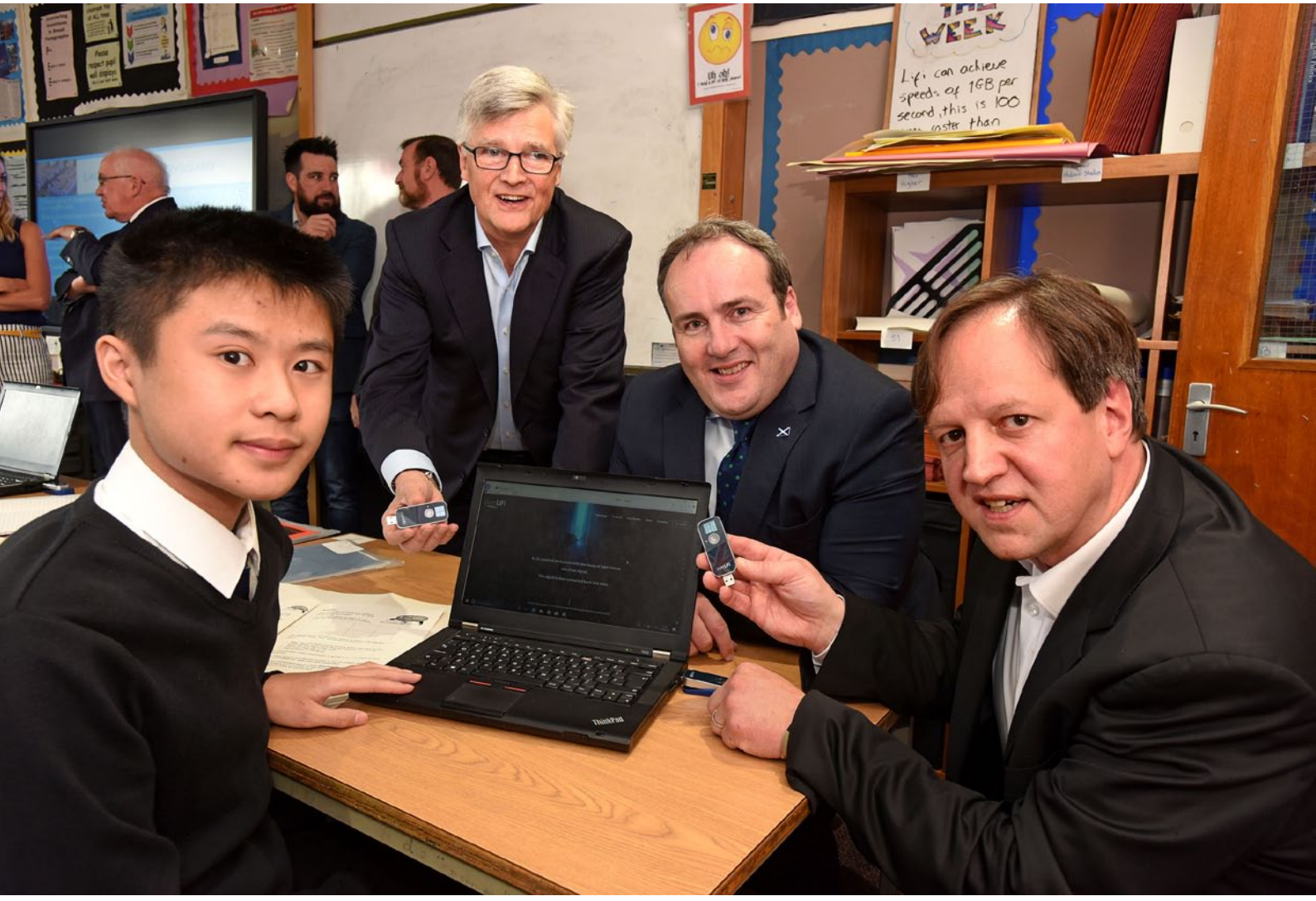
Riding the Light
Improving Bandwidth with LiFi



LIFI IS LIGHTING THE WAY TO WIRELESS LEARNING

Wireless technology has become an essential part of educational infrastructure, but the current WiFi bandwidth is coming under increasing strain with the exponential growth of wireless-enabled devices that are connected to the internet and the expansion of digital learning tools such as HD video, e-books or interactive educational games. This is set to continue as e-learning evolves to incorporate emerging technologies, like virtual reality and augmented reality, in the classroom, which require significant bandwidth. However, there is a relatively simple and tested solution at hand and that is to use light bulbs to transmit data through LiFi.

As more and more devices require wireless connection, the infrastructure is struggling to deliver enough bandwidth. Harald Haas introduces a new technology that allows data to be transmitted through light waves, enabling greater access in a cost-effective way.

WIFI IS COMING UNDER PRESSURE

WiFi has transformed the way we use devices in all aspects of life, reducing the need for wired-in computers and opening the way to a new generation of portable laptops, smartphones and tablet devices.

The figures for the growth in mobile data use are staggering. In 2016, mobile data traffic grew by 63 per cent and 60 per cent of total mobile data traffic was offloaded onto the fixed network through WiFi or femtocell, according to CISCO Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2016-2021 White Paper. It is forecast that by 2020 there will be 20 billion devices wirelessly connected to the internet. Almost 80 per cent of the wireless data is being consumed by bandwidth-hungry video for entertainment, video streaming and virtual and augmented reality.

However, the ability to access data, information and entertainment on the move through WiFi has devoured vast swathes of the available radio frequency spectrum on which it relies.

This looming spectrum crunch means that we must find an alternative to ensure wireless communications can not only continue to meet current requirements but, more importantly, the expected rise in demand in the future.

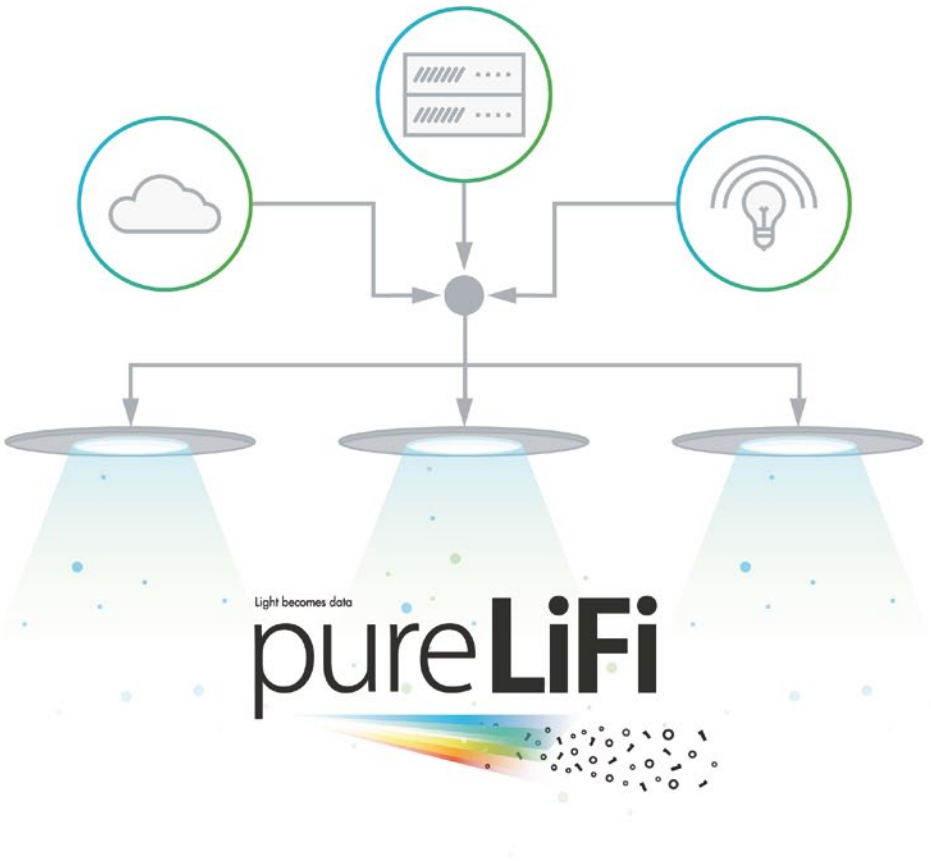
WIRELESS COMMUNICATIONS IN EDUCATION

Schools are a prime example of how wireless communication has been transformational. Two decades ago, pupils used computers in dedicated IT suites, but in the modern school, functioning without wireless is not an option.

While there is still a place for the wired-in computer, wireless-enabled devices offer greater versatility through the multi-purpose use of classrooms.

In addition to the substantial online educational resources—videos, e-books, podcasts and more—blended learning now offers the opportunity to use digital media alongside traditional teaching methods to provide students with a more personalised learning environment through independent online study and curriculum delivery via a digital platform. The development of virtual reality and artificial intelligence offers further enhancement for education. Virtual reality can enable a student to travel to different continents or time periods and experience different cultures or eras from their desks, while artificial intelligence can be used to help predict a student's individual learning needs.

All of this relies on an increasing number of wireless-enabled devices—from laptops or tablets for students to interactive whiteboards, VR headsets and TVs—with an internet connection offering high bandwidth and low latency. There is also the growth of the Internet of Things (IoT) for devices that form part of the wider school environment, such as heating systems controlled by temperature sensors, occupancy sensing for recording attendances and video surveillance monitoring that utilises AI/machine learning to enhance security. All of these devices are connected via the internet.

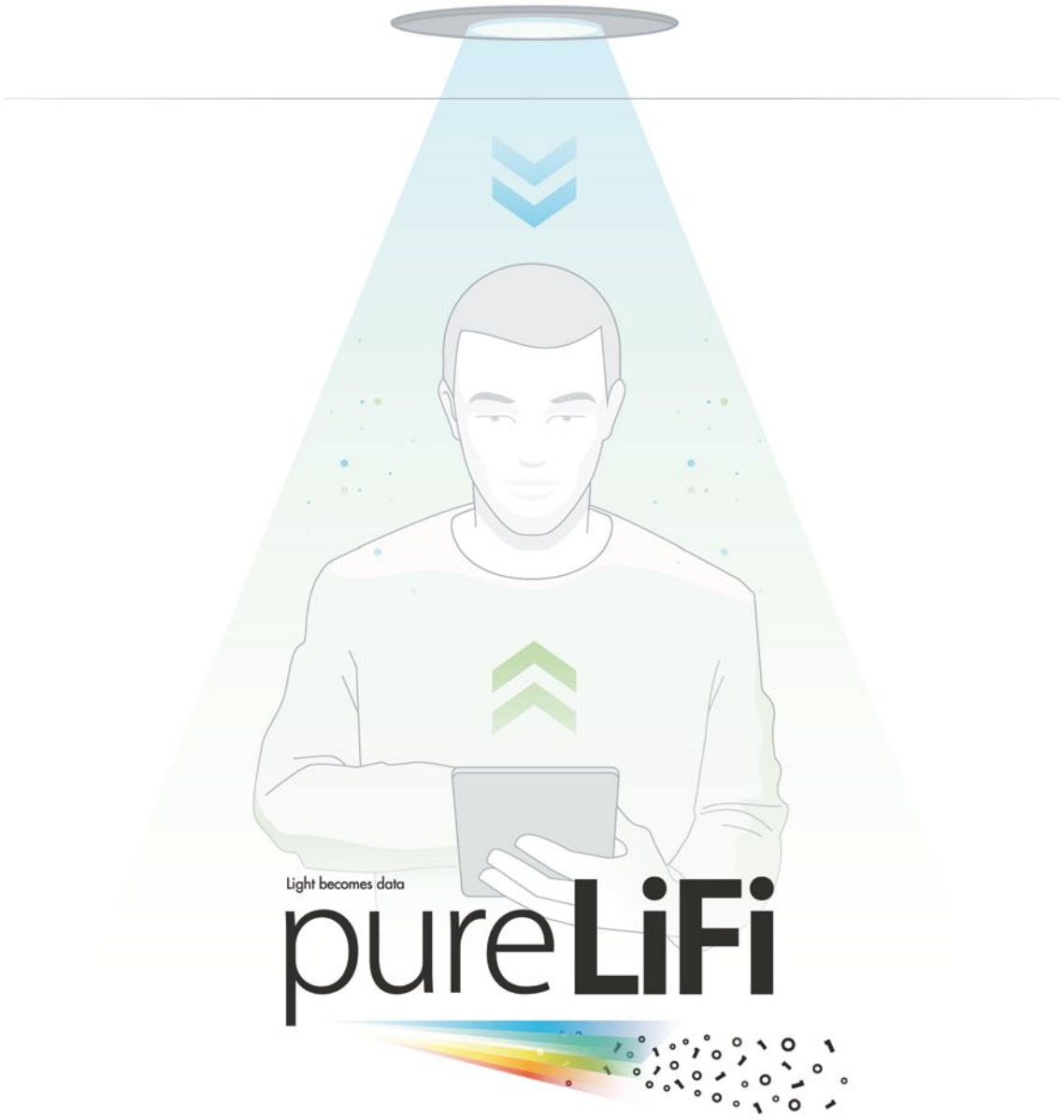


'We are pleased to support a Scottish-born company whose complementary, emerging technology has the potential to transform delivery of wireless broadband communications. The pilot trial in Kyle Academy represents a potentially very valuable contribution to our knowledge and understanding of evolving 5G technologies' – Paul Wheelhouse, MSP Minister for Energy, Connectivity and the Islands.

LIFI: THE SOLUTION FROM THE CEILING

It is against this background that schools need to start exploring options to provide greater bandwidth—while ensuring low latency and security—to be able to cater for, and benefit from, the growing number of devices and digital tools as well as cope with sudden spikes in usage when an entire class streams a video.

The solution to this can be found in the classroom ceiling—adapting existing lighting systems for LiFi to provide the next generation of high-speed wireless internet connectivity.



I coined the term ‘LiFi’ in a TedGlobal Talk in 2011, and demonstrated the transmission of a video by an ordinary LED light installed in a desk lamp. To expedite the commercialisation and widespread adoption of LiFi, in 2012, I co-founded pureLiFi as a spin out from the University of Edinburgh. But while we believe we have provided pioneering contributions to the field of optical wireless communications by introducing LiFi as wireless networking solution, we are not alone in appreciating its value: an increasing number of organisations—including blue-chip organisations—have invested in LiFi, with companies such as O2 recently announcing that they are exploring LiFi as a means of future-proofing its network as it paves the way for 5G in the UK.

The principle of using light to transmit data is well established, from the TV remote to the lasers that send data down fibre optic cables. However, LiFi enables a fibre-like experience in free space, providing almost unlimited wireless data rates. My group at the University of Edinburgh has shown that it is possible to reach 1 Terabit/second in the foreseeable future without expensive beamsteering technology—which would mean, for example, that a 5 GB video could be downloaded in 0.04 seconds.

LiFi can be installed anywhere that light bulbs are used. The same light energy used to illuminate a room can be used for communication, using the basic infrastructure to install almost limitless wireless communications capacity.

The technology uses light rather than radio waves to wirelessly transmit data, offering unprecedented bandwidth that significantly enhances the connectivity of the classroom.

It uses both the visible and non-visible (Infrared) portions of the light spectrum, which operate at much higher frequencies than the radio spectrum. The IR and Visible Light Spectrum ranges between 300 GHz and 770 THz, while the Radio Frequency spectrum ranges from 3 kHz to 300 GHz.

This massive range of light spectrum in comparison to radio spectrum is what enables the far greater LiFi bandwidth, which is 2,600 times greater than the bandwidth with radio.

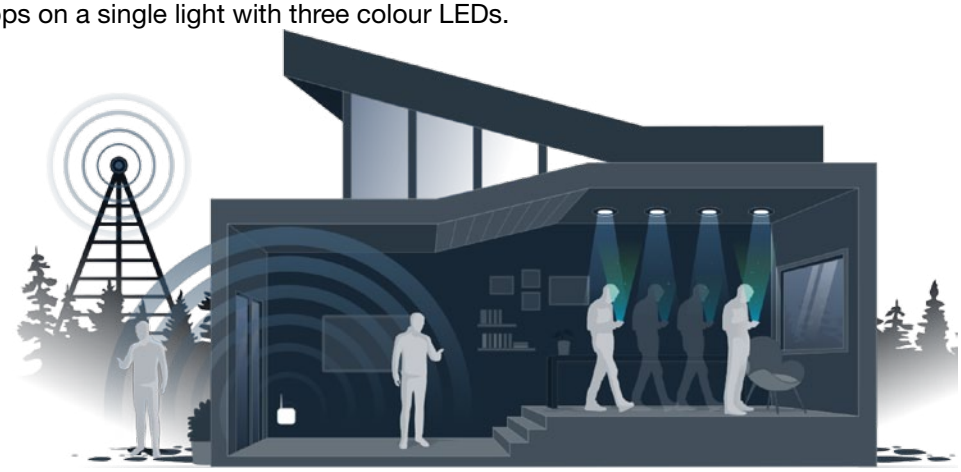
The light modulates at extremely high frequencies undetectable to the human eye, allowing the high-speed transmission of data.

It is bidirectional, which means that it can send and receive information. Bidirectional communication, or two-way communication, is a fundamental requirement for using the internet. This feature is what allows us to interact with the internet, calling up a website by sending data and streaming a video by receiving data.

The system works by installing an LED with a digital signal processor that is connected to a network or server. The LED/luminaire then converts the digital signal into an optical signal that is transmitted to a device with a photoreceptor, and which also has an infrared LED to transmit data back to the luminaire and the network. It works with LED lights and can be used with many off-the-shelf LEDs. As LiFi becomes more widely used, the technology will be embedded in all mobile devices.

'LiFi was born in Scotland at a TED Global talk that I presented in 2011. Seven years later, I am absolutely thrilled to see true LiFi deployed for the first time in a school in Scotland. Connectivity has become a basic need to enable prosperity. This world's first pilot not only offers secure connectivity in a school, but hopefully inspires the next generation to join us in innovating for humanity and prosperity' – Professor Harald Haas of University of Edinburgh and co-founder of pureLiFi.

When it comes to speed, this rapidly maturing technology shows great promise. Older versions of WiFi specify rates of up to 54 Mbps, while newer standards such as 802.11ac can extend these to 1 Gbps. Likewise, the 802.11ad can achieve rates of up to 7 Gbps and it uses very high frequencies in the 60 GHz range. My research group in collaboration with Prof Dawson (University of Strathclyde) have already demonstrated data rates of more than 10 Gbps on a single micro-LED, translating to theoretical rates of up to 30 Gbps on a single light with three colour LEDs.



ONE OF THE WORLD'S FIRST LIFI SCHOOLS

At pureLiFi, we have worked on trials with more than 100 organisations in 23 countries in sectors including telecommunications, engineering, disaster response and defence.

In August, Kyle Academy became the first school in the UK to benefit from fully-networked and mobile LiFi.

The school hosted a project that showed how LiFi can be used in practice, with pureLiFi and the LiFi Research and Development Centre at the University of Edinburgh providing resources for the pilot scheme with hands-on support and subsequent testing.

The project was overseen by Scottish Futures Trust, which supports the Scottish Government's Digital Strategy.

The installation at Kyle Academy used eight LiFi-enabled LED light bulbs in the ceiling and students were given access to LiFi-XC Stations or dongles

that plug into their laptops, enabling high-speed connectivity through the lights.

The students in the LiFi classroom were able to use LiFi to download videos and course content, while students in neighbouring classrooms were able to use WiFi more reliably because LiFi significantly relieved pressure on existing radio frequency bandwidth.

BRIGHT FUTURE FOR WIRELESS

LiFi should not be seen as a replacement for WiFi, but as a complementary and additive technology that can provide wireless communications where WiFi is lacking, weak or unsecure by relieving the strain on the existing system and enhancing speeds, reliability and security.

The user experience of both is similar. LiFi can be fully networked across rooms, corridors and buildings, allowing fast and seamless handover between lights as users move around, and it has the ability to work outdoors, even in bright sunlight, as the modulated light can still be detected. LiFi can also be used in the dark by switching to the infrared spectrum. pureLiFi is also working with partners to ensure that there is a seamless handover between LiFi and WiFi.

The work done by pureLiFi and successful projects such as the Kyle Academy scheme have shown how the technology can transform the mobile communications experience. There is a bright future for LiFi as it evolves into a mass-market technology and offers a viable option for enabling education establishments to benefit from the significant digital resources already available today.

Professor Harald Haas is the Co-founder & Chief Scientific Officer of pureLiFi Ltd and the Director of the LiFi Research and Development Centre at the University of Edinburgh. He pioneered research into LiFi and was first to introduce the term, which was listed among the 50 best inventions in TIME Magazine in 2011.

For further information on this technology, check out these videos:

How Does LiFi Work? www.youtube.com/watch?v=AKvvEqm9Nv4

Ted Talk with Harald Haas: Wireless data from every light bulb www.youtube.com/watch?v=NaoSp4NpkGg