Analysis of 5G Network Planning and its Achievements of MIMO Antenna to Improve Total Throughput in Simulation software

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***Abstract*— Cellular and Mobile communication system has grown exponentially. Throughput performance is the major point for mobile network. Higher throughput is mostly important for users and operators. It helps users to decreases and save the time enables them to use applications and services requiring higher throughput. This research paper is an attempt to contribute in this field to give more details about these challenges. The Fifth generation Radio network planning involves coverage estimation and capacity evaluation. Planning method used MIMO antennas with different antennas array patrons and using 5G specifications. Planning the network will be simulated using Linkplanner software. In this research paper, we are planning the network for Hyderabad city area.**

Keywords- Fifth Generation, Network capacity, Network Planning, MIMO antenna, Linkplanner.

1. INTRODUCTION

Radio frequency coverage and system capacity are two most important parameters for any mobile radio network planning. The first is related to the quality of service offered by the operator in the service area, while the second determines the total number of subscribers that can be served in the area. In this research, examine the performance of the future fifth generation cellular and mobile network in the millimeter wave band, considering these parameters.

5G systems have begun field testing and deployment plans are being formulated, following the completion of comprehensive standardization efforts and the introduction of multiple technological innovations to improve data rates and latency. Like previous terrestrial wireless technologies, construction of 5G systems will initially occur in areas of higher population density that offer the best business cases without fully addressing air and marine applications. Therefore, satellite communications will remain indispensable as part of an integrated 5G/satellite architecture to achieve truly universal coverage.

2. RF COVERAGE AND CAPACITY FOR COLOCATED 2G/3G/4G

First, we simulate cellular network in the microwave band, where the second-, third-, and fourth- generation (2G, 3G, and 4G) systems are collocated on the same BS sites. Collocation is a cost- effective and popular approach, which has helped operators to prune down deployment costs for their 3G and 4G networks by sharing sites with the 2G systems. Base station (BS) locations and the orientation of its antennas are typically designed to achieve a desired coverage within a particular cell. Tri-sector BS (or sites) have been widely used in cellular planning due their better interference rejection compared to the omni-directional antenna sites. Useful RF coverage (i.e., cell size) for any cellular system is generally inversely proportional to the carrier frequency; the higher the frequency the higher the path loss (PL) and the smaller the cell size. In cellular planning, PL must be estimated for a deployment environment and the cell coverage determined based on the base station (BS) and mobile station (MS) parameters for the technology concerned. PL for 2G networks operating at carrier frequency fc d 1.5GHz can be calculated using the Hata model shown in Eq. (1), while PL for 2G networks operating in the frequency range 1.5GHz d fc d 2GHz.

DIFFRENCE BETWEEN 4G AND 5G: The important specifications of all cellular generations given below table.

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
Technologies	ANALOG MODULATION	GSM,IS-136,PDC,IS-95	UMTS, WCDMA	LTE, EE, wimax	RAT
DRAWBACKS	ONE WAY COMMUNICATION	VOICE CALLS, SMS	BROWSEING IS VERY SLOW	LESS APLLICATIONS	

Table1: Specifications of cellular generations

In 4G wireless LAN is IEEE 802.11n but 5G WLAN is IEEE802.11ac. which improves the throughput performance of the network.

- 4G: fourth generation mobiles faster than 1G,2G ,2.5G and 3G.
- 4G is around five times faster than existing techniques.
- 4G downlink speed is 100Mbps and upload speed is 50Mbps.
- 4G use LTE (long term evolution), EE and Wi Max technique.
- In 4G technique they use 2x2 MIMO antenna at both transmitter and receiver end to improve communication performance. Which provide faster speed.

WITH AND WITHOUT MIMO ANTEENAS

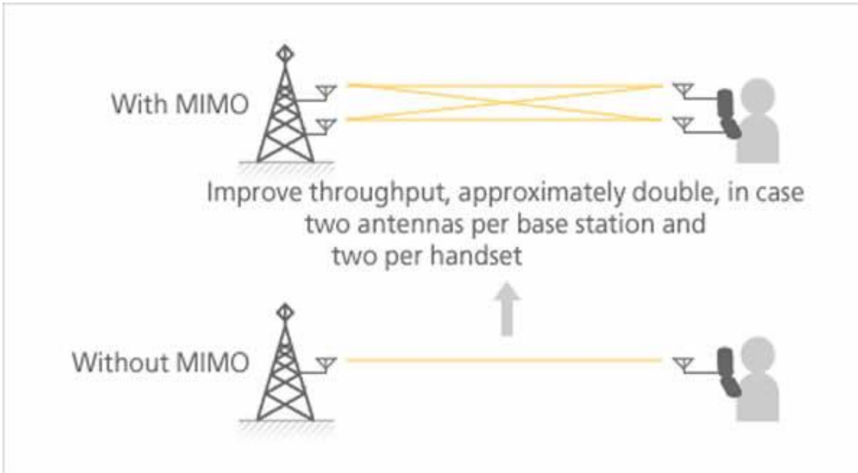


Fig 1: With and Without MIMO Anteenas

2x2 MIMO ANTENNA

- To help the user equipment's to identify the requirements of RF network.
- To discuss and agree on the RF design requirements, assumptions, and objectives of the transmitters and receivers.
- To identify the requirements of coverage, traffic, and various level service or network design.
- To 5G radio access will be built upon both new radio access technologies (RAT) and evolved existing wireless technologies (LTE, HSPA, GSM and Wi-Fi). 5G is faster than 4G.it provides nearly 10Gbps data rate, whereas 4G provide only 1Gbps.
- Downlink peak data rate is 20Gbps. Uplink peak data rate is 10Gbps, latency is less than 1ms(<1ms).
- In 4G they use only 2x2 MIMO antenna. but i we can design 5G RF Network by using. 4X4 MIMO antenna.

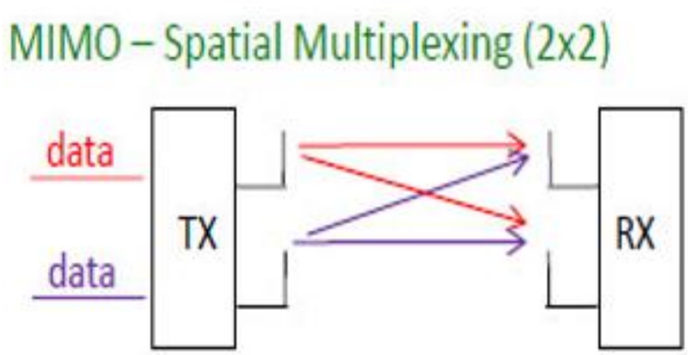


Figure 2: 2x2 MIMO

In fourth generation used 2X2 MIMO antennas its better performance, coverage than other earlier mobile generations.

MIMO is a radio communications technology or RF technology that is mentioned and used in many new technologies these days. WiFi, LTE and many other radio, wireless, and RF technologies are using new MIMO wireless technology to provide increased link capacity and spectral efficiency combined with increased link reliability using what were previously considered interference paths. Even now, there are many MIMO wireless routers on the market, and as this RF technology becomes more widespread, more MIMO routers and other pieces of wireless MIMO equipment will be seen. In 4G technique they use 2x2 MIMO antenna at both transmitter and receiver end to improve communication performance. Which provide faster speed.

3. 4G Mobile Communications Generation Systems using 2*2 MIMO antenna.

4G Multiple Input and Multiple Output (MIMO)is the technology that uses many antennae at the transmitter and the receiver end largely increases the data transmission rate. MIMO carries out three major functions, 1. Pre-coding, 2. Spatial multiplexing, 3. Diversity coding. Spatial multiplexing is otherwise termed as the space division multiplexing technique. This technique helps the transmitter antenna to transmit many signals from different streams of data to different receiver antennas simultaneously through the same frequency at the same time and sector frame. Further, the user equipment decodes each of the data stream data and from which the original sequence data is reconstructed. The pre-coding phase, the transmitting signal is being pre-processed in the radio frequency system and enhancing the pre-processing performance and efficiency of the spectrum.

Coverage by	**Surface (km²)**	**% Computation Zone**
Signal Level (DL)	**5.26**	**96.2**
Best Signal Level	0.064	1.25
Best Signal Level (dBm) >=-75	0.213	3.98
Best Signal Level (dBm) >=-80	0.82	14.99
Best Signal Level (dBm) >=-85	2.15	37.99
Best Signal Level (dBm) >=-90	3.41	65.15
Best Signal Level (dBm) >=-95	4.52	81.62
Best Signal Level (dBm) >=-100	4.99	91.15
Best Signal Level (dBm) >=-105	5.26	96.25

Table2: simulation result for 4G system using MIMO

Coverage prediction by Signal level

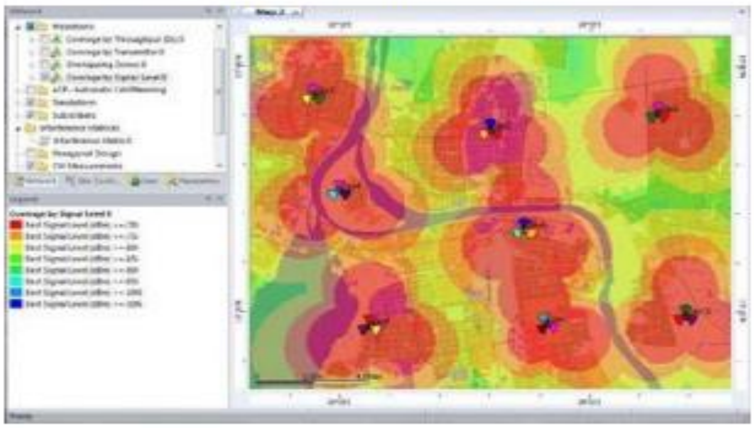


Figure 3: Simulation result for 2x2 MIMO antenna

In the above figure, the sites are designed at longitude 078.64624E and latitude 17.4731N, and the total coverage is 96.25% of the total area that can be covered by LTE service, which means the best signal (dBm) = -75.61 Bm with a standard deviation of -56.35.

4. Base station antenna model in 5G

In 4G they use only 2x2 MIMO antenna. but i we can design 5G RF Network by using 4X4 MIMO antenna in SU-MIMO and MU-MIMO give better capacity than 2x2 MIMO. Utilizes LTE, 5G based mobile communication technology for MU-MIMO and fix the antenna array size of 4x4, which outperforms the MIMO, SU-MIMO, and 2x2 MIMO. Therefore, communication standards and technologies continue to increase and the number of users in cells maximizes and the requirement for tremendously maximized MIMO antenna supports for LTE, 4G, and 5G communications and its frequency bands supported. A model for improving the performance of antennae using Multiple Input Multiple Output (MIMO) technologies.

For that in this study, a new MIMO is designed with the use of dual polarization-based network sites and a 4×4 MIMO sector-based antenna for subscriber modules. The configuration of Dual Polarized Network Sites is 5.25 to 5.85GHz, 2 feet with 0.6M height for Point to Point (P2P) and Point To Multi-Point (PMP) ePMP 4×4 MU-MIMO to Subscriber by ePMP 3000, 5.8GHz at 5825 to 5875MHz Access Point (AP) radio frequency (RF) band for SU-MIMO and 4×4 MIMO.

5G Specifications

Parameters	Values
Data rate	20Gbps
Frequency	3 to 300 GHz
Handoff	Vertical & Horizontal
Frequency band	3 – 300 GHz
Multiplexing	BDMA and CDMA
Peak data rate	10Gbps
Speed for uploading	10Gbps
Speed for downloading	20Gbps
Spectral efficiency	120b/s/Hz
Data bandwidth	1Gbps
Transmission time interval (TTI)	100 microseconds to 4 milliseconds
Delay	Less than 1 milliseconds
Mobility	500Kmph
Density connection	1000000 Km^2
Technologies	Unified IP, Seamless Integration of broadband, OFDM modulation
Core Network	5G Network Interface and Flatter IP Network

Table3: Specification of 5G Mobile RF planning

Base Station Antenna Design for 5G Cellular Communication using MIMO

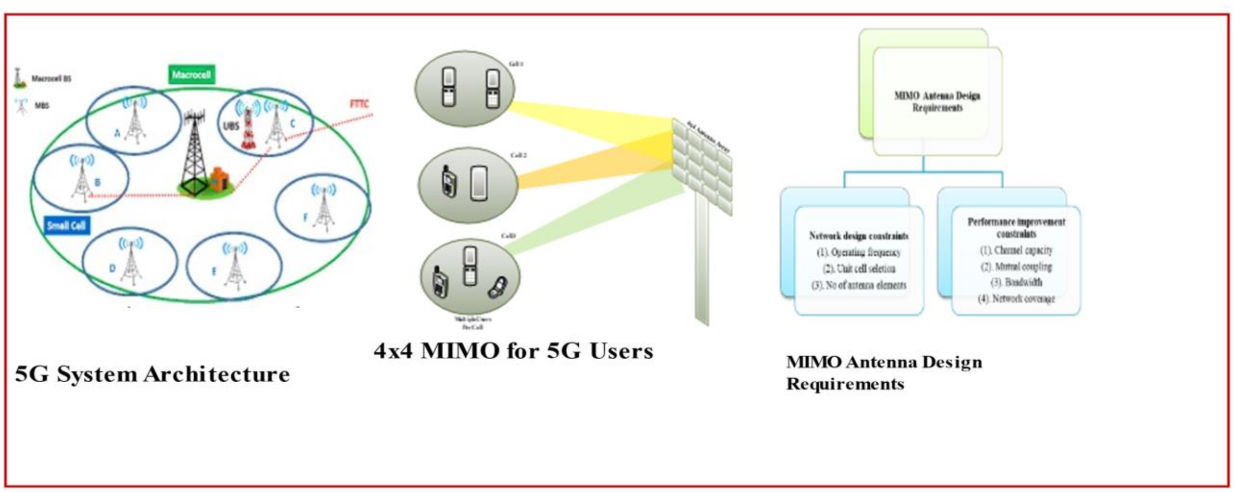


Figure 4: Fifth Generation Mobile Network by using MIMO antennas

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 through which conceivable arrangements and the measure of system hardware are assessed, based on the operator's requirements related to the following.

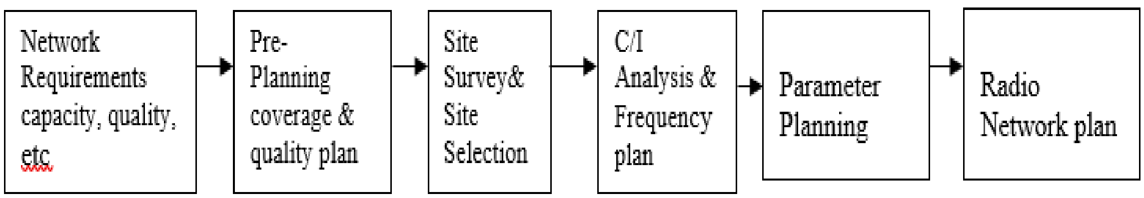


Figure 5: The radio network planning process

Coverage:
- Coverage of regions
- Area type data
- Propagation conditions.

Capacity:
- Spectrum accessible
- Subscriber development conjecture
- Traffic density data.

Quality of Service:
- Area location probability (coverage likelihood) Blocking probability.
- End client throughput of sites,
- Resulting in a more effective frequency usage and minimal interference

The main goal of 5G is to provide a high data rate, low latency, and packet-optimized radio access technology that supports flexible bandwidth deployments capable of 20 Gbps download speed and 10 Gbps upload speed. The fifth generation uses both FDD and TDD as duplex techniques to accommodate all kinds of spectrum resources.

5. Performance of MIMO in 5G

5.1 Performance Analysis: for SU-MIMO

A model for improving the performance of antennae using Multiple Input Multiple Output (MIMO) technologies. The configuration of Dual Polarized Network Sites is 5.25 to 5.85GHz, 2 feet with 0.6M height for Point to Point (P2P) and Point To Multi-Point (PMP) ePMP 4×4 MU-MIMO to Subscriber by ePMP 3000, 5.8GHz at 5825 to 5875MHz Access Point (AP) radio frequency (RF) band for SU-MIMO and 4×4 MIMO. Dual Polarized Vertical Antennas – this type of antenna is used on SISO technology.

In most cases, Omni-Directional Antenna is used as well as its capability to meet the network performance requirements such as Frequency band, Gain, RF Power Handling, and other parameters.

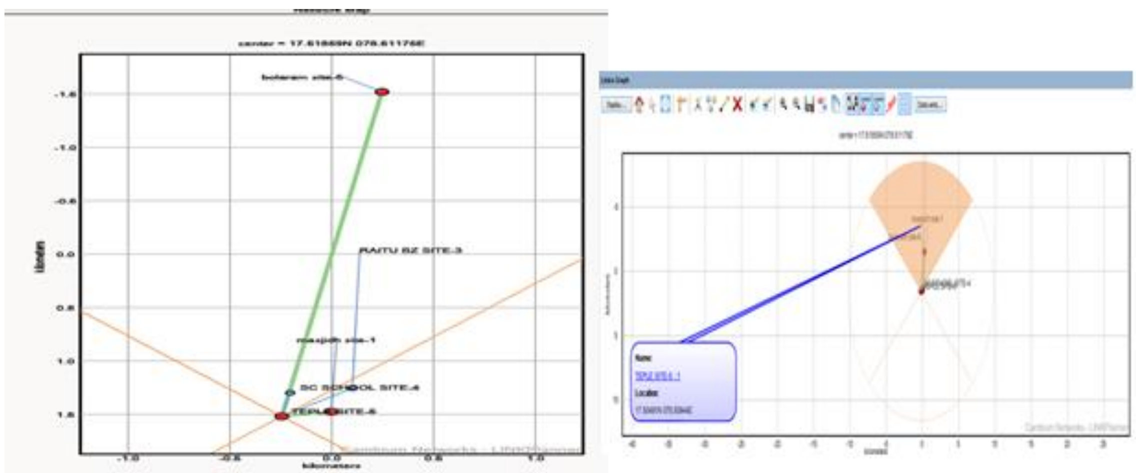


Figure 6: Planning of RF Network Offline and online Map

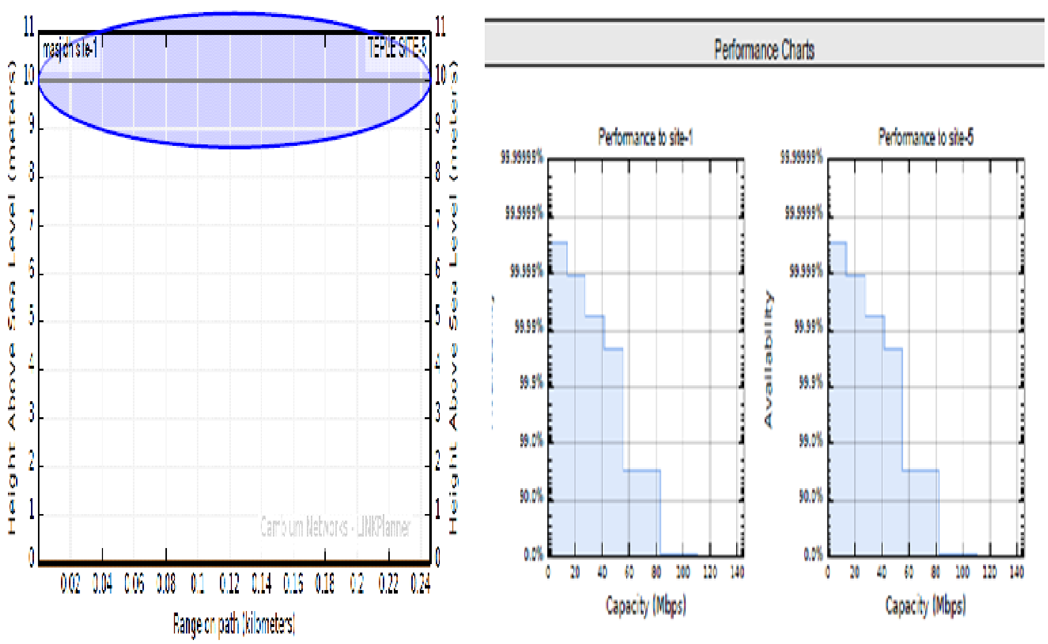


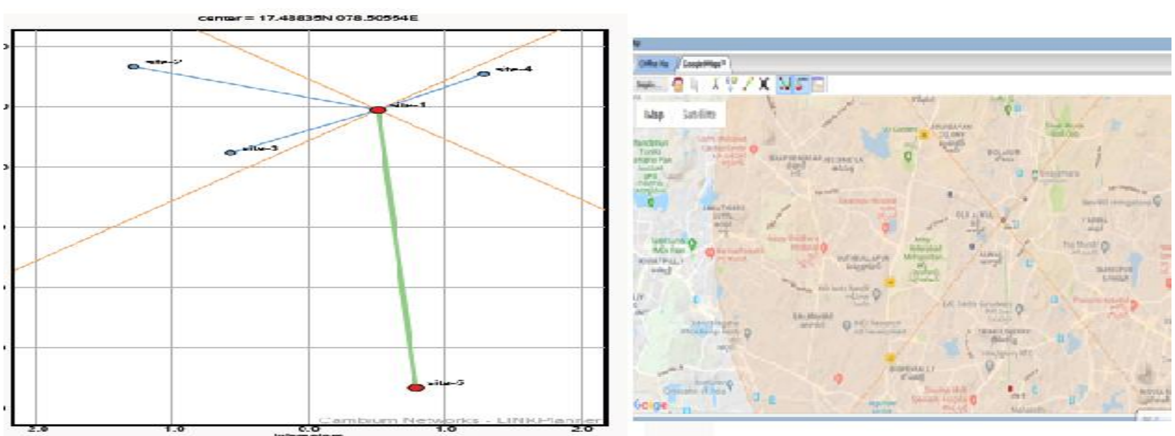
Figure 7: capacity performance charts of the site1 &5

RF network performance results for 2x2 and 4x2 SU- MIMO antenna

	2x2 MIMO site result	4x4 SU-MIMO site result
Country	India	India
Antenna Type &Description	2×2 MIMO	4x4 MIMO
RF Frequency Band 5.8 GHz (5825 to 5875 MHz)	1710MHz-1785 MHz,1805 MHz-1880 MHz	5.8 GHz (5825 to 5875 MHz)
RF Channel Bandwidth	5 MHz	40 MHz
MIMO Mode of transmission	2×2 MIMO	4x2 Single User
predicted the total output coverage	96.2%	99.9995%
Link Range	5.26km	0.224 km
Cable Loss	2dB	0.8 dB
Channel Bandwidth	5 MHz	40 MHz
Max EIRP	22 dBm	36 dBm
Predicted Receive Power	43dBm	-54 dBm ± 5 dB
Propagation	Cost-hata	ITU-R
Antenna Gain	18dBi	28.58 dBi
Transmitter Output Power	18.0 dBm	22 dBm

Table4: Simulation result comparison between 2x2 and 4x2 SU- MIMO antenna

5.2 Performance Analysis: for DL/UL by using MIMO-A/B antennas



(a)Offline Map (b)Google Maps

Figure 8: Planning of RF Network Offline and online Map

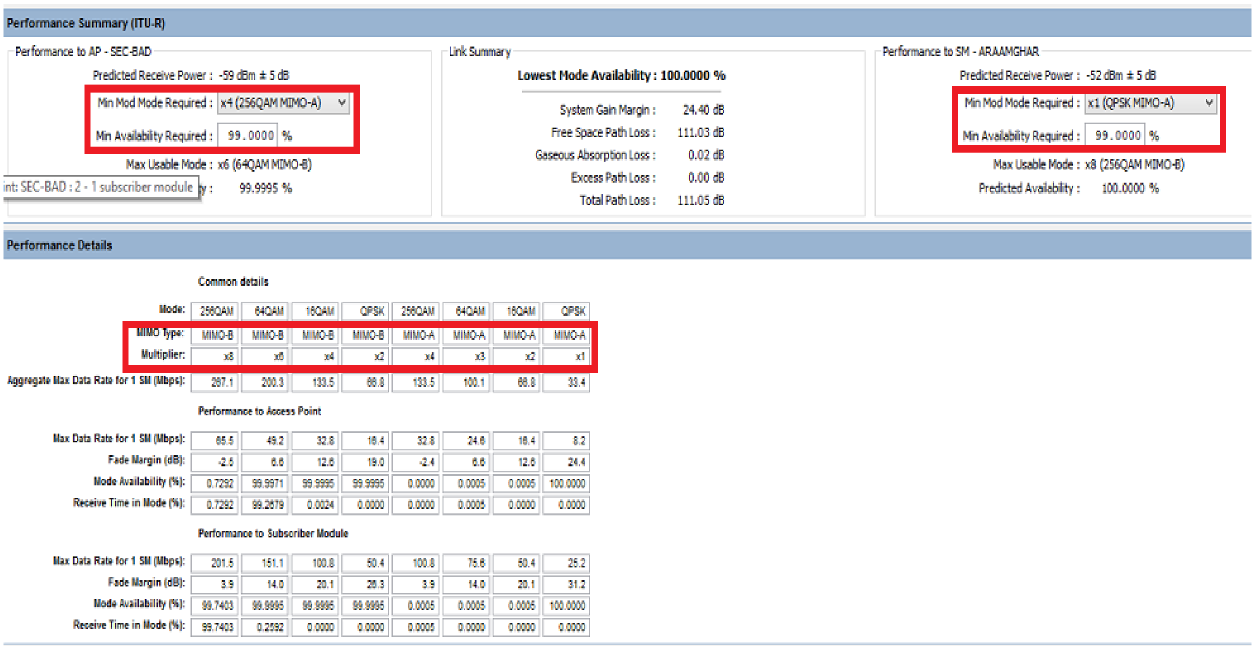
The PMP link connection is between more than 3 BS towers. Also, in this 1 site it is done in the form of a hub site, while other sites have been considered as subscriber sites. The link in blue has been a PTP link connection and the points in blue have been considered as subscriber sites.

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

Table5: Experimental outcomes for MIMO-A/B

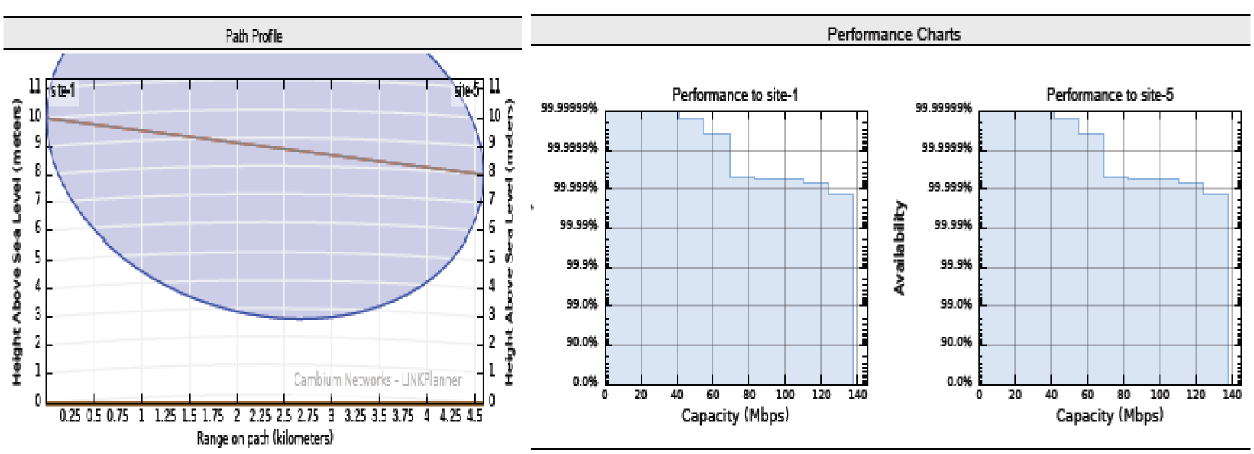
In this test, the MIMO –A/B antenna has been estimated, the overall output coverage has been 99.9995% on the access point antenna side and on the subscriber antenna side 100% coverage. Modulation mode availability. Where we use *4 Tx/Rx on the access point antenna side and *1 subscriber antenna side Tx/Rx. We use 4 x 1 transmission modes.



Common details								
Mode:	256QAM	64QAM	16QAM	QPSK	256QAM	64QAM	16QAM	QPSK
MIMO Type:	MIMO-B	MIMO-B	MIMO-B	MIMO-B	MIMO-A	MIMO-A	MIMO-A	MIMO-A
Multiplier:	x8	x6	x4	x2	x4	x3	x2	x1
Aggregate Max Data Rate for 1 SM (Mbps):	267.1	200.3	133.5	66.8	133.5	100.1	66.8	33.4
Performance to Access Point								
Max Data Rate for 1 SM (Mbps):	65.5	49.2	32.8	16.4	32.8	24.6	16.4	8.2
Fade Margin (dB):	-2.5	6.6	12.6	19.0	-2.4	6.6	12.6	24.4
Mode Availability (%):	0.7292	99.9971	99.9995	99.9995	0.0000	0.0005	0.0005	100.0000
Receive Time in Mode (%):	0.7292	99.2679	0.0024	0.0000	0.0000	0.0005	0.0000	0.0000
Performance to Subscriber Module								
Max Data Rate for 1 SM (Mbps):	201.5	151.1	100.8	50.4	100.8	75.6	50.4	25.2
Fade Margin (dB):	3.9	14.0	20.1	28.3	3.9	14.0	20.1	31.2
Mode Availability (%):	99.7403	99.9995	99.9995	99.9995	0.0005	0.0005	0.0005	100.0000
Receive Time in Mode (%):	99.7403	0.2592	0.0000	0.0000	0.0005	0.0000	0.0000	0.0000

Figure 9: Experimental performance of AP and subscriber antennas UL/DL outcomes

5.3 Performance Analysis: for MU-MIMO antennas:



(a) (b)

Figure 10: (a) path profile of sites, (b) capacity performance charts of the site1 to 5 for MU-MIMO

Access points						
Product	**Band**	**Bandwidth (MHz)**	**Latitude**	**Longitude**	**Antenna**	**Height (m)**
ePMP 3000	5.8 GHz	80 MHz	17.50584N	078.51031E	90° ePMP 4x4 MU-MIMO Sector Antenna	10
ePMP 3000	5.8 GHz	80 MHz	17.49945N	078.50016E	90° ePMP 4x4 MU-MIMO Sector Antenna	10
ePMP 3000	5.8 GHz	80 MHz	17.51119N	078.51754E	90° ePMP 4x4 MU-MIMO Sector Antenna	10
ePMP 3000	5.8 GHz	80 MHz	17.51230N	078.49353E	90° ePMP 4x4 MU-MIMO Sector Antenna	10

Table6: (a) Hub site, (b) subscriber site Access points and PMP Links and (c) Access points

The network sites have been designed using 5.25-5.85 GHZ, 6-FT (1.8M), high performance 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 9.

HUB SUMMARY	
Hub Name	site-1
Number of Access Points	4
Number of Connected Subscribers	3
Total Predicted DL Throughput	991.95 Mbps
Total Predicted UL Throughput	160.50 Mbps
Total Throughput	1152.45 Mbps
ACCESS POINT SUMMARY	
Equipment Type	ePMP 3000
Antenna Type	90° ePMP 4x4 MU-MIMO
Modeled Beamwidth	90°
Antenna Tilt	0.0° (uptilt)
Max Range	10 kilometers
RF Frequency Band	5.8 GHz (5825 to 5875 MHz)
RF Channel Bandwidth	80 MHz
MIMO Mode of transmission	4x4 Multi-User
Total Predicted DL Throughput	554.16 Mbps
Total Predicted UL Throughput	84.33 Mbps
Total Predicted Throughput	638.49 Mbps
DL/UL Ratio	75/25
Antenna Azimuth 90.00° from True North	90.00° from True North, 90.64° from Magnetic North
SUBSCRIBER MODULE SUMMARY	
Name	site-2
Product	ePMP Force 300-25
Range	1.920 km
Antenna Gain	22.4 dBi
Driver Mode	TDD
Transmitter Output Power	18.0 dBm
Synchronization Source	GPS
Cable Loss	0.8 dB
Free Space Path Loss	113.46 dB
Excess Path Loss	0.00 dB
RF Frequency Band	5.8 GHz (5825 to 5875 MHz)
Max EIRP	38.0 dBm
Output Power	18 dBm
Mode of Availability	100%
RF Channel Bandwidth	80 MHz

Table6: Experimental result for MU-MIMO for 5G network

6. Simulation Result comparisons for 5G system 2x2 MIMO, SU- MIMO and MU- MIMO site result

	TWO by TWO MIMO site result	**SU-MIMO site result**	**MU-MIMO site result**	**Significance of parameters**
Country	India	India	India	Place of site
Antenna Type &Description	2×2 MIMO	4x4 SU-MIMO	4x4 MU-MIMO	Model of MIMO antenna
RF Frequency Band	1710MHz-1785 MHz, 1805 MHz-1880 MHz	5.8 GHz (5825 to 5875 MHz)	5.8 GHz (5825 to 5875 MHz)	Radio frequency band that is used for communications transmission and broadcasting (3kHZ to300GHZ).and reduce the interference caused by the communication system.
RF Channel Bandwidth	5 MHz	40 MHz	80 MHz	RF channel Bandwidth will increase the down loading speed to down load files or videos from one website to another.
MIMO Mode of transmission	2×2 MIMO	4x2 Single User	4x4 Multi-User	In MU-MIMO RF signal ability to send/ receive several users simultaneously, instead of just one in SU-MIMO ability to send/ receive single user at a time ("single user").
predicted the total output coverage	96.2%	99.9995%	99.9999%,	It shows predicted received time mode of the signal.
Link Range	5.26km	0.224 km	1.920 km	It shows distance between cell site to other cell site
Cable Loss	2dB	0.8 dB	0.8 dB	The loss introduced by the cable varies with frequency
Max EIRP	22 dBm	36 dBm	38.0 dBm	EIRP is the product of transmitter power and the antenna gain and it is the measured radiated power of an antenna in a specific direction

Predicted Receive Power	43 dBm	-54 dBm ± 5 dB	-51 dBm ± 7 dB	The Predicted Receive Power shown is that the most receive power once mistreatment merchandise in adaptive Modulation mode that adapt the transmit power with modulationmode. there's continuously little variation like -+ 5 dBm
Propagation	Cost-hata	ITU-R	ITU-R	It give the specific direction
Antenna Gain	18 dBi	28.58 dBi	35.4 dBi	If gain increases performance of network is also increases
Transmitter Output Power	18.0 dBm	18.0 dBm	18.0 dBm	Tx O/p power increased by the gain or loss of the antenna system. As opposition the ability created into a 50Ω load connected at the antenna port, this relates to the ability really radiated once the antenna is connected

Table6: Simulation result comparisons of different MIMO sizes for 5G network

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 availability.

7. CONCLUSION

In this work the 4X4 MIMO antenna is predicted, the total output coverage is 99.9999%, and using MU-MIMO 4x4 transmission mode, from the past figure, area of the absolute processing region. The management profile speaks of the normal. Quality signaling throughout the region. From the simulation, it can be determined that 99.9999% of Hyderabad city areas can be covered by 5G service. This mime antennas used for micro base station applications.

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