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LTE Signal Relay System using 28 GHz Millimeterwave Micro Cell design for Smart Home

Subhankar Shome[(1)], Rabindranath Bera[(1)] , Soumyasree Bera[(1)] and Samarendra Nath Sur[(1)]

(1) Sikkim Manipal Institute of Technology, Sikkim Manipal University, Sikkim, India

Abstract

Mobile internet requirement is growing day by day, as 5G is coming up and targeted to connect billions of new devices that will connect to operators' networks over the next decade and beyond. To get advantage of connected devices and high speed data communication, every Indian should have connectivity with moderate data speed. Next generation mobile network is also deploying the small cell network structure to handle this huge mobile phone user and connected devices. In reality India is still not ready to adapt these changes due to deficiency in required infrastructure. This work is focused to develop small cell millimeter wave community mobile Internet relay system, dreaming to provide internet facility with a moderate data rate to every Indian. This small cell design is step towards 5G infrastructure development and same can be useable for 5G deployment as it is designed over 28Ghz frequency range, which is recommended for 5G communication.

1. Introduction

Internet usage is more in urban areas where literacy is more, supported by better local connectivity infrastructures. But for a wider reach, especially to rural India, there is a demand for other technologies that are more accessible and at suitable price points. Mobile penetration has been successful from this perspective and has not only been used for networking & communication, but has gained a significant place in doing business and to stay in touch with latest information. Mobile network is further dreaming for multipurpose uses in the form of Control activity, Virtual reality, augmented reality and many more. Here 5G mobile [1] are coming in the society to fulfill all this dreams. Future mobile is becoming an essential device for every person. In Indian scenario this most essential device which can make society better is not reachable to every citizen. In India the mobile user with Smartphone and internet is near about 33 per cent, and in rural areas it is only 16 percent, a report released at the 'India Mobile Congress 2017'[2]. Here is a big gap in-between the need and availability of mobile internet in the Indian society.

In this article we address this internet problem of rural India. Authors have a very bad experience to get internet, when they will visit their birth places in rural areas. In this article author have measured the recent condition of Sajinagachi village in Kolaghat area of West Bengal, which village can be declared as NOT Spot as there is very week availability of Mobile Internet inside any village houses. This problem can be solved by two ways,

i) Mobile service providers build up their infrastructure to provide connectivity in the NOT SPOT Zone, which is totally dependent on their decision based on commercial analysis.

ii) Build community mobile Internet relay system to serve in a small community area in every village.

This work is based on second solution and formulated a small cell for mobile internet relay system using 28 GHz millimeter wave link.

2. Layout

In this work, microwave wave large cell is relayed for further mobile communication support in NOT spot area. Macro cell has been designed to serve local villagers using millimeter wave, this macro cell is designed in 28 GHz band for experimental purposes. The system block diagram is shown in the figure 1, and explained below,

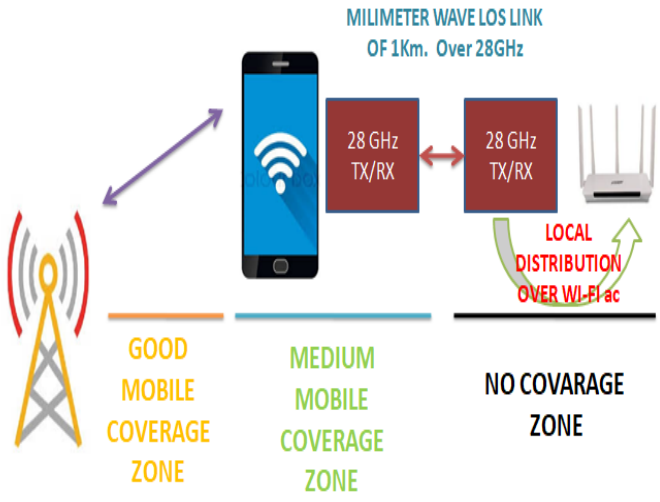

Figure 1: system black diagram for 28 GHz Micro cell design

In the above system block diagram the mobile coverage is divided into 3 zones. First zone is declared as good

Mobile coverage zone which is approximately less than 1 Km from the existing microwave mobile tower, after that 1 to 3 Km range is considered as medium signal strength coverage zone, and after that 3-5 Km or more than that is considered as NO coverage zone, as there is no mobile signal reaching inside the houses situated at zone -3, even very week signal strength is observed in open places.

In this research, we have explored zone-2 which is Medium signal coverage zone to place our system which will relay the mobile signal in zone -3 which is NO coverage area, using millimeter wave system. This system is mainly designed to serve internet in rural area, which motivate more people to connect with digital India program.

In Zone -2 the internet data rate is measured upto 30 Mbps, which is available in every smart phone of this region. This data can be shared with another Wi-fi ac or Wi-Fi bg router using HOTSPOT feature of Mobile phones. Authors switch ON the hotspot mode of smart phone and connect a Wi-fi router with it. This router setting is selected in client mode in which share data is available. In this mode, client router will act as a repeater, and the same data which is coming from connected smart phone that will get available in every LAN and WLAN port of the router.

Now here data reaches to millimeter wave system, 28 GHz millimeter wave system accept data using LAN port. Mobile phone is not possible to connect with it directly as there is no any LAN port available in mobile. Wi-fi router in client mode is working as a bridge for Internet data in between microwave mobile and millimeter wave system. Millimeter wave system is connected with the LAN port which available in the client router. In this way Mobile Internet is routed to the millimeter wave system using a client router.

Up to this, researchers are worked towards internet connectivity to 28GHz transceiver, which accepting any connectivity through LAN port. In this way one 28 GHz transceiver is connected with data connection and installed in Zone 2. One 28 GHz transceiver is providing 20 dB gain along with another 38 dB gain is available with Antenna. So around 58 dB of system gain is available to the user, which can be covered a long distance in LOS path. Other terminal of same LOS 28 Ghz link is planned to place in the NO coverage zone, where it will receive the relayed signal. This NO coverage zone is defined as zone 3 where user can enjoy internet with moderate data speed. This internet again can be distributed using LAN or WLAN switch. Authors are expecting a very low loss communication as millimeter wave LOS link runaround for small cell design; the theoretical Received Signal Level (RSL) is calculated and shown in figure below. [3]

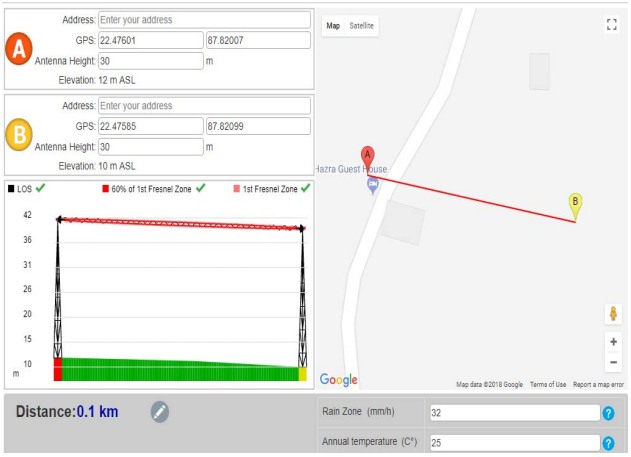

Figure 2: One Part of Path Calculator for 28 GHz link

Two locations are shown in above figure which is pointed out by A and B, both locations is coming under Kolaghat area in West Bengal. Point A is coming under Zone-2 where people are getting 30 Mbps data in open places, but point B is just 100 meter apart coming under Zone -3 where people are not getting internet inside houses. Figure-3 is showing the calculated RSL values between point A and B under kothaghat location. System parameters for small cell design are as below:

Link 1 (One TX One RX) Frequency : 28GHz
Link 2 (One TX One RX) Frequency : 27 GHz
Antenna Gain : 37.9 dBi
Antenna Size : 0.3 Meter
Antenna Beamwidth : 2.5 Degree
Transmit power selected : 0 dBm, (available 20dBm)
System bandwidth : 60 MHz (FCC)
Modulation/Demodulation : 32QAM

Considering the above parameters our RSL is calculated as -28.75 dBm for designed small cell, and this system is calculating a maximum through put of 190 Mbps. This system capacity value can vary by changing the bandwidth and modulation parameter, maximum capacity of the system is 490 Mbps.

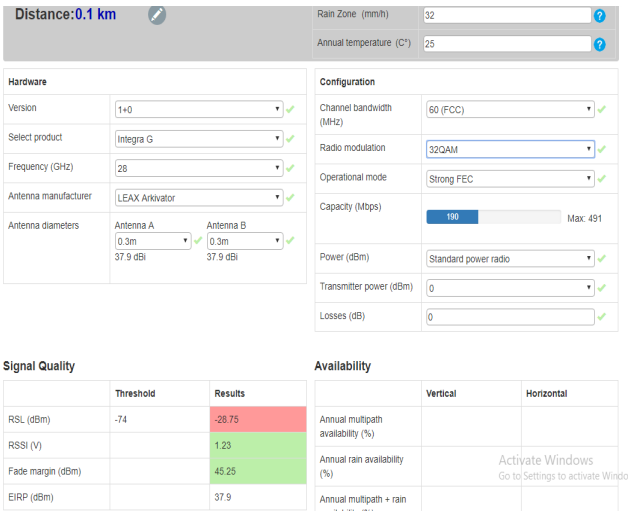

Figure 3: Part two of Path Calculator of 28 GHz

3. Simulation

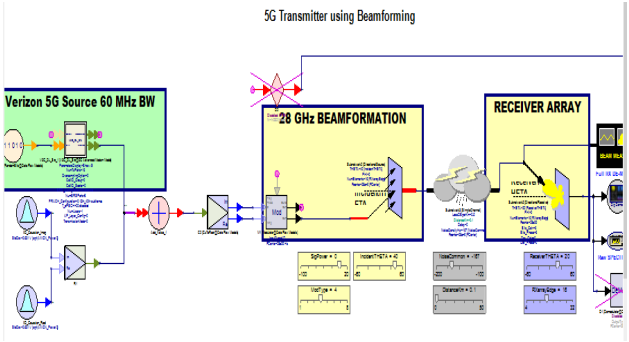

Figure 4: Path Loss Calculation using 28 GHz Link Simulation

The same environment according to Hardware parameters are simulated using SystemVue software. Verizon 5G sources is used in baseband with 60 MHz Bandwidth, 28 GHz carrier frequency is selected to simulate the real hardware and array antenna configuration is used to achieve beam formation as we targeted to create a 3 dB beam width of 3 degree. Verizon 5G downlink source uses a set of digital modulation like [QPSK, 16QAM, 64QAM] for the downlink shared channel. In this case, the QPSK modulation has been used. Further, the necessary control channels have been modeled for Verizon 5G downlink standard. Then, in the simulation, Verizon 5G data is further passed through multi carrier modulation i.e., OFDM. After designing the source signal, it is contaminated with channel noise and passed through a channel having the path length of 100 meter. The antenna beam formation is considered with the help of a 64-element Uniform Rectangular Array. The synthesized beam width is achieved as 5^0. The incident angle of departure (elevation) has been kept as 60^0 and the angle of departure (azimuth) is 0^0. In hardware experimentation 0.3 meter LEAX Arkivator [4] dish antenna is used with system where 3 dB beamwidth is specified to 3 degree. Simulation results are shown in result section.

4. Small Cell Design for RELAY SYSTEM

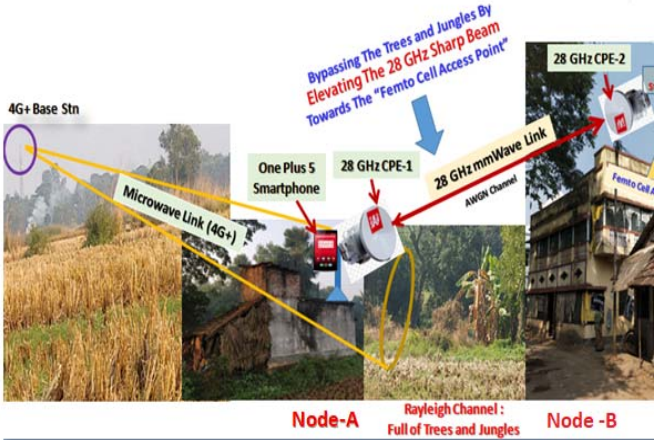

Figure 5: The Actual Picture of the Location and 28GHz Link establishment plan.

The 4G base station is visible in figure-5 which is far apart from Node A which is coming under Zone -2 where 30 Mbps data rate is measured in open place, here one 28 GHz transceiver along with Wi-Fi Client mode Router is placed as RELAY SYSTEM, Basically Node A is working as a Community Tower which is connected with available Mobile Internet and relaying the same to Node B, which is placed under Zone 3, where NO Internet is observed inside the building shown in this picture. On the top of this building we placed another 28 GHz system to establish the LOS link. This building is acting as a distribution center of the received relay signal. Now signal can be distributed over small area using WLAN or LAN switch. In this way a micro cell is designs using millimeter wave propagation which is future goal of 5G mobile communication.

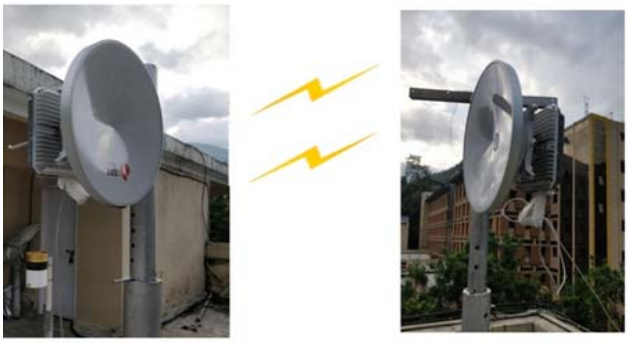

Figure 6: Real Hardware setup of 28 GHz Link in over 100 meters.

Whole is experimented over 100 meter of distance, one transceiver is relaying the mobile data using Wi-Fi bg interface in client mode, but we are recommending to use Wi-Fi ac in-between Mobile and 28 Ghz system, then there will be less chance of data drop for this interface circuitry. Internet data speed is measured in source Mobile which is around 20 MBPs going to be relayed. Another 28GHz transceiver received and again distributes it over a WLAN, here another mobile is connected as a final USER and data speed is measured on it using Speed test software, which is showing around 10 MBPs for Remote USER.

3. Results

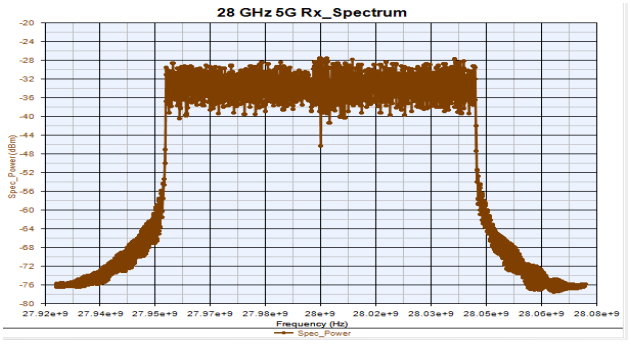

Figure 7: Received Power Level = -30 dBm at 100 meter range over the air 28 GHz.

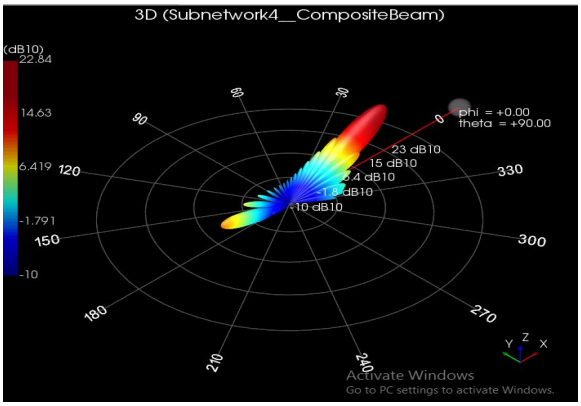

Figure 8: Simulated Beamformation of 5 degree Beam width

Figure 7 and 8 is showing the simulated result for 28 Ghz link. Here simulated system bandwidth is 60 Mhz and antenna beamwidth is 5 degree where -29 dBm received power is achieved over 100 meter of simulated distance.

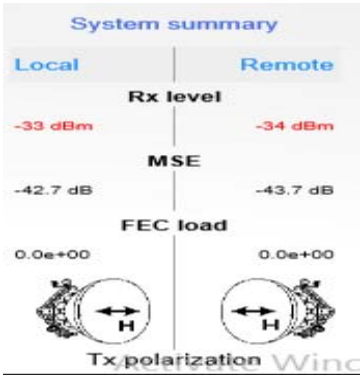

Figure 9: RSL of 28GHz Hardware Link

The Experimental RSL Level is -33dbm for Local 28 Ghz transceiver placed in Node A and -34dbm for Remote transceiver placed at Node B. The data throughput is also measured for Mobile internet at the source end and after relaying the over 28 Ghz link.

3.1 Table

RECEIVE SIGNAL LEVEL (RSL) VALUES

Calculated Value	Simulated Value	Experimented value
-28.75 dBm	-29 dBm	-33 dBm

In this above Table Received signal is compared in three different aspects, One is theoretical value another is simulated value and third one is experimented value, Simulated and theoretical value is supporting the experimented one.

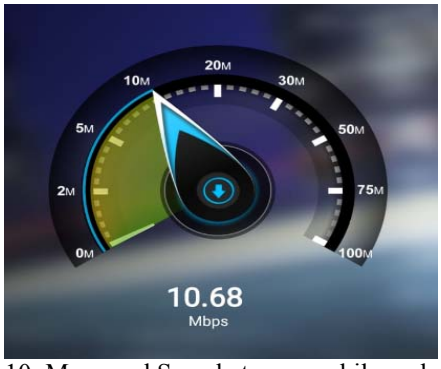

Figure 10: Measured Speed at user mobile under NOT SPOT Zone

4. Conclusion

This work is planned to serve internet in rural India. Here a village of West Bengal is consider as Target Village, and authors are planning to install the whole infrastructure there as described in section –I. The experimentations are carried out in SMIT, Sikkim before reaching in the experimental zone. The authors are initiated few propagation study also using the millimeter wave link to get an idea about channel impact over 28Ghz. RSL verified is verified in three different way, and shown in the Table -1, which is coming more or less same, which proves the plan is emulated in SMIT, will work in rural India also.

6. Acknowledgements

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7. References

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