DOI: https://doi.org/10.33103/uot.ijccce.23.1.7

Interference Effect Evaluation with Radio Over Fiber In 5G Mobile System

Khasraw A. Abdulrahman[1], Jalal J Hamad Ameen[2]
[1,2]*Electrical Engineering Department, University of Salahaddin, Erbil, Iraq*
[1]*khasrawkh@gmail.com*, [2]*jalal.hamadameen@su.edu.krd*

Abstract— *The fifth generation (5G) of mobile technology is emerging as a advance communication network, delivering elevated speeds, coverage and reliability, this technology like other technologies not clear from drawbacks and limitations, 5G mobile system like other mobile systems 4G, 3G and 2G affected by interference and signal quality is going to be decreased because of higher number of C-Node-Bs which is because higher frequency and smaller coverage, in this paper, interference effect has been studied with both types cochannel and adjacent channel, best case and worst cases has been presented simulated and calculated the signal to interference ratio vs cluster size for different pathloss exponents , models and techniques of minimizing this effect has been studied starting with 5G cell planning, then a proposed network using optical fiber between C-Node-Bs, the proposed network model will minimize the interference effect to about negligible level, results shown in this paper about total length of fiber optic cables and cluster size, also, an example with best cluster size has been presented.*

Index Terms— *5G mobile system, Interference effect, C-Node-Bs with optical fiber.*

I. INTRODUCTION

The 3rd Generation Partnership Project (3GPP) has accepted a preliminary categorization of the new Radio (NR) 5th Generation (5G) Interfaces. The non-standalone operation is the primary deployment of (5G New Radio), will depend upon present LTE networks for preliminary get right of entry to and mobility management, it became executed in 2019. Help for standalone operation is achievable with the launch of the 5G center network, and the base stations in the fifth Generation (NR) are abbreviated as (gNB), related to the 5G core Comprehensive support for New Radio fifth Generation and all applicable functions without supporting the base stations or core networks in the (Long Term Evolution) [1].

In cellular communication, interference is defined as the presence of an unwanted signal in the presence of a desirable signal. Essentially, it is a disruptive change of a signal. All electric equipment produces unwanted electromagnetic interference (EMI) that will reduce the performance of radio equipment [2]. The number of wireless devices (smartphones, laptops, sensors) is growing quickly. In many urban locations, not only are there many Wi-Fi networks, but also additional systems such as Bluetooth, microwaves, and wireless A/V transmission systems. However, there is a limited amount of spectrum accessible [3]. As a result, interference between systems in this range is highly possible. Interference differs from noise in that it can be anything that interferes with the usable signal. Temperature, loud system voice indicators, gamma rays, contaminants, and different elements can all reason noise. Thus, it isn't interference; however, Interference worsened a community's overall performance and subscriber experience. Inside the subsequent-era cellular network with a couple of low strength nodes, random deployment, and frequency re-use eventualities, the device is causing excessive interference problems. Hence, interference is an important task of a unique aspect for the spectrum

Received 25/June/2022; Accepted 14/September/2022

DOI: https://doi.org/10.33103/uot.ijccce.23.1.7

of a completely new and possible 5G cellular system, [4] Co-channel interference and adjacent channel interference are the two most prevalent forms of interference.

Interference management can be described as a technique or process employed for the control and mitigation of interference. It can be further described as a scheme for interference cancellation, avoidance or reduction in a system [5].
The frequency reuse technique can be used to enhance channel capacity. The equal radio frequencies can be applied on radio transmitter sites internal a cellular location that are separated by means of an appropriate distance to avoid a lot of interference. The method of reuse frequency lets in an intense boom inside the variety of clients can participate inside a geographical region on a confined quantity of radio spectrum. Despite the fact that the technique of reuse frequency will increase the potential for constant to be had frequency spectrum; the crosstalk problem is the downside of this method between the channels. The interference between the cells which uses the equal frequency introduce when the signal capacity is increase. Therefore, the source of (ACI and CCI) is the method of frequency reuse in mobile radios [6].

A. Co-Channel Interfereeence (CCI)

is one of the most significant restrictions in mobile systems, and it is mostly caused by frequency reuse spectrum allocations, particularly when frequency planning has not been optimized. This sort of interference reduces the carrier-to-interference power ratio (C/I) near the cell's perimeter, resulting in reduced system capacity, more frequent band-offs, and missed calls [7].

Co-channel cells have to distincted by a certain radius to reduce (CCI). When the cells are about the same size, you can apply:

- Co-channel interference is unaffected by transmit power.
- The radius (R) of the cell and the distance (D) to the center of the nearest co-channel cell determine (CCI).
- Interference is decreased by increasing the ratio Q (= D/R).
- For hexagonal geometry of cell, $Q = D/R = \sqrt{3N}$ (1)
- Higher value of Q enhances transmission quality as it will have smaller co-channel interference level.

Where Q is co-channel reuse ratio and N is the cluster size.

TABLE I. CO-CHANNEL REUSE RATIO FOR SOME VALUES OF (N)

Cluster Size (N)	Co-Channel Reuse Ratio
3	3
7	4.58
12	6
13	6.24

The signal-to-interference ratio (S/I) of a mobile receiver monitoring a forward channel is given as:

$$\frac{S}{I} = \frac{S}{\sum_{i=1}^{io} Ii} \quad (2)$$

Received 25/June/2022; Accepted 14/September/2022
 ISSN (Print) 1811-9212 ISSN (Online) 2617-3352

DOI: https://doi.org/10.33103/uot.ijccce.23.1.7

In which (S) is the specified power signal in the meant base station, (i0) is the quantity of co-channel interfering cells. And (Ii) is the power of interference produced by using the (i_{th}) interfering co-channel mobile (BS).

Measurements of signal propagation on cellular radio channels show that the power of the received signal decreases everywhere, usually with the power law of the distance between transmitter and receiver. Determine approximately the average power (Pr) at distance d from the transmitting antenna

$$Pr = Po\left(\frac{d}{do}\right)^{-n} \qquad (3)$$

or

$$\Pr(dBm) = Po(dBm) - 10n\log\frac{d}{do} \qquad (4)$$

Here, P0 is the power received in the short range from the transmitting antenna d0 to the nearest reference point in the remote field area of the antenna, and n is the path loss index.

- **Best Case Signal-to-Interference Ratio**

when (Di) is the distance between the (i_{th}) interferer, then the power received is proportional to (Di)^(-n). As a result, the S/I for a mobile device may be expressed as:

$$\frac{S}{I} = \frac{R^{-n}}{\sum_{i=1}^{io} (Di)^{-n}} \qquad (5)$$

In view of just the 1st layer of interfering cells, if all of the interfering base stations are same distant from the intended base station and this distance is same the distance (D) between cell centers, (5) shorten to:

$$\frac{S}{I} = \frac{(D/R)^n}{io} = \frac{(\sqrt{3N})^n}{io} \qquad (6)$$

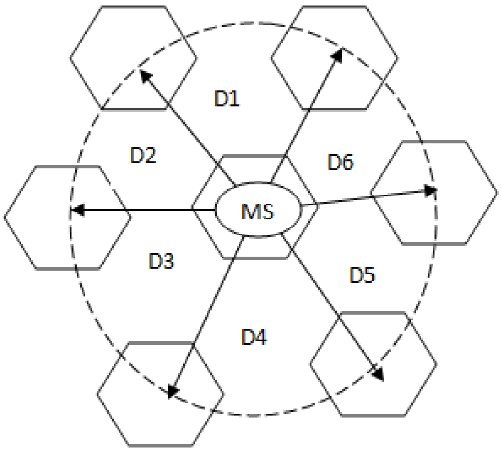

FIG. 1. BEST CASE SIGNAL TO INTERFERENCE RATIO [8].

If, cluster size is N=7, and the exponent of path loss is (n=2,2.5,3,3.5,4,4.5,5), Assume in the first tier have six co-channel cells, and all the co-channel cell have equal distance from the mobile.

Signal-to-Interference ratio can determine by (6), and co-channel reuse ratio by (1).

Received 25/June/2022; Accepted 14/September/2022

ISSN (Print) 1811-9212 ISSN (Online) 2617-3352

DOI: https://doi.org/10.33103/uot.ijccce.23.1.7

TABLE II. BEST CASE SIGNAL TO INTERFERENCE RATIO AND CO-CHANNEL REUSE RATIO

Cluster size (N)	**path loss exponent (n)**	$Q = \frac{D}{R} = \sqrt{3N}$	$\frac{S}{I} = \frac{(D/R)^n}{io} = \frac{(\sqrt{3N})^n}{io}$
7	2	4.58	5.42 dB
7	2.5	4.58	8.73 dB
7	3	4.58	12.04 dB
7	3.5	4.58	15.34 dB
7	4	4.58	18.65 dB
7	4.5	4.58	21.95 dB
7	5	4.58	25.26 dB

The Signal – to – Interference ratio for the best case has been simulated using MATLAB R2021a, and evaluated with different parameters as shown in *Fig. 2*.

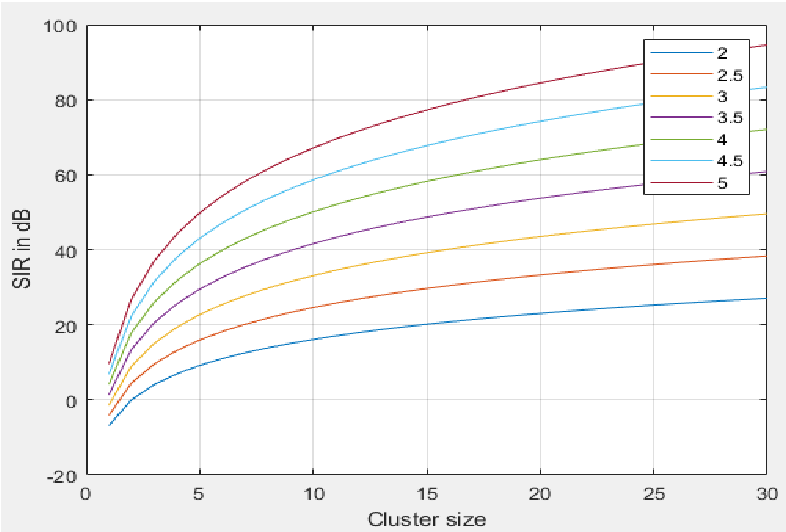

FIG. 2. BEST CASE RELATION BETWEEN CLUSTER SIZE AND SIR.

- **Signal – to – Interference Ratio (Worst Case)**

presume (MS) is at the border of cell [9]. The estimated S/I ratio in this example is provided by

$$\frac{S}{I} = \frac{R^{-n}}{2(D-R)^{-n}+2(D)^{-n}+2(D+R)^{-n}} \quad (7)$$

Where, (R) is the radius of cell.
(D) is the interference distance.
(n) is the exponent of path loss.

$$\frac{S}{I} = \frac{1}{2(Q-1)^{-n}+2(Q)^{-n}+2(Q+1)^{-n}} \quad (8)$$

Where, $Q = \frac{D}{R} = \sqrt{3N}$, and N is cluster size

Received 25/June/2022; Accepted 14/September/2022
 ISSN (Print) 1811-9212 ISSN (Online) 2617-3352

DOI: https://doi.org/10.33103/uot.ijccce.23.1.7

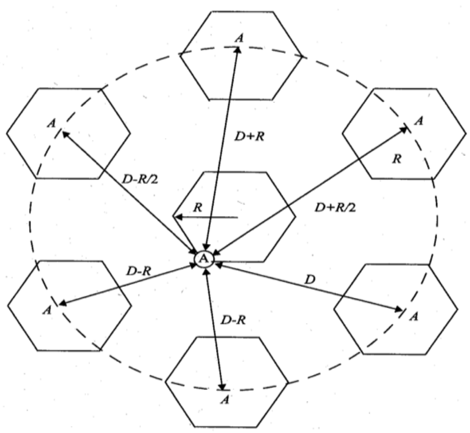

FIG. 3. SIGNAL – TO – INTERFERENCE RATIO (WORST CASE) [8].

If, cluster size is N=3, and the exponent of path loss is (n=2,2.5,3,3.5,4,4.5,5), presume the first tier have (6) co-channel cells, each at a different distance from the mobile.

The signal-to-Interference ratio can determine by equation 8, and co-channel reuse ratio by (1).

TABLE III. WORST CASE SIGNAL TO INTEREFENCE RATIO AND CO-CHANNEL REUSE RATIO

Cluster size (N)	**pathloss exponent (n)**	$Q = \frac{D}{R} = \sqrt{3N}$	$\frac{S}{I} = \frac{1}{2(Q-1)^{-n} + 2(Q)^{-n} + 2(Q+1)^{-n}}$
7	2	4.58	5.09 dB
7	2.5	4.58	8.14 dB
7	3	4.58	11.3 dB
7	3.5	4.58	14.25 dB
7	4	4.58	17.32 dB
7	4.5	4.58	20.28 dB
7	5	4.58	23.22 dB

The worst case of the (SIR) has been simulated using MATLAB R2021a, and evaluated with different parameters as shown in *Fig. 4*.

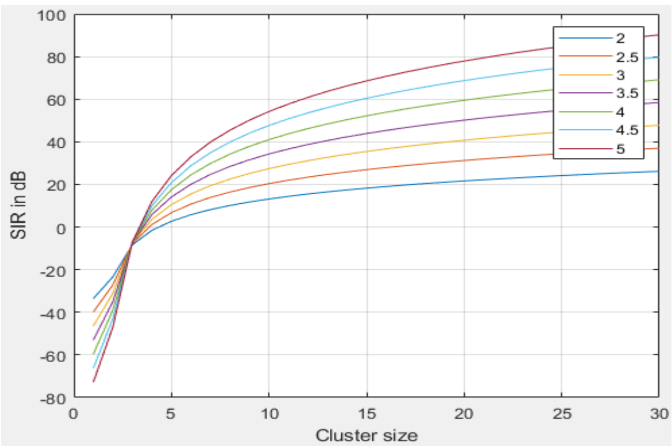

FIG. 4. WORST CASE RELATION BETWEEN CLUSTER SIZE AND SIR.

Received 25/June/2022; Accepted 14/September/2022

 ISSN (Print) 1811-9212 ISSN (Online) 2617-3352

DOI: https://doi.org/10.33103/uot.ijccce.23.1.7

TABLE IV. COMPARISON BETWEEN (BEST AND WORST) CASE IN DIFFERENT PATH LOSS EXPONENT

Cluster size (N)	pathloss exponent(n)	$Q = \frac{D}{R} = \sqrt{3N}$	BESTCASE S/I	WORST CASE S/I
7	2	4.58	5.42 dB	5.09 dB
7	2.5	4.58	8.73 dB	8.14 dB
7	3	4.58	12.04 dB	11.3 dB
7	3.5	4.58	15.34 dB	14.25 dB
7	4	4.58	18.65 dB	17.32 dB
7	4.5	4.58	21.95 dB	20.28 dB
7	5	4.58	25.26 dB	23.22 dB

To finding the signal to interference ratio is given by signal power divided by interference power, Table IV. shown that the value of S/I in the best case in different value of path loss exponent(n) and cluster size =7 is greater than the value of S/I in worst case. For example, when N=7, n=4 and Q=4.58 the table shown that in the best case (S/I = 18.65dB) and in the worst case (S/I=17.32dB), So the problem due to co-channel interference is (S/I=17.32) which is below of the required amount of S/I because the required amount of S/I is (18dB), That's why we are seen that this is worst case and the user will not able to get the require amount of signal.

II. RESOLVED PROCESS OF CO-CHANNEL INTERFERENCE (CCI)

Co-Channel Interference resolve Techniques.

A. Interference Reconstruction Technique: Approaches to interference reconstruction work by reconstructing all users' signals and in the incoming signals, computing their cross-correlation components.

B. Techniques for Equalization: Techniques for Equalization take into account multipath access interference to be a selected instance of (serve) multipath interference.

C. Directional antenna Design: Using a directional antenna facilitates reduce co-channel interference. This means that at a base station, every mobile is separated into 3 or six sectors and employs 3 or six directional antennas. Every zone assigns a fixed of frequencies or channels, decreasing interference between cells.

D. Parasitic Elements: We may lower the CCI by employing parasitic components. Parasitic antennas can be designed as follows:
(Normal distance) and (closed relative distance).

E. Power control: Reduce the CCI by lowering the Base Tran-receiver power in these approaches. As we know, as cell size lowers for a given radio channel, the (co-channel reuse distance rises), and hence (CCI) drops more.

F. Diversity Receiver: When a signal's performance is increased by making a change in at the receiving end the extra interference will not produce. a variety of plans are used at the receiving end of antenna is a unique plan to reduce interference.

G. Smart antenna: The best promising technology are clever antenna the usage of for growing wireless network potential with the aid of efficiently decreasing (multi-way and CCI). It employs adaptive beam

Received 25/June/2022; Accepted 14/September/2022

 ISSN (Print) 1811-9212 ISSN (Online) 2617-3352

DOI: https://doi.org/10.33103/uot.ijccce.23.1.7

formation algorithms in dynamic surroundings to constantly modify the load of antenna arrays for producing a beam to robotically follow desired customers and prevent Interference from other subscribers by inserting nulls into their rules. Smart antennas make use of an array of radiating components. Those additives' indicators are blended to generate a transportable or switchable beam sample that follows the person of hobby. The arrays in a smart antenna system aren't smart in and of themselves; it's far the virtual sign processing that makes them so. Virtual beam forming refers to the act of integrating alerts after which focusing the radiation in a certain direction [10].

H. Tilting antenna: CCI also it is possible to decrease manually or electrically tilting a base station antenna down. This method weakens characters taken horizontally. Given this principle, the design of a base station that interferes with a single angle of inclination improves the CCI, because the two antennas operate at different signal powers [8].

B. Adjacent Channel Interference (ACI)

If you are receiving alerts at frequencies near to your own, you may be experiencing ACI. Adjoining channel interference (ACI) is interference that is caused by power from another channel's signal source that is too close by. Poor filtering of modulation components in frequency modulation (FM) systems, bad tuning, or low-quality frequency control can lead to interference from nearby stations [11].

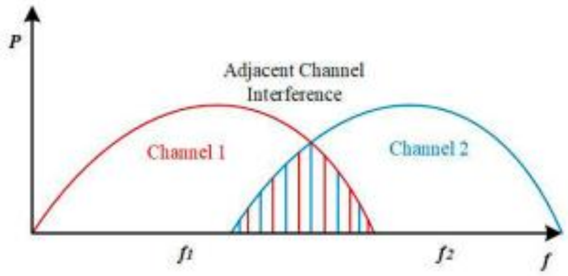

FIG. 5. ADJACENT CHANNEL INTERFERENCE (ACI) [4].

The signal-to-Interference ratio (S/I) in (ACI) can be written as:

$$\frac{S}{I} = \left(\frac{d1}{d2}\right)^{-n} \quad (9)$$

Where

$d1$: is the distance between user and the BTS fir it.

$d2$: is the distance between the user and BTS with neighbor channel.

If the subscriber $1 = 400$ m , $d2 = 100$m and path losses exponent n=7.

The signal-to-Interference ratio can determine by equation 9.

$$\frac{S}{I} = \left(\frac{d1}{d2}\right)^{-n} = \left(\frac{400}{100}\right)^{-5} = -30.13\ db \quad (10)$$

Two varieties of ACI.

A. Imperfect Filtering: Users' contemporary need is for a few-price smartphone, which means that a lower-fee filter, resulting in expanded interference. Filtering couldn't be extra effective on the MS website online. Another choice is to make use of high priced, the base station's filters are exceptionally well-designed. Certainly, the expense of the bottom station is co-owned by a large number of clients. As a end result, neighboring channel interference is managed more at the base station stage than on the handset level. If the interferer is quite near to the receiver of the subscriber, the situation might be

Received 25/June/2022; Accepted 14/September/2022
 ISSN (Print) 1811-9212 ISSN (Online) 2617-3352

DOI: https://doi.org/10.33103/uot.ijccce.23.1.7

severe. This is due to the nearby mobile unit's effective signal, which creates neighboring channel interference. As a result, crosstalk happens at the receiver, and if the interference is inside the manipulate channel, one of the phone calls may be lost [8].

B. Near Far effect: The close some distance effect is the only other consequence of adjacent channel interference. What's the close to-some distance impact, precisely? Count on Emitter A and Transmitter B function on adjoining frequency channels; While the receiver is far from the desired broadcaster and extremely close to the unwanted transmitter, neighboring channel interference will grow. While there is interference near the base station, it radiates on the adjoining channel, despite the fact that the subscriber is a long distance away from the base station. It's miles worth noticing that the exponent of the path loss is more or less four. The sign power gradually declines to an electricity of four of the space. As a result, If the interfering phone is near to the base station and the user is slightly away from the base station, the base station signal will be strongly interfered with. The instance allow navigation. First, the base station and users are installed. That's why, the user is cell and far from the bottom station. But there are various uses, such as having an interfering handset interior an automobile that occurs to be toward the bottom station. Unfortunately, the interferer emits in a close-by frequency range. as well as, if the user is making an attempt to establish contact with the base station, the sign is quite faint by the time it reaches the bottom station. The exponent of path loss is rather big. So, whilst the signal level acquired at the bottom station is low, it is able to still be processed. It's far inside the limit. However, the interferer, that is drastically in the direction of the bottom station, is emitting within the subsequent band, and numerous powers is leaking in due to the defective filters. However, it is plenty extra energetic [12].

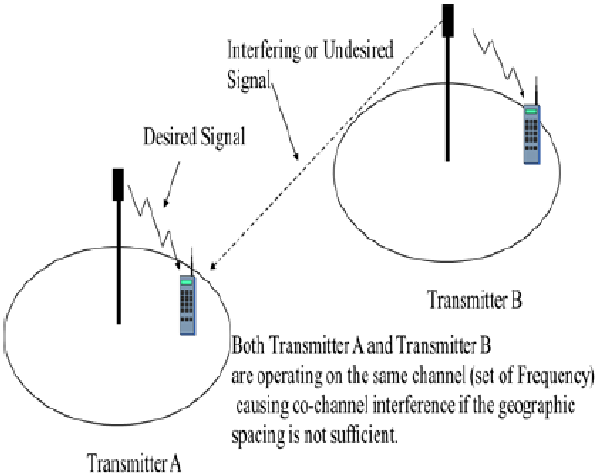

FIG. 6. ACI IMPACT [8].

III. RESOLVING PROCESS OF ADJACENT CHANNEL INTERFERENCE (ACI)

A. Careful filtering

As a result, thorough filtering can decrease neighboring channel interference, resulting in more costly filters. As demonstrated in *Fig. 4,* our daily usage filter behaves exactly just like the genuine filter, causing interference in both the upper and lower channels. If we usage the "best filter," as shown in *Fig. 4,* instead of the real filter, there is no interference in the top channel, and the interference in the bottom channel is reduced. However, the cost of this sort of filter is often prohibitively expensive.

Received 25/June/2022; Accepted 14/September/2022
 ISSN (Print) 1811-9212 ISSN (Online) 2617-3352

DOI: https://doi.org/10.33103/uot.ijccce.23.1.7

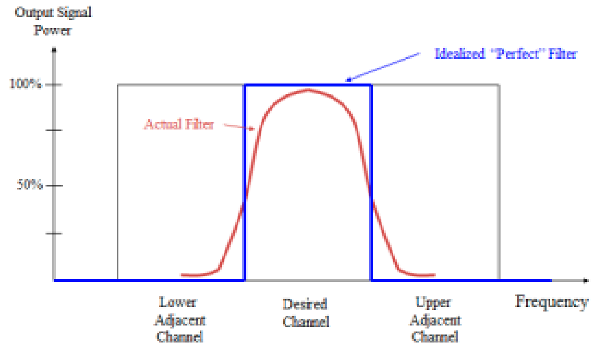

FIG. 7. NEAR FAR IMPACT [8].

B. Careful channel assignment

Smart frequency separation is some other way for lowering neighboring channel interference. Channels are the frequency bands that ought to assign various users. Frequency bands at the moment are explicitly allotted as and when want develops. But the venture should no longer begin with the 1st band and then visit the subsequent bands. in reality, they should be stored as far apart as possible. There might be several strategies for allocating frequency bands. Count on there may be a set of frequency sub bands assigned to a selected cellular, and our project is to allocate these frequency bands. However, the goal is to optimize the frequency separation between every channel. It's far now early sunrise, and the 1st user needs a channel. So, as someone trying to allocate a separate channel, I provide say, the first channel. It is probably any of the available channels, and I have decided on the first. Glaringly, whilst the 2nd request arrives, the second and third bands must no longer be available. In reality, I need to offer the most room among them. So, I will provide the second one user the band that is the furthest away. As a result, the most spacing will reduce the ACI [8].

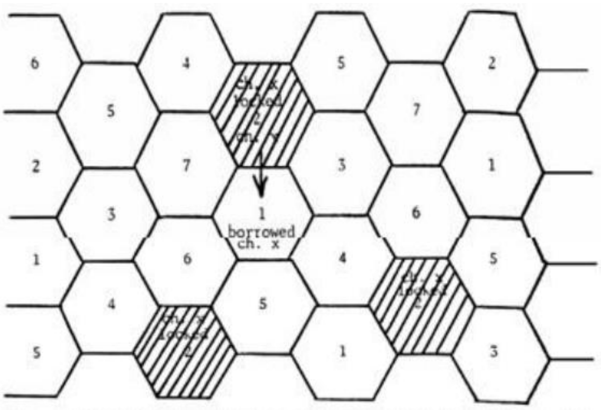

FIG. 8. CAREFUL CHANNEL ASSIGNMENT. [8].

IV. UTILIZING OPTICAL FIBER IN 5G SYSTEM

Base stations are known as Node-Bs in 4G mobile networks, and each group of these Node-Bs is connected to radio network controllers (RNCs) by microwave connections, similar to the GSM system, before linking these RNCs to the core network via SGSN and GSGN. Because the C-band is (4-8) GHz, microwave links have various problems, such as interference with other signals, particularly C-band satellite communications. As a result, if microwave linking were employed for a 5G mobile system with a frequency of 5G sub-c-band (6) GHz, interference with C-band transmissions would be an issue.

Received 25/June/2022; Accepted 14/September/2022

 ISSN (Print) 1811-9212 *ISSN (Online) 2617-3352*

DOI: https://doi.org/10.33103/uot.ijccce.23.1.7

The length of the fiber optic cable among adjoining base stations BS needs to be more than two times the reuse distance (D) of each base station for cluster length (N), therefore, the length of the fiber for distinctive cluster sizes may be received as shown in Table IV.

TABLE V. FIBER LENGTH AND CLUSTER SIZE CALCULATIONS

Cluster Size (N)	L (Fiber Length, km)
3	2R
7	3R
12	4.5R
13	6R

Where is R is the radius cell in kilometer, N is the cluster size, and L is the fiber length in kilometer.

The hexagonal cell's area can be determined as follows:
For the planned C-RAN, the number of first-tier base stations = 6, second-tier base station number = 12, third-tier base station number = 18, i.e., For each successive tier, 6 base stations might be added. After calculating for each group, the total base stations number required for a specific coverage area and cluster size may be calculated, as shown in Table VI.

TABLE VI. FIBER LENGTH (L) AND CLUSTER SIZE CALCULATIONS (N)

No. of (N)	No. of Tiers	No. of (BSs)	Coverage Area	L (Fiber Length, km)
1	6	127	(2.6 x R2) x 127	2R
3	6	381	(2.6 x R2) x 381	3R
4	6	508	(2.6 x R2) x 508	3.4R
7	6	889	(2.6 x R2) x 889	4.5R
12	6	1524	(2.6 x R2) x 1524	6R
13	6	1651	(2.6 x R2) x 1651	6.2R

If, Cluster Size N = 7, BTs radius cell R = 0.5 km, the in all area coverage = 577.85 km^2 and the L between two base stations BSs should be greater than (L > 2290 km), if the totality parts of fiber for each group (126 parts of fibers = 288.69 km), after the L for the (7 groups = 2020.83 km).

The fiber will be multi-mode since it is better for short distances than single mode, which is better for long distances.

V. CONCLUSIONS

In this paper, Discusses in detail the deferent types of interference in mobile systems. Especially the two major kinds of interference (co-channel interference (CCI) and adjacent channel interference (ACI)), Also how to calculate signal to interference ratio S/I value in both (best case and worst case) signal to interference ratio. At the same time, we simulated both cases by using MATLAB R2021a, we found that both cases have a direct relationship with the

Received 25/June/2022; Accepted 14/September/2022
 ISSN (Print) 1811-9212 ISSN (Online) 2617-3352

DOI: https://doi.org/10.33103/uot.ijccce.23.1.7

path loss exponent (n). We have shown this clearly in (Tables I and II) and in (*Fig. 1* and *2*), by increasing the value of path loss exponent (n) the signal to interference ratio (S/I) increased. The process of resolving co-channel interference (CCI) and adjacent channel interference (ACI) is also described in detail and the techniques are presented in writing and figures. And we calculate signal to Interference Ratio in case of adjacent channel interference. Optical fiber link is an underground link, unlike microwave link, which has many disadvantages such as atmosphere effects, and interference with other signals, especially C-band satellite signals, because the C-band is (4-8) GHz. Thus, if microwave linkage were used for a 5G mobile system which has the frequency 5G sub c-band (6) GHz, the interference with C-band signals would be a problem, but using fiber optics, this problem is solved. The optical fiber affects co-channel interference because of reuse distance and fiber length. Finally, we have discussed the use of optical fiber in 5G mobile system to eliminate interference problem. And we have done a mathematical model when the cell radius is equal to 500m, cluster size =7 and the type of fiber used is multimode fiber because for short distance.

REFERENCES

[1] H. Elgendi, M. Mäenpää, T. Levanen, T. Ihalainen, S. Nielsen, and M. Valkama, "Interference Measurement Methods in 5G NR: Principles and Performance," in *2019 16th International Symposium on Wireless Communication Systems (ISWCS)*, 2019, pp. 233-238.

[2] P. Ankarson, U. Carlberg, J. Carlsson, S. Larsson, and B. Bergqvist, "Impact of different interference types on an IEEE 802.11p communication link using conducted measurement," in *2014 International Symposium on Electromagnetic Compatibility*, 2014, pp. 550-554.

[3] J. v. Bloem, R. Schiphorst, T. Kluwer, and C. H. Slump, "Interference Measurements in IEEE 802.11 Communication Links Due to Different Types of Interference Sources," in *2012 8th International Conference on Wireless Communications, Networking and Mobile Computing*, 2012, pp. 1-6.

[4] M. U. A. Siddiqui, F. Qamar, F. Ahmed, Q. N. Nguyen, and R. Hassan, "Interference Management in 5G and Beyond Network: Requirements, Challenges and Future Directions," *IEEE Access*, vol. 9, pp. 68932-68965, 2021.

[5] B. Bakare, O. J. Abayeh, and S. Orike, "Application of Frequency Reuse Technique for the Management of Interference in Cellular Network in Port Harcourt," vol. 11, pp. 16-24, 01/21 2022.

[6] S. M. Usha and K. R. Nataraj, "Analysis and mitigation of adjacent and co-channel interference on AWGN channel using 8-PSK modulation for data communication," in *2016 International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET)*, 2016, pp. 922-926.

[7] M. Orooji, E. Soltanmohammadi, and M. Naraghi-Pour, "Evaluating the effects of co-channel interference inwireless networks," in *2013 IEEE International Conference on Acoustics, Speech and Signal Processing*, 2013, pp. 4693-4697.

[8] T. Sheikh, "A Survey of Reduction the Interference on Cellular Communication System," *International Journal of Computer Applications*, vol. 95, p. 4, 06/30 2014.

[9] I. Mahmoud, O. Elgazzar, S. Hashima, and H. Konber, *An Accurate Model of Worst Case Signal to Interference Ratio for Frequency Reuse Cellular Systems*. 2016.

[10] M. S. W. Prof.B.G. Hogade, Dr.Shrikant and K. B. ", ""Mitigating the Effect of CCI and Multipath in Mobile Communication using Smart Antenna"," *IJERA" National Conference on Emerging Trends in Engineering & Technology*, pp. Page.no.366-370., (VNCET-30 Mar'12).

[11] A. Zubow and R. Sombrutzki, "Adjacent channel interference in IEEE 802.11n," pp. 1163-1168, 04/01 2012.

[12] W. Nam, D. Bai, J. Lee, and I. Kang, "Advanced interference management for 5G cellular networks," *IEEE Communications Magazine*, vol. 52, no. 5, pp. 52-60, 2014.

Received 25/June/2022; Accepted 14/September/2022

 ISSN (Print) 1811-9212 ISSN (Online) 2617-3352