it's another big development to put a photonic engine with the driver chips, the TIA and the receivers. Then, in March, the firm demonstrated a fully-functional 12.8Tb/s Ethernet switch based on CPO passing live traffic, exploiting four of its 1.6Tb/s engines. 'You have the switch ASIC and you have to put the photonics around the entire chip because the I/O is so dense,' Blum explained.

This demonstration is a 'stepping stone', he continued. 'The data rates that we would likely use for switches at 50TbE will be higher, using

a 3.2Tb/s or 6.4Tb/s PIC, scaling that to the next switch.' After Intel attains that performance level it will ask the rest of the industry for commitments from hyperscale data centres to deploy these switches. 'That's an ask for the entire ecosystem to make that happen,' Blum admitted. 'It's not something that Intel or any other company would do in isolation.' Blum also wants agreement on format standards. 'To communicate between your photonic chip and the switch ASIC, you need some kind of short-reach Serdes' he said. 'What do you put on the photonics? What do you put in a switch ASIC? That needs to be aligned across the industry'.

Chicken and egg

Andrew Rickman, CEO of Oxford-based silicon photonics firm Rockley Photonics echoed this outlook. 'There is a chicken-and-egg problem,' he said. 'Production deployment of CPO needs substantial investment in technology and field trials, but this requires some form of financial commitment from the end-users.' There is a clear need for agreement across the industry on numerous factors, he added. These include the interfaces between the ASIC and the optics, packaging and form factors of the CPO assembly, the engines, the external laser source and on the format of the overall supply chain.

In 2020, Rockley demonstrated a 25.6Tb/s OptoASIC switch. Its OptoASIC devices combine one or more PICs and ICs within a single package, such as a switch ASIC and the surrounding optics. They use OptoEngines to convert between optical and electrical signals for eight duplex channels each, a figure that is likely to be more when commercialised. 'Internally, the OptoEngine comprises a transmit PIC, receive PIC, and corresponding transmit and receive ICs required to interface the main ASIC's Serdes channels with the PICs,' said Rickman. 'The transmit PIC incorporates modulators to imprint the electrical signal on

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THIS MIGRATION HAS IMPORTANT RAMIFICATIONS FOR BOTH VENDORS AND USERS OF DATA CENTRE OPTICS
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the outgoing optical signal. Optical power may be provided by lasers either integrated directly on the PIC, or coupled in from an external laser source. The receiver PIC incorporates photodetectors to convert the incoming optical signal back to the electrical domain.'

CPO will also benefit users of high-performance computing systems and specialised systems for machine learning, AI or big data processing, Rickman observed. 'Generally, any use case where bandwidth is getting constrained by power, density, or cost can benefit from CPO,' he said.

The fact that silicon-photonics-based integration can enable high-volume OBO and CPO products reflects the supply chain's maturity, Rickman added. That's thanks to silicon photonics' key advantage of using volume manufacturing to drive down cost. However he emphasised again that adoption is the main hurdle. 'CPO needs to overcome substantial inertia to move an entire industry away from the entrenched model of pluggable optics,' Rickman said. 'This migration has important ramifications for vendors and users of data centre optics.' ■

A TALE OF TWO PLATFORMS

COULD INDIUM PHOSPHIDE PHOTONIC INTEGRATION BE KEY TO THE
ONGOING DEVELOPMENT OF HIGH-PERFORMANCE COHERENT OPTICS?
KEELY PORTWAY INVESTIGATES

To address the undeniable growing demand for higher bandwidth, optical vendors have been playing their role with the development of various coherent optical transceivers for different areas of the market, each with its own set of design considerations.

Historically, the most used material platform for the photonic integrated circuits (PICs) behind these products has been indium phosphide (InP). However, the increase of silicon photonics in recent decades has promised to disrupt the optical components industry with a common platform on which diverse optical functions can be integrated – in a way that scales easily to high volumes – while keeping manufacturing costs low.

With new developments in this area, will this ultimately start to make InP irrelevant? Not so, argues Paul Momtahan, director of solutions marketing at Infinera. 'There's been quite a bit of buzz about [silicon photonics] in the industry,' he said. 'We have been asked "is this still a place for InP?" But, there are arguments for both

sides of the InP/silicon photonics debate. If you look at the coherent flow bubbles, it's maybe not quite a 50/50 split, but there are vendors using InP, particularly if they have a background and assets and InP, and their vendors are using selective atomics. We believe there's a very clear case for InP.'

Loss and gain
Both technologies have their advantages. Silicon, for example, can provide low losses for its passive components to support manufacturing of very small photonic circuits.

However, its physical properties prohibit capabilities such as optical gain for laser or amplification functions. This means that silicon-based transceivers would require a separate, unintegrated InP-based laser and erbium-doped fibre amplifier (EDFA), while InP-based transceivers can be built as fully integrated PICs.

This presents some obvious cost and footprint benefits to using InP, which are punctuated by the use of waveguides, rather than coupling optics when it comes to

performance and power consumption, thanks to the avoidance of coupling losses.

'One of the big differences between InP and silicon photonics,' said Momtahan 'is how they use different physical effects to change the refractive index. InP uses the opto-electric effect and silicon photonics uses the plasma-dispersion effect. The indium phosphide effect is much more efficient.'

Momtahan explained there are two things we can look at in terms of efficiency. 'One,' he said, 'is how long the modulator is, and the other is how much voltage. Comparing InP with silicon photonics to get the same effect, we either need 10 times the length of modulator or 10 times the voltage. So, InP is 10 times more efficient at changing the refractive index.'

This, he added, will have a fundamental physical advantage in terms of the modulator. 'Generally, when you go to a new speed, a higher baud rate, it is typically InP that is the first material to provide the modulator for that. But both technologies are improving. Eventually silicon photonics will probably do 90+ GBd modulators, but at that stage InP will have moved on to 120+ GBd.'

Need for speed
Momtahan believes these speeds are the way in which the industry will move in terms of PICs. 'The industry is looking at 120GBd as a next step. InP will be a key component of that in terms of the photonics, because of the aforementioned benefits. What you will see

is the next generation of modulators that come after the current 90+ GBd. These will also be InP.'

As well as the provision of instant bandwidth, the benefits of any coherent technology cannot be discussed without mentioning distance. This is another area in which Momtahan believes there is a distinct advantage.

The firm partnered last year with network provider Windstream for a live network trial that successfully achieved 800Gb/s single-wavelength transmission over 730km across Windstream's long-haul network between San Diego and Phoenix, using Infinera's Ice6 gift-generation coherent technology. Another successful test was performed alongside th operator Verizon, which achieved an 800Gb/s single-wavelength transmission over 667km between Nashville and Atlanta; and a 600Gb/s single-wavelength transmission over 2,283km from Atlanta to Memphis, with a loopback in Memphis.

'It is advantageous to the industry being able to do these very-high-capacity wavelengths of long distances, that we're doing with Ice6,' explained Momtahan. 'That also has significant benefits, in terms of driving down the cost-per-bit, driving down the power consumption, and increasing the spectral efficiency. So that's kind of where we're at with the Ice6.'

High-performance
Momtahan believes that InP could be the superior photonic integration material for the high-performance segment, although he recognises that silicon photonics can still be an

> EVENTUALLY SILICON PHOTONICS WILL PROBABLY DO 90+ GBD MODULATORS, BUT AT THAT STAGE INP WILL HAVE MOVED ON TO 120+ GBD

attractive option for applications that perhaps have more modest data rate requirements, or where vendors may not have the necessary expertise to build a fully-integrated InP-based PIC, or are unable to make the substantial investment in building their own InP manufacturing facility.

Several research groups suggest one promising path could be hybrid integration, integrating lasers on top of complex silicon photonics with the integration of silicon photonics PICs with InP PIC circuits. 'Time will tell,' said Momtahan. 'There's a little bit of a battle going on there. The silicon photonics folks are trying to catch up. We'll see what happens. Certainly for Infinera, our future generations will be based on InP.' ■
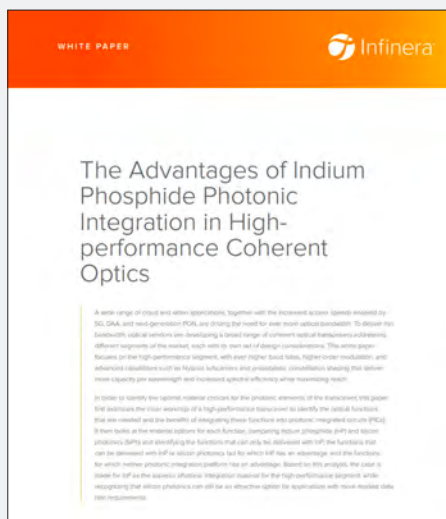
CENTRE OF
ATTENTION

THE RISE OF THE DATA
CENTRE HAS ARGUABLY
DRIVEN MUCH OF THE
DEMAND FOR GREATER
BANDWIDTH AND HIGHER
DATA RATES. WHAT
DOES IT MEAN FOR THE
COMPONENTS MARKET?

KEELY PORTWAY

The data centre market is a particularly wide-ranging one, with one of the driving forces in recent years the emergence of the hyperscale data centre or cloud service provider.

Despite the pandemic causing chaos in most sectors, much industry intelligence about data centres points to ongoing growth. The *Data centre construction – global market trajectory and analytics* report from Research and Markets, for example, highlights that, amid the crisis, the global data centre construction market was estimated at $19.4bn last year. This is now projected to reach a revised $31bn by 2027, growing at a compound annual growth rate (CAGR) of 6.9 per cent over the analysis period.

Gartner focuses on data centre infrastructure spend in its report, *General manager insight: data centre infrastructure spending downturn and three actions for recovery*. Market intelligence first stated that, despite a 10 per cent spending decline in 2020, the data centre market will rebound over the next four years.

Growing pains

End-user spending on global data centre infrastructure, the report states, is projected to reach $200bn this year, an increase of 6 per cent from last year.

Naveen Mishra, senior research director at Gartner, explained: 'The priority for most companies in 2020 was keeping the lights on, so data centre growth is generally being pushed back until the market enters the recovery period. Gartner expects larger enterprise data centre sites to hit pause temporarily, then resume expansion plans early this year.'

There is, of course, one exception to those 'hitting pause', as one might imagine. Mishra elaborated: 'Hyperscalers will continue with their global expansion plans due to continued investments in public cloud.'

While pandemic lockdowns prevented a high percentage of facility construction in

> HYPERSCALERS WILL
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2020, end-user spending is expected to grow in single digits starting in this year. Mishra continued: 'Much of the reduced demand in 2020 is expected to return in 2021, when staff can physically be onsite. For now, all data centre infrastructure segments will be subject to cost containment measures, and enterprise buyers are expected to extend life cycles of installed equipment.'

Cost optimisation

Data centre infrastructure general managers should seek to prioritise a select set of existing and new customers, said Mishra. Specifically, Gartner recommends training the sales force to engage with the chief financial officer and chief procurement officer on a set of cost optimisation initiatives, such as renegotiating IT contracts, optimising cloud costs and consolidating IT.

Another recommendation is to create an industry playbook that helps technology providers understand Covid-19's impact on a range of different industries to then recommend short- to mid-term action items for the given providers by each industry.

Finally, recommends Mishra, it would be worth investing in a new go-to-market model for digital natives to drive innovation. 'Build momentum around hybrid IT and consumption-based pricing,' he said, 'to improve mind share with digital natives.'

In terms of the market's impact on component vendors, the issue of cost optimisation is not necessarily something that has only come about due to the pandemic. As a manufacturer of 3D glass-based integrated optical components for the data centre, Optoscribe has seen a number of trends in this area since its inception more than a decade ago.

CTO Nick Psaila explained: 'We make glass components that go inside data centres, such as transceiver modules and some of the components of the fibre infrastructures of the data centres – basically glass chips that go into these and the interface between the fibres and the active parts of the transceiver.

'For our data centre customers we have been helping to try and drive down the overall costs of the modules by facilitating easier methods of assembly and packaging.'

Performance vs cost

While the data centre market is expected to remain buoyant, the driving forces are, in many cases, also the challenges when it comes to components. Psalia said: 'One of the biggest pressures on the industry, as a whole, is to simultaneously increase the speed and bandwidth of these transceivers, while dropping the price per-gigabit per-second.'

Another trend within data centres impacting on component suppliers is the fibre itself, specifically, the debate between multimode and single mode fibres. 'Previously, the data centre had been dominated by multimode,' said Psalia. 'That's another trend that substantially

moved forward, and that's been fueled by the hyperscalers specifically. They've taken these architectural decisions. This compares to the challenge we were talking about earlier, in terms of trying to drive down the cost of these transceivers, because we have to do that with single mode transceivers, which are even more complicated to build.'

This performance-cost balance has been a key driver when it comes to product development, with new technologies that can help to address the challenge of building these transceivers in a more cost-efficient way.

Said Psalia: 'The big hyperscale data centre users have a lot of buying power, which can put pressure on the components manufacturers to drive all of their margins out. In some cases, there will be technologies that inevitably cannot cost-reduce beyond a certain point.

'This will drive solutions that enable those lower costs per-gigabit per-second, but also, technologies which can scale in terms of density. So the number of channels is also going up for these transceivers, and also the depth and speeds of each channel.'

Optoscribe's own product development in this area recently produced a monolithic glass chip for low-loss coupling to silicon photonics (SiPh) grating couplers. The chip is designed to overcome fibre-to-SiPh photonic integrated circuit (PIC) coupling challenges to enable high volume automated assembly and help drive down costs.

It was created using the company's high-speed laser writing technique and features low-loss light turning curved mirrors, which are formed in the glass, to direct the light to or from SiPh grating couplers. This prevents the need for bend-tolerant fibre solutions.

To help address footprint challenges, the

> BIG HYPERSCALE DATA CENTRE USERS HAVE A LOT OF BUYING POWER, WHICH CAN PUT PRESSURE ON COMPONENTS MANUFACTURERS TO DRIVE ALL OF THEIR MARGINS OUT

chip also has a low-profile interface of less than 1.5mm in height. This allows compact interface layouts that alleviate packaging constraints. It is compatible with industry-standard materials and processes, helping to maximise performance.

'We launched the OptoCplrLT chip in December,' said Psalia, 'and we're continuing to work on a range of additional products that we look to launch over the coming year in this application space. The technology has a lot of advantages, particularly in the form factor and also in facilitating passive alignment, for example, to try and drive down the cost of these assemblies.' ∎

Optoscribe
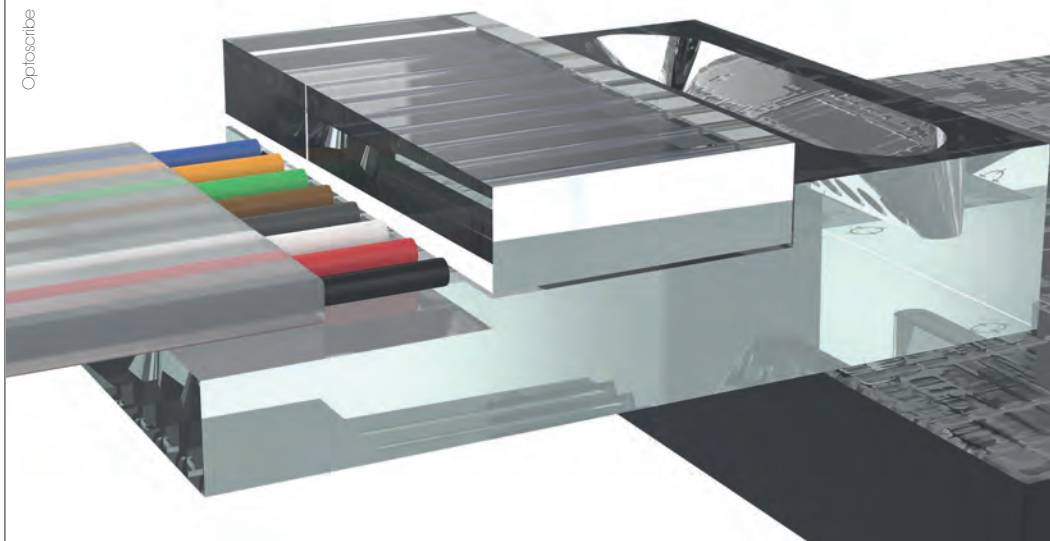
New component technologies have many advantages when it comes to driving down the cost of assemblies

PARTNERING FOR THE
FULL PACKAGE

IN THE SECOND PART OF OUR SERIES ON THE FTTH 'CHAIN', KEELY PORTWAY CONSIDERS CHALLENGES DURING THE INSTALLATION STAGE OF WORKS, AND AVAILABLE SOLUTIONS

The importance of reliable connectivity has never been more recognised than now. While ambitious targets have been in place across the world for fibre deployment for some time, the ongoing pandemic has served to push it to the forefront.

Yet, there is still so much to be done. Take Britain, for example, which, despite vocal recognition from the government, is still a fair way behind many of its Organisation for Economic Co-operation and Development (OECD) counterparts when it comes to fibre infrastructure. In fact, it ranks 35th out of the 37 OECD countries for the proportion of fibre in its total fixed broadband infrastructure.

The incumbents have been playing their part to close the gap, but interestingly, it has been the emergence of the alternative network providers (altnets) that has really helped the UK catch up – particularly when it comes to some of the most under-served areas of rural Britain.

History repeating

As a distributor of quality cable management products and specialist tooling for the communication industry, and an end-to-end solution provider to engineers since 1919, Mills is well placed to have been at the forefront of many trends and challenges in the industry. The company has shared its tooling, cabling systems, PIA and – in association with CommScope – connectivity equipment, not to mention their heritage of engineering experience, with larger and smaller providers alike for several decades.

Chairman, Jerry Mills said: 'I'm proud of our heritage. We are a fourth-generation business and we have always been an engineering business. I joined towards the end of the 70s and what we're seeing at the moment has some similarities with what happened with cable TV in the 80s, when American communication companies came to the UK and installed coax cables to provide cable TV. Within about five years of that particular period, the cable TV companies realised that they could actually offer telephone over those particular cables. So they re-ran a lot of their existing cables in their existing ducts.'

Unlike American cable companies from that decade, many emerging, smaller altnets don't have sufficient financial backing for long-term network growth.

Couple this with an ever-changing market and its increased capacity demands, the independents see a significant change in network costs. To help the altnets, global

network infrastructure provider CommScope developed the FTTH ePlanner.

This is a UK-specific planning tool designed to guide network designers through the steps and decisions involved in the network planning process.

The ePlanner helps engineers to quickly identify the best network design topology for any project. At the end of the process, the tool can be used to help the project team create a detailed bill of materials.

Engineers provide input regarding demography type and density, take-up rate business case and any infrastructure constraints. The tool can then walk them through the design aspects that need to be considered, and

own copy, and then set up a video meeting with the architect and the chief engineer of that particular ISP.

'We would also work in conjunction with CommScope,' said Mills. 'They've got around 40 to 50 years of experience in building networks and they are also aware of the more specialist products that they're bringing to the market, that they have developed for certain ISPs.'

This specialism is an area in which the ePlanner helps Mills ensure they can offer their individual customers exactly the right solution for their individual business. Mills explained: 'There is a commonality between the ISPs building the networks, but

> ❝
> IT'S A HIGH-QUALITY, RELIABLE SYSTEM. WITH THE EPLANNER IN OPERATION, YOU CAN TAILOR IT AND MAKE IT A VERY COST-EFFECTIVE SOLUTION FOR YOUR CUSTOMER'S BUSINESS
> ❞

explains the available options and the pros and cons of each. The completely virtual ePlanner also considers any key regulatory and standards-based requirements that could affect the design. The goal is to help the altnets reduce the amount of time and cost involved in developing and deploying their networks.

Quality street
As a partner to CommScope, Mills is able to use the ePlanner to help deliver its end-to-end solution package to customers.

Mills explained: 'CommScope is known as the quality brand in the market. It's a high-quality, reliable system and with the ePlanner in operation you can tailor it and make it a very cost-effective solution for your customer's business. It's very easy to use, as it breaks down into three components: inside plant, outside plant, and then customer connection.'

In terms of how Mills puts the ePlanner to use, the first step is to have the customer download their

they've also all got something different about them, which can make it very difficult to be sure that you're stocking the right product. CommScope has the most comprehensive range in the business. That's the reason we partner with them. The ePlanner gives another dimension and it's something that other connectivity manufacturers can't offer.

'It is probably the first tool that we use when we're being asked to consider a network!'

For Mills, the ePlanner is also something of an affirmation that the company has selected the right connectivity partner, fitting in perfectly with its 'end-to-end' promise to customers. 'From our point of view,' he said, 'it fits in really well with the complete package because we've built up a massive range of PIA products. So we can offer – with CommScope's help – the complete solution.

We can kit out that solution, from engineers' tools to the joints and the infrastructure products, so it works very well and it is a good association with CommScope.' ▪

HAND-IN-HAND

HOW WILL THE NEXT-GENERATION OF OPTICAL NETWORKS PROVIDE THE CAPACITY TO SUPPORT UNWAVERING INCREASES IN TRAFFIC, AND DOES ONE SOLUTION REALLY 'FIT ALL'?

KEELY PORTWAY

As the world struggles to settle into the 'new normal', today's optical networks need to be flexible in their architecture blueprint, while adapting to new technologies to provide the kinds of new capacity and service options to meet accelerated demand for higher bandwidth.

Speaking at the virtual NGON DCI event, as part of a panel discussion on the topic, Timothy Munks, senior principal analyst at Omdia said: '2020 was a very challenging year for optical networks. We've had the "work, learn, play" at home and what we are seeing is sustained bandwidth use throughout the whole day at former peak levels. For example, the average subscriber in North American cable TV networks between 9am and 5pm is about 6.3G, and that's up some 41 per cent.'

Despite this, Munks said that in general the networks have performed 'amazingly well', with limited supply line disruptions between March and May. 'For the most part,' said Munks, 'these were overcome and we're not seeing supply line disruptions anymore.'

Even without the pandemic-factor, however, the market continues to be driven by the need to increase capacity and lower the cost-per transported bit. Much of the work to do this focuses on adding L-band and increasing C-band. 'The thing you want to do most,' said Munks, 'is get as much out of the fibre

rates at very useable distances. The higher data rate per wave, the less cost per bit. This is useful for everyone from internet service providers, content providers, and so on. Classic customers that require the ability to drive down cost per bit. It's really quite amazing, the performance that can be achieved with fifth generation technology. It's really difficult to point to one piece of coherent innovation and say "that's the thing"'.

Acacia's marketing vice president Tom Williams agreed that network operators are under pressure to build and deploy multi-generational architectures comprising terminal equipment and optical line-systems to support both current and future data rates in an efficient, scalable and cost-effective way.

'Traditionally,' he said, 'coherent optical transmission was primarily used for longer reach applications, but traffic patterns are changing in ways that are leading to the need for high-capacity interconnects that target shorter reaches in a power-efficient, cost-effective manner.'

This next-generation optical technology, he feels, has additional benefits to operators, because it can be used in a more bespoke way. 'We're taking the pluggable solutions and making them a little bit more tailored to the application,' he said. 'As pluggable coherent expands, it's no longer a "one-size-fits-all" approach, we're tailoring solutions for the individual applications.'

Indeed, both organisations have introduced their own solutions. Infinera's ICE6, with features such as Nyquist subcarriers, probabilistic constellation shaping (PCS), and a high modem signal-to-noise ratio (SNR) featured in a number of successful trials last year. Likewise, Acacia's pluggable modules were used late last year as part of a successful module-level interoperability test between DSPs in 400ZR and OpenZR+ operating modes.

On the competing solutions available, Williams added: 'It's good for the market that we have these different types of solutions and it doesn't have to be an all or nothing. They're providing solutions about different types of optical network applications. When you get coherent into the right form factor so that it's simpler to deploy, that's when you start to address the broader market.'

All about choice
Like coherent, PAM4 optics can be used to put more bits into the same amount of time on a serial channel to double the density of the data and achieve a higher bandwidth for the same data path. So, for a given channel, twice the data could be pushed through for the same frequency and channel bandwidth.

Anthony Clarkson, technical director EMEA at Precision OT, believes that there are a number of technical challenges of moving beyond 10Gb/s in the access network. 'Distinct from backbone and metro networks, access networks have two key features,' he said. The first is a 'wide variety of link lengths that

IT'S REALLY QUITE AMAZING, THE PERFORMANCE THAT CAN BE ACHIEVED WITH FIFTH-GENERATION TECHNOLOGY

connect multiple locations using outside plant infrastructure. Though an access network can have link lengths that span 10 to 120km, the majority of links span 40 to 60km.'

Secondly, access networks have a large number of links that leverage diverse protocols and data rates, which adds to the complexity of the overall network. 'As if operating access networks was not already complex,' said Clarkson, 'upgrading bandwidth above 10Gb/s brings its own set of issues.'

One is the optical link budget. 'When network operators push past 10G per lambda,' said Clarkson, 'optical link budget considerations become paramount. Overall, the amount of optical power at the link receiver must be above the receiver's sensitivity to successfully gain a link. As access networks span longer distances, accounting for link budgets becomes increasingly complex. Though one can always add optical gain to a system with amplifiers like EDFAs, additional amplification always brings an increase in noise.'

Go the distance
Optical signal-to-noise ratio (OSNR) is also an issue. Just because a receiver sees light above sensitivity, does not mean, says Clarkson, that data is being transmitted successfully. 'The OSNR is the ratio of the actual signal level to the level of noise in the system. The smaller this number, the more likely there will be bit errors in the transmission. As links move to higher order modulation schemes to get more bits per symbol (such as PAM4 or QAM), the better the OSNR needed to distinguish the signal levels. Digital signal processors (DSPs) and forward error correction (FEC) can be used to compensate for bit errors, but they also add complexity, power, latency and general interoperability concerns.'

Thirdly, said Clarkson, is chromatic dispersion. 'For networks with bandwidths of 10Gb/s and above, chromatic dispersion has a negative impact on optical transceiver receiver sensitivity. In slower signaling systems, ample time between symbols means that spreading does not create an issue.

However, as the baud rate increases, the pulse spreading causes symbols to overlap each

bandwidth as you can, so expanding the C band and L band is a way to do this before you have to start deploying more fibre.'

That, of course, requires the development of a host of technology ecosystems to support the enhanced spectrum range.

Constant improvement
Also on the panel discussion was Geoff Bennett, Infinera's director for solutions and technology. He discussed how some of the next, or 'fifth', generation coherent optics play their role: 'Every generation of coherent offers better performance at lower data rates than the previous generation at that data rate,' he said. 'So, they're allowing us to go to even higher data

OPTICAL NETWORK
EQUIPMENT
MANUFACTURERS HAVE
A STRONG ROLE IN
MAKING NETWORKS OF
THE FUTURE A REALITY

other, resulting in inter-symbol-interference (ISI).'

At bandwidths of 10Gb/s, Clarkson said chromatic dispersion can limit network links to approximately 80km. 'Past 10Gb/s, at bandwidth rates of 25Gb/s and beyond,' he said, 'chromatic dispersion begins to limit link distance to 15 to 20km. This does not meet the distance requirements of most access networks today. Though dispersion compensating modules (DCMs) exist, they add higher levels of system complexity.'

As detailed previously, coherent and PAM4 optics are attractive solutions for evolving access networks for higher speeds and bandwidth while addressing these challenges. However, Clarkson believes that each technology also has its own limitations.

Looking at PAM4, he explained the standard employs four amplitude channels, each with two bits, which doubles the data rate, making it twice as efficient as legacy binary models. 'Compared to the space and power requirements of coherent optics,' said Clarkson, 'PAM4 leverages components that can fit in smaller, more common form factors such as the QSFP28 model. As such, it delivers significant cost savings advantages to network operators that leverage it. However, going past 100Gb/s at an optical link reach of 5km requires amplification, dispersion compensation and/or forward error correction (FEC) on the optical line. This means the installation of active equipment and greater power expenditure, potentially mitigating PAM4's low-cost advantage.'

Cost factor
Although access-centric CFP, CFP2 and QSFP56-DD/OSFP coherent optics, said Clarkson, 'enable a long link reach of greater than 100km (up to thousands of kilometres for CFP and CFP2) at data rates as high as 400G, they have higher space and power requirements than other types of transceivers used in an operator's access network. As a result, leveraging coherent optics potentially raises total operator costs, which poses a challenge to network operators with constrained budgets.'

Despite these perceived drawbacks, said Clarkson, both coherent optics and PAM4 technology will play a strong role in propelling access and other networks to 800G and beyond. 'What is missing from the discussion, however, is a solution that can solve for the longer reach and costlier nature of coherent optics and the cost-effective yet constrained reach of available PAM4 solutions.'

As Williams highlighted, there are many network applications, each of which have their own applications. Modern access networks can serve many different types of structures, from cell towers, enterprise buildings and multi-dwelling units, to data centres, aggregation sites, schools and sports stadiums. 'The new trend in access networking,' said Clarkson, 'is a focus on data transmission across shorter distances, often less than 40km. Extremely low latency requirements are also adding a new and interesting dimension into the access network, especially as 5G rollouts continue.'

For Clarkson, access network operators require a solution that can achieve three key requirements. One that allows for 100G DWDM, to ensure the speed and capacity needed to meet current and future end-user requirements; one that leverages a common transceiver form factor, like QSFP28, for seamless interoperability and cost savings, and one that enables data transmission at a reasonable distance of 40km without requiring any external transport equipment.

Trend setter
The trend here, said Clarkson, is a positive one. 'In fact, a new dawn for access networks

is already emerging,' he enthused. 'We are now part of an advanced engineering group that is developing a commercial 100G DWDM QSFP28 switch pluggable product, which does not require any DCM or other equipment for transmission up to 40km. This new transceiver is designed to meet the needs that other high-bandwidth, high-speed solutions cannot.'

The product is 4TB of maximum capacity with bidirectional capabilities, all in the common and cost-effective QSFP28 form factor.

'This is the vision I see for the future of European access networks,' said Clarkson, 'solutions that will make it easier for network operators to upgrade their access networks without breaking the bank.'

As we launch into 2021, Clarkson believes that one thing is clear, 'the future of the optical access network in Europe is bright.' With governments continuing to invest in 5G rollouts and individual network operators jockeying for position, the trend toward convergence and the need for higher speeds and bandwidth is only heating up.

'Optical network equipment manufacturers have a strong role to play in making the networks of the future a reality,' said Clarkson.

'Though existing coherent and PAM4 solutions help operators overcome the challenges of upgrading bandwidth to a certain extent, there is still room for improvement. Fortunately, that time has come, and European network operators can look forward to a bold future.'

Williams concurs, stating that whatever the path may be, 'this industry has always been very good at coming up with the right solution.' ■

A SMART
FUTURE

LOOKING INTO TELECOMMUNICATIONS' FUTURE,
IT COULD BE ARGUED AI AND TELCOS WILL
EFFECTIVELY TRANSFORM EACH OTHER

RAF MEERSMAN

L ast year was one of countless changes. Changes that have been happening in the past 10 years took a quantum leap in the past 10 months. Can you believe that a year ago, many of us flew halfway around the world for a one-day meeting? That remote education, remote first-line health advice, or even working from home (or anywhere) seemed like a distant future?

The world has adapted rapidly. Operators worldwide reported overnight increases in bandwidth usage between 20 and 50 per cent. It is our sector that was able to provide the infrastructure, services, flexibility to support this change without any major hiccups.

Look in the mirror

The telecom sector was ready for this sudden 'fast forward'. Just like AI is ready for its breakthrough. Companies have been adopting AI faster, to minimise the spread of the coronavirus by human contact.

Our industry is the catalyst of this adoption. But have we looked in the mirror? Are we aware of how these AI innovations affect our own industry? If we are willing to embrace the benefits of digitisation through AI, I see an industry that can become an innovation leader.

Today, there is already a myriad of AI applications available in all stages of the network lifetime.

If you remember, even back in 2010, Swisscom claimed that its robot-driven fibre grid deployments yielded a 50 per cent cost saving. If cars can drive autonomously, why can't digging machines do the same?

Moreover, on the monitoring side, there are AI techniques being developed which can predict faults and even make equipment self-heal, like the automatic restart of a server. AI capabilities can also be used to enable network function virtualisation (NFV), which allows infrastructure owners to offer access to its equipment to altnets. This means the birth of infrastructure as a service (IaaS).

Let us not forget about AI possibilities to protect networks. Self-learning algorithms can discover how to better detect and block intrusions on devices embedded in the network. As 5G introduces countless new antennas and connected devices, it will become much more vulnerable to attacks.

Practical optimisation is key

There is also the planning and design stage of network deployments. This is a subject I care a great deal about, and I am sure we will see radical changes here as well.

We already see AI-based innovation in the gathering and cleaning of digital data where field surveys, for example, could be replaced by virtual reality sessions. Walking the streets from behind your desk, combined with automated recognition of sidewalk borders, survey types, poles, etc. Intrigued yet?

We have been on the AI track for more than 15 years now. As a next step we are adding AI technologies based on machine learning to the software. Practical optimisation is key here: optimising cabinet and closure coverage and sizes; optimising cable and duct routes; optimising demand point connections by

> IT IS OUR SECTOR THAT WAS ABLE TO PROVIDE THE INFRASTRUCTURE, SERVICES, FLEXIBILITY TO SUPPORT THIS CHANGE WITHOUT ANY MAJOR HICCUPS

finding the right cost-coverage threshold per connection, etc.

All this can be underpinned by smart algorithms that understand more than just the logic of mathematical formulas. They need to learn from the best network designers about the balance between cost optimisation and constructability. Here lies our investment, our desire to improve.

The role of the telecom industry has grown significantly this year. And it has the potential to continue to do so. Let's implement new technologies and inspire the rest of the world. How is your organisation contributing to the future of the telecom industry? ■
Raf Meersman is CEO at Comsof

BENDING OVER
BACKWARDS

HOW CAN MODERN FIBRES BE DESIGNED TO COMBINE PERFORMANCE OPTIMISATION AND SUSTAINABILITY?

KEELY PORTWAY

The demand for bandwidth has unarguably skyrocketed in recent years, thanks largely to the increased appetite for online gaming, content streaming and social-media use. With 5G drawing closer, this demand is likely to grow even further, which could be something of a strain for network providers and operators.

It is widely acknowledged that fibre is the best way to achieve this higher bandwidth, and deployments are happening at pace. Even a global pandemic has not slowed them down. If anything, it has brought their importance firmly into public consciousness. The pandemic has also highlighted sustainability, heralded in many markets as key to post-Covid recovery programmes.

In Europe, for example, the green agenda is vital when it comes to the anticipated recovery. EU president Ursula von der Leyen highlighted in her State of the Union speech that 'the European Green Deal is our growth strategy'. As part of this, the European Commission (EC) plans a massive wave of renovation to modernise Europe's buildings and critical infrastructure. Improved broadband connectivity, said the EU, will enable a more inclusive, resilient and innovative Europe. It will allow the connection of more objects and processing of more data, to better understand energy consumption and cut emissions in other sectors by 15 per cent.

Carbon-neutral targets
Operators are certainly aware of this, and a number have already committed to ambitious carbon neutrality targets and using renewable energy sources, including Telia Company, TDC, Telecom Italia, KPN, Proximous and Telefonica, to name a few. So, how can the fibre and cable vendors help them to do this, without compromising on performance?

According to Ole Suhr, account manager at OFS Optics, modern fibres can and should be designed to optimise the performance of the newest and most advanced transmission systems. These transmission systems can be power hungry, but Suhr believes it is now possible for some of the most sophisticated fibres to support power savings.

He explained: 'The transmission system manufacturer is always trying to squeeze more capacity into each fibre, because it's more efficient, so it's eventually cheaper. As a fibre producer, it is important to work together with them, trying to make fibres to support that as well as possible.'

For Suhr, an ideal solution is a single mode fibre that has low attenuation, combined with a larger core. 'That would mean,' he said, 'that you can basically pump more light into the fibre without getting problems. Then you can reach longer, and are not quite as sensitive to noise. These two things benefit each other and help the transmission systems either transmit longer or transmit a larger capacity.'

The company's TeraWave ULL fibre, for example, is a 125μm² large area, ultra-low loss ITU-T G.654.B fibre. Its core has an effective area 49 per cent greater than G.652.D single-mode fibre, to reduce nonlinear effects that can limit reach. Its origins are interesting and, you could be forgiven for thinking, quite far removed from the metro and data centre applications that use it today.

'You could look on it as sort of spin-off for a submarine fibre,' explained Suhr. 'We have been working in the submarine area for quite some time now, and we work with fibres that have even larger cores.'

Handle with care
One of the challenges with a larger core fibre, however, is that it can prove more difficult to handle, the larger it gets. 'That's not really a problem for submarine systems,' said Suhr, 'because they need to be handled very specifically. But if you want to use the fibre in a terrestrial, normal, land-based transmission system, it can become more sensitive to handling.'

This is where the latest generation of bend-insensitive fibres come in, and the OFS product was designed to meet and exceed the most recent G.654 recommendation – G.654.E – which was created to help improved bending performance even for fibres with an effective area as large as 125μm². The development was aided by the company's experience in the development of its EZ-Bend fibre, which Suhr says 'is the most bend insensitive fibre on the market.'

Among other sustainability benefits, the latest generation of optical fibres, such as the TeraWave ULL, can also save power when operating the transmission systems, as Suhr went on to say: 'If you use a fibre such as this, you will, from time to time, be able to save an amplifier, or save a line card in the transmission system. This means that you also save the power that would otherwise have been used for writing these components.'

But that's not all, revealed Suhr: 'Further to that, when you are using the fibre, it offers you

> **IF YOU WANT TO USE THE FIBRE IN A TERRESTRIAL, NORMAL, LAND-BASED TRANSMISSION SYSTEM, IT CAN BECOME MORE SENSITIVE TO HANDLING**

the opportunity of creating sort of a "sweet spot" for the transmission line card, especially the input side of that. This means that the line card can actually save power as well.'

That's because the line card does not have to work so hard to correct the received signal from the fibre, thanks to its low level of non-linearities and low attenuation. Concluded Suhr: 'We believe this is a more sustainable fibre because it allows less power use when operating the network.' ■
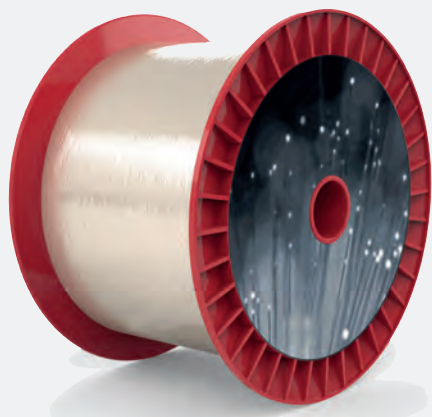
TeraWave® ULL fibre is a registered trademark of OFS Fitel, LLC

NEW KIDS ON
THE RURAL BLOCK

ALTNETS COULD BE THE KEY TO CONNECTING RURAL AREAS IN 2021

MICHAEL ARMITAGE

Fibre broadband is now in more European homes than ever before, but there's still a long way to go. The UK, for example, has a large fibre gap in comparison with other developed countries, despite government backing to accelerate its delivery. This is especially true in rural areas.

That said, the altnet sector – made up of alternative providers to major players BT Openreach and Virgin Media – is working hard to change the situation. A recent survey by the Independent Networks Co-operative Association (INCA) revealed that altnets increased their full-fibre coverage by 50 per cent in 2019, covering 1.2 million premises across the UK. This is expected to have risen to 2.4 million premises in 2020.

However, recent developments have made nationwide coverage more difficult to achieve. The UK government's promise to deliver gigabit broadband to every home by 2025 was quietly scaled back in the Chancellor's spending review in November.

Instead, it has now set a target of 85 per cent coverage, which is not too far away from the estimated 70 per cent coverage that commercial roll-outs have been predicted to achieve without state support.

Meanwhile, the largest providers have

indicated that the cost of reaching the most remote areas is simply not financially viable for them.

State of connection
Some 96.5 per cent of the UK currently get 'superfast' speeds of 30Mb/s+, according to official figures, but only 34 per cent can access Gigabit broadband services.

Meanwhile, an estimated 608,000 homes across the UK do not have any access to a decent and reliable connection, which is defined as 10Mb/s+. In some parts of Scotland, more than four in five properties fall into this category, and in rural Wales, as much as 30 per cent of the population have barely functional broadband.

Any reduction in government spending will only exacerbate this situation further. Providers should therefore stick to the 2025 target, irrespective of the government's position.

The cost of the growing digital divide between rural and city areas is too great for the long-term future of the UK, so 2021 has to be a key year for building bridges, rather than burning them.

Bridging the divide
Put simply, communities with a poor internet

Shutterstock

> **THE LARGEST PROVIDERS HAVE INDICATED THAT THE COST OF REACHING THE MOST REMOTE AREAS IS SIMPLY NOT FINANCIALLY VIABLE FOR THEM**

connection get left behind. The pandemic has made this clearer than ever before, as regional lockdowns put added pressure on unreliable broadband connections.

With many forced to work from home while their offices are closed, individuals have relied on their home internet to carry on with their lives.

While mostly successful on a national level, research by Zen has revealed that more than four-fifths have suffered from an unreliable connection. This is particularly prevalent in rural areas.

Even so, a survey of Londoners aged 18 to 34 found that 55 per cent are considering a move to the countryside as a result of the pandemic. Cheaper housing, more space and the ability to work from home are key factors in this trend, which would not only help address the long-standing 'brain drain' in the countryside, but also provide a significant boost to local economies.

However, the same survey, by the Country Land and Business Association (CLA), also showed that areas which cannot meet the demand for fast internet access are less likely to attract new residents.

So, how can progress in this area be achieved, and what role do altnets have to play?

Altnets can deliver

Altnets are typically more nimble and focused than some of the major broadband suppliers, which is partially why they have enjoyed the exponential growth that has laid the foundations for their success.

The main opportunity for altnets to deliver fibre to the premises lies between the cities and the areas where government funding is being rolled out. The fact that the major players continue to focus on cities leaves much greater ground for transformation in rural areas.

With the right priorities, cost structure and technology solutions, altnets can improve the connection in the areas where others won't go in 2021.

This will mean taking a hyper-localised approach and working with the communities themselves to accelerate the changes. By doing so, altnets will be able to improve the lives of the people who have been left behind by the major providers, as well as the regions in which they live in.

Achieving this goal will be challenging, but it will also be an opportunity for the new kids on the block to keep rural areas connected. ■

Michael Armitage is CEO at Broadway Partners

OUT WITH
THE OLD?

IS LEGACY MULTIMODE FIBRE READY FOR FUTURE BANDWIDTH NEEDS?

KEVIN LENGLÉ

Multimode fibre is widely associated with short-haul, and is particularly prevalent in enterprise and data centre markets. This article dispels some myths about multimode fibre and its intrinsic limited bandwidth.

In recent years, new optical technologies have emerged and many players are launching product lines that can leverage the full potential of multimode fibres and increase their bandwidth capacity.

As a relevant alternative to recabling, these technologies can solve many problems in a practical, economical and ecological way. In particular, it presents a number of opportunities to the LAN market, in terms of future-proofing existing campus cabling infrastructure.

Multimode fibre is a proven technology to provide high-speed connections between very short distances. It is particularly popular in data centres with OM3/OM4/OM5 multimode fibre type. It is by no means a new technology, it has been used in the telecoms sector since the early deployments of the 1980s, notably within local area networks.

But, what about first generation OM1 and OM2 multimode fibres deployed massively in campus cabling infrastructure? Are these capable of meeting the growing demand for high-throughput on these networks?

A perfect 10

Bandwidth-intensive applications and latency-aware traffic types are becoming ubiquitous in LAN. As a result, it is necessary to be able to reliably transport these data streams with a high quality of service in the campus. A standard requirement is often 10Gb/s over the links between floors or buildings constituting the cable mesh in campus networks.

A large majority of these multimode fibres do not support throughput of more than 10Gb/s over campus-wide links. This is largely due to the optical design of this fibre type. Contrary to the active components of the network, for which upgrades can be carried out relatively easily, the optical cabling infrastructure has a performance envelope that generally could not be increased without physically changing the cable that carries the information, such as deploying new generation cables (OM5 or SMF).

Multimode possesses intrinsic performance limitations which are inherent to its physical properties. More specifically, for multimode optical fibres widely installed in LANs, such as OM1 (62.5/125μm) and OM2 (50/125μm), high-speed transmission is limited as a result of modal dispersion, which is a distortion mechanism occurring in all multimode fibres.

The higher the transmitted throughput is, the greater the distortion is. For a given throughput, it reduces the distance that can be reliably attained between transmitter and receiver.

This problem was discussed a few years ago in IEEE and MSA groups. Designed for backward compatibility with OM1 and OM2 fibres, an alternative type of 10Gb/s interface had been developed within the IEEE 802.3aq standard, referred to as LRM (long-reach multimode). By using electronic dispersion compensation signal processing technology, combined with specific light launching conditions into the fibre using mode conditioning patch cords, it is possible to achieve a reach of 220m. But this does not cover all today's LAN needs, in terms of bandwidth.

Trials and tribulations

A typical solution that prevents throughput and distance limitations due to modal dispersion in currently deployed multimode fibres would therefore be to replace them with new-generation multimode fibre, or with a single mode fibre that does not experience modal dispersion. However, redeploying the fibre is often a difficult task. It depends on the distances involved and involves removing and replacing the fibres.

An audit of the cabling infrastructure is necessary to verify the availability of the cable ducts, as well as their condition. Depending on the case, microtrenching or civil engineering may be required to deploy new cable. This kind of operation could be very intrusive.

But optical technologies have evolved. Following the light-launching principle used in this IEEE LRM standard (offset launching), the best-case scenario would be to perform a mode-conditioner, enabling a launching condition that accurately excites only the

> MULTIMODE IS BY NO MEANS NEW, IT HAS BEEN USED IN THE TELECOMS SECTOR SINCE THE EARLY DEPLOYMENTS OF THE 1980S
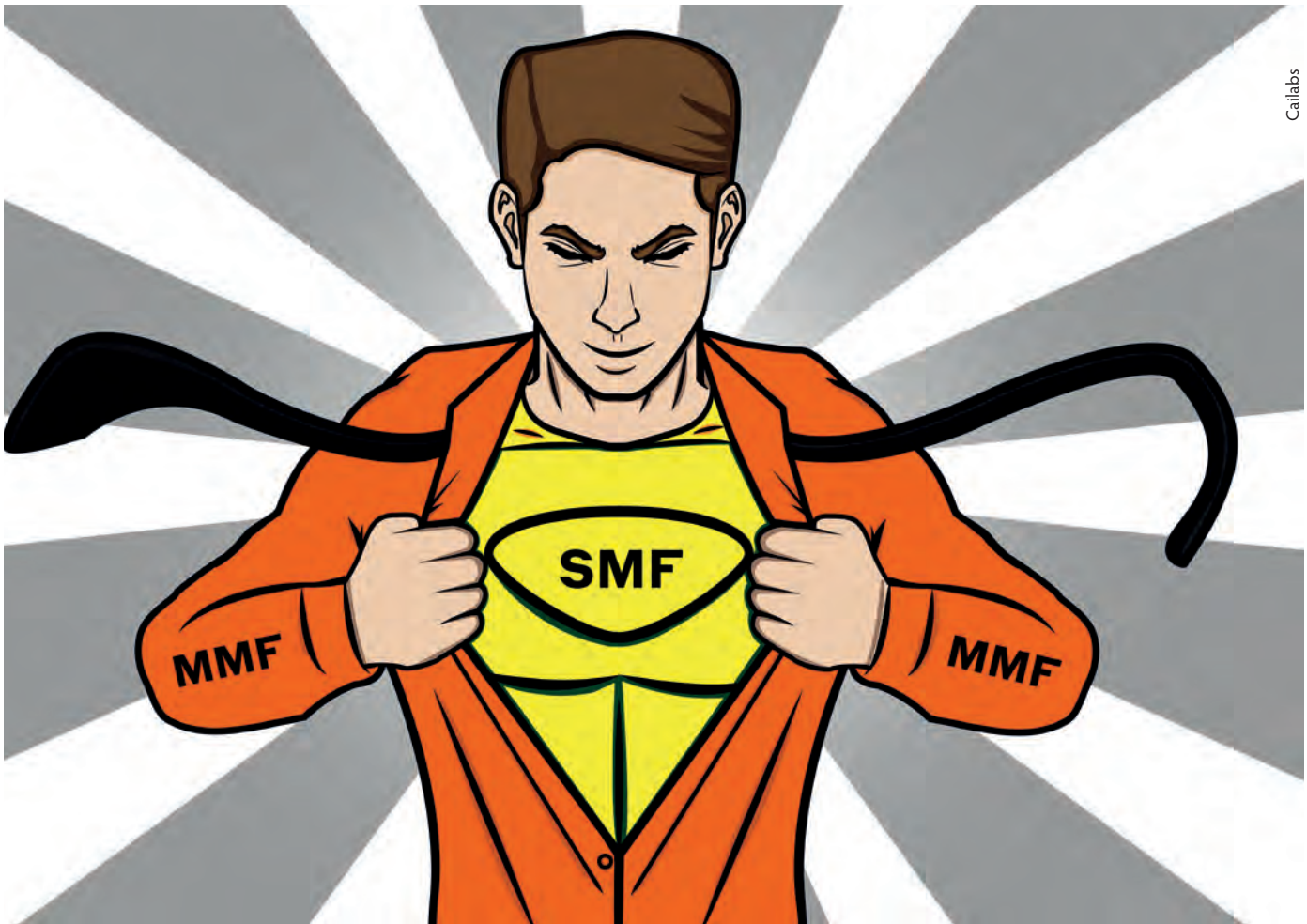
Cailabs

> NOWADAYS THERE ARE TECHNOLOGIES THAT ENABLE FLEXIBLE AND COMPLETE LIGHT SHAPING THROUGH A SUCCESSION OF VERY COMPLEX OPTICAL LENSES

fundamental centre mode into the multimode fibre core.

In this way, the light transmission within the fibre would no longer induce modal dispersion, as only one mode would propagate, a kind of quasi-single-mode transmission over the multimode fibre. Nowadays, there are technologies that enable flexible and complete light shaping through a succession of very

complex optical lenses. Such technologies shape a laser beam from a transceiver in such a way that each mode in the fibre can be independently and precisely excited.

This kind of technology is used as a way to increase transmission capacity of existing multimode fibres by performing centre launching on legacy multimode fibres.

By overcoming speed and distance limitations, bit rates like 10/25/40/100Gb/s can be carried over an existing legacy multimode infrastructure of several kilometres, allowing for a progressive and flexible evolution of the legacy network optical infrastructure, compatible with any type of 62.5/125μm or 50/125μm multimode fibre.

Getting physical
In addition, being that such technologies consist solely of optical elements, the solutions are passive (no energy consumption, no configuration, no monitoring) and operate at the level of the physical layer, which makes them transparent to the wavelength, the communication protocol and modulation format being used.

Beyond the increase in bandwidth, it is now possible to perform the single mode/multimode media converter function in a totally passive way thanks to this modal approach.

Indeed, this function can be found in many

cases of use in the LAN, especially in a context of campus extension. It is therefore possible today to achieve the transition without any active layer. As a complement, this modal approach also makes multimode fibres compatible with single mode wavelength-division multiplexing (WDM) technologies, enabling a gradual and flexible increase in network capacity towards very high-speed broadband and thereby ensuring a durable cabling infrastructure.

In conclusion, the limited capacity of LAN cabling infrastructure is a prevalent issue and complex wiring cases are not uncommon. You do not have to remove and replace the old cable by default. You now have the possibility to upgrade legacy multimode fibres.

These modal adapting passive technological approaches have already proven their effectiveness across numerous industrial, military, university and hospital campuses around the world. As a complement to traditional cabling, this new trend to transform multimode into single mode fibre makes it possible to recycle the existing cabling infrastructure, one more step towards green IT, with proven benefits for end-customers and ICT professionals. ■

Kevin Lenglé is product line manager at Cailabs

CAN WE
FIX IT?

HOW DO WE, AS AN INDUSTRY, BUILD BETTER BROADBAND FOR
A POST-PANDEMIC WORLD? THE ANSWER COULD BE FIXED

STEFAAN VANHASTEL

At the peak of the pandemic, broadband demand went off the charts as families forced into lockdown found themselves having to work, learn and live entirely online.

Zoom video traffic increased ten-fold in a week. Video and IPTV streaming went up as much as 60 per cent. Virtual Private Network (VPN) use rose 100 per cent. Online gaming grew an incredible 400 per cent in some cases. The number of simultaneously connected devices also multiplied, as children switched to e-learning, adults adapted to remote working, and everybody watched Netflix – all at the same time.

There is little doubt that Covid-19 will have a permanent effect on human behaviour. This includes our digital behaviour, and will surely be a catalyst for governments, broadband providers, and other interested stakeholders to act. Why? Because broadband has proven itself to be a critical utility during this pandemic, protecting both citizens and economies.

Keep on growing

Of course, it was 5G that took the lion's share of attention in the telecoms industry pre-Covid. But as keen as we all are to see 5G mobile deployments accelerate, the pandemic

> **BROADBAND HAS PROVEN ITSELF TO BE A CRITICAL UTILITY DURING THIS PANDEMIC**

has shown it is the fixed networks that have provided the resilience the country needed.

During lockdown, fixed networks were responsible for 70 per cent more traffic than 3G, 4G and 5G combined. Indeed, mobile networks sometimes struggled with degradation in speeds and latency due to congestion, but that is not surprising when you remember that mobile is designed for people on the move, not in lockdown. Mobile networks are, of course, hugely important; however, countries need to find the right balance of fixed and mobile infrastructure for their citizens.

The increase in traffic on fixed networks has been somewhat of an onslaught. Until now, fixed network operators have been

using growth models that predicted a gradual increase in bandwidth demand of 30 to 40 per cent over the next three or four years. In comparison, Covid-19 generated 30 to 40 per cent growth almost overnight. This has placed unprecedented pressure on providers to maintain service levels and ensure high sustained speeds.

Protect and serve
Many operators around the globe have already announced programmes to accelerate fibre investments and upgrades. Governments, too, recognise the need. They are acutely aware that almost a billion households in the world have no fixed broadband, and another 500 million have low-speed broadband services unable to support the new normal in digital behaviour.

These households are vulnerable, and their lack of connectivity hinders a country's ability to protect its citizens, its society and its economy. The challenges are threefold: connecting the unconnected, boosting capacity in underserved communities, and ensuring that even well-served areas do not run out of capacity with this new-normal behaviour.

Broadband providers are actively recalculating for network capacity planning. If we now consider a typical household that may

be homeworking, e-learning and e-entertaining, we can estimate that the minimum download speed needed is 50Mb/s. Ideally, it is more, but 50Mb/s is really the new minimum.

What's more, households have become video content creators via Zoom, Webex, MS Teams, etc, so upstream speeds must also increase, to a minimum of 15Mb/s. These changes in usage methods necessitate fibre – GPON or XGS-PON – or fibre extension technologies like G.fast. If that is not enough, the increase in simultaneously-connected devices means providers must consider the capacity and performance of the in-home wifi network as well. There is little point providing hundreds or thousands of megabits to the building, only to create a bandwidth bottleneck inside the home.

Traditional network design assumes not all households need bandwidth at the same time, so operators oversubscribe the network. For example, a Gigabit passive optical network (GPON) fibre to the home (FTTH) network with a capacity of 2.5G is used to connect up to 16 or 32 homes with a one Gigabit service.

Outdated approach
This works because, statistically, it is unlikely that more than two people will need that full Gigabit capacity at the same time. That is why

the approach is called statistical multiplexing. That approach no longer works. Suddenly, with more households simultaneously connected (and not just at off-peak times), we have lost the overhead capacity that ensured Gigabit services could be delivered. Operators who had plans to upgrade to 10G next-generation PON in three or four years need to do so now. There is a knock-on effect in aggregation links and switching capacity, as well.

So, where to start? Broadband providers can, of course, seize the opportunity and monetise the increased demand for higher bandwidth. But governments must react as well. Broadband plans drawn up in the pre-Covid era need updating with fresh targets for coverage and minimum service levels, and new incentives for investment. Subsidies, taxation, private investment incentives, rights-of-way regulations, up to and including government-owned broadband utilities should be considered.

To paraphrase Winston Churchill, one should never waste a good crisis. But in the case of broadband, the impetus for change will actually serve us all well in the event of the next crisis. Let's not waste it. ∎

Stefaan Vanhastel is CTO and head of marketing, fixed networks at Nokia

HIGH
TIME

A GLANCE AT THE CURRENT MARKET FOR FIFTH-GENERATION COHERENT OPTICS, AND SOME OF THE LATEST DEVELOPMENTS AVAILABLE

KEELY PORTWAY

Before the pandemic began, all eyes were on fifth-generation coherent optics as one of the biggest trends to shape the industry, with expected demonstrations at all of the key industry events.

While the global situation prevented much of the interaction and face-to-face views of this technology, it did not stop its development ,and there have now been a number of trials and demonstrations from vendors and operators alike, highlighting the achievements of higher wavelengths, such as 600 and 800G.

This was evident as the first physical events returned late last year: The 2020 China International Optoelectronic Exposition (CIOE) and Optinet China. According to industry analyst firm, LightCounting, exhibits at CIOE 'surprised the attendees' with numerous live demos of 400 and 800G optics, and these were 'the highlight of the exhibit.'

Industry insight and market research firm Cignal AI has kept track of trials and deployment announcements in this area, with the recent report *5th Gen Coherent Trials and Deployments*.

It tracks publicly announced, terrestrial trials and network wins by vendors of fifth generation coherent optics. The first fifth generation announcements, it cited, were in January last year. The Covid-19 shutdown, however, impacted the vendors' ability to complete trials with some customers, but announcements picked up in June.

In summary of these announcements, Infinera demonstrated the capabilities of its ICE6 over long distances at 800Gb/s. As an example US operator, Verizon used ICE6 in a successful test in its live fibre network to move 800Gb/s of data on a single wavelength across longer distances. A 800Gb/s single-wavelength transmission was accomplished over 667km between Nashville and Atlanta.

Ciena, meanwhile took the time to do a limit-pushing trial of Wavelogic 5e in partnership with Canadian service provider Telus. The company revealed it was able to transmit an 800Gb/s signal over 970km during the trial.

In Europe, Swedish operator Telia Carrier is using Acacia's 400G coherent modules, plugged directly into Cisco routers, to increase bandwidth demand. Leveraging the coherent modules with OIF 400ZR and OpenZR+ operating modes, the solution is designed to support data rates from 100G to 400G depending on the desired reach.

The modules also support client n x 100GbE multiplexing functionality as well as 400GE transport.

This architecture has been selected to help Telia Carrier cost-effectively handle the projected traffic growth for the coming years while, crucially, preparing to support the next transition to 800G or beyond.

COMMERCIAL PRODUCTS

Other vendors that offer fifth generation optical engines include Huawei, with its OptiXtreme H7 chipsets. It's an 800G tunable optical module, based on technology developed by component subsidiary HiSilicon.

Nokia, meanwhile, released its PSE-V fifth generation coherent engine last year. The

Sponsored by

INFINERA: FEATURED PRODUCT

The GX Compact Modular Series, powered by Infinera's ICE6 800G optical engine, offers superior optical performance and scalable connectivity in a compact, flexible package. Its modular sled-based architecture with integrated optical line system capabilities enables optimised support for numerous network applications.

The GX Series offers leading programmability and performance, with support for up to 800G per wavelength along with feature-packed automation.

It supports deployments over virtually any optical line system and allows operators to save on CapEx and OpEx with industry-leading power consumption and a pay-as-you-grow modular design.

ICE6 enables network operators to meet the demands of rapid bandwidth growth by providing the greatest capacity at the greatest reach, resulting in a solution with the lowest cost and power per bit and the highest spectral efficiency possible. While 800G is its headline rate, ICE6 is also shattering optical transmission expectations for 600Gb/s and 400Gb/s per wavelength.

PSE-Vs (super-coherent) can run up to 90GBd, and employs the second generation of Nokia Bell Labs-pioneered probabilistic constellation shaping (PCS). It is capable of transporting up to 800G, while providing greater reach, lower power per bit, and greater spectral efficiency. The PSE-Vc (compact) enables programmable capacity from 100 to 400G with metro to long-haul capability.

NeoPhotonics also recently announced a coherent modulator and receiver for enabling 800G and above-per-wavelength applications. The Class 60 versions of its Coherent Driver-Modulator (CDM) and Intradyne Coherent Receiver (Micro-ICR) are designed to address the next generation of 100+ GBd systems to meet ongoing growth in demand for bandwidth, especially between cloud data centres. The Class 60 suite allows increasing symbol rates from the 64+ to 100+ GBd. These components work together to enable customers to implement single wavelength data transmission near one Terabit per second over data centre interconnect (DCI) distances, as well as long-haul 400~500Gb/s transmission.

## BRISTOL INSTRUMENTS: FEATURED PRODUCT

For the manufacturers of high-capacity optics and transceivers, the 338 Series Optical Wavelength Meter from Bristol Instruments combines speed, accuracy and affordability to address manufacturers' most critical requirements.

The wavelength of CW and modulated signals is measured to an accuracy as high as ±0.3 pm.

A measurement rate of 25Hz results in reduced test times to optimise manufacturing throughput. This instrument features a convenient touch-screen display to report data in a variety of formats and can interface via SCPI using USB, Ethernet or GPIB.

Additionally, the rugged design of the 338, coupled with Bristol's five-year warranty provides reliable operation and the lowest cost of ownership, when compared with similar systems.
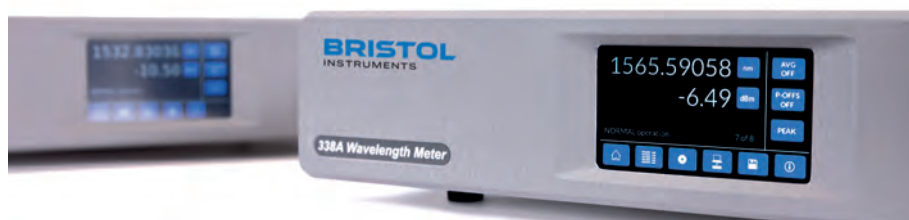
PRODUCT
UPDATE

Optoscribe serves chip for fibre-to-SiPh PIC coupling

www.optoscribe.com

Optoscribe has launched a monolithic glass chip for low-loss coupling to silicon photonics (SiPh) grating couplers.

The OptoCplrLT chip is designed to overcome fibre-to-SiPh photonic integrated circuit (PIC) coupling challenges to enable high-volume automated assembly and help drive down costs. Created using the company's high-speed laser writing technique, OptoCplrLT features low-loss light turning curved mirrors, which are formed in the glass, to direct the light to or from SiPh grating couplers. This prevents the need for bend-tolerant fibre solutions.

To help address footprint challenges, the chip has a low-profile interface of less than 1.5mm in height, which allows compact interface layouts that alleviate packaging constraints. It is also compatible with industry-standard materials and processes; for example, the glass chip has a coefficient of thermal expansion matched to the silicon chip, helping to maximise performance.
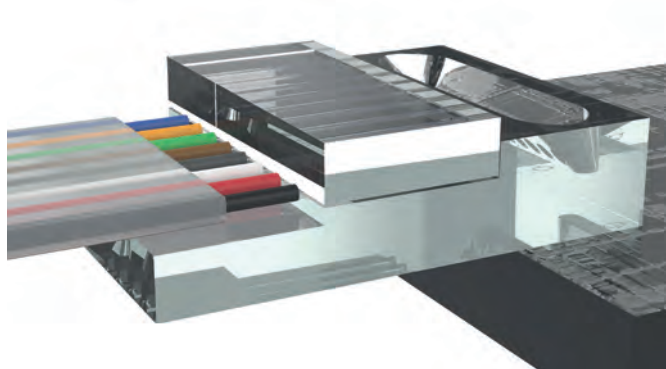
Viavi optimeter helps to reach the last mile

www.viavisolutions.com

New from Viavi Solutions is the Viavi Optimeter, a network test tool designed to speed and simplify last-mile optical fibre activation and maintenance.

It's estimated that 250,000 technicians will be tasked with fibre installation and maintenance duties over the next three years to keep up with the demand for global broadband deployments. This rapid growth is driving the need for certification tools that are easy to use, to ensure successful service turn-up on the first truck roll, thereby avoiding activation delays, increased churn and excessive installation costs.

The versatile Optimeter combines the functionality of a broadband or GPON/XG(S)-PON power meter with fibre certification and connector inspection in a simple, all-in-one solution for effortless FTTx certification and troubleshooting, regardless of field technicians' experience. It was designed to reduce truck rolls and trouble tickets by proving successful fibre install passes, or providing clear fault ownership information to stop unnecessary handoffs.

Kevin Oliver, vice president and general manager, converged instruments and virtual test, at Viavi said: 'Pressure to meet demand for new PON/FTTH service often leads to minimal testing or even no testing. As a result, technicians are not able to complete install and activation on the first visit between 20 to 50 per cent of the time, leading to poor customer experiences and lost revenue.

'As service activation failure rates and maintenance costs continue to rise, the Viavi Optimeter is a critical tool for premise and home techs to make sure that last-mile fibre installation is done right the first time, improving deployment success rates and reducing the need for return visits.'

## STL reveals intelligently-bonded ribbon cable at FTTH Conference

www.stl.tech

STL launched the Celesta ribbon optical fibre cable at the virtual FTTH Conference.

The cable is designed as an intelligently-bonded ribbon to help operators roll out high-capacity networks at a fast pace, by putting more fibre in the available duct infrastructure.

It is a high-density optical fibre cable with a capacity of up to 6,912 optical fibres. This design combines robust performance for duct installations with the productivity of high-count mass fusion splicing. The result is a 26 per cent slimmer cable compared to traditional loose tube cables with the same fibre count. Its compact, blow-optimised design allows for efficient duct space use, enabling operators to install up to 2,000m of cable in less than an hour.

Phill Coppin, STL associate vice-president for technologyconnectivity solutions at said: 'We believe Celesta is an ideal product for the new normal, which will be characterised by accelerated network roll-outs and seamless user experience.'
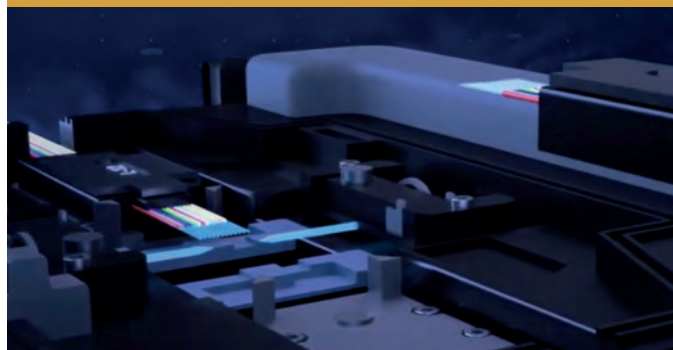
PPC 'Hapi' to launch new installation tool

www.ppc-online.com

PPC Broadband has launched the Hapi Miniflex cable installation tool.

Designed as a cost-saving device for efficiently deploying Miniflex fibre cable in commercial offices, residential homes, and multi-dwelling units, the tool is easy to use and employs a fibre loading mechanism for protecting the fibre cable, saving the installer valuable time and resources.

It is designed for simple manual operation, so does not require a power source. More specifically, it can deploy into microduct routes of more than 300m at up to 30m per minute.

Users will find the tool lightweight, compact and portable. All components, including the ruggedised carrying case, weigh only 3.1kg.

NeoPhotonics launches Class 60 for Coherent

www.neophotonics.com

NeoPhotonics has added Class 60 versions of its Coherent Driver-Modulator (CDM) and Intradyne Coherent Receiver (Micro-ICR) to its suite of high-bandwidth Coherent components.

Optical performance improvement due to increased baud rates enables customers to pack more data over longer distances for better economics, lower cost per bit, lower operating expenses and lower power consumption, all under the same hardware envelope as they currently experience with Class 40 components.

Class 60 additionally extends the speed-over-distance performance of existing Class 50 products by increasing the 3dB bandwidth from 50 to 60GHz. The components work together to let customers implement single wavelength data transmission near 1Tb/s over data centre interconnect distances, and long-haul 400~500Gb/s transmission.

The suite of components is designed to work together with the company's Nano ultra-narrow linewidth external cavity tunable laser, which cuts the size approximately in half compared to current Micro-ITLAs, while featuring industry-leading linewidth and low phase noise with low electrical power consumption.

Optelian disaggregated platform designed for deployment flexibility

www.optelian.com

Optelian has introduced its Deploy Anywhere Series – a multi-service, compact and hardened (OSP-compliant) platform designed for multi-haul transport upgrades, remote business services access and fibre deep architectures.

Purpose-built for where deployment flexibility and scalability of service growth can be unpredictable, the hardened platform is capable of being deployed in harsh environments – where a temperature-controlled shelter or facility does not exist – while still providing next generation multi-service capability anywhere from 1G to 1.6T.

The first member of the series is the TMX-4400.

This is described as an ideal DWDM transport solution for any haul deployment of hardened 100/200/400 GbE or OTU services.

It interfaces a 100 to 400G QSFP28/DD on the client side, and a CFP2-DCO on the line side with software-programmable DWDM modulation supporting operation from 100 to 400G, including openZR+, CableLabs and openROADM standards.

Red Lion switches things up

www.redlion.net

Red Lion has introduced NT4008, a new 8-port Gigabit-managed industrial Ethernet switch series. The NT4008 series switches are certified to meet Profinet PNIO v2.34 Conformance Class-B standards to ensure seamless integration into Profinet networks using standard PLC configuration and management tools.

The switches are NT4008 UL Class 1, Division 2 and Atex-listed for use in hazardous and ordinary locations, ABS certified for shipboard applications and EN50155 certified for rail applications, ensuring reliable operation in nearly any environment. The IP-30 metal DIN-Rail enclosures, redundant 12–58 VDC power inputs, wide -40 to 75°C operating temperature ranges and up to 50G shock resistance handle even the most extreme industrial conditions.

With copper and fibre options in both Fast Ethernet and Gigabit configurations, as well as advanced security and traffic control, Red Lion's NT4008 combines the power of Profinet real-time data exchange with Red Lion's expertise.

PHOTOPTICS 2021

9th International Conference on Photonics, Optics and Laser technology

11-13 February, 2021

Online Streaming

Keynote speakers

Dieter Bimberg, Bimberg Chinese-German Center for Green Photonics of the Chinese Academy of Sciences, CIOMP and Center of Nanophotonics, TU Berlin, Germany

Jean-Jacques Greffet, Laboratoire Charles Fabry, Institut d'Optique Graduate School, Université Paris-Saclay, France

Enzo Di Fabrizio, Polytechnic of Turin, Italy

Gershon Kurizki, Weizmann Institute Of Science, Israel

www.photoptics.org

photoptics.secretariat@insticc.org

MicroCare cleaning technology expands for the workspace

www.microcare.com

MicroCare's new Stereze line of workspace cleaners and hand sanitisers has been launched to support the fight against the coronavirus.

Using existing MicroCare product development and manufacturing capabilities, the range was formulated using a high-purity alcohol-based solution which is focused on high-performance cleaning.

It includes 70 per cent Isopropyl Alcohol (IPA) surface cleaning wipes and a liquid refillable spray bottle for use in communal areas such as public spaces. Complementing these are the hand sanitiser wipes, gel and spray, which are Food and Drug Administration registered.

The range is safe to use on a variety of metals and plastics including tables, desks and countertops, tools and machinery. Available as a liquid refillable pump spray or as a multi-purpose wipe which has been manufactured to be tear-resistant and stand up to rigorous scrubbing on rougher surfaces.
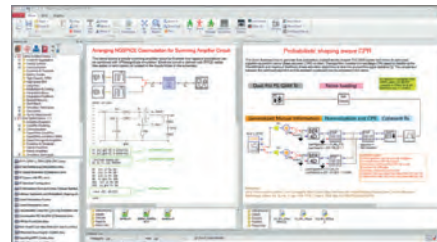
The pre-saturated wipes can be used on electronic devices such as touch screens, mobile phones and keyboards, as there is no pooling of liquid to cause problems.

They do not leave particulates, scents or residue behind, which other low-purity alcohol cleaners can.

Latest software launch for optical transmission systems and components

www.vpiphotonics.com

The latest design suite from VPIphotonics - Version 11.1 - is designed to provide access to professional application-specific simulation tools and several pluggable toolkit extensions with common usability, design process, and data analysis capabilities.

Version 11.1 offers advances in simulation and design flow for applications using probabilistically shaped QAM with polarisation multiplexing, digital signal processing, PAM4 signalling, transient Spice simulations, integrated optical modulators, multimode fibres and couplers, and more.

The firm's software solutions can be a useful tool when it comes to successfully performing many research and design projects, for commercial applications as well as for educational institutions.

André Richter, general manager of VPIphotonics said: 'With the improved capabilities provided in Version 11.1, our modelling suite will continue to deliver industry-leading results that empower our users to define the cutting-edge.'

EDUCATIONAL RESOURCES

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*registration may be required

ADVANCED FIBERS FOR INCREASED SUSTAINABILITY AND REDUCED COSTS IN METRO/DCI APPLICATIONS

OFS

Modern fibers should be designed to optimize the performance of the newest and most advanced transmission systems. Such systems are power hungry, but it has now proven possible for the most sophisticated optical fibers to support actual power savings of the transmission equipment.

ofs — A Furukawa Company

FTTH NETWORK EPLANNER

COMMSCOPE

The purpose of this document is to guide UK network planners and engineers through the design, selection, and identification of the necessary components for fibre optic networks that best suit their specific application needs.

COMMSCOPE®

THE ADVANTAGES OF INDIUM PHOSPHIDE PHOTONIC INTEGRATION IN HIGH-PERFORMANCE COHERENT OPTICS

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A wide range of cloud and video applications, together with the increased access speeds enabled by 5G, DAA, and next-generation PON, are driving the need for ever more optical bandwidth.

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100GBAUD+ SILICON PHOTONICS SOLUTIONS DRIVE OPTICAL NETWORK EVOLUTION

ACACIA COMMUNICATIONS

This paper describes how silicon photonic (SiPh) opto-electronic integration and packaging, with its improved RF performance, is designed to enable next-generation coherent transmission beyond 100Gbaud and provide network operators with the ability to avoid "half-step" capacity upgrades and allow them the full step upgrades they need without sacrificing reach or stranding network bandwidth when migrating from current-generation solutions.

ACACIA COMMUNICATIONS, INC.

OPTICAL SIGNAL-CONDITIONING ENABLES COHERENT MODULE TESTING

VIAVI

Today's network bandwidth demand is being enabled by advanced DSP engines. Increasing deployed bandwidth is accomplished through two factors; a pure baud rate / data rate increase per channel and an adaptability to accommodate many different and changing network topologies. To enable the flexibility required in todays network, these DSP's not only adapt in real time to a wide range of network impairments (i.e. loss, noise, distance, dispersion), but also report the values they are compensating for. This dramatically simplifies network planning and monitoring.

VIAVI

MULTIMODE FIBER IN THE ENTERPRISE - A STANDARDS UPDATE

OFS

Enterprise network customers and vendors - in fact, the entire data communications industry - benefit from interoperable, multivendor industry standards developed by the interaction and coordination between Telecommunications Industry Association (TIA) and International Electrotechnical Commission (IEC) component/fiber standards, American National Standards Institute (ANSI)/ TIA and International Organization for Standardization (ISO)/IEC structured cabling standards and Institute of Electrical and Electronics Engineers (IEEE) Ethernet and InterNational Committee for Information Technology Standards (INCITS) Fibre Channel application standards.
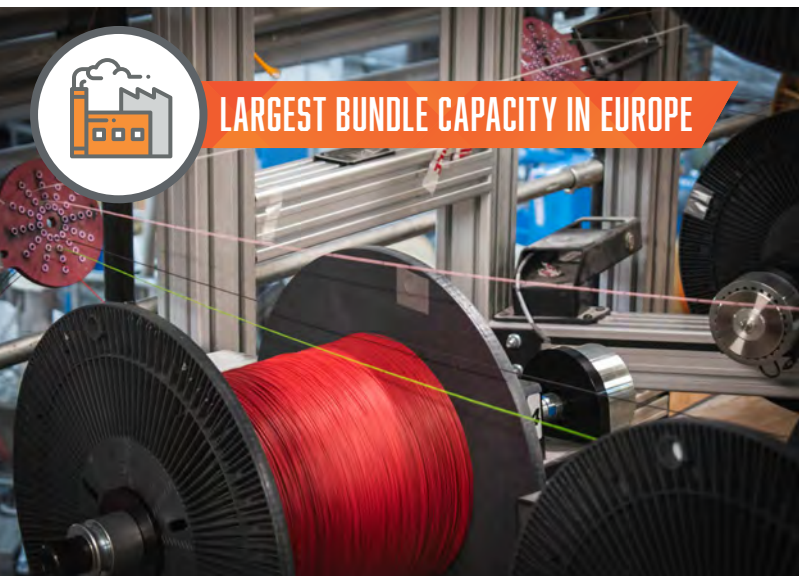
ofs — A Furukawa Company