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Improvement of 5G Network Coverage and Capacity by Using MIMO-A/B Antenna Planning in Prediction Software

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Abstract

Cellular and Mobile communication system has grown exponentially (rapidly). This improvement motivating the companies move towards to plan the new network continuously. It works from first generation to fourth generation. Now many cellular companies planned and started their scenarios toward fifth generation (5G). In every generation they are increasing the data rate transmission to achieve user's requirements. This paper is an attempt to contribute in this field to give more details about these challenges. The 5G Radio network formation comprises coverage assessment and capability estimation. Planning method and scenario used in this 3GPP planning is in MIMO-A/B antenna and 5.8MHz frequency for good reporting, the Government allocated frequency for cellular operators. This network formation is replicated by utilizing Link planner software. In present project, we plan the network for Hyderabad city area.

Keywords: Fifth generation, network capacity, network planning, 3GPP, MIMO-A/B, link planner.

1. Introduction

ABOUT ALL G TO 5G: Cellular and Mobile communication is quickly emerging finished an excellent developed voice communication as well as tremendous improvement in data streaming. Radio technologies promote of the equivalent cellular structure in the year of 1980's. That growth we seen in 1G, 2G, 3G to 4G are Presently we are learning about 5G system. Since it provides more speed than other earlier generations. Here from the beginning of 1st generation 1G in 1980, second generation 2G in 1990, third generation 3G in 2000, fourth generation 4G in 2010 and finally the fifth generation 5G under the planning and development launch in present market of 2020.

DIFFRENCE BETWEEN 4G AND 5G: here in present scenario the 4G systems are LTE-A and Wi-Max, 3G systems are UMTS and LTE and 2G system is GSM. Beyond these systems 5G radio access system uses together 2 novel radio access technologies RAT and also the current wireless technologies LTE, HSPA, GSM and finally the Wi-Fi
The main specifications of all cellular generations given below.

Table 1. Specifications of Cellular Generations

specifications	1G	2G	3G	4G	5G
Data capacity	2Kbps	10Kbps - 473Kbps	384Kbps- 30 Mbps	100Mbps to 1Gbps	20 Gbps
Frequency	800 to 900MH	850MHz to 1900MHz	1.6 to 2.5 GHz	2 to 8 GHz	3 to 300 GHz
Multiplexing	FDMA	TDMA, CDMA	CDMA	CDMA	CDMA, BDMA

In 4G wireless LAN is IEEE802.11n but 5G WLAN is IEEE802.11ac.it improves the throughput performance of the network.

5G Introduction

5G technology gives certain specifications such as data rate must be equal to 10 Gbps i.e approximately 10 to 100x over an development of 4G and 4.5G networks, 1 ms potential with 1000x bandwidth per unit area, an amount of 100x associated devices per unit area over 4G LTE by 99.99% availability and 100% attention,90% drop in network energy procedure with 10 year battery life for low power IoT devices.

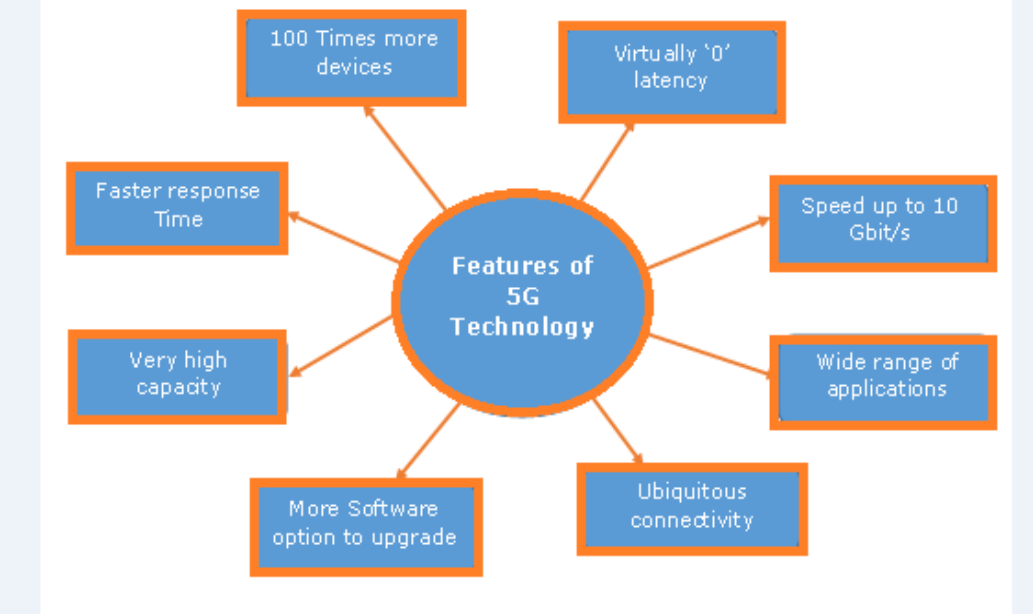


Fig. 1; Features of 5G

The next generation mobile networks (5G) have started to endure to grow globally In addition to speed gains, the fourth generation network has a number of other advantages. The present LTE frequency range (600 MHz to 6 GHz) as well as millimetre wave (mmWave) bands (24–86 GHz) will be used for 5G. ITU IMT-2020 and/or 3GPP Release 15 standards must be met by 5G technologies;[citation required] Despite the fact that IMT-2020 calls for data rates of 20 Gbit/s, 5G speeds in sub-6 GHz bands are comparable to 4G.[3][4].5G is broadly accepted to be more astute, quicker and more productive than 4G allowing table examines 4G against 5G improvements and notices distinction anywhere in the range of 4G

and 5G remote advances. It makes reference to fundamental correlation somewhere in the range of 4G and 5G shown in below table.

5G would recognize networks accomplishment by giving zero-distance network among individuals and associated machines. The exponential growth of remote information the study of a 5G cellular infrastructure has been sparked by services fueled by mobile Internet and smart devices. Multimedia applications will require 5G systems to fulfil a wide range of criteria, plus increased peak and user data rates, decreased latency, improved interior coverage, and enhanced energy effectiveness, among others.

The following are the key advancements and ways to meeting the necessities for 5G systems.

- Densification of current cellular networks by adding a large number of tiny cells and enabling point-to-point (P2P) communication (e.g., device-to-device [D2D] and machine-to-machine [M2M] communication-enabled multi-tier heterogeneous systems).
- Transmission and reception in real time (e.g., full-duplex [FD] communication).
- The technologies of huge multiple-input multiple-output (massive-MIMO) and millimeter-wave (mm-wave) communications.
- Energy efficacy is enhanced by energy-aware communication and energy collection.
- Virtualization of wireless resources and cloud-based radio access network (C-RAN).

Table 2. Fundamental Correlation Between 4G and 5G

specifications	4G	5G
Full form	Fourth Generation	Fifth Generation
Peak Data Rate	1 Gbps	10 Gbps
uploading speed	50Mbps	10Gbps
Downloading speed	100Mbps	20Gbps
Data Bandwidth	2Mbps to 1Gbps	1Gbps and higher as per need
Spectral Efficiency	30 b/s/Hz	120 b/s/Hz
TTI (Transmission Time Interval)	1 ms	Varying (100 µs (min.) to 4ms (max.))
Latency	10 ms (radio)	<1 ms (radio)
Mobility	350 Kmph	500 Kmph
Connection Density	1000/Km2	1000000/Km2
Frequency Band	2 to 8 GHz	3 to 300 GHz
Technologies	unified IP, seamless integration of broadband LAN/WAN/PAN and WLAN	Unified IP, seamless integration of broadband LAN/WAN/PAN/WLAN and advanced technologies based on OFDM modulation used in 5G
service	Dynamic information access, wearable devices, HD streaming, global roaming	Dynamic information access, werable devices, HD streaming, any demand of users
Multiple Access	CDMA	CDMA,BDMA
Core network	All IP network	Flatter IP network, 5G network interfacing(5G-NI)
Handoff	Horizontal and vertical	Horizontal and vertical

5G cell towers are telecommunications installations that have the potential to increase wireless signals ten times faster than 4G. The 5G network will be based on small cell site technology, by antennas as close as 500 feet apart, since high frequency waves have a difficult time going over distance and done obstacles.

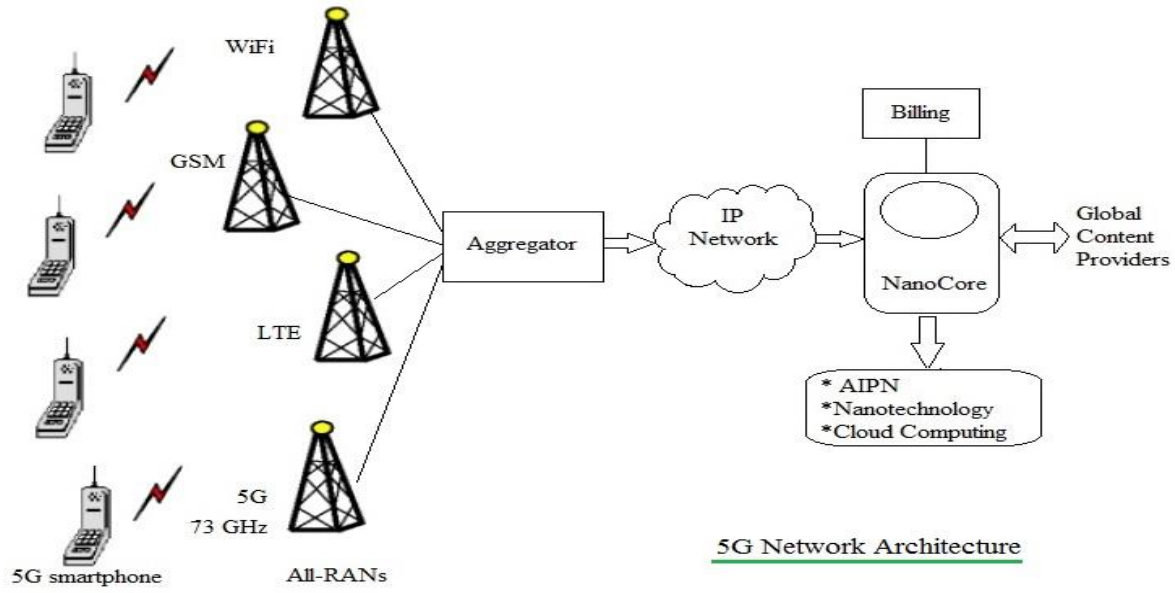


Fig. 2; Fifty Generation System Architecture

2. MIMO Antennas

MIMO "Multiple-In Multiple-Out" is very popular array antennas. This antennas are used to start in fourth generation in LTE technologies. Purpose of these antennas in cellular communication is to improve the speed to access the network for users. Earlier generations vertically polarized signals are broadcast, so the wave goes "up and down." However, LTE MIMO waves are slant polarized, meaning that each wave is rotated 450 degrees from mirrored, with the first at 450 and the second at 1350. Polarization diversity is a clever mechanism that allows our modem to distinguish two distinct streams of the same frequency assigned by the phone tower. Our modem contains two internal antennae, each of which is responsible for receiving one data stream. Having two independent exterior antennas is really important. Large data transmissions at millimeter-wave wavelengths result in a high-dimensional spatial signal space, which could be demoralized for critical limit increases via high-dimensional multiple-input multiple-output systems. (MIMO) procedures.

3. Problem Statement

Long Term Evolution (LTE) is 4G technology that caters to the needs of consumers that require high-speed data. LTE development is still concentrated on major cities such as Kathmandu, Pokhara, Khartoum, and Banepa, to name a few. It is feasible to begin developing 5G networks in some other area such as Hyderabad city.4G LTE radio frequency is planned by using 2*2 MIMO antennas. In this research fifth generation system is planning by using 4*4 MIMO and 8*4 MIMO antennas. This array multiple- input and multiple-output antenna will increase the capacity, coverage, gain, speed than 2*2 MIMO antennas. 4*4 antennas capable of transmitting information two times as fast as 2x2 MIMO

4. Exploration Objectives

The required focus of this thesis is to project the 5G system of RF network in estimated preparation tools and watch its capacity, reporting and huge Quality of Service.

5. Literature Review

The 3rd Generation Partnership Project (3GPP) works to give 5G-NR (New Radio) as its 5G communication normal plan. This 3GPP standards organization which develops some stranded rules for 5G mobile communication. 3GPP Partner telecommunications companies are seven like ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, and TTC. This develops and maintains the network.3GPP technology provides UMTS and associated 3G standards, as well as HSPA. LTE and associated 4G principles, as well as LTE Innovative Fifth generation give a lot of speed for smaller areas however LTE provide more coverage for more distance but speed is a smaller amount than 5G.

Wireless network MIMO permits the spreading and reception of more than one data signal concurrently over the identical radio channel. Whereas enormous MIMO structure able to provide great amount of antennas. Massive MIMO improves the coverage speed. This technology still in research for Fifth generation 3GPP proposed Massive MIMO antennas to design base stations. But all Mobile devices are not support that technology, For instance, the iPhone XR provisions 2x2 MIMO, while the iPhone XS supports 4x4 MIMO. This technology still in research

MU-MIMO (Multiple Input from Multiple Users Numerous Output) refers to the ability to send data to multiple users at the same time rather than just one, or to transfer data to network users using multiple data streams at the same time to boost speed. SU-MIMO is a term that refers to a system that (Single User-MIMO) MIMO is a multi-transmitter/receiver expertise that dedicates the entire access point's bandwidth to a single high speed device for the duration of the time slice.

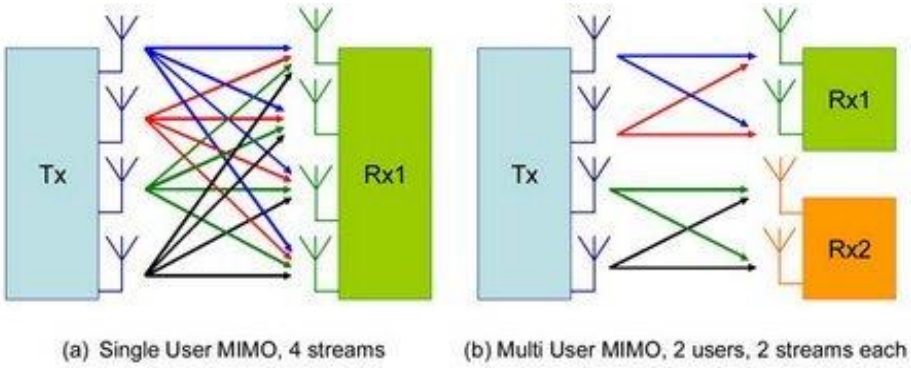


Fig. 3; (a) SU-MIMO, (b) MU-MIMO

Digital Beam Forming: Because the same PRBs (frequency/time resources) can be used to transmit data for numerous users simultaneously, digital beam forming improves cell capacity. A large beam forming with association antenna with two hundred pieces is used in a 5G system at 15GHz by 100MHz TDD. The classification is considered to adapt very flexible UE beam forming beam forming, and its management channels are designed to be ultra-lean.

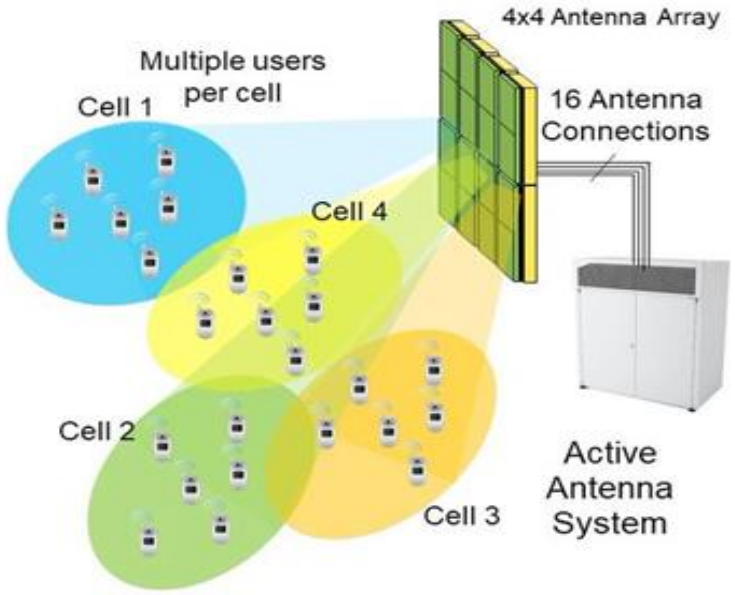


Fig. 4; Beamforming for 4*4 MIMO Antennas

SDFM

SPATIAL MULTIPLEXING: Spatial multiplexing (SM) is a spread procedure in MIMO wireless communication, Fibre-optic communication and other communications technologies to diffuse self-governing and distinctly free and independently encoded data signals, recognized as "streams". Hence, the space dimension is recycled, or multiplexed, in excess of one time. 2x2 MIMO is essentially two tributaries of data for diffuse and obtain paths; 4x4 MIMO is four streams.

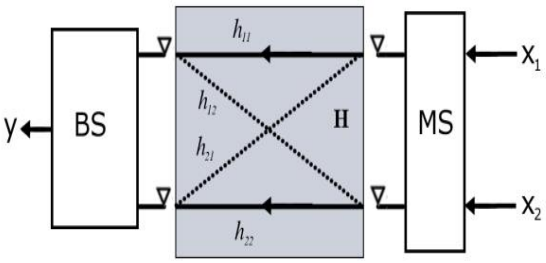


Fig. 5; Spatial Multiplexing in MIMO

$$\mathbf{y} = \mathbf{H}\mathbf{k}\mathbf{x} + \mathbf{n}$$

$$\boldsymbol{Y} = \begin{bmatrix} y_1^1 \\ y_2^1 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} n_1^1 \\ n_2^1 \end{bmatrix}$$

$$\boldsymbol{Y} = \begin{bmatrix} y_1^1 \\ y_2^1 \\ y_1^{2*} \\ y_2^{2*} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \\ h_{12}^* & -h_{11}^* \\ h_{22}^* & -h_{21}^* \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} n_1^1 \\ n_2^1 \\ n_1^{2*} \\ n_2^{2*} \end{bmatrix}$$

MM-WAVE: Millimeter wave, is also called as enormously huge recurrence (EHF) or very huge recurrence (VHF) by the ITU, it tends to be utilized for fast remote broadband interchanges. Millimeter wave is an immature band of range may be utilized in a wide scope of items and administrations such as fast, point-to-point remote neighborhood (WLANs) and broadband admittance. In broadcastings, millimeter wave is utilized for variability of amenities on mobile and remote systems, as it considers sophisticated information rates equal to 10 Gbps. Millimeter waves have short wavelengths that range from 10 millimeters to 1 millimeter. Downpour and moistness can affect execution and diminish flag quality, a condition realized downpour blur. Because of its small scope of round a kilometer, millimeter wave goes by viewable pathway, so its high frequency wave-lengths could be obstructed by physical objects such as buildings and trees.

3GPP: To the end client the administrator plans won't be unmistakable, and worldwide roaming terminals will most likely develop for those customers who are eager to pay for a global service. Over time, progress will be made toward all-IP networks, in which all amenities are offered over packet switched networks. Voice, short messaging, WAP, and email are all circuit switched services in GSM. While speech is still transported over the circuit switched network, 3GPP Release '99, in conjunction by the packet core network, provides a huge range of novel packet switched services Through the advent of IP Multimedia Subsystem (IMS) in 3GPP Releases 5 and 6, packet switched networks can now provide almost all services, making network management and service design easier. This development is shown in Figure.

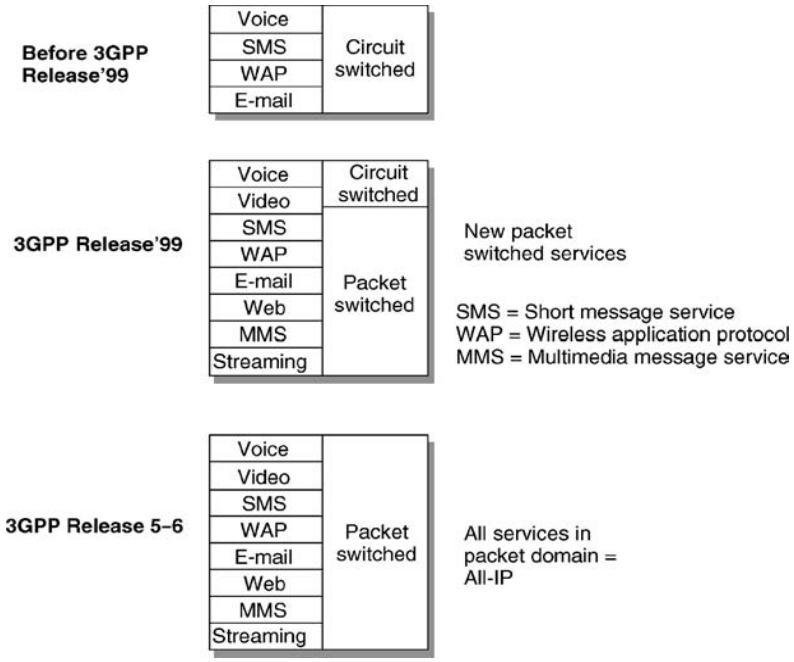
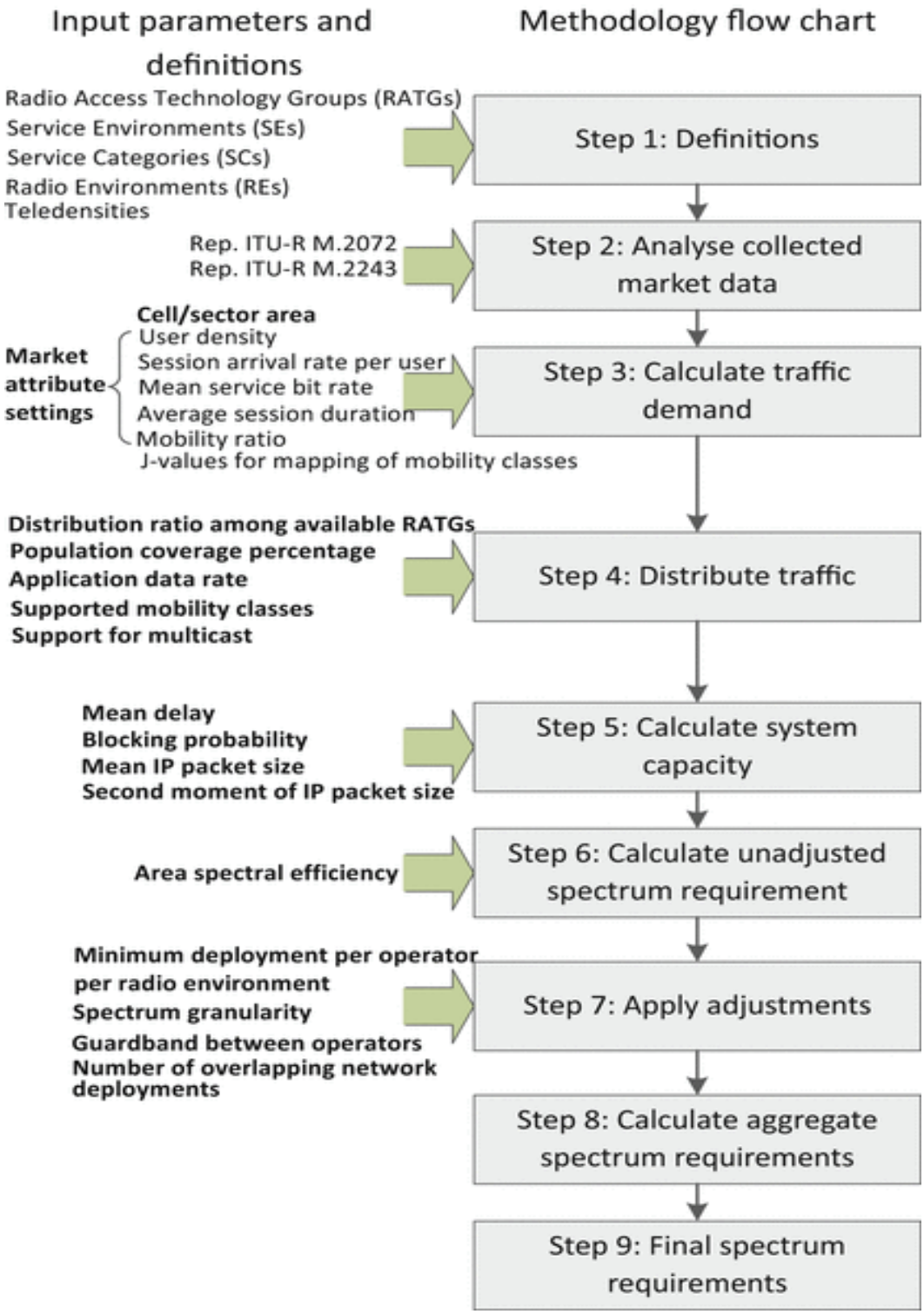


Fig. 6; Development to All-IP 3GPP

6. Methodology of Radio Network Planning

The structure of radio system arranging (RNP) is the premise of the development of a remote portable system. The structure dimension of system arranging chooses the future format of a system, and its including dimensioning, point by point Capacity and inclusion arranging, and

system advancement GSM, WCDMA, LTE radio system dimensioning is a procedure done by conceivable arrangements and the measure of system hardware are assessed, depending on the operator's necessities associated to the subsequent.



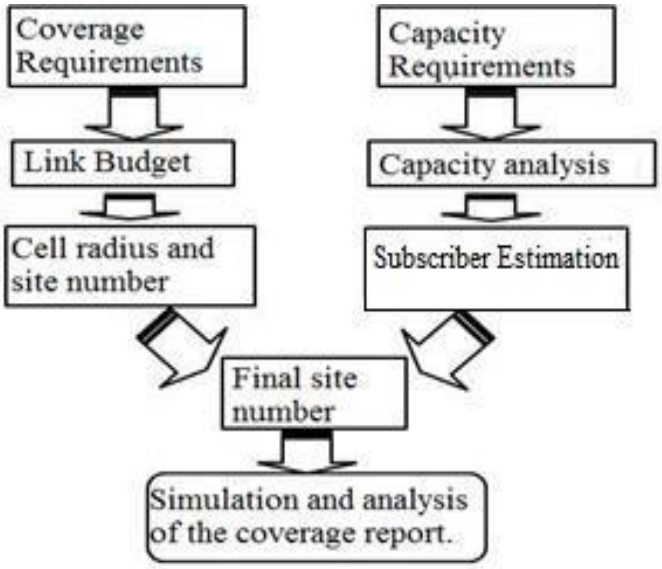


Fig. 7; Flow chart of RF Network Planning

Exposure

- Exposure provinces
- Zone type data
- Propagation circumstances

Capacity

- Spectrum accessible
- Subscriber development conjecture
- Traffic density data

QOS (Quality of Service)

- Area location probability (reporting likelihood) Obstructive probability
- End client amount of sites
- Resulting in a more effective frequency usage and minimal interference

Radio link budget and coverage analysis, capacity approximation, and, eventually, estimates on the size of sites and base station hardware, radio network controllers (RNC), equipment at various interfaces, and core system components are all part of the dimensioning process (for example Circuit Switched and Packet Switched Domain Core Networks).

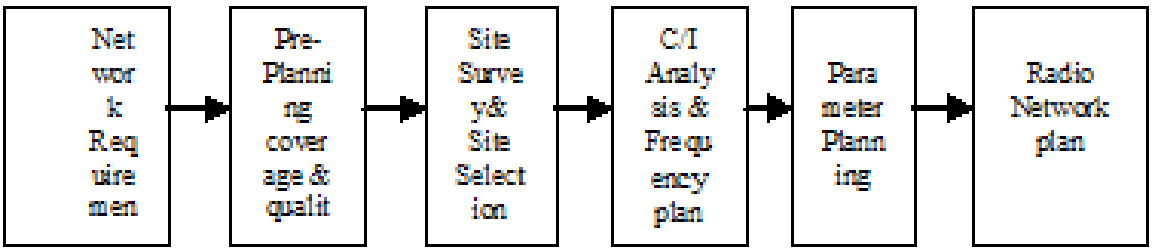


Fig. 8; The Radio Network Planning Process

The main aim of 5G to offer a huge data rate, low inexpression and packet enhanced radio access expertise supportive flexible bandwidth deployments by proficiency of 20Gbps downloading rapidity and 10Gbps uploading rapidity. Fifth generation utilizes together FDD and TDD as duplexing methods to provide all sorts of spectrum possessions.

7. Radio Network Planning Tool

To design the radio network for Fifth generation mobile communications, here we are utilizing prediction software Link planner. This is a Multi-technology network strategy stage that provides wireless operators all over the network lifecycle, since primary design to densification and optimization. This programmer is a free network design and optimization platform. This software package includes a high performance broadcast control engine, categorized networks, multi-service traffic modeling, and instinctive frequency/code planning and optimization. Link planner now includes an automatic cell planning (ACP) module, which was added in version 3.4. Link planner allows data distribution, data integrity monitoring, and relaxed connection through other IT systems in multi-user scenarios thanks to novel database architecture.

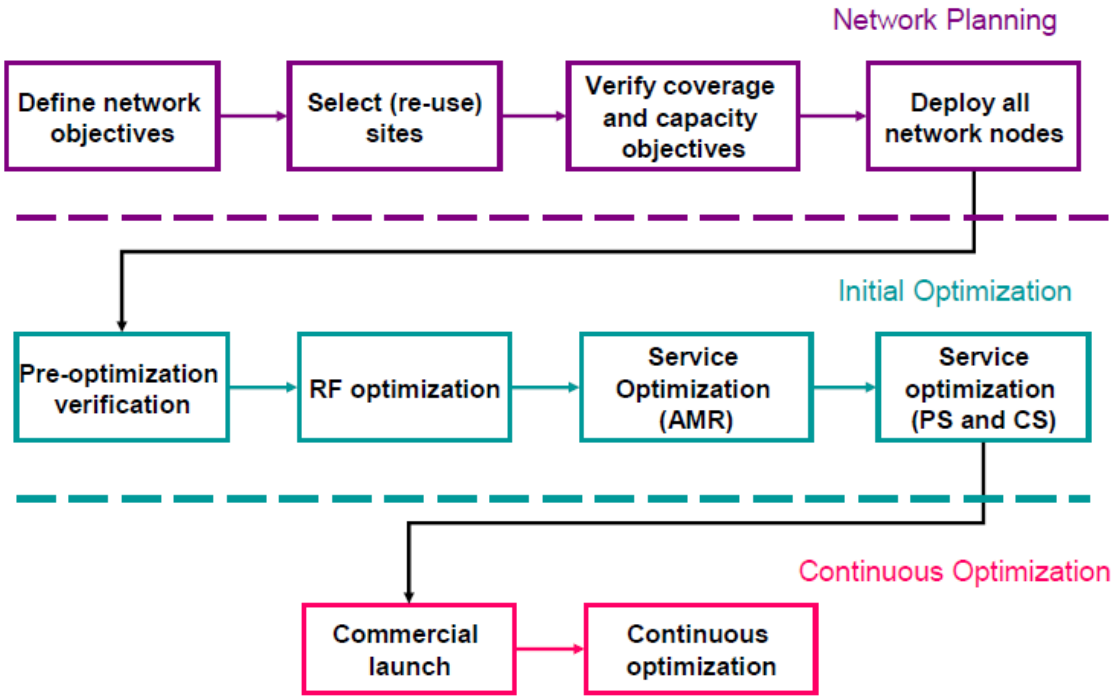


Fig. 9; Summary of Network Deployment Steps

Network Modeling

- Provision for numerous carriers and frequency bands (e.g., UMTS 900/1800/1900/2100)
- HSPA and HSPA+ modeling
- MIMO modeling
- VoIP modeling

8. Experimental Outcomes and Discussion

Generation of forecast plots depending on reproductions or on user defined cell load figures, as well as,

- Ec/Io forecast plots
  - Downlink and uplink Eb/Nt forecast plots
  - Provision areas
  - Amount of servers
  - Abdication areas
  - Intrusion and pilot pollution
  - BER/FER/BLER
  - HSPA forecast plots
  - MIMO provision zone

For a good coverage the following parameters should be changed/ installed.

- Location (longitude/latitude)
- Installation of additional antennas (Number of sectors 4 sector or
- 5 sector)
- Antennas Height/Ground
- Antenna Models i.e. Directional or Omni directional MIMO antenna
- Azimuth angle
- Tilt (Mechanical down tilt and additional electrical down tilt)
- Maximum power (up to 46 dBm)

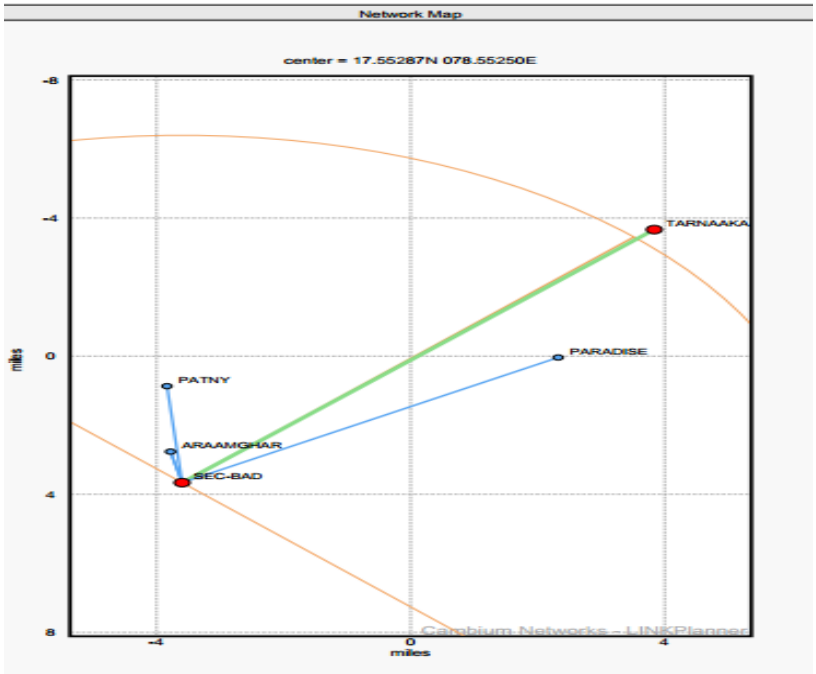


Fig. 10: Planning of RF Network Offline Map

The connection of PMP link is among greater than 3 BS towers. Further, in this 1 site performs in the form of hub-site while other sites have been considered as subscriber-sites.

The link of blue-color has been a connection of PTP link and dots of blue-color have been considered as sites of subscriber.

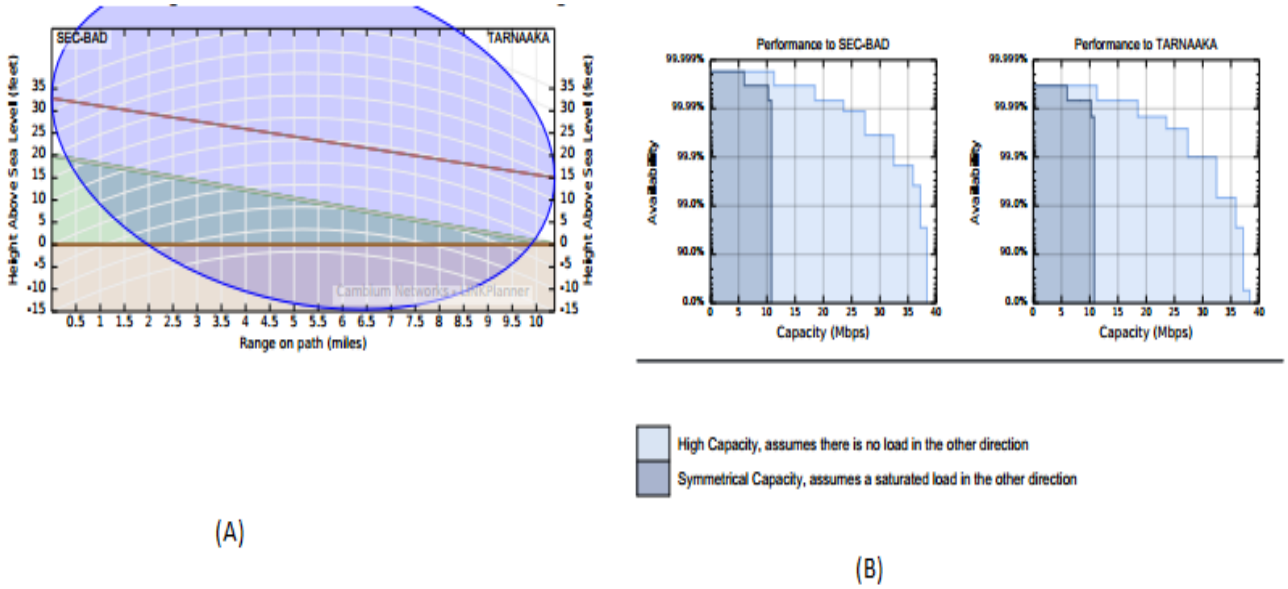
Table 3. Map Locations of Sites

NETWORK SITES					
Name	**Lat**	**Longi**	**Maximal Height (m)**	**Links of PTP**	**Hub of PMP**
SEC-BAD	17.49990 N	078.49830 E	33	1	YES
site-1	17.60584 N	078.61031 E	33	1	NO
SUBSCRIBER SITE					
Name	**Lat**	**Longi**	**MAXIMAL Height (m)**	**Links of PMP**	
PARADISE	17.55230N	078.587503E	33	1	
PATNY	17.54030N	078.49470E,	33	1	
ARAAMGHAR	17.51289N	078.49553E	33	2	

We have devised 5 sites, 2 of the sites utilize link PTP. Hub site has been utilized by site SEC-BAD. Aimed at connection of PMP, we have considered 3 sites as exhibited in tab.

Table 4. PTP LINK BS Coverage

LINK of PTP									
Name	**Range (km)**	**Multiply**	**Sum of Throughput (Mbps)**	**Accessibility of link**	**Left Height (m)**	**Left Gain (dBi)**	**Right Height (m)**	**Right Gain (dBi)**	**Link Loss (dB)**
SEC-BAD to TARNAAKA	10.377	ePMP2000	21.61	100	33	35	8	35	121.1



(A) (B)

Fig. 11; (a) Path Profile of Sites, (b) Capacity Performance Charts of the SEC-BAD &TARNAAKA

The network sites have been designed using 5.25-5.85 GHZ, 6-FT (1.8M), huge presentation dual pole radio waves with maximum performance. Also, 6 feet has been the height of the antenna and 5.8 GHz is the 5G frequency band used. 40MHZ has been considered as channel bandwidth. IP has been an optimization. All 1,5 network sites have been showcased along with their capacity performance in fig.

Table 5. Estimated IP Availability

	Performance to SEC-BAD	Performance to TARNAAKA
Mean IP	10.8 Mbps	10.8 Mbps
IP Availability	99.9983 % for 1.0 Mbps	99.9966 % for 1.0 Mbps

Link Summary			
Link Length	10.377 mi.	System Gain Margin	21.15 dB
Band	5.8 GHz	Mean Aggregate Data Rate	21.6 Mbps
Regulation	India	Annual Link Availability	99.9966 %
Modulation	Adaptive	Annual Link Unavailability	17.8 mins/year
Bandwidth	40 MHz	Frame Size	128 Bytes
Total Path Loss	132.45 dB	Prediction Model	ITU-R
System Gain	153.60 dB		

In sec-bad site, network sites have been declared and the result of experimentation has been specified in. Network site coverage has reached 99.99%. Among these three sites, one site has been considered to be a subscriber site and a link to the Hub site was provided to improve capacity and performance to meet customer needs. The act of a central site as a BS access point. The planning of the RF network has been considered within an area of 10Km.

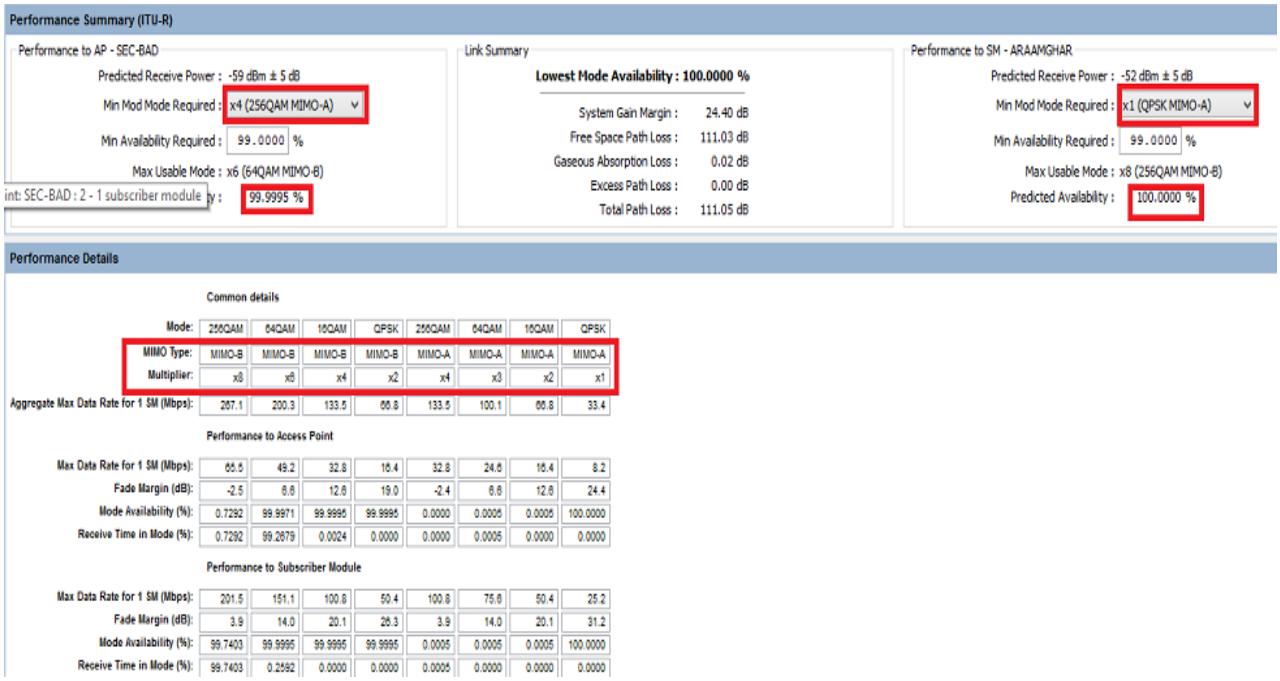


Fig. 12; Experimental Performance of Sites Sec-bad and Aramghar UL/DL Outcomes

Hub Summary	
Name of Hub	site-1
Amount of APs	4
Amount of linked subscribers	3
Overall estimated DL throughput (TP)	991.95 Mbps
Overall estimated UL TP	160.50 Mbps
Overall TP	1152.45 Mbps
Summary of APs	
TYPE OF DEVICE	ePMP 2000
Type of antenna	90° ePMP MIMO
Beam width	90°
Tilt of Antenna	0.0° (uptilt)
Highest Range	10 kilometers
Frequency Band of RF	5.8 GHz (5825 to 5875 MHz)
Channel Bandwidth of RF	80 MHz
MIMO	MIMO-A/B
Overall estimated DL TP	554.16 Mbps
Overall estimated UL TP	84.33 Mbps
Overall estimated TP	638.49 Mbps
DL/UL Ratio	75/25
Summary of Subscriber Module	
Name	site-2
Product	ePMP 2000
Range	10.377miles

Gain of Antenna	153.60 dB
Mode of Driver	TDD
Output Power of Transmitter	18.0 dBm
Source of Synchronization	GPS
Loss of Cable	0.8 dB
Path Loss of Free Space	132.25 dB
Excess Loss of Path	0.00 dB
Frequency Band of RF	5.8 GHz (5825 to 5875 MHz)
Highest EIRP	38.0 dBm
Output Power	18 dBm
Mode of Availability	99.9983%
Channel Bandwidth of RF	40 MHz

PTP LINK EXPERIMENTATION OUTCOME FOR SEC-BAD AND ARAMGHAR	
Name of the link	SEC-BAD AND ARAMGHAR
Country	India
PTP Mode of ePMP	PTP
Polarization	Dual
Product	ePMP 2000
Description and antenna type	Radio Waves 6ft High Performance Dual-Polar Parabolic
Antenna	3.0°
Gain of Antenna	23 dBi
Height of Antenna	33.0 meters AGL
Frame size	128 bytes
Highest mode of Mod	MCS15 (64QAM 0.83)
Highest sum of IP throughput	275.13 Mbps
Length of Link	10miles
RF frequency band	5.8 GHz (5825 to 5875 MHz)
Regulation	India
Modulation	Adaptive
Channel Bandwidth of RF	40 MHz
Gain of System	153.60 dB
Overall loss of Path	132 dB
Gain Margin of System	21.15 dB
Prediction approach	ITU-R
Availability of Annual Link	99.9983%
Mode of AP	TDD PTP
Mean sum of Data Rate	275.1 Mbps
DL/UL Ratio 50/50	75/25
Highest EIRP	36.0 dBm
Output Power	2.0 dBm
Beamwidth	90degrees

Total predicted UL Throughput	8.19 Mbps
Total predicted DL Throughput	50.38 Mbps
Less IP Throughput needed	10.00 Mbps
Losses	
Index of Refractivity	ITU-R P.453-9
Path Loss of Free Space	132.25 dB
Loss of Diffraction	ITU-R P.526-10
Propagation	ITU-R P.530-12
Total Loss Path	132.45 dB

In this examination, antenna MIMO –A/B has been estimated, the overall coverage of output has been 99.9995% at access point antenna side and subscriber antenna side 100% mode of modulation avilability. where as we used *4 Tx/Rx at access point antenna side and *1 Tx/Rx subscriber antenna side. We utilize 4 x 1 mode of transmission, from earlier fig. The profile speaks direction towards normal quality. From experimentation, it has been exhibited that depends on MIMO size how antenna serve the signal and give the signal avilabulity99.995% of Hyderabad city regions have been covered through a service 5G.

9. Conclusion

Investigation of radio system 5G organizes are to exhibit the suitable features of 5G for exhibiting the significant approaches for proliferation of radio organizing for measuring the component count of system and inclusion. This project implements several devices utilized in the radio-planning network. By this, depends on the radio architecture organizing technique, used Hub, AP, Subscriber antenna devices with different parameters. In this investigation observed by increasing and changing MIMO antenna, size how it changes, its signal availability changes designed. By enhancing the MIMO size, 5G network availability is also change.

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