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# Survey on FTTA and FTTB to Improve Performance of Mobile Networks

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***Abstract*** **- The continuous pursuit to improve the cellular communication networks lead to fit the huge demand of high data rates for the users. This paper reviews the Fiber To The Antenna (FTTA) and Fiber To The Base Station (FTTB) techniques as the ideal and best solutions in the world of modern communications. These techniques characterized by several features that gives a very positive addition to the existing networks, that is because the fiber optic technology has very wide bandwidth , higher data rates , very low power loss, and it is the main component of FTTA and FTTB solutions as well as it's avoid many defects which causing several prospective problems such as complexities in installation, limited development and costly consumption. When the comparison had done between the traditional system and the developed system , the differences was clear and large among them in favor of the developed system, here is also the explanation why and how fiber optic technologies are used efficiently in 4G networks, through reviews the advantages , challenges and the ways to overcome it in the FTTA and FTTB solutions.**

***Index Terms*** **- FTTA, FTTB, Integrated Optical and Wireless Network.**

## I. INTRODUCTION

The technical developments in the recent telecommunication world have been rapid, where communications have permeated in most of the daily life applications, which cause increasing demand on the huge capacity and higher data rate in order to have high efficiency and quality of services for all users around the world.

Originally the mobile systems have been designed for Circuit Switched (CS) voice traffic. Then after that it is developed and modernized towards the Packet Switched (PS) domain, to cover the continues demand for mobile data services such as mobile Internet access ,video streaming, gaming, navigation, banking, or IPTV. Fig.1 shows the trend of huge increase of user data rates in communication systems during one decade [1].

Here came the trend to introduce highly efficient a new elements in terms of data transfer speed with less interference, less noise , lower power consumption and lower cost. In addition to flexibility and high scalability according to the needs of the network.

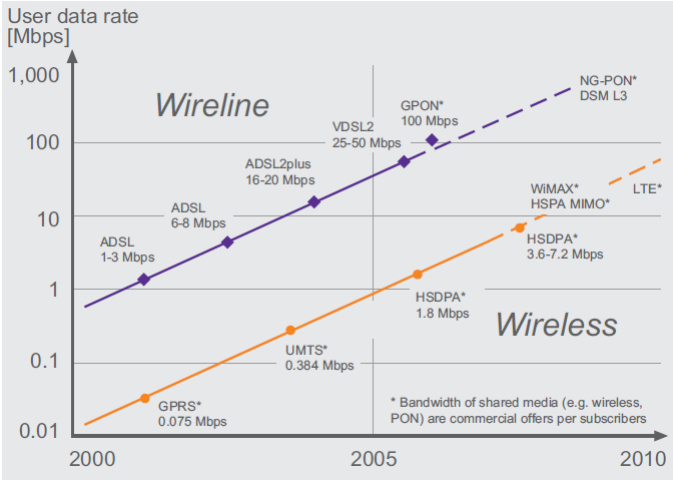


Figure.1. Increasing data rates in fixed and mobile services[1].

The optical fiber system currently considered the most suitable compared to the systems used recently. Fiber optics play an important role as ideal alternatives to traditional modes of data transport with limited potential , as it can easily be integrated into existing systems without complications. Therefore it is the first and best solution among all the available solutions so far.

## II- CLASICAL ARCHITECTURE OF MOBILE NETWORK SYSTEM.

In traditional method, coaxial cables are the medium, connecting the base station on the ground to an antenna on the tower, and used for transmitting high-frequency radio signals. Generally, almost 35% of the signal power is lost in coaxial cables (7/8 ") having a length of 30m and around 50 % of the


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signal can be degraded before the signal is even transmitted by the antenna [2]. As result of these losses, a deterioration of the transmission power occurs, which cause a reduction of the reception signal quality due to increased signal noise.

The radio communication system is mainly related to the Radio Frequency (RF) component, and is relied upon as a means of transferring data through the carrier air medium. That is why it has been still present during all successive developments. As they operate in a traditional composition based on coaxial cables as means of transport which leads to significant energy consumption that should be minimized as much as possible. The Radio Base Station (RBS) transmit the RF signals from the Base Station (BS) to the antenna through the coaxial cables mounted on a mast 30 to 100 meters above the base station [3].

The RBS architecture consist of several components such as Base Band Unit (BBU), signal power amplifier, RF filter, radio signal modulator as well as transmitter and receiver antenna as in Fig. 2 .

The whole control operations and base band signal processing are executed here. Before transmitting the signal to the antenna, the RBS modulates the data signals into allocated high-frequency band and consequently amplify the power of the modulated signals

Then , the output signals are transmitted via coaxial cables to the Tower Mounted Amplifier (TMA) from where the re-amplified signals are sent to antenna through coaxial jumper cables ,then the signals are radiated into free space.

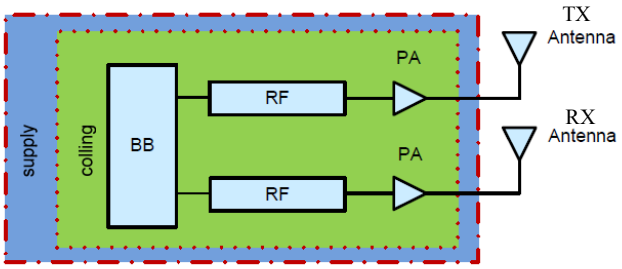


Figure.2. The classical architecture of RBS.

On the other hand, RBS is connected to the Base Stations Controller (BSC) via the microwave system, which have problems with limited capacity and distance that leads to less of flexibility and scalability infrastructure as illustrates in Fig. 3 .

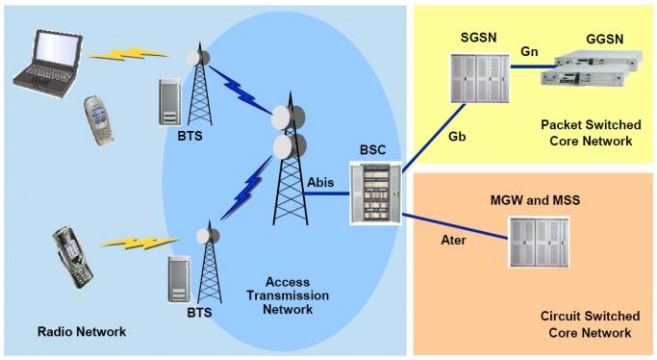


Figure.3. the classical architecture of mobile network system

## III- FIBER TO THE ANTENNA SOLUTION.

To get huge enhancements to the network performance , flexibility , speed and mobility, while reducing infrastructure and operating costs , will resort to FTTA as integrated solution for optical and wireless networks, furthermore, it can be easily eliminates the requirement of massive feeder cables from the Base Transceiver Station (BTS) to the antenna, and within the antenna itself, by replacing them with an optical feeds.

This solution is evolving, as continue increase of requirements of the data content and speed in the 4$^{th}$ generation (4G) communication systems. FTTA has served as an enabling architecture for the deployment of 4G mobile communications systems and later 5G.

In this part, will be review FTTA architecture, physical components, benefits and challenges.

### *A. Architecture of FTTA*

The evolved idea of new architecture of FTTA is based on insertion a new separated units as Remote Radio Unit (RRU) and BBU, where it is instead of one BS unit which performing all functions and interfacing to both the backhaul network and the antennas via coaxial cables . The separation of power and signal components from the BS to a smaller BBU at the bottom of the tower and multiple fiber feed RRUs at the top of the tower , as shown in Fig. 4. Fiber cables replace coaxial feeders running up the tower and their relocation to the top of the tower mast in RRU's.


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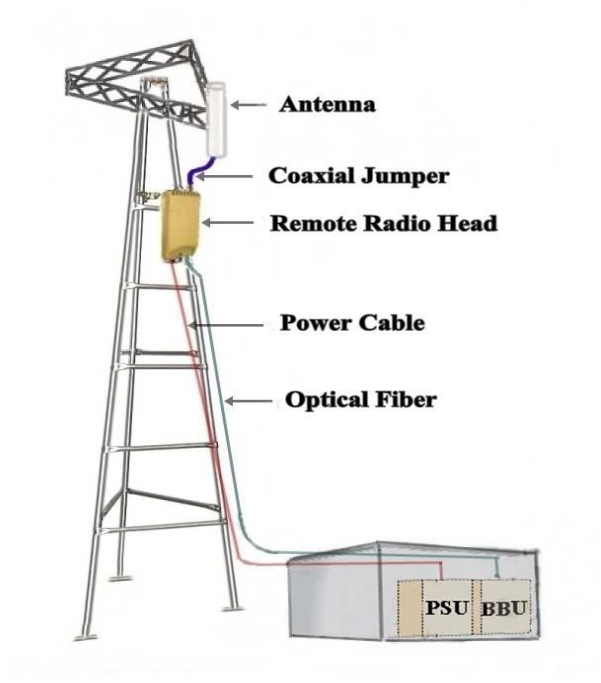


Figure.4. the architecture of FTTA.

This separation has allowed cell tower operators to comply with the performance requirements of 4G systems, created a smaller and greener footprint for the reconfigured BS, led to a reduced power, cost, and paradigm weight for the overall tower structure. The main component of this architecture are BBU, RRU, Hyper Cables , and coaxial jumper cables .

1)The Base Band Unit.

BBU is the common and fundamental unit that related between the FTTA and FTTB technologies where the BBU performs first step of digital processing of the baseband signals and delivered to RRU as part of FTTA architecture along with performing all functions of other side BSC as part of FTTB architecture.

2)The Remote Radio Unit.

The RRU consist of number of digital interfacing and processing functions as well as analog functions, all components collects into one device with low-weight (9.0 to 15 Kg) .The RRU is considered as the most important change in the evolved architecture of the cell site. The idea of RRU is the goal of development which is represented in shifts the whole high frequency and power electronic parts from the base station to a location adjacent to the antenna.

The characteristics of these changes include keep the control and base band signaling components in the BBU ,the small Form-Factor Pluggable (SFP) transceiver is the last signal generation unit in the BBU which converts the electrical signal to an optical signal. The optical signal is then transmitted via fiber optic cable from the BBU to one or more RRU's located close to antenna.

In the other side another SFP transceiver receive the optical signal at the input of RRU and converted it back into an electrical signal, where it is amplified and converted into a carrier frequency and fed to the antenna via a short coaxial cable jumper[2] .

Additionally, RRU is supplied with -24V or -48V DC through heavily shielded cables from the Power Supply Unit (PSU) at the bottom of the tower as shown in Fig.4. The existing coaxial feeders in the traditional system can be used for this purpose. Solar panel system also can be used to supply the power to RRU.

3)Hyper Cable Technology.

Advanced technology permits us to use hybrid cables where there is ability to combine power and optical fiber elements in a single cable cross section. There may also exists separate optical and power cables, reusable feeders that reuse coaxial cables that already exist to carry the power while a new fiber optic data cable is fed through the existing central duct.

Cases where involves upgrading the existing site reusable feeder cable solution is the most effective. The low friction design of the optical fiber means that the site engineer simply has to feed it in from the top connection of the antenna or RRU, usually at a height of 50 to 100 meters above ground. As a short length is inserted, the cable continues to fall under its own weight.

4)Coaxial Jumper Cable.

Later on, the optical signal is transmitted over the optical fiber to the RRU that converts the optical signal back into an electrical signal with the help of another SFP module, prior to high-frequency modulation and final power amplification. Then using short coaxial cables(Jumber 1/2”), RF signal is transmitted to the antenna for broadcasting.

*B. Advantages of FTTA.*

The FTTA technique has a several advantages such as :-

1) Eliminate The Energy Loss in the Transmission Medium.

Concerns about signal loss can be overcome by generating signal near to the antenna. By replacing the coaxial cables with fiber optics and new modifications to the positions of RRUs and antennas , due to the light weight of optical fibers, which reduces the load on the tower [4].


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2) High Speed Of Data Rate.

The speed obtained using optical fiber during the transmission to the antenna in the FTTA system is in femto second domain, this is a great achievement compared to the traditional system, where the coaxial cables has an electric speed for transmitting data which operating in micro or nano second domain. The coaxial transfer speed is 10 Mbps [5].

Alcatel-Lucent and BT have successfully tested data speeds of up to 1.4 terabytes per second via the current commercial fiber optic cable and the data transfer speed of 31 terabytes per second via 7200 km long long-range fiber optic [6].

3) Offers Wide Range Coverage and Huge Capacity.

Since the coaxial cables are greatly susceptible to be damaged, the transmission distance via coaxial cable in legacy system is limited to less than 50m. In case of larger distances, to eliminate the problem and extend the radio cell coverage by using low-loss but expensive coaxial cables which are also time-consuming to install due to their large external diameter. On the contrary, Single Mode Fiber optic (SMF) gives the opportunity to extend the transmission distance limits up to 15 or even 20 km [4].

In addition to that, most of the time, advanced antenna techniques like Multiple In Multiple Out (MIMO) and Remote Electrical Tilt (RET) are supported by RRUs that offer major increase in data throughput and link range without additional bandwidth or increased transmitting power [7].

4) Reduce Installation Time.

Installation is faster by fiber solution compared to coaxial solution . A team of four technicians would complete a coaxial tower work in four days while in FTTA is only three experts technicians and two days are needed. New upgrades are coming, such as Corning Inc. has developed a technology where installation is possible within one day using three labor hands [8].

5) Power Reduced.

The installation of FTTA in terms of replacing the coaxial cable with the optical cable and the presence of power amplifiers in the RRU reduces the loss of signal strength. The RRU power amplifiers allow the use of 48V DC instead of 110V AC and thus reduce the transport power cost taking into account frequency of the radio signal.

6) Reduced Cooling System.

The RF amplifier in the RRU tower is naturally cooled by air, which in turn reduces the need for a cooling system compared to conventional radio frequency amplifiers used in BS's. The cooling system conserves approximately 25% of the site energy which used in RRU's, also previously the most of the power is used in the amplifiers are results as heat. The continuous active cooling systems is needed and increases the cost of energy.

7) Lower Cost.

Already we have found that reduced cooling system along with use of hybrid cables greatly reduce the cost for the FTTA solution. Also, due to lower rental costs of telecoms facilities and antenna sites, operating costs are reduced. For instance, reinstalled fiber optics infrastructure in city networks or in buildings can be used to establish the connection between the BS and the RRU. Again, network operators have to spend huge amount of money to rental and licensing issues for BS and antenna sites.

As a solution, FTTA can be used, which permits BS to be installed at greater distances from the RRUs. Fiber feeds RRU can save around 50-60% on total maintenance and installation costs compared to coaxial cables deployments [8]. This makes things easier for the operators to acquire new sites to optimize network coverage when it is needed.

*C. Challenges of FTTA.*

This new technical developments as any other new technique isn't free from facing some of potential or unexpected obstacles during its installation and operation, which led to the some challenges that have a negative impact on the quality and efficiency of system performance. These challenges must be analyzed and solved to minimize or eliminate the consequences , those challenges including :-

1) The Water and Moisture.

Since the FTTA architecture make it vulnerable to external environmental factors such as rain and humidity as the coaxial cable and its connections are heavily affected by water leakage which directly affects the high frequency of the signal and damage it [9].

This challenge has been overcome in several ways by companies specialized in addressing these problems through methods like using tapes and mastic to wrap around connectors. As well as other methods more developed to avoid the disadvantages of the previous traditional method, including pre- stretched pipes (Hot pipe and cold pipe), also The sealing gel around the edges forms an effective barrier surrounding the connection. All those methods are easy in installation without tools, where is normally one person can installed in a minute or less[10].


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2) The Surge And Lightning Strike.

In the new FTTA structure ,The RRU is located at the top of the tower's mast and exposed. There are also power cables coming from low-voltage power supply (-48 V DC) and coaxial jumpers (copper wire) This structure is permanently, so the problem of surge and lightning cannot be avoided during planning, this challenge must be taken into account to protect the entire architecture from surge and lightning that which electrical components are exposed in the environment (without any convincing protection)[11].

Also elements that aren't directly affected by lightning , will experience some effects of the electromagnetic field due to the excessive flow of current which resulted from a high voltage on the elements around the exposed area of lightning strike.

In this case the solution to this challenge will be protect the system with various Surge Protection Devices (SPD) and must be included on the output side of the power source to protect the sensitive components of the power source.

3) The Human Labor Skills.

This is a type of technology that needs highly skilled workers and experience in dealing with optical cables and RRU's in terms of installation of other components at high altitudes above ground. Fiber optic is more susceptible to damage caused by crimping, bending or tension during pulling compared to pulling cable trunks or feeders, which significantly reduces fiber performance.

The solution for this challenge is by training the workers properly and rehabilitate them well and provide a suitable tools for the repair and installation processes.

## IV- FIBER TO THE BASE STATIONS SOLUTION .

This solution is Associate in integration of Microwave (MW) and optical networks, it's a potential candidate for increasing capability and quality as well as decreasing prices within the broadband access network .

FTTB makes it possible to centralize the RF signal processing functions in one shared location called Main Switch Room, and then to use optical fiber to distribute the RF signals to RBS's.

FTTB is a new system for feeding RF signals from either the BSC to RBS directly or from RBS to the antenna elements at the air interface. RF system designers are familiar with the few major limiting characteristics of coaxial cables as the increase in RF loss with frequency and length.

This type of system has lower transmission loss and greater power efficiency than the current systems. Other advantages including antenna main beam steering ,reduces antenna weight , reduced susceptibility to RF interference on the feeder network and simplified site installation. By using the MW technique, the data rates for communicating between the BSC and the RBS directly ,or through node site have been relatively low.

As the need for higher densities of RBS's develop and as wireless networks increases, also the need for higher data rates and higher data bandwidth between the RBS and the BSC has become apparent, here is comes the fiber optics as evolved solution.

### *A. Architecture of FTTB .*

Subcarrier Multiplexing (SCM) is multiple RF carrying signal to transmit through optical fiber using single wavelength. The SCM has ability to place different optical carriers together closely as in Fig. 5. Wavelength Division Multiplexing (WDM) is a multiplexer at the transmitter to join the signals together, and a de-multiplexer at the receiver to split them apart again [12].

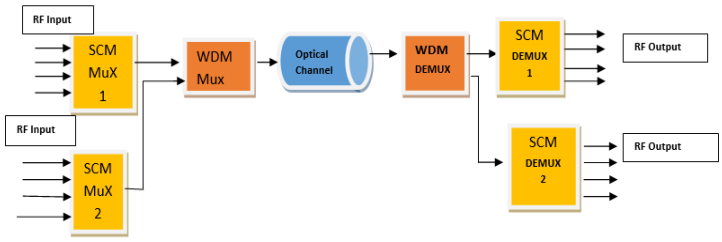


Figure.5. the architecture of SCM/WDM

SCM used in conjunction with WDM to utilize any significant fraction of the fiber bandwidth. The results is present higher bandwidth for long distance communication system. For example in SMF the distance could be reach to 150 km by using SCM/WDM for Radio over Fiber.

### *B. Benefits of FTTB.*

The FTTB techniques has many benefits including :-

1) Low Attenuation loss .
2) Large bandwidth .
3) Low RF power of RRU.
4) Dynamic resource allocation .
5) Line Of Sight (LOS) operation (multipath fading effects are minimized) .
6) Immunity to radio frequency interference .


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### *C. Challenges of FTTB.*

One challenge from the perspective of FTTB is the location of radio head and fiber optic transceiver in a harsh outdoor environment - especially severe weather at elevated, exposed heights. The components must operate over extreme environmental conditions, over a wider temperature range. The typical BTS application requires a fiber transceiver to operate over a range of 40 degree Celsius to 85 degree Celsius temperature.

The other challenge is The power supply to the Transceivers must be stable and noise free in order to maintain error free performance for the data passing through fiber optic link.

## V- CONCLUSION

the FTTA and FTTB as technical solutions offers increasing in the data flow rates as the main requirement in future applications , and those solutions has a lower loss of coverage and greater energy efficiency, where it is using 30% less energy than current traditional systems . This survey shows analysis of the current obstacles in the running systems and that barrier the deployment of 4 and 5G networks (as Smart City Needs) in the future. The solution to overcome those problems by using the fiber optic in transmission media as alternative system and get rid of MW and coaxial cables.

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