CELLULAR SIGNAL RECEPTION AND BOOSTING

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***Abstract*— Bad cell phone reception is a ubiquitous problem in remote areas. People are facing problems like few or no signal bars, frequent dropping of calls, low data rates and delayed texts. It can make a frustrating experience when you are in urgency and your network service troubles you.**

This paper provides probable reasons and possible solutions for poor network coverage in distant places. The major objective of our paper is to bring forth the science behind a cell tower, the technology involved in it and provide a solution to enhance the reach of the weak signal to remote areas.

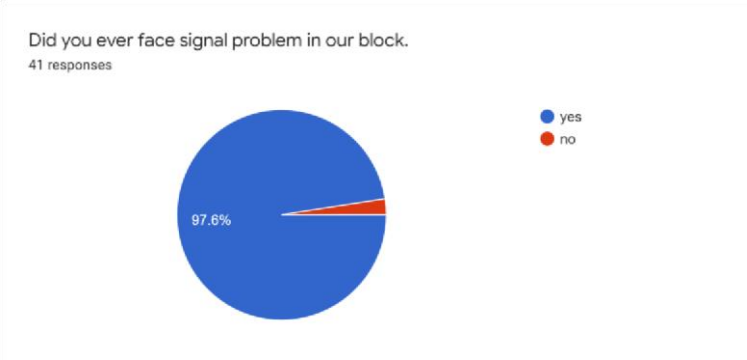
***Keywords*— Mobile station, Base Transceiver Station, Base Station Controller, Mobile Switching Centre, Mobile Signal Booster.**

I. INTRODUCTION

In today's hectic world, we rely heavily on sharing information, there is no doubt that communication plays a vital role in human life and society. Therefore, cell phones are the perfect way to stay connected and communicate with people. In the event of emergency, having a cell phone can allow help to reach you quickly and could possibly save lives.

Poor network signal in isolated places has become a
considerable issue now-a-day. Signal need to be amplified or boosted to a level where it can reach up to areas with hilly terrains or thick walls.

This cell phone signal can be enhanced by using a mobile signal booster. This circuit consists of an external antenna which receives the weak signal



that is typically found outside the home, office or vehicle and then gives it to an amplifier block that amplifies the signal and an output antenna broadcasts it to the area with low or no signal.

II. LITERATURE/SURVEY

For all of us mobile phones have become part of our life. Imagine you are cleansing your house and you turned up your radio in your mobile to play your favourite music on it so that you could do your work joyfully. You are navigating the kitchen, your dining hall, your study room with ease. But, once you move upstairs, the music starts fading in and out.
What might be the reason?
The answer is poor signal reception.
The causes for poor signal reception fall under the following categories:

- Localized poor coverage due to destructive interference or building materials.
- Obstacles between phone and nearest cell tower.
- Geographical distance from nearest cell tower.

The above pie chart portrays the results of a survey which was conducted by us. From the results of the survey it is self-evident that most of the students have faced and are still facing cellular network related problems in

our block. This topic grabbed our attention towards mobile communication and raised a level of curiosity to know what is actually happening when a call is placed from our mobile phone.

III. METHODOLOGY

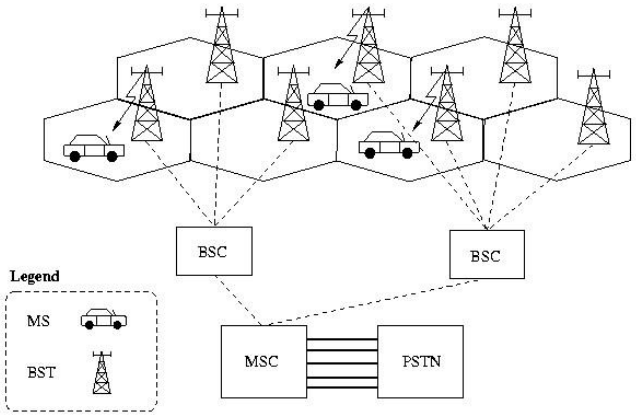
Many a time, our inquiring minds might have been struck by a question: How a mobile phone places a call?

Let's explore the technology behind mobile communications. When you speak on your phone, your voice is picked up by your phone's microphone. The microphone turns the voice into a digital signal with the help of MEMS sensor and IC. The digital signal contains your voice in the form of zeros and ones. An antenna inside the phone receives these zeros and ones and transmits them in the form of electromagnetic waves. Electromagnetic waves transmit these binary digits by altering the wave characteristics such as amplitude, frequency, phase or combinations of these. If you find a way to transmit these EM waves, then you can talk to your friend over phone. However, these waves cannot travel long distances. They lose their strength due to presence of physical objects, electrical equipment and some environmental factors. In fact, even if there are no such issues, EM waves would not carry on forever due to the earth's curved structure. To overcome these issues cell towers were introduced using the concept of cellular technology.

Cellular Technology:

In cellular technology a geographical area is divided into hexagonal cells with each cell having its own tower and frequency slot. Generally, these cell towers are connected through wires, or more specifically optical fibre cables.

These optical fibre cables are laid under the ground or ocean to provide national or international connectivity. The EM waves produced by your mobile are picked up by your tower in your cell and convert them into high frequency light pulses. These light pulses are carried to base transceiver box, located at the base of the tower for further signal processing. After processing your voice signal is routed towards the destination tower. Upon receiving the pulses, the destination tower radiates it outwards in the form of EM waves and your friend's phone receives the signal. This signal undergoes a reverse process, and your friend hears your voice. So, its true that mobile communications are not completely wireless.



Now, before a mobile phone can establish a call, it first needs to establish a connection to the available service provider network. Whenever a mobile phone is switched on, it first scans the group of forward control channels to determine the strongest one. Then it keeps on monitoring the same channel until the signal level drops below a minimum level after which it again starts to scan. Every mobile phone repeats this process as long as it is kept switched on. The signal level of the current channel which the phone is locked to will be displayed on the handset.

So now let's see the steps that occur when a mobile phone user dials a number to make a call. First of all, a call initiation request is sent on the reverse control channel. Along with this request, the mobile phone also sends its Mobile Identification Number (MIN), Electronic Serial Number (ESN) and the dialled telephone number. The base station receives

this data and sends it to the Mobile Switching Centre (MSC).

Before moving further, we need to know that Mobile communication is successful only when your tower transfers the signal to your friend's tower. But how does your tower know in which cell tower area your friend is located? Well, for this process your cell tower gets help from something called MSC.

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Mobile Switching Centre (MSC):

The MSC is the central point of a group of cell towers.
Before moving further, let us know more about MSC.

When you purchase a SIM card, all the subscription information is registered in a specific MSC. This MSC will be your home MSC. The home MSC stores information such as service plans, your current location and your activity status. If you move outside the range of your home MSC, the new MSC which serves you instead is known as foreign MSC. As soon as you enter the foreign MSC region, it communicates with your home MSC. In short, your home MSC always knows in which MSC area you are in.

MSC validates the request by checking the MIN with the records on its database. If it is valid, a connection to the called party is made through Public switched Telephone network (PSTN). Then the MSC requests the base station to move the mobile phone to an unused voice channel so that the conversation can begin. Once a call is in progress, the MSC adjusts the power transmitted by the mobile phone as it moves in and out of the coverage area of each base station.

So, this is how a call is placed and received.

✞ Location update:

To understand in which cell location the subscriber is within the MSC area. The MSC uses few techniques.

1. Time based: It updates the subscriber location after a certain period.
2. Location area based: When the phone crosses a predefined number of towers, the location update is again done.
3. When the phone turns ON: When the device is turned ON, the location of the device is again updated.

Frequency spectrum:

Frequency spectrum is quite important in mobile communications. To transfer zeros and ones in digital communication, each subscriber is allocated a frequency range. However, the frequency spectrum available for cellular communications is quite limited and there are billions of subscribers. This issue is solved with the help of two technologies.

A. Frequency slot distribution:

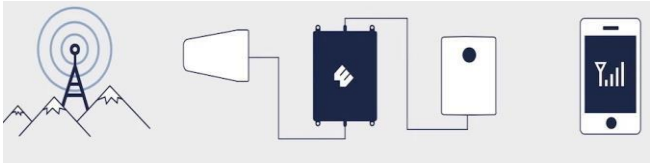
In this technique, different frequency slots are carefully allocated to different cell towers.

B. Multiple Access technique:

In this technique, this frequency slot is efficiently distributed amongst all the active users in the cell area.

By now, we briefly understood how a call is placed and received. Now all we need to know is, how this signal can be boosted so as to make it available in low or no signal areas. The circuit required to perform this function is Mobile Signal booster.

Mobile Signal booster:



A cell phone signal booster (also known as a signal extender, signal amplifier, or cell phone repeater) works by pulling in weak outside signal, boosting

it, and rebroadcasting the boosted signal into the desired areas. They also work in reverse: the signal booster will receive the signal from your phone and send it back to the tower.

Most signal booster kits are composed of three main elements:

1. **An External Antenna** – Used to capture the weak cell phone signal.
2. **An Amplifier** – Used to boost the weak signal.
3. **An Indoor Antenna** – Used to rebroadcast the enhanced signal inside your home, office, or car.

External antenna:

The external antenna (also called a donor antenna) is the first major component of a cell phone booster. They capture the weak 3G and 4G LTE signals.

There are two types of outside antennas:

Omni-directional Antenna: This antenna pulls in signal from every direction or a 360-degree angle. They are best for people who have medium to strong signal outside, or multiple cell towers nearby to boost multiple carriers.

Uni-directional Antenna (also known as Yagi): This antenna (shaped like a triangle) pulls signal from a 45degree angle. They are designed to point in the direction of the nearest tower. Having a more focused signal, allows the antenna to reach farther than an omni antenna would. A specialized performer used for extremely poor signal and those who only want to boost a single carrier.

The location of the antenna is crucial; it can dramatically affect the power of the signal that is being sent to the amplifier. You will want to set up the antenna on the side of your home that has the best signal. There are different methods you can use to find the location with the best signal; you can use the number of bars on your phone, smartphone apps, or use field test mode.

You will want the antenna to be as high as possible to have a better line of sight with the cell phone towers and decrease the number of obstructions between you and the towers. Usually, the higher the antenna is, the better the capturing of signal will be. Normally, the outdoor antenna will be mounted on the roofline of the house; you can use an existing vent pipe or a pole mount. It's important that the outside antenna is placed on or near the edge of the roof. If you have a Yagi antenna, it should be pointing away from the house towards the nearest cell tower.

Amplifier:

The amplifier is the second major component of a mobile signal booster. Once the poor signal is pulled in from the outside antenna, it is sent to the amplifier for boosting.

To understand how amplifiers, work and how to choose the best cell phone signal booster kit, you will have to be familiar with different terms.

1. Coverage Area:

There is a variety of different amplifiers available, and they all vary in how many square feet they can cover. Amplifiers designed for small homes can cover up to 2,500 sq ft, and the coverage area for medium to large homes can range from 5,000 sq ft to 7,500 sq ft. For commercial buildings, there are commercial amplifiers available that can cover areas up 100,000 sq ft.

Keep in mind that the quality of your outside signal and the type of amplifier purchased can affect the coverage area.

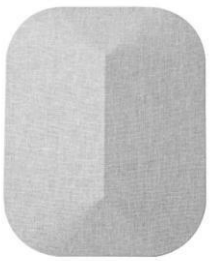
2. Signal strength:

When looking at different signal boosters you will see the terms dB (decibels) and dBm (decibel-milliwatts). What do they mean?

Cell phone signals are radio waves, they operate within a certain frequency band in the radio spectrum. The signal can be measured in dB or dBm.
Decibels (dB) are used to measure an increase or decrease in signal strength (gain or loss); they measure the radio waves. Decibel-milliwatts (dBm) are used to show how much power the amplifier is capable of producing, or how much power your mobile devices are getting.
The bars on your mobile phone are a representation of how strong the cellular network is. Generally, cell phone signal levels can range from -50 dBm to -120 dBm. In "bar" talk, 50 dBm is full bars, and -120 dBm is a dead zone.

All amplifiers are measured using dB outputs; this would be the max gain the amplifier offers. What an amplifier does is potentially increase your dB (signal gain) to get you closer to the -50 dBm range. For example, if your signal level is 110 dBm, and the amplifier has a max gain of +50dB, your signal will be close to -60dBm (-100+50=-60).

Indoor Antenna:



The inside antenna is the third major component of a cell booster.

Once the amplifier has boosted the signal, it's passed onto the inside antenna to rebroadcast the signal to the desired areas.

There are two types of indoor antennas:

1. **Panel Antenna:** This antenna (pictured above) is generally wall-mounted and tends to send signal cone ranging from 45-70 degrees, meaning that the strongest signal will be delivered to the areas closest to it.

2. **Dome Antenna**: This antenna is generally ceiling mounted and tends to equally distribute the signal in all directions or a 360-degree angle. They will work best when trying to boost the signal in a large area.

When installing the indoor antenna, make sure there is at least a distance of 20 feet vertical or 50 feet horizontal between the outside and inside antennas. This will prevent oscillation, which will cause your signal booster to automatically shut down.

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CONCLUSIONS

1. This paper provides the brief understanding of cellular communication and signal amplifiers.

2. We were able to find out geographical location as the major problem for low signal in our block.

3. Understanding of the internal architecture reveals the uprising complexities which acts as the limitations when we tend to build the prototype.

4. Building a product could be real conundrum keeping in the mind the present knowledge we acquired. But a Quick fix for this problem could be understanding the internal mechanism and opting for a product.

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