iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 Issue: XII Month of publication: December 2023

DOI: https://doi.org/10.22214/ijraset.2023.57798

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue XII Dec 2023- Available at www.ijraset.com

The Role of 5 G in Optical Fiber

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Abstract: Connected society and people is a vision nursed and promoted by most business and social enterprises for several years. This is supported aptly by 5G networks. 5G is one of the most advanced wireless technologies that assure ultra-low latency and swift data delivery. Unlike 3G and 4G networks, the 5G uses a different set of frequencies to deliver services. It uses Sub-6-GHz worldwide for mobile connectivity and 24 GHz for high-bandwidth coverage. In 4G networks, small number of macro cells was employed to cover one square mile. However, in 5G, many microcells are used to cover a square mile. The deployment would vary on a case-to-case basis, but a 1:600 ratio assures a new level of densification. Optical fiber is the new choice for connecting this dense mesh of 5G microcells. Why is it so?

I. A BRIEF INTRODUCTION TO FIBER OPTICS

Fiber optics, also known as optical fiber, is the technology where information is transmitted in light pulses across plastic or glass fiber. A fiber optic cable may comprise a few hundred glass or plastic fibers in its core. These fibers are surrounded by another layer of glass known as cladding. The cladding is further protected by a buffer tube and an additional jacket layer protects the individual strands. The cladding and the fiber optic core both have different refractive indices. The light bends at certain angles when it passes through these areas. This light bending occurs in a zigzags pattern, which is known as total internal reflection. The light signals travel 30% slower than light speed due to denser layers of glass or plastic fibers. Repeaters are used at distant intervals to boost the signal strength in fiber optics transmission. These repeaters regenerate the optical signals through series of conversions and transmissions. Fiber optic cables are known to support up to 10 Gbps. These fiber optic cables are distinguished into single-mode fiber and multimode fiber based on the type of fiber used.

1) *Single-mode Fiber:* These cables have a glass fiber core of small diameter, which helps prevent the possibility of attenuation. This enables the signals to travel long distances.
2) *Multimode Fiber:* These cables possess large glass fiber core and light signals bounce multiple times when passing through them. This bouncing introduces attenuation, which is a reduction in signal strength. This attenuation also means a high possibility for signal loss, interference, and soon.

A. Why Fiber Optics have Gained Popularity over Copper Cables

Fiber optics has been around for a while and has been an integral part of several fast-expanding networks. The following reasons make them popular over copper cables.

1) These cables can support high bandwidths.
2) They support high data transmission
3) There is minimal power loss across long distances.
4) Fiber optic cables are immune to electromagnetic interference and their security cannot be compromised easily.
5) They remain unaffected by electrical noise.
6) Fiber optic cables comprise no metallic conductors, which makes them more corrosion-resistant than copper cables.
7) They have longer life spans than copper cables.

B. Why is Fiber Optic Networks preferred in 5G?

A 5G Operator Survey released by the Telecommunications Industry in 2017 states that fiber is important for the backhaul of 5G networks. The same survey reported that many companies will be embracing 5G by 2020 and the demand for fiber optics in such networks will increase. The following reasons substantiate the increasing demand for fiber optics in 5G.

1) *Increasing Focus on Data Transmission:* 5G supports many modern technologies such as IoT, big data, and 400G. All these technologies produce humongous data and depend on real-time data collection and transmission. Nowadays, most businesses rely on these technologies for their business decisions. Thus, high bandwidth and low latency is needed for quick data transfer. Fiber optic cables meet these requirements easily.

2) *High Radio Frequencies:* 5G requires high frequencies for handling large amounts of data. These high frequencies are operable for short distance ranges. However, to support multigigabit data transfer, these networks require several small cells covering small areas. These cells redistribute the signals through the air or directly across a vast area. The cells draw these signals from cellular carriers. Based on the application, these cells may be sized as small cells, cloud RAN (CRAN), distributed antenna systems (DAN), enterprise radio access networks (RAN), and femato cells. Fiber optics support high frequencies and can handle high amounts of data while assuring scalabilityandsecurity.
3) *High Network Availability:* With businesses going digital, high-speed network availability is now a necessity. Nowadays, people and businesses both use a large number of devices. Some of these devices are operated by people, while others operate on auto-pilot mode. These devices are connected to the network and operate independently. By using fiber optics in the networks, businesses can leverage capacity levels and improve bandwidth assured by 5G.

II. HOW OPTICAL NETWORKS ARE ENABLING THE 5G ADVANTAGE

The fifth generation of broadband cellular network technology (5G) offers a more than tenfold increase in speed compared to 4G. It handles a wider variety of devices, provides greater reliability, and operates with lower latency. These benefits signal why 5G services will reach $600 billion in global revenue by 2026, according to a study from Juniper Research.

Photonics-related hardware innovations plus software advancements enable the 5G rollout by improving optical network performance. In these networks, indium phosphate or indium gallium arsenide lasers send modulated beams, centered on wavelengths of 1310 or 1550 nm, down single-mode optical fibers over distances of a few kilometers or tens of kilometers. At the other end of the fiber, detectors and associated gear decode the signal. Typically, suppliers package the source and the detector together into a transceiver. Increasing the transmission rate involves faster transceiver modulation, more complex encoding, or a combination of the two.

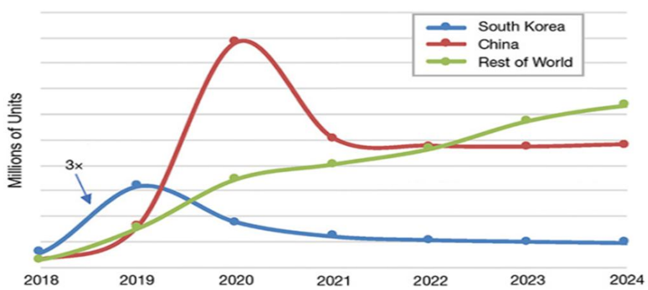

Fig-1.Shipments of high-speed optical transceivers. These devices support transmissions >10 Gbits/s to the cell tower, or they may support fronthaul transmissions. Figures for South Korea are multiplied 3× to improve visibility. Courtesy of LightCounting.

The 5G rollout is happening across live global networks, which presents a challenge for carriers, according to Markus Forester, head of product management at transmission technology supplier Pan Decoma Direct. There may be five mobile operator nodes in a tower, resulting in a bandwidth demand up to 125 Gbits/s. This demand occurs in addition to the demand from existing 4G traffic, and all of this data often moves over existing fiber infrastructure.

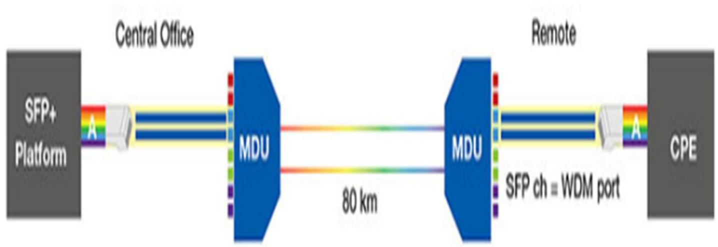

Fig-2.The basic operation of autotunable optics.

When signaling to each other, optical transceivers automatically adjust their wavelength without the aid of an engineer. SFP: small form factor pluggable; MDU: mux/demux unit; CPE: customer premises equipment; WDM: wavelength division multiplexing.

III. WHY 5G IS DIFFERENT

5G enables the vision of a truly connected society with its impact being felt across virtually every industry. The Internet of Things (IoT) will transform the economy and the way we live our lives. 5G will similarly change and create new economic opportunities.

1) 5G Smart buildings/cities/communities will provide more efficient services to citizens, increase collaboration among different economic sectors, and encourage innovative business models in both private and public sectors.
2) In healthcare, 5G will enable virtual medicine to substantially increase the effectiveness of preventative care, as well as robotic surgery.
3) Autonomous vehicles will help make transportation safer, parking easier, and improve traffic flow and congestion.

The opportunities above depend heavily on real-time data, and the need for lower latency and higher bandwidth becomes much more critical. This, in turn, drives the need for edge computing to enable critical data to be transferred quickly.

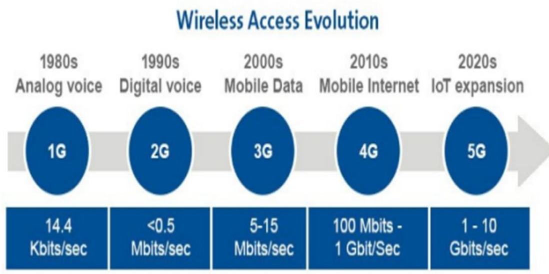

Fig-3.Cellular capabilities have gone from analog voice, at 14.4 kbits/ec, to the promise of Internet of Things connectivity at multiple gigabits per second. The next step in wireless access evolution, to 5G, will be vastly different from previous steps.

The early development of cellular networks leveraged macro towers using lower-wavelength spectr4um capable of covering wide physical areas, positioning some up to 25 miles apart (if topology allowed). Towers, however, couldn't be placed everywhere, and small cells and radio heads were increasingly deployed to get the radio closer to the user.

Small cells began to augment coverage and capacity in both 3G and 4G deployments, the term "densification" was introduced. With 5G, unlike its predecessors, a different set of frequencies will be used to implement new services. Sub-6-GHz will be used worldwide as the basis for city-wide mobile connectivity, while higher parts of the spectrum (millimeter wave frequencies of 24 GHz and above) will be used for high-bandwidth coverage. This new higher-band spectrum inherently has more significant distance coverage limitation. Thus, densification takes on an entirely new meaning.

As the figure "Current 4G vs. future 5G networks" shows, the range of a typical 4G macro cell today can theoretically cover 10 square miles. The plans for 5G have as many as 60 small cells covering just one square mile. Actual deployment needs would vary, but a 1:600 ratio is a whole new level of densification to consider.

Optical fiber is the preferred medium for existing wireless backhaul networks, and even in networks where this is not the case, the wireless backhaul eventually needs to connect into a fiber backhaul. Fiber will also be preferred for what is known as "fronthaul," connecting the dense mesh of 5G small cells. Why is this? Increased speeds with lower attenuation, immunity to electromagnetic interference, small size, and virtually unlimited bandwidth potential are among the many reasons why fiber is the right choice. The question becomes, "How many fibers are needed to support each cell?" And the answer will depend primarily on what technology protocols will be employed. Using our 60-cells-per-square-mile example, some estimates suggest the opportunities that will come from 5G depend heavily on real-time data, making lower latency and higher bandwidth more critical than ever. 8 miles of fiber cable would be needed to connect them. But wait, we need more information...

Today, many operators are using the Common Public Radio Interface (CPRI) protocol for radio heads on macro towers to support a wide variety of cellular services (2G, 3G and 4G/LTE). Traditionally, each sector and each band received a dedicated pair (one fiber each for transmitting and receiving data); operators could drop 24 or 36 fibers at a cell site and feel confident they had room to grow capacity at that location.

Operators will need to decide on retaining point-to-point dedicated net-works and protocols or opting to employ wave division multiplexed (WDM) solutions to lower the fiber count needs.

With a WDM solution, the same macro tower previously described could be serviced with only two fibers. There are tradeoffs with either method, and individual circumstances may lead to different decisions.

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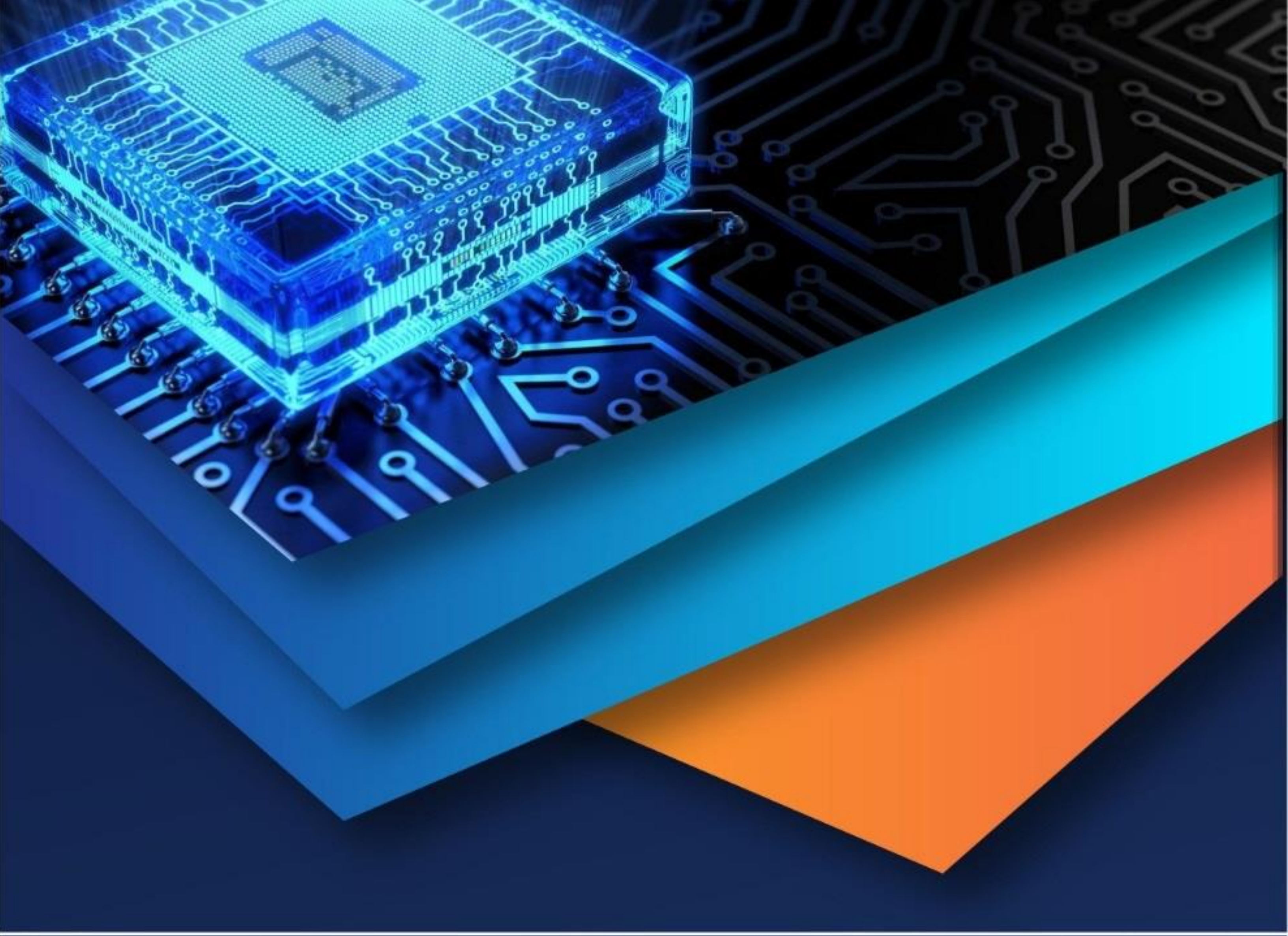

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