SSRG International Journal of Electronics and Communication Engineering Volume 7 Issue 3, 29-34, March 2020
ISSN: 2348 – 8549 /doi:10.14445/23488549/IJECE-V7I3P105

Optimal Energy Efficiency Through DPSN Based 5G Network

G.V.Ramanaiah[1], L.Krishnakavya[2], P.V.RajyaLakshmi[3], V.SaiKumar[4], Sk.ShahedAli[5]

([1]Associate Professor, [2345]UG Students, Department of ECE, PSCMR College of Engineering and Technology, Vijayawada,520001, Andhra Pradesh, India.)

Received Date: 18 February 2020
Revised Date: 25 March 2020
Accepted Date: 31 March 2020

Abstract *— With the increase of new operator(s) for mobile equipment's utilizing 4G services, these 4G network services extended rapidly. Presently focus is moved to 5G advances specifically meeting high data rates. To meet the necessary data rates, network densification is a clear way. Integrating Small cells in ultra-dense with mm-Wave backhauled massive MIMO enabled base stations is a successful method for accomplishing network densification, yet it to be designed in an energy effective way. This paper will propose an optimal Energy Efficient(EE) tractable model for designed Small cell DPSN (Digitally Phase Shifter Network) architecture integrating Massive MIMO based mm-wave backhauled network. This paper examines the practicality of DPSN based mmWave Massive MIMO-based backhaul for 5G Ultra-Dense Small cells. Afterward, tractable uplink general Energy efficiency(EE) optimized framework is determined for a proposed network concerning the Small cell Base Station(BSs) density, the transceiver hardware impairments, and the pilot reuse factor. One of the proposed network's key highlights is simultaneously supporting numerous Small cell Base Stations(SBS) in an energy-efficient way utilizing general Energy Efficiency maximizing framework.*

Keywords—*5G, Network densification, mm-Wave, DPSN, Massive MIMO, Optimal Energy Efficiency*

I. INTRODUCTION

The explosive traffic demand is an important problem in current cellular networks, including the fourth advanced technology (4G) network. There is a need for the next era of wireless communication technology(5G), which could aid the ever-increasing needs for higher data rates and make sure a consistent high-quality of service (QoS) all through the entire network. Simultaneously, the information and communication technology (ICT) enterprise's power consumption and the corresponding energy-related pollution have become important societal and economical concerns. To meet such 1000_higher data rates without increasing the ICT footprint, new technologies that improve the overall energy efficiency (EE) through 1000_ need to be developed. The consensus is that future 5G networks should realize the targets of 1000-fold system capacity, 100-fold energy efficiency, and 10-fold decrease latency. To comprehend such a high-end 5G network, two promising technologies are "small cells" and "Massive MIMO." Integration of those technology permits us to obtain network densification in an energy-efficient way. Due to ultra-dense small-cellular BSs, better frequency reuse can be obtained, and energy efficiency can also be improved substantially because of the reduced path loss in small cells. To access ultra-dense small cell base stations in a cellular network, a dependable, cost-effective, gigahertz bandwidth backhaul connecting the macrocell BS and the related small-cellular BSs is a prerequisite. It has been validated that backhaul with 1~10 GHz bandwidth can sufficiently effectively support a small cell network. Conventional optical fiber enjoys massive bandwidth and reliability, but its utility to ultra-dense networks as backhaul might not be an alow-cost choice for operators due to deployment and installation restrictions. Hence, wireless backhaul, specially millimeter-wave (mm-Wave) backhaul, is an attractive solution for operators to overcome geographical constraints. Mm, Wave backhaul benefits are: A huge quantity of underutilized band in mm-Wave can be leveraged to offer the capability of gigahertz transmission bandwidth, which differs from scarce microwave band in traditional mobile networks. Many antennas can be deployed without difficulty for mmWave communications because of the small wavelength of mmWave, which can enhance the signal directivity (reduce the co-channel interference) and link reliability (mitigate the large path loss) for mmWave backhaul. This paper considers the combination of mmWave with a large number of antennas, which is also referred to as mmWave massive Multiple Input Multiple Output (MIMO), to offer wireless backhaul for future ultra-dense 5G small cell network. However, when the network includes massive MIMO structures, the area throughput is enhanced by using the multiplexing gain, even as the array gain from coherent processing allows for major decrementation in the emitted power. Like small-cell networks, however, the potential throughput gains from massive MIMO come from deploying more hardware (i.e., multiple antenna branches for one BS), which in turn

increases the circuit power consumption of one BS.
In short, both densification technologies can improve the area throughput and decrease the radiated power, but at the cost of deploying greater hardware infrastructure. The general EE of the network may be advanced if those benefits and costs are properly balanced. This paper's main objective is to optimize the proposed network, i.e., integrate these two technologies for maximal EE.

A. Related Works

The EE of cell networks has been defined from various perspectives. One of the maximum common definitions is a benefit-cost ratio, in which the service quality per area unit (a.u.) is compared with the associated energy costs. In this paper, the following preferred definition is used

$$EE = \frac{\text{Area spectral efficiency}}{Transmit\ power + Circuit\ power\ per\ a.u}$$

Most of the previous works that calculated the EE, as described above, have centered on the single-mobile case wherein the interference from other cells is neglected. However, the EE calculation of multi-cell networks is much more concerned than in the single-cellular case because of the complex network topology and the arising inter-cell interference. The only approach is to rely on heavy Monte Carlo simulations. However, Monte Carlo simulated outcomes are often anecdotal, given that one cannot separate essential properties from behaviors induced through parameter selection.

Alternatively, simplified network topologies can be considered, consisting of the Wyner model or the symmetric grid-based deployment. However, these models can not capture the irregular structure of deploying small cellular base stations. The necessity for developing tractable (but reasonably accurate) models for future dense networks has extended the interest in random spatial concepts, precisely, using equipment from stochastic geometry, wherein the BS places form realization of a spatial point process—commonly a Poisson point process (PPP). A huge advantage of this technique is providing tractable expressions for key performance metrics, including the coverage probability and the network's average SE. A few previous works have also derived EE-associated performance metrics and showed how they rely on the BS and UE densities.
This paper specializes in UpLink (UL) analysis; in contrast to other papers, most work on the EE in multi-cell networks, the usage of stochastic geometry has focused on the Down Link(DL). Furthermore, prior works usually aim to calculate the optimal Energy-efficient parameters for the proposed network, as shown in Figure 1, utilizing the DPSN transceiver architecture.

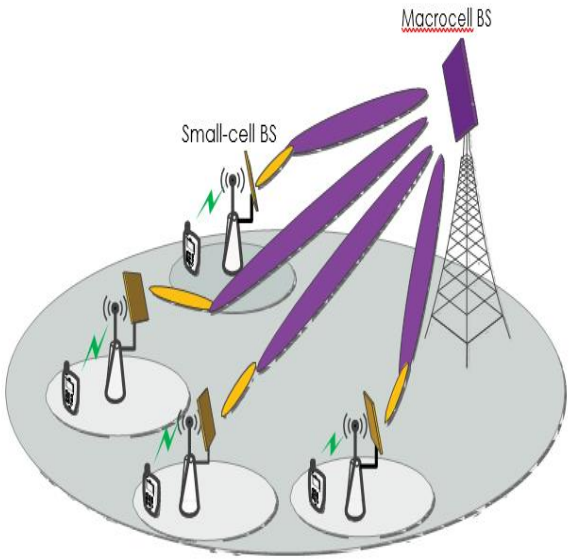

Figure1:mmWavemassive-MIMO-based wireless backhaul for 5G Ultradense small cells network

B. Major Contributions

This paper considers the UL of a multi-cell multi-user environment of the network and calculating optimal EE. To attain a multi-cell multi-user network, P2MP reliable backhauling is necessary. So, considering Digital Phase Shifter Network (DPSN) based mm-wave Massive MIMO network is a feasible solution. Because traditional mm-wave multi-antenna structures utilize single RF chain and analog phase shifters for precoding / combining are restricted to Single-User [SU]-MIMO with a single stream. Full digital precoding in massive microwave MIMO aids multi-user [MU] MIMO, but it needs one particular RF chain to be connected to every antenna that may be unaffordable in mm-wave communications. Combining both analog and digital, i.e., the hybrid precoding / combining scheme is proven to be powerful for mm-Wave massive MIMO with reduced transceiver cost and complexity.

Nevertheless, it is supported employing MU-MIMO with a single stream for each user; however, for the MU-MIMO with more than one stream, DPSN based hybrid precoding / combining scheme proven to offer the better spectral efficiency MU-MIMO with multiple streams. In this network, we consider the distribution of BS according to a homogenous PPP of intensity λ. Each BS is prepared with M antennas and communicates with K single-antenna UEs uniformly distributed within its coverage area. The expression of new lower bound of the average SE that is computed from tools of stochastic geometry and classical statistics is used to define the EE metric through additionally the use of the power consumption model developed, which not accounts for the radiated strength but also for the operating power required by (among others) analog transceiver chains, digital processing, and backhaul infrastructure. EE maximization problem formulated under the assumption that a given average SE target per UE should be met with equality to assure good service quality.

C. Outline

The paper is categorized as follows section-II introduces the System model of the network that is under investigation. Section III presents the generalized word maximization of EE of network concerning the optimization variables of pilot reuse factor, BS density, transmission power, and the variety of UE's and antennas per BS. The presented optimized EE formulae are calculated and analyzed numerically for the proposed network in Section IV. Finally, the major conclusions and implications of the paper are drawn in Section V.

II. SYSTEM MODEL

We consider the UL of an mm-wave backhauled Massive MIMO-enabled ultra-dense small cellular network designed to serve a dense heterogeneous distribution of UEs. This is modeled using the stochastic geometry framework adopted in which the Small cellular BSs are dispensed spatially in R2 according to a homogeneous PPP $\phi\lambda$ of intensity λ (measured in BSs according to km2). More precisely, in any location of size A (measured in km2), the number of Small cell BSs is a Poisson distributed stochastic variable with mean cost λA. The BSs are uniformly and independently distributed over the area. Each of them is equipped with an array of M antennas and serves K single-antenna UEs, which can be selected randomly from a very large set of UEs within the cell since we treat K also considered an optimization variable. We were assuming that each UE connects to its closest BS such that the coverage area of a BS is its Poisson Voronoi cell. The UEs are assumed to be uniformly disbursed inside the Poisson-Voronoi cell of their serving BS. Note that the geographic places of UEs and BSs are correlated under this model, such that small cells serve greater UEs in unit area than larger cells. We interpret this as a sensible network deployment where the BSs are matched to UEs' heterogenous distribution. The translation invariance of PPPs allows us to perform statistical performance evaluation for a normal UE (located, for instance, in origin) that is statistically representative for every other UE within the network. Assume that this standard UE has the arbitrary index k and is connected to a BS. This is called the standard BS and is denoted as BS0 $\phi\lambda$.

III. FRAMEWORK

As described in Section II, we focus on the UL EE defined as the benefit-cost ratio between the Area spectral efficiency (ASE) [bit/symbol/km2] and the area power consumption (APC) [J/symbol/km2]. The ASE can be defined as

$$ASE = \lambda\, K\, SE$$

in which SE discussing here is lower bound carried out on UL average SE defined per UE

$$SE = \left(1 - \frac{\beta K}{S}\right)\log_2(1 + SINR)$$

To specify the APC, we begin by observing that with the adopted power-control policy, the average radiated power per UE is

$$\frac{S-(\beta K-1)}{S}\mathbb{E}\{p_{ji}\} = (1 - \frac{\beta K-1}{S})\rho\omega\frac{\Gamma(\frac{\alpha}{2}+1)}{(\pi\lambda)^{\alpha/2}}$$

We have used the truth that every user transmits one pilot symbol and S-βK information symbols per coherent block of total length S. Then, we take a look at that the APC ought to account not only most radiated power, however also for the dissipation in analog and digital hardware, digital signal processing, backhaul signaling, and other overhead costs (which include cooling and power supply losses). A particular and generic model that considers all those elements the currently proposed and the APC is computed as

$$APC = \lambda\left(\left(1 - \frac{\beta K-1}{S}\right)\frac{\rho\omega}{\eta}\frac{\Gamma(\frac{\alpha}{2}+1)}{(\pi\lambda)^{\alpha/2}}K + \mathcal{C}_0 + \mathcal{C}_1 K + \mathcal{D}_0 M + \mathcal{D}_1 MK\right) + \mathcal{A}.ASE$$

Where η(0, 1] is the linear power amplifier efficiency, C0 models the static power intake at a BS, and D0M is the energy consumption of the BS transceiver chains, which scales with the quantity of BS antennas. Moreover, C1K +D1MK represents the energy fed on at the UEs and the aid of the signal processing tasks at the SBS. Maximization of EE problem discussing inside the network is framed as follows, for any given frame length(S), propagation parameters (α,ω), and hardware characteristics (η, ϵ, A, C0, C1, D0, D1) for a tuple of parameters θ =(β, ρ, λ, K, M) limited EE maximization problem is

$$\max_{\theta\in\Theta} EE(\theta) = \frac{ASE(\theta)}{APC(\theta)}$$

Subject to SINR= γ

Where Θ is the feasible parameter defined as

$$\Theta = \{\,\theta\colon \rho \geq 0, \lambda \geq 0, \beta \geq 1, (M,K) \in \mathbb{Z}_{+}, K\beta \leq S\,\}$$

With K$\beta \le$ S being the upper limit on pilot signaling overhead. The parameter $\gamma > 0$ is used to impose on average SE constraint $log2(1+\gamma)$ [bit / symbol / user] . Using these conditions, we acquire the maximum EE of the network with a suitable throughput. Unconstrained EE maximization often results in operating factors with very low SE per UE.

A. Feasibility

Due to the unavoidable inter-cell interference in cellular networks, the optimization problem is best feasible for a few values of γ. This possible range is obtained as follows

$$\gamma < \frac{S(\alpha-1)(1-\epsilon^2)}{1+\epsilon^2 S(\alpha-1)}$$

The above range indicates that the maximal SINR level is constrained with the aid of the hardware impairments, via ɣ, and through the severity of the pilot contamination, which is determined by the path loss exponent α and the coherence block length S. These are the only limiting factors as M->α. Assume as an instance that ϵ=0:05 and take into account the exceptionally conservative propagation parameters α=3andS=200. For these numbers, the upper restriction of the average SE consistent with UE is $\log_2(1+199.5)$ = 7.65, which is substantially better than the SE of contemporary systems. This method that the optimization problem is possible in maximum cases of practical interest.

B. Optimization concerning BS. Density

Optimizing with respective to BS density and radiated energy, the EE maximization problem reduces to

$$\begin{aligned} \underset{\rho,\lambda\ge 0,\ M,K\in\mathbb{Z}_+}{\text{maximize}} \quad & \text{EE}(\beta^\star) \\ \text{subject to} \quad & \frac{B_1\gamma}{M(1-\epsilon^2)^2 - B_2\gamma} \ge 1 \\ & \frac{B_1\gamma}{M(1-\epsilon^2)^2 - B_2\gamma} \le \frac{S}{K} \end{aligned}$$

With EE(β*) as given below
EE (β*)=

$$\frac{K\left(1-\frac{K}{S}\frac{B_1\gamma}{M(1-\epsilon^2)^2-B_2\gamma}\right)log_2(1+\gamma)}{\left(1+\frac{1}{S}-\frac{K}{S}\frac{B_1\gamma}{M(1-\epsilon^2)-B_2\gamma}\right)\frac{K\rho\omega}{\eta}\frac{\Gamma(\frac{\alpha}{2}+1)}{(\pi\lambda)^{\alpha/2}}+\mathcal{C}_0+\mathcal{C}_1K+\mathcal{D}_0M+\mathcal{D}_1MK+\mathcal{A}K\left(1-\frac{K}{S}\frac{B_1\gamma}{M(1-\varepsilon^2)^2-B_2\gamma}\right)log_2(1+\gamma)}$$

The optimal values for the BS density λ and the power control coefficient ρ might be given with the aid of defining for $\rho = \lambda\tilde{\rho}$ and considering any set of M, K for which maximization problem is viable then EE(β*) is a monotonically growing function of λ and is maximized as λ ->∞. The average transmits power then goes to zero. This shows that it is foremost to have as excessive BS density as possible from an EE perspective.

This is probably surprising considering smaller cells cause greater interfering UEs in each cell's place, but this trouble is resolved through the assumed power control policy that progressively reduces the transmit power as the BS density increases. The most important consequence of letting λ grow large is that the transmit power becomes negligible compared to the circuit energy in every cell.

C. Optimal Pilot Reuse Factor β

To calculate the optimal value of the pilot reuse factor β with the other optimization, variables are fixed, thinking about any set of{ ρ, λ, M, K } for which the optimization problem is feasible. The pleasant SINR constraint is chosen via

$$\beta^\star = \frac{B_1\gamma}{M(1-\epsilon^2)^2 - B_2\gamma}$$

where

$$B_1 = \left(\frac{4K}{(\alpha-2)^2} + \frac{K + M(1-\epsilon^2)}{\alpha-1} + \frac{2(K+\frac{\sigma^2}{\rho})}{\alpha-2}\right)$$

$$B_2 = \left(K + \frac{\sigma^2}{\rho} + \frac{2K}{\alpha-2}\right)\left(1+\frac{\sigma^2}{\rho}\right) + (1-\epsilon^2)\epsilon^2 M.$$

Firstly, Recall that increasing β interprets into allocating a larger portion of every UL block for pilot transmission so that each pilot symbol is on average only utilized in 1/β of the cells inside the network. This results in higher channel estimation accuracy and much less coherent pilot contamination. Secondly, β* is an increasing characteristic of B_1 and also of B_2, for the reason that a larger B_2 makes the denominator smaller. Consequently, The above equation suggests that to guarantee a sure average SINR, β* must grow with K. This is intuitive considering that greater UEs per cell approach means greater inter-cell interference, which can be partly suppressed by growing the estimation accuracy and decreasing the pilot contamination; namely, the usage of a greater β.

Similarly, β* decreases with ρ because higher transmit powers lessen noise's detrimental effect, leading to better estimation accuracy and an extra interference-limited regime. Moreover, β* is a decreasing M function because a progressed array gain makes the system much less sensitive to interference and estimation errors. Increasing the path loss exponent α leads to a smaller β* (since B_1 and B_2 are reduced), which is natural considering intercell interference decays greater quickly. The fact that β≥1 implies that we can acquire the most effective values of γ for $\frac{B_1\gamma}{M(1-\epsilon^2)^2-B_2\gamma} \geq 1$, which otherwise even β = 1 would provide an SINR higher than γ.

IV. RESULTS

Calculating the Energy Efficiency concerning the proposed optimized variables discussed in the framework in mm-wave enabled Massive MIMO 5G small cell network produced the effects on Energy Efficiency (EE) as follows

A. Optimizing the Energy Efficiency of network:

Three special SINR constraints are taken into consideration in Fig. 2: γ = 1, 3, 7 which corresponds to the common SEs log2 (1+γ) ϵ {1; 2 ; 3 }. In all three instances, the EE is computed using the lower bound at the common SE. From the figure within the proposed network, the Energy Efficiency Maximization problem is solved when BS density is infinitely large. EE as a function λ (BS density) will be improved as λ tends to infinity. It can be drawn from the end result that the EE decreases as the γ SINR constraint increases.

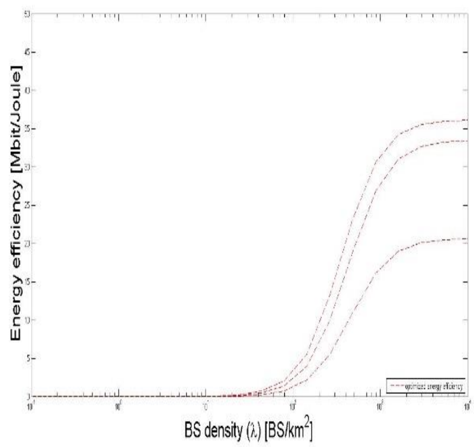

Figure 2: Energy efficiency(in Mbit/J) as a characteristic of the BS density in BS/Km2 for distinct SINR constraints.

B. Optimal Pilot Reuse Factor

At γ = 3 or, equivalently, the average SE per records symbol at log2(1 + γ) = 2. Fig. 3 shows the EE lower bound as a function of M and K while β is optimized. The global EE maximum gives an EE of 32.74 Mbit/J and is done by way of (M; K) = (91; 10) using the pilot reuse thing β*= 7:08. The intuition behind this end result is that the strong inter-cell interference in dense deployments is successfully mitigated through MRC when the BSs are equipped with many antennas and also with the aid of the usage of a substantial pilot reuse component (to guard in opposition to channel estimation errors and pilot contamination).

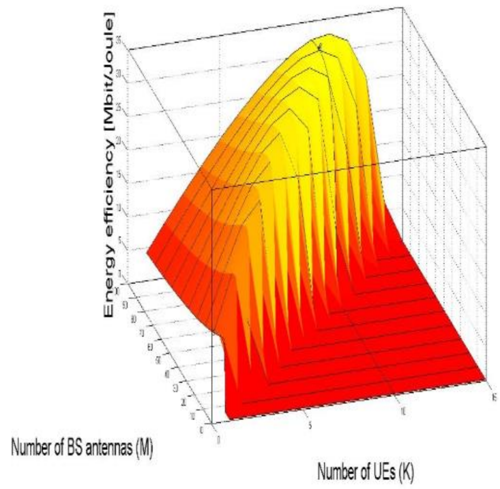

Fig:3 Energy efficiency (in Mbit/J) for γ = 3. The global optimum is star-marked with respective to β

C. Impact of Transceiver Hardware Impairments

Next, we keep in mind the saturation regime where λ -> α and exemplify the impact of transceiver hardware impairments on the EE. Fig. 4 shows the EE as a feature of hardware impairments (ϵ) in DPSN network proposed, the level of hardware impairments. As expected, the EE decreases with ϵ because the desired signal energy decays as (1-ϵ2)2. The loss is marginal for ɣ = 1; it could be pretty large when ɣ increases.

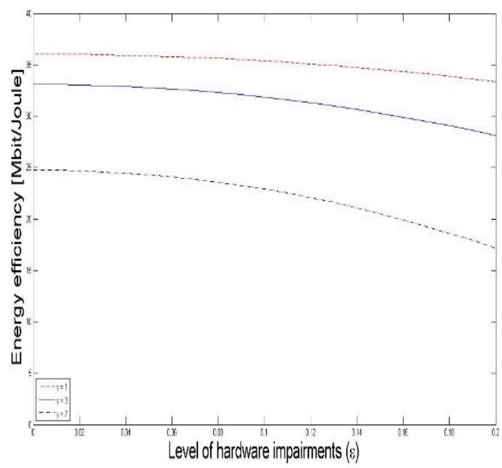

Fig4: Energy efficiency (in Mbit/J) as a characteristic of the extent of transceiver hardware impairments, ϵ, for different SINR constraints

This clearly shows that hardware impairments greatly affect the channel capacity inside the high SNR regime (i.e., for large ɣ) even as their impact is negligible within the low SNR regime. The results of Fig. 4 imply that for the proposed network, the EE loss because of hardware impairments is negligible for low ϵ. Since these values correspond to the operating points that supply the highest EE(see Fig.2), we may additionally conclude that the proposed DPSN network has a negligible impact of high EE for modest levels of hardware impairments.

V.CONCLUSION

Achieving Network densification in an Energy Efficiency manner is a prime contribution for 5G Network. The only straightforward way to fulfill high data rates with less traffic is densifying the mobile network with mm-wave backhauling massive MIMO-enabled 5G small cellular network. This paper discussed this network's feasibility with DPSN transceiver architecture and framework of optimal Energy Efficiency calculation for cellular networks. Later, using the framework, the Optimized EE is calculated for the proposed DPSN based mmWave backhauled massive MIMO enabled future small cells network. The results acquired indicates with an increase in small cell base stations, increase in intercell interference, increase in pilot reuse factor, and the increase in the level of transceiver hardware impairments effect on EE of the community is optimized at a certain stage which allows us to achieve an optimized EE through DPSN based 5G network. These insights also verified that the proposed community could simultaneously and multiple small cell base stations in energy efficiency. In the future, this optimal EE may be applied even at the macro Base Station; in addition to on this paper, the Massive MIMO enabled only at the macro base station for simplified calculation, further proceedings can put in force the massive MIMO on the small mobile base stations additionally so that greater users can concurrently be served with more gain.

REFERENCES

[1] Gao, Z., Dai, L., Mi, D., Wang, Z., Imran, M. A. and Shakir, M. Z. (2015) "*MmWavemassive- MIMO-based wireless backhaul for the 5G ultra-dense network*". IEEE Wireless Communications, 22(5), 13–21.

[2] Singh, S., Kulkarni, M. N., Ghosh, A. and Andrews, J. G. (2015) "*Tractable model for rate in self- backhauled millimeter-wave cellular networks*." IEEE Journal on Selected Areas in Communication, **31** (10), 2196–2211.

[3] J. Hoydis, M. Kobayashi, and M. Debbah, "*Green small-cell networks*," IEEEVeh. Technol. Mag., vol. 6, no. 1, pp. 37–43, 2011.

[4] S. Mohammed, "*Impact of transceiver power consumption on the energy efficiency of the zero-forcing detector in massive MIMO systems*," IEEE Trans. Commun., vol. 62, no. 11, pp. 3874–3890, 2014.

[5] E. Bjornson, L. Sanguinetti, and M. Kountouris, "*Designing wireless broadband access for energy efficiency: Are small cells the only answer? " in Proc* IEEE International Conference on Communications (ICC), 2015.

[6] E. Bjornson, L. Sanguinetti, and M. Kountouris, "*Energy-efficient future wireless networks: A marriage between massive MIMO and small cells*," in Proc. of IEEE 16th International Workshop on Signal Processing Advances in Wireless Communications (SPAWC), June 2015, pp. 211–215

[7] G. Miao, "*Energy-efficient uplink multi-user MIMO*," IEEE Trans. Wireless Commun., vol. 12, no. 5, pp. 2302–2313, 2013.

[8] GreenTouch Green Meter Research Study, "*Reducing the net energy consumption in communications networks by up to 90% by 2020*," Tech. Rep., Jun. 2013.

[9] E. Bjornson, L. Sanguinetti, J. Hoydis, and M. Debbah, "*Optimal design of energy-efficient multi-user MIMO systems: Is massive MIMO the answer?,*" IEEE Trans. Wireless Commun., vol. 14, no. 6, pp. 3059– 3075, 2015.

[10] P. Senthil, Sr. Dr. Stanly, M.Suganya, S.S.Inakshi "New sushi sen methods IEEE802.1 Analysis " International Journal of Recent Engineering Science 7.1(2020):17-20.

[11] Khaled Elbehiery, Hussam Elbehiery, "Millennial National Security's Cornerstones 5G, Cloud Technology, and Artificial Intelligence" SSRG International Journal of Electronics and Communication Engineering 6.8 (2019): 44-54.