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HIGH-SPEED CONNECTIVITY

OPTICAL FIBER, EDUCATION AND THE DEVELOPING WORLD

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Humans have an instinctive need to communicate with each other. Some of the most poignant scenes from the pandemic have been of family members and friends waving at each other through windows or neighbors holding up signs on their balconies. Stowed away in our homes, there is the looming reality that we rely on the internet to connect beyond those windows and balconies. What makes this connectivity possible — which we also hope is at a high speed — is light.

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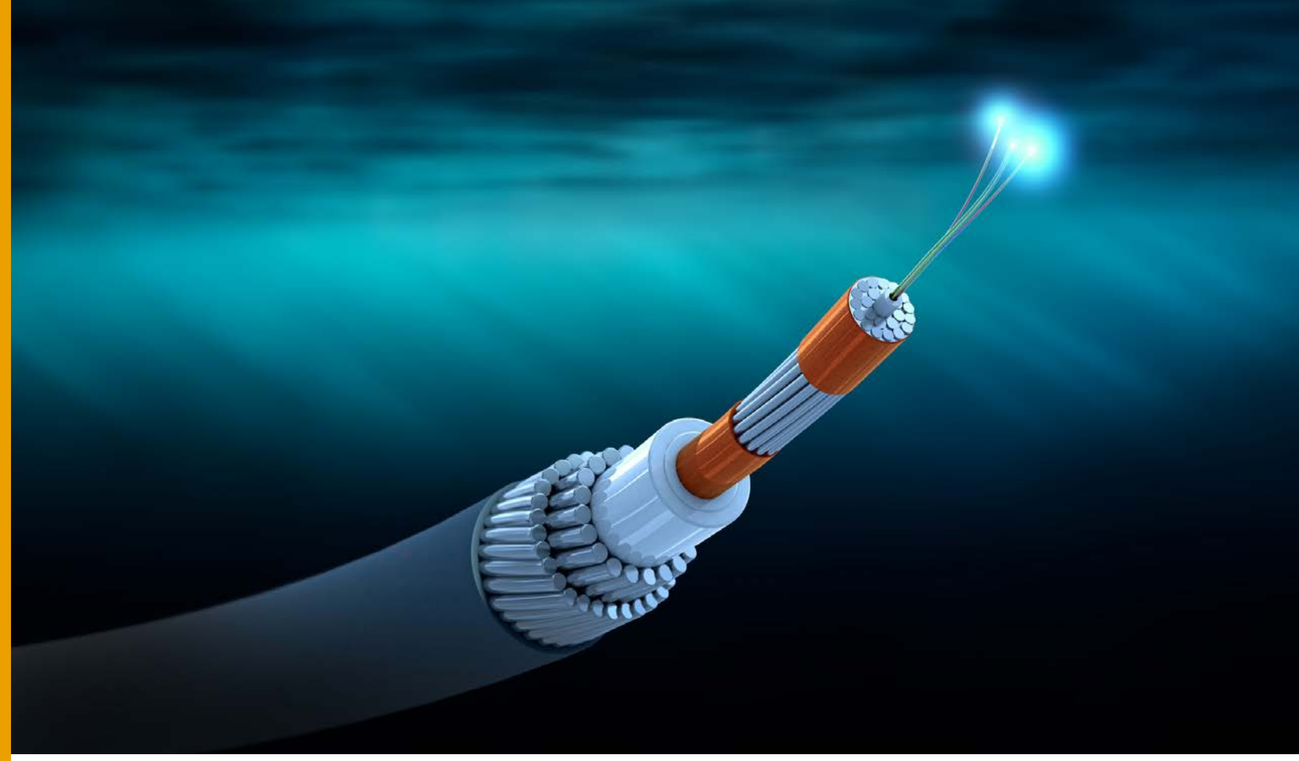

Even though we think of light as visual, it increasingly transmits the sound of the human voice. Over the last half-century, scientists have discovered how to make thin and incredibly pure glass fibers. They've also discovered how to transmit light through them, which is what we call optical fiber/fiber optics. Because of this technology, the world has become connected together with optical network cables that transmit vast volumes of information around the planet.

Although the space age of the 1960s ushered the era of telecommunications satellites bouncing radio signals across continents, today's long-distance telephone calls and social-media chatter are much more likely to arrive via optical fiber communications. Since the first transatlantic optical fiber cable went online in 1988, companies and countries have collaborated in assembling many more data pipelines, including the planned Pacific Light Cable Network, which will carry 120 trillion bits of data per second between Los Angeles, USA, and Hong Kong, China.

But what about the nations like my own Pakistan that are often called, economically speaking, "developing nations"? Are we participating in the worldwide connectivity revolution of the last few decades? Although developing nations vary widely due to wealth, population distribution, topography, and geographic isolation, they are racing to catch up and bridge the digital gap. However, it's times like our current situation when we are weathering a pandemic that the digital gap for high-speed connectivity seems especially wide, particularly with regards to education.

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OFFERING LIGHT-BASED SOLUTIONS AND TELECOMMUNICATIONS IN THE DEVELOPING WORLD

Optical fiber is what enables wireless communication, which has become one of the most important mediums of transmission of information between devices. In this technology, electromagnetic waves transmit information through the air without requiring any cable or wires or other conducting materials.

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Although cellular phones don't need cables or wires for you to receive calls and texts, the towers that deliver these signals must be connected to the larger communications networks. This means optical fiber cables can transmit information faster and with less environmental impact and maintenance than copper wires. Several kilometers of optical fiber can be manufactured at a much less cost than the same length of copper wire, however, optical fiber loses less signal along the way than copper wire. Unlike electrical signals transmitted in copper wires, light signals from one fiber -to not interfere with those of other fibers.

The more robust the optical network is, the more wireless connectivity is available. You can guess that developing nations would not have as much connectivity. If we look at Pakistan, in South Asia with a population of 212 million people, we see optical fiber backbones between major cities, yet many rural areas that still lack wireless or fixed signals.

Out of the estimated population (212 million), Pakistan has more than 140 million cellular subscribers, The nation also has around 45 million 3G/4G subscribers, more than 3 million fixed local line subscribers and approximately 48 million broadband subscribers. Compare this to the United States, which has a staggering 422 million cellular-service accounts for a population of only 329 million – more devices than people.

Pakistan is investing in its infrastructure to handle the growing demand for internet. Over the last 10 years, one of the companies, Multinet, has constructed a 12,000-km, multi-layered optical fiber network that spans more than 120 cities across Pakistan. For international connectivity, the nation participates in the Pakistan-China Fiber Optic Project, which is an 820-km-long optical fiber cable constructed between the Khunjerab Pass on the China-Pakistan border and the city of Rawalpindi. However, it's still not enough to catch up to developed nations, so a model that may work is banding together like the International Telecommunication Union's "moonshot" to double Africa's internet connectivity by 2021 and to provide universal access by 2030.

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LIGHT AND EDUCATION: MAKING THE HIGH-SPEED CONNECTION

As many of us are now experiencing globally, high-speed connectivity can greatly increases access to everything- including education. Many education programs are “going virtual”. Ironically, since 2002, Pakistan has had a virtual university that delivers video lectures on TV channels. Students have been able follow these lectures – unless they don’t have televisions at home.

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During the COVID-19 pandemic, Pakistan’s government-operated broadcaster has just started a daytime educational television channel. Although the network reaches throughout the country, most middle-class households can afford just one television for the whole family, and students must compete with other family members for viewing time.

Other programs in Pakistan are attempting to go virtual too. A couple universities in the country’s major cities and the majority of private schools are using cloud-based video-conferencing to instruct students quarantined at home. However, for most of the government-run schools, which have many more students than the private schools, the free-of-charge level of video-conferencing is insufficient to reach all students studying in a particular class. Even if the schools can arrange for some way to pay for a higher level of service, the same challenge as with our virtual university and broadcasted education program remains.

Many developing countries, including Pakistan, have made great strides towards the high-speed communications infrastructure needed for remote learning, but there are still many hurdles exacerbated by our current crisis:

1. In many cases, the internet is available, a device to access it isn’t. Without a computer, tablet or smartphone, they can’t learn at home.
2. Some students are too far from repeating towers and have no signal at all, and thus more infrastructure is needed.
3. In some countries, plans to access the internet are priced beyond the financial reach of many families.

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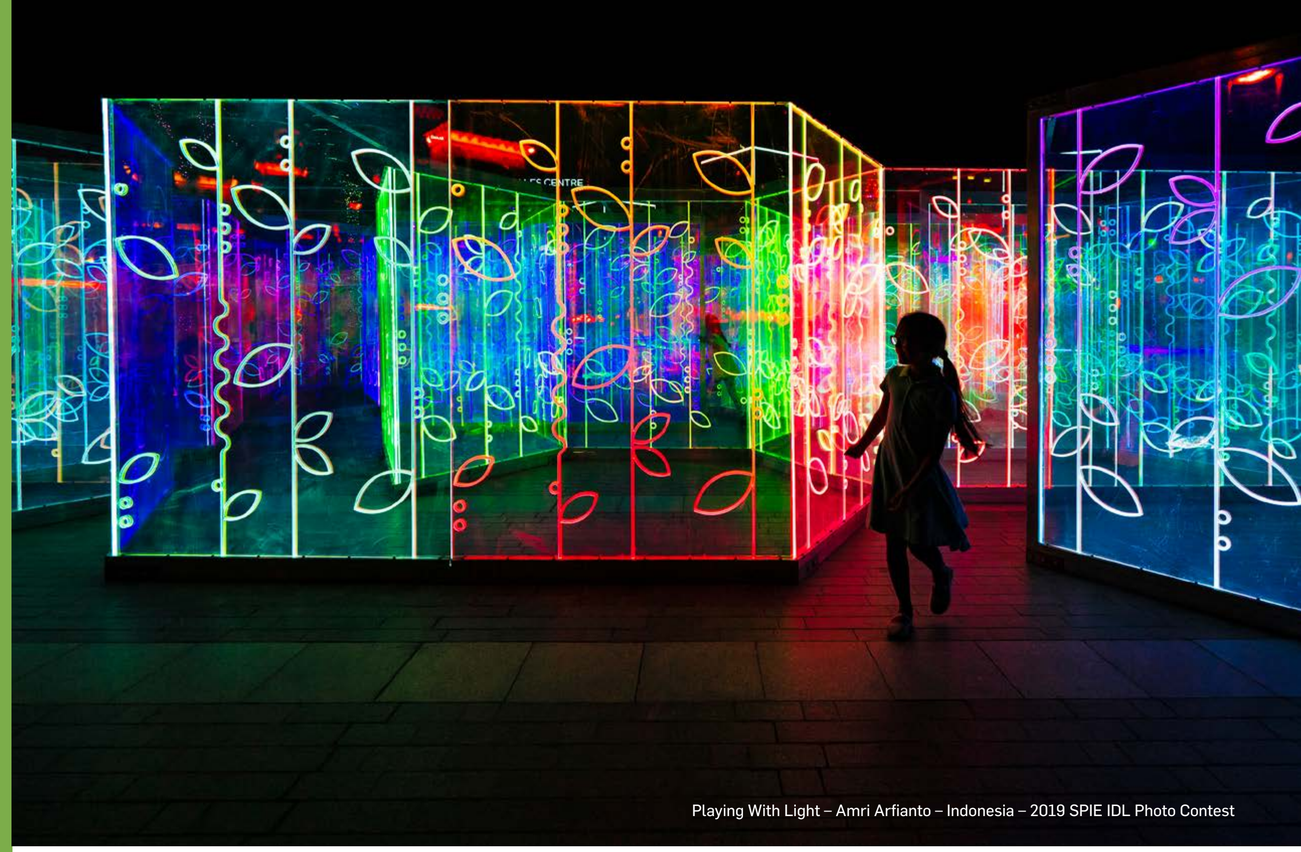
SOURCES OF HOPE: OTHER LIGHT-BASED SOLUTIONS FOR EDUCATION



Playing With Light – Amri Arfianto – Indonesia – 2019 SPIE IDL Photo Contest

Light-based technologies have also revolutionized the displays and computer systems needed to access the internet. From sophisticated manufacturing processes that etch tiny circuitry into silicon wafers to make computer chips, to the LED pixels that light up smartphone display screens, todays' devices are smaller, cheaper and more powerful because of the science of light and light-based technologies.

In addition to enabling the internet and user access to it, there are solutions to powering the telecommunications network. All of the devices connected to it all run on electricity – which sunlight can provide. Photovoltaic solar-panel farms generate safe, clean, renewable electricity to power the telecom infrastructure. Pakistan's Punjab province has such an installation, called Quaid-i-Azam Solar Park, producing 100 MW. Pakistan gets about 7 percent of its electricity needs from renewable sources, and renewable electricity is an area where both the developed and developing nations are expected to grow.

Solid-state indoor lighting with LED lamps is another light-based technology that can help people study safely at night. It may be hard to imagine for some, but there are places are only beginning to gain access to other lighting besides candles and kerosene lamps. These inefficient, flame-based lighting sources create pollution and possibly health problems later in life. As the cost of solar panels goes down and LED lighting becomes commonplace, remote communities where the cost of delivering electricity is high, may see an alternative of solar-panel farms to power their lights, computers, and other devices – all enabled by innovation in the light-based technology.

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LOOKING TO THE FUTURE

In a remarkably short time, we have witnessed amazing technological innovation from PCs to smartphones, from tablets to wearable devices, and from video-game cartridges to streaming movies. As we look back at the amazing invention of optical fiber and its enabling impact on all of these tools, apps and devices we rely on, it's fun to imagine what might be next. For example, Li-Fi is a relatively new type of visible light communication that encodes data signals in the beam from a LED light.

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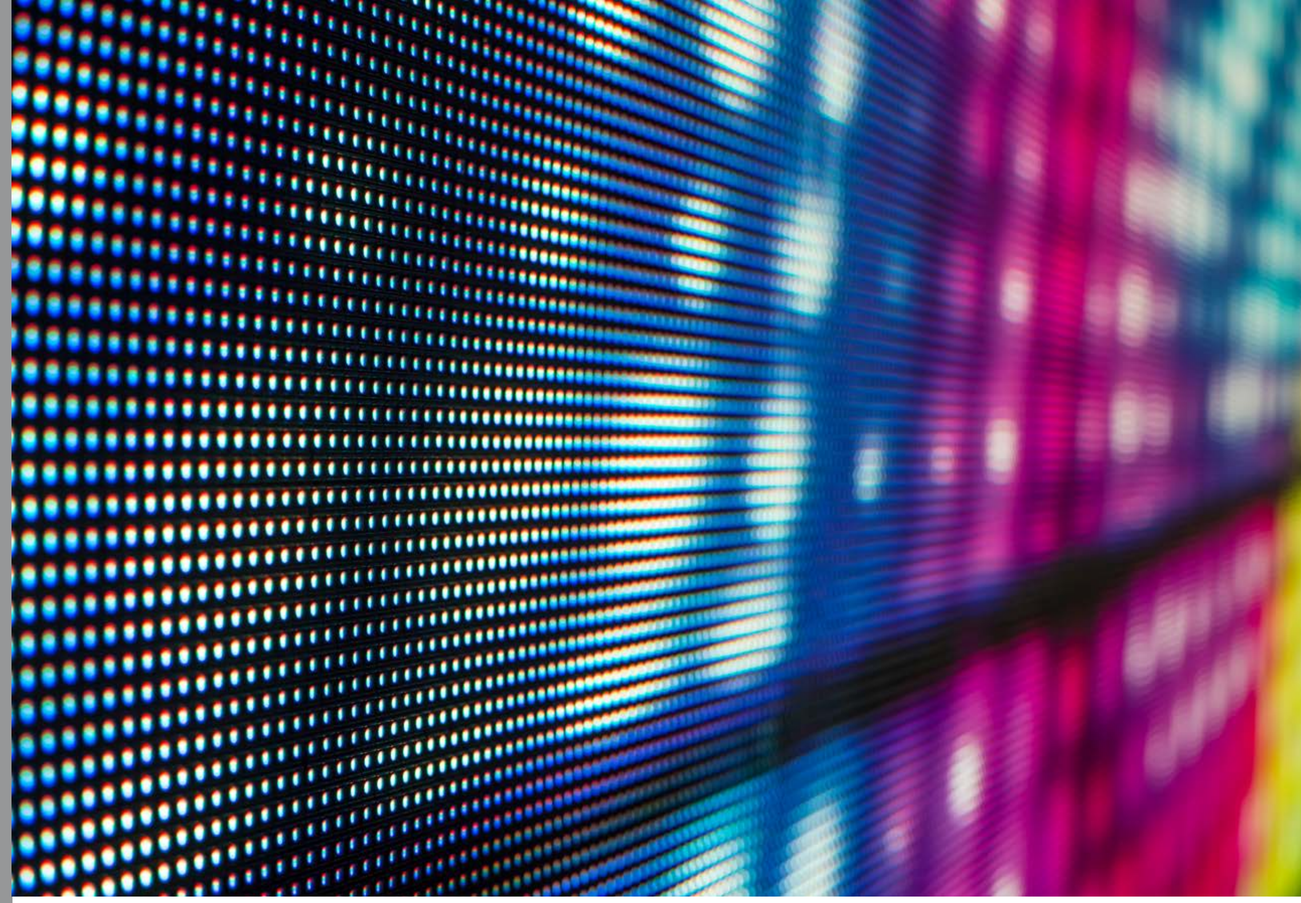

Li-Fi can't pass through walls the way radio-frequency wireless signals can, but the technology can send a focused data beam to the device of a person flying as an airline passenger, sitting in a classroom, or dining in a restaurant. Other light-based technologies such as optical sensors and miniaturized cameras will connect to form not just "Internet of Things" homes, but smart neighborhoods and even smart cities.

A future where all can benefit from these new technologies depends on access. Global internet traffic is expected to increase drastically, with 28 billion devices connecting to the information network and 12 billion of them mobile devices in the next two years. Investment in optical fiber infrastructure and the science of light will improve access to high-speed connectivity for all nations.

This access is essential to seeing a prosperous future in an age where the ability to stay connected impacts education.

Through light-based solutions, we can hope that connectivity in developing nations may not be so different from the rest of the world.