Optimized beamforming strategy for 5G mobile communication with integrated quantum computing

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Abstract—Mobile communication and accessing the internet is growing rapidly in recent years. Providing the seamless data connectivity among the cellular users is becoming a basic service requirement of the mobile users. The fifth generation mobile communication is still developing by using the beamforming model which generates the transmission beam based on the location of the user. This model applies the phase arrayed antenna to complete the transmission among mobile devices. The proposed solution is developed to fulfill these requirements that integrate the data connectivity for large set of users by combining the 3d beamforming strategy with optimized beam allocation in FDD cell. The switching beam forming angle is selected by applying the optimization process which is used to generate signals for the communication. The spatial relationships between the dimensions are identified with respect to the factors defining and maintaining the communication of the mobile users. The simulation results outcome the proposed solution achieves the best performance compare to the existing beamforming in terms of Success Delivery Ratio (SDR), Signal To Noise Ratio (SINR) and throughput of data transmission.

Keywords— 5G, BDMA, NanoCore, Quantum Network,IEEE802.11ac, Smart Antenna,

I. INTRODUCTION

Centralized mobile communication in wireless networks [1] are widely installed and provides the service access to the users in terms of Internet similar to the wired networks. Packet losses in cable communication are mainly due to the link congestion occurred in the routers, and it is handled by dropping the packet received at each terminal whenever the buffer is complete [2] occupied. The placement of the [3] connectivity stations are also the primary problems for the wireless communications. The primary target of mobile communication systems is to give enhanced hypermedia communication facilities to a number of mobile devices with low prices. The difficulty in mobile communication equipment is to build communication, applying bounded frequency and assets.

Fifth generation network will be employed to provide the support the enhanced communication between billions of devices with extreme data rate. This communication model provides the high speed communication with minimum amount of jitter and transmission latency. Fifth generation technology provides the high quality communication like wired communication by applying the enhanced service support using the beamforming technique.

Beam generation[4] process is the most leading technique which is executed by using the smart antennas for the communication model. This approach [5] combines the transmission and broadcasting pattern of each elements of the antenna present in the array of antennas. The phased array antenna is used to form the directional beam and energy concentrated rays. Radio Frequency (RF) communication part is designed and merged with the antenna array system. This pattern is control the vector which operates the control of the antenna array. This antenna produces the directive beam which contains the data in the modern modulated form.

Smart aerial generates the Spatial Division Multiple Access, which is able to identify [7] the aggregate provision by several signal tracks while even with similar patterns of frequent, Code and Time division. By applying the antenna theory, the adaptive model [14] is obtained with high resolution of array signal modelling. This can achieve the enhanced communication paradigm in future wireless communications. The solution is designed by selecting the optimal beam among the cellular user in beam-generative cell. IEEE 802.11ac standard is used under the development of Fifth generation mobile communication paradigm.

II. IEEE 802.11AC

The signal coexistence in wider channel is becoming very tougher in IEEE 802.11ac. In order to increase the probability of the communication with lower noise [8] is increased due to the non-coexistence in the data transmission. It is very hard to select the main operating channel in common overlapping network with non-overlapping frequency. The extended model to provide the medium access in 802.11n to wider channel is introduced in 802.11ac. This strategy improves the co-channel operation with the enhanced support for the secondary channel accessing.

The improved dynamic channel operation is included in the notification frame in the 11ac standard. With the characteristics of the 802.11, random backoff [9] with wider bandwidth operation is sensed in the idle Inter Frame Sequence (IFS) in
the transmission. The situation of handling the busy channel is executed with the Mid-Packet Signal Detection (MPSD) applied in the secondary channel process. The propagation of signal is initiated after completing the IFS process.

III. 5G TECHNOLOGY

The research system telecommunication is currently designing the next generation communication standard beyond the 4G-LTE. Besides the problem arising in the 4G-LTE, the solution to handle the high speed [10] multimedia streaming is under developing in the 5G technology. The system is planned to provide, the faster internet connection which allows the mobile broadband users to access high speed communication. This setup is made feasible to the transmission of large quantity multimedia data by populating as the High Definition (HD) streamed media.

IV. 5G NANOCORE

The NanoCore technique is introduced by merging the Nano technology, Cloud computing, and IP platform to establish the high speed and large data storage [13] communication in wireless networks. This model applies the NanoScience to operate the execution in the scale of NanoMeters by incorporating the Molecular Nano Technology (MNT). It is the revolution of next generation, industrial pattern to create the telecommunication with the enhanced service and security support. The NanoEquipment (NE) are used to create an identity for the mobile modules which facilitates the ambient intelligence with computation combined with the available communication.

V. BEAMFORMING MODEL

The centralized communication between mobile users and beam generative stations is established by performing the ranging process. The beam generative station maintains the ranging timer to execute the periodical broadcasting process with the defined time interval. The mobile devices which required to connect with the beam generative station receives the broadcasted signal and send request to connect with the beam generative station. The initial mode of communication is maintained by using the control channel communication and the transmissions are performed in control frequency. Mobile device sends the connection request along the credentials attached in the request message, including the user identifier and private information regarding the user connection.

Upon receiving the unique identifier from the beam generative station, mobile device holds the connection ID, and request for the frequency set to initiate the session with the beam station. The beam station performs the RSS [15] propagation and either validates the GPS location of the user or use he inverse RSS propagation to localize the user. From the locations of the user and beam station, beamforming angle is estimated using the arc tangent method. This computation provides the most accurate beam generative angle for communication in both uplink and downlink paradigm. The estimation provides the value in the unit of radians, and the conversion model is required to convert into degrees. The regular radians to degrees conversion is used to complete the angle conversion process. From the estimated beam angle unlink and downlink beam generative angles are computed by subtracting the values from 90 degree scale.

The frequency division duplexing is combined with the beam generative model to adapt the spatial changes occurred in the data communication. The complete network region is subdivided into numerous number of cells based on the spatial locations in the region. The cell is in the form of hexagonal shape which is easy to manage the users in the network. This hexagonal shaped cell is primarily used to maintain the seamless connectivity among the mobile users and beam generative station. And also the handover, including the both horizontal and vertical has less complexity compared to the other shaped cells.

Based on the placement of the mobile users, currently operating cell is identified and the connectivity is maintained with the cellular tower according to the positions. The beam angle generation process is proceeding with the locations of both user and tower. Z-shaped arc is formed between these two nodes and angle at the intersecting point is defined as the communication beam angle. The sum of both intersecting angles will be 90 degrees, which are based on the triangulation method.

Inside the communication cell, frequency division duplexing is applied to differentiate the communication between users. The OFDMA technique is initially modeled to allocate the individual unique frequency for the mobile users. The frequency is selected from the licensed frequency spectrum.

VI. OPTIMAL BEAMFORMING IN 5G

Wireless communication is improved by utilizing the spread spectrum by applying various techniques. Fourth generation of the wireless network model is developed by means of long term evolution (LTE) and wimax technology, which is stepped ahead with the 5g communication paradigm. BDMA is designed in the 5G communication which uses the beam forming technique to create spatially related beams. The angle projections in 3D space are modelled in the Figure 6.1.
The smart beamforming technique models the beam angle generation using the Equation 6.1, 6.2, and 6.3. The distance between the Transmitter and Receiver is computed in 3D space. The intersecting angles are computed by taking the x, y, and z as reference placements.

\[
\text{placement}_x = \text{dist} \times \sin^{-1} \theta \times \sin^{-1} \phi \tag{6.1}
\]

\[
\text{placement}_y = \text{dist} \times \cos^{-1} \theta \times \cos^{-1} \phi \tag{6.2}
\]

\[
\text{dist} = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2} \tag{6.3}
\]

where, \( \theta \) and \( \phi \) are angles at intersecting points.

Based on 4D computation model with respect to the time as the 4th dimension in this computation, the Equations 6.1 and 6.2 are derived as 6.4 and 6.5 as follows,

\[
\text{displacement}_x = \int_{\theta_1}^{\theta_2} \int_{\phi_1}^{\phi_2} ((\text{dist} \times \sin^{-1} \theta \times \sin^{-1} \phi) \, d\theta \, d\phi \tag{6.4}
\]

\[
\text{displacement}_y = \int_{\theta_1}^{\theta_2} \int_{\phi_1}^{\phi_2} ((\text{dist} \times \cos^{-1} \theta \times \cos^{-1} \phi) \, d\theta \, d\phi \tag{6.5}
\]

By applying the first single integration using (uv) approach the Equations 6.4 and 6.5 will be 6.6 and 6.7 for only the integration value.

\[
\text{displacement}_x = \text{dist} \times \int_{\theta_1}^{\theta_2} \int_{\phi_1}^{\phi_2} \left[ \left( \sin^{-1} \theta + \sqrt{(1 - \theta)} \right) \, d\theta \right] \, d\phi \tag{6.6}
\]

\[
\text{displacement}_y = \text{dist} \times \int_{\theta_1}^{\theta_2} \int_{\phi_1}^{\phi_2} \left[ \left( \cos^{-1} \theta + \sqrt{(1 - \theta)} \right) \, d\theta \right] \, d\phi \tag{6.7}
\]

The substituted values of the Equations 6.6 and 6.7 are shown in Equation 6.8 and 6.9 respectively.

\[
\text{displacement}_x = \text{dist} \times \int_{\theta_1}^{\theta_2} \int_{\phi_1}^{\phi_2} \left[ \left( \sin^{-1} \theta + \sqrt{(1 - \theta)} \right) \times \sin^{-1} \phi \, d\phi \right] \tag{6.8}
\]

\[
\text{displacement}_y = \text{dist} \times \int_{\theta_1}^{\theta_2} \int_{\phi_1}^{\phi_2} \left[ \left( \cos^{-1} \theta + \sqrt{(1 - \theta)} \right) \times \cos^{-1} \phi \, d\phi \right] \tag{6.9}
\]

The final derivation of the Equations 6.8 and 6.9 will become the expected displacement in both dimensions and it is shown in equation 6.10 and 6.11

\[
\text{displacement}_x = \text{dist} \times \left[ \left( \sin^{-1} \theta + \sqrt{(1 - \theta)} \right) \times \sin^{-1} \phi + \sqrt{(1 - \theta)} \times \sin^{-1} \phi \right] \tag{6.10}
\]

\[
\text{displacement}_y = \text{dist} \times \left[ \left( \cos^{-1} \theta + \sqrt{(1 - \theta)} \right) \times \cos^{-1} \phi + \sqrt{(1 - \theta)} \times \cos^{-1} \phi \right] \tag{6.11}
\]
It outcomes in combined transmission model in uplink and downlink communication, the proposed Optimal Beamforming for 5G achieved the better performance compare to the BDMA Beamforming in terms of throughput, SDR and SINR.

VIII. CONCLUSION

Optimal 5G strategy for mobile communication using the selective beam selection with the beamforming model is designed for the 5G communication. The switching beam forming angle is selected by applying the optimization process which is used to generate signals for the communication in the proposed solution. The communication strategy is developed by incorporating the NanoCore which modulates the signal generation process. The identification of the spatial relationships between the dimensions is performed to maintain seamless communication of the mobile users. The simulation results showed that the proposed solution achieved the best performance compare to the existing beamforming in terms of SDR, SINR and the throughput of data transmission.

REFERENCES

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Figure 7.3 SINR comparson (5G vs 5G-Optimal)