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IMPROVING SPECTRAL EFFICIENCY AND COVERAGE CAPACITY OF 5G NETWORKS

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ABSTRACT. As the number of internet user is increasing exponentially, demand of bandwidth, speed and carrier frequencies are also raising proportionally. To meet the users demand, existing 4G is not enough, hence the requirement of high speed and superior quality internet leads 5G network. The technology of 5G network needs huge number of devices and unmatched numbers of antennae which must support many number of new applications with lots of enhanced features in terms of speed, data rate, latency, coverage capacity, spectral efficiency etc. This paper reviewed some of the general aspects 5G network and focus on two important features namely spectral efficiency and coverage capacity. The critical analysis of a proposed combined technology is presented which suggests a grouping of micro cell, joint transmission coordinated multipoint (JT CoMP) and massive MIMO to improve both the spectral efficiency and the coverage capacity with less intricacy. This paper also investigates grouping of cells termed as cooperation area (CA) the interference and its reduction in 2G networks in Long Term Evolution (LTE).

1. INTRODUCTION

The fourth Generation of internet (4G) is a product of massive use of technology in wireless mobile devices used worldwide [14]. But the drawback that

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4G faced was broken backwards. The broken backwards include spectrum crisis and high energy consumption where these challenges cannot be met by 4G. 4G included a very high carrier frequencies with very large bandwidth, extreme base station, number of antennas which have never used before as well as device densities. Thus designers searched for the advanced network which could demand for a high data rates, the mobility and the requirements by wireless applications. Hence the highly integrative , universal high rate coverage and a seamless user experience started on new technology called fifth generation(5G), which is going to deploy in the year of 2020 by LTE AND WIFI standards [1]. Hence this proposed system is done using a 5G based cellular architecture. The technologies used for this are MIMO, energy efficient communications, cognitive radio networks and visible light communication [8, 9]. The role of 5G in micro cell massive MIMO will help in reducing the latency and bandwidth with enhanced indoor coverage and higher peak [7].Organization of paper is as follows. Section II presents the macro cell in the networks. Section III gives the introduction about the JT CoMP. Section IV and Section V explains the grouping of micro cell and forecasting of feedback channel. Section VI concludes the paper followed by references.

2. Macro Cell In A Network

The macrocell networks are defined as the combining of micro cells in huge numbers. It is also called as mitigation network. These micro cells are used in the advanced techniques which have special characteristics (Eg: JT Comp) like low transmit power and different radio propagation. In a very short time there is no direct contact between a micro cell and the macro base station. Hence for a 5G network the simplest solution is micro and macro cells that use a robust method which is kept for different and independent frequency layers that works parallel. Thus the above method gives the spectral efficiency without any interference during the transmission. Hence the performance analysis in 5G shows that high spectral efficiency is obtained by the reusability of full frequency in micro cells which maintains the Integrity of specifications.

2.1. **Massive MIMO.** Massive MIMO indicates the usage of more number of antennae per cell than the normal MIMO system. The number of antennae in massive MIMO is 10 times more than normal MIMO system [10, 11]. Due to this structure, the upper bound is set on spectral efficiency where the parallel services can be possible and the beam forming gains are achieved. This system actually requires orthogonal channels for the error estimation. For non-linear systems, the estimation of error propagation is minor since it has high signal to Interference pulse noise ratio. The major drawback of MIMO its cost which is more and hence the complexity in the circuit is also more.

3. JT COMP TECHNOLOGY

The 2G network was considered very powerful internet standard which is based on an ordinary frequency reuse concept. For 2G network, frequency reuse technique is adequate. However, to maintain higher spectral efficiency, it is demanded that no cell in the system should go into inactive state which may be a cause for severe intercell interference. In order to reduce the interference, a Intercell Interference Coordination (ICIC) scheme is utilized in LTE. This interference can be avoided only if the network base station is used with a high throughput of gain about value of 300

JT CoMP is a physical layer based converting mobile network, which consists of 2 processes: synchronization and the estimation [12]. These two techniques between the cooperating cells are capable of making the signals into sampled one and transmit the sampled data at higher speed. The cells use the centralized processing using the new algorithms. The new algorithms are suitable for multisite demo systems which uses group formation, selecting more number of users and the interfering floor spring. However one major drawback of JT CoMP obtained in this paper was the high interference. But this can be easily eliminated by using Global Positioning System (GPS).

4. GROUPING OF MICRO CELLS

As the use of real web by several calculations will limit the involvement, the antenna based number of cells still does. It is well known that cells have to be limited otherwise the backhaul traffic will increase. To solve this, the coordination area (CAs) are used which can be defined simply as the grouping of cells which forms clusters. CAs increases the number of users and servers which are coordinated together such that it neglects the involvement. This means that the residual inter cluster interference is involved less. But the clustering and user increase becomes a tough challenge and for the heuristics to be more efficient in the real time implementation.

4.1. **Cover-Shifts.** Cover shift defines the need for a stationary method for a very long period of time to prevent the interference. The CAs gets enlarged with three sectors on three adjacent sides so that the users have strongest interfering cells [3] [16]. Still now using this, the out of cluster interference is harmful. Hence the cover shifts are used where the active antenna can support even though a smaller angle is little in-bound and large tilt for out-bound beams. Thus CAs are introduced on the radio resources. When the power is allocated, the interference gets reduced. The optimal user selection is very complex which is reduced by cover shifts. Using flexible clustering and user centric clustering, the performance is improved [16].

4.2. **Continuous selection of users.** For the efficient user selection, a new analytical heuristics is launched. The vertical beams touch the ground after 0.33 times when angle goes down by the macro cells. These cells makes micro cell placement at five different locations [3]. The successive user group searches for orthogonal channels which first select a user in the micro cell. This is only for the feedback reduction. This user is combined with other cells. Replacing the user cells are done with reduced performance if users do not experience performance gains. During some iteration, users are cooperated for obtaining gain; clustering success rate is improved in the micro cell which has minority in it. Spectral efficiencies goes beyond a well-known bound level and out of cluster interference limitation in clustering, which is done by selecting the best rank in each cell per site. The cluster formation using the best rank selection will minimizes the feedback, backhaul and complexity of JT CoMP where it uses algorithms to achieve gain JT CoMP [5]. Fig. 1 show the throughput statistics of consumers for all micro cells and all surrounding macro cells respectively using the same clustering and user selection and the full rank in each cell over the full 20 MHz bandwidth. Fig. 2 show the optimized performance after choosing the 25

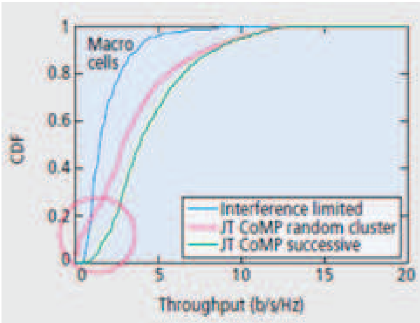

FIGURE 1. Throughput statistics for macro cell

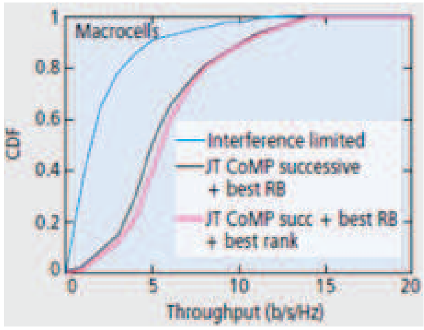

FIGURE 2. Optimized performance of micro-cell

5. COMPRESSING AND FORECASTING OF FEEDBACK CHANNELS

For a 2×2 MIMO HetNet assuming ideal CSI, spectral efficiencies of 6 to 7 b/s/Hz and 4 to5 b/s/Hz are achieved in the micro cell and in surrounding macro cells, which are at 500 m distance between macro sites deployment with JT CoMP, and other micro and macro cells. This occurs in system-level simulations. Practically 100

5.1. **Compressing the Feedback.** For JT CoMP, the feedback compression is considered huge. In different frequency sub bands, the non-overlapping clusters are formed such that the overall fractional bandwidth is limited [5]. To reduce the feedback requested from the users, flexible group formation of channels and successive user selection lead to non-disturbance path [3]. To obtain the transformation of the channel from the frequency domain to the time domain and selecting the most relevant paths [16] estimation of the noise and out-of-cluster interference floor is achieved. The required quantization is finally occurred [13]. Hence to compress the feedback, a combination of clustering, tap selection, and quantization is used.

5.2. **Forecasting of channel.** State-of-the-art prediction techniques like Kalman and Wiener filtering have the potential to make JT CoMP links more robust for CSI delays of a few milliseconds and at moderate mobility. Note that the precoding can be adapted to different reliabilities of the predicted channels. Kalman filters provide reliability information intrinsically, which can be reported semi-statically from the terminals [15]. Doppler-delay-based prediction is a recent approach. The channel for each link between a transmitter and a receiver antenna can be modelled by a number of multi-paths with their individual amplitude, time period and doppler frequency. From these parameters estimation can be done for each path. Next, the multi-path parameters are assumed to remain static over short periods of time. Then the channel can be predicted in future by inserting the estimated parameters into the channel model. This approach has been studied using the standard spatial channel model. [2].

A significant improvement of the mean square error by using a few doppler frequencies (MSE) for the CSI can be achieved for each path, even at 30 km/h and 2.6 GHz for each and every path. In a further step, Doppler delay and Kalman prediction were both tested over measured channel data. Channels were measured coherently at a velocity up to 30 km/h at 2.66 GHz in 20 MHz bandwidth from three base stations in an urban macrocell [4]. Thermal noise was set to âĂŞ120 dBm per subcarrier, and 5-bit quantization was used for detection and computing for real and imaginary parts of the channel coefficient. Computation using the Kalman filters was done to get perfect CSI. For both methods, an order of 10hz (numbers of filter poles) was found to be sufficient. Results shown in center, are based on these measurements, using a channel history of 50 ms, CSI updates every 2 ms, and a prediction horizon up to 20 ms. For typical feedback delays between 5 and 10 ms, significant improvements of the MSE can be observed. The two methods follow different concepts. While the feedback overhead of the delay method is smaller, the sparse inverse discrete Fourier transform (DFT) comes in the method for extraction of the taps to degrade the performance slightly. The Kalman filter is based on damped sinusoids instead of perfect ones, limiting the achievable prediction accuracy which could improved CSI translates to better performance [4]. Without prediction in moving scenarios, JT CoMP gains can even be negative. Using appropriate feedback intervals together with prediction, substantial gain can be realized by JT CoMP. If the prediction failed is occurred, prediction is performed at the terminal, which is compared with the latest measurements. The network can be informed about unusual prediction errors via a low-rate low-latency feedback channel. Feedback compression, shorter feedback intervals, and a powerful predictor are regarded as important enablers for JT CoMP. A well designed feedback scheme reduces the overhead and counteracts the time increased over the air and while the CSI is transported over the backhaul. Ultimately, such a scheme allows for higher mobility. Thus the comparison between the MSE (dB) and the feedback delay is shown in the Figures 3 and 4.

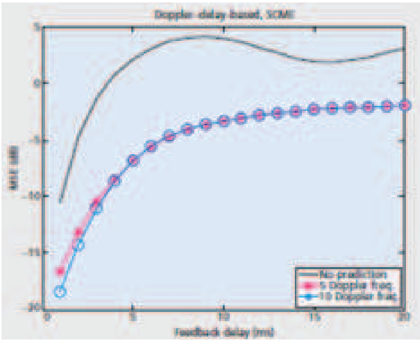

FIGURE 3. CSI vs Feedback delay

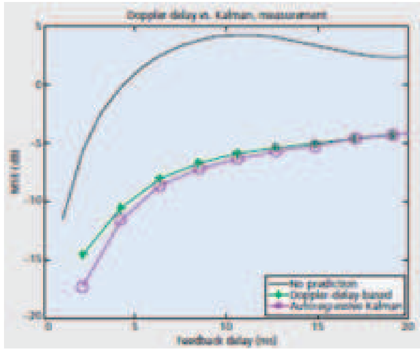

FIGURE 4. MSE vs feedback delay

6. A NEW ERA OF 5G SPECTRUM

In this section, an integrated approach of three technologies: JT CoMP, Massive MIMO and Micro cell to improve spectral efficiency and coverage capacity is presented.

6.1. **An improved coverage in indoor using MIMO.** A thorough knowledge of many number of antennas at typical outdoor hotspot locations helps in making better replacement of network capacity. The continuous use of frequencies in the network will lead to a high speed data coverage making of better improvement and the increased network range of different things for the hotspot location. Apart from this, the shorter distances between base stations and terminals and a higher line of sight (LOS) also makes advantageous.

6.2. **Description of MIMO and JT CoMP.** We know that JT CoMP uses many more antennas (Eg. massive MIMO). By doing this, the spectral efficiencies can reach values up to 100 b/s/Hz [3].The gain of a ray of particle is made large such that interference gets lowered between inter-stream and inter-cell. Again the cells are increased to raise the power. The trade-off between spatial multiplexing and diversity gains are made for 5G MIMO services in the upcoming years. Services like machine type communications or host to host services are supported; more antennas can be deployed to service the number of users. In the high-raised sites, setting up more number of antennas leads to increased wind load and the visibility which becomes a challenging one. Due to these contents along with a fixed vertical ray of particle of the micro-cell panel antennas with the continuous work without any waiting time, they realize certain down tilt ray. When each antenna is operated separately, there is increase in flexibility, vertical ray particle. If a simple fixed grid of beams (GoB) is erected, CoMP becomes easy to comprehend. The cell has rows and columns which is further divided into radial subsectors. By increasing the number of columns in the array, the vertical GoB is applied in the azimuthal direction. MIMO cells restricts the interference of overlapping sectors at different sites is reduced with massive use of antennas. Usually the interference between the cell sites is produced which can eliminate this disadvantage by using this JT CoMP. Practical experimentation of antennae leads to more RF chains, more converters(DAC & ADC), and more signal processors which becomes costlier and more complex. Thus very large MIMO arrays will increase the sufficient beam-forming rays and reduces the effort of the required performance.

6.3. **Method of combining cells.** 5G integrated approaches are used toimprove the spectral efficiency. For this method the mobile nodes shares the spectrum of data such that the coordination among the network is maintained. This is done basically by distributed joint signal or processing centralized processing. A high spectral efficiency with high capacity, high speedand low latency are required for a back haul to interconnect the number of base stations and to deliver the amounts of data the number, a backhaul with high speed is needed to interconnect. Thus both high capacity and low latency are required for obtaining a high spectral efficiency in the proposed architecture [6].

6.4. **Performance Analysis Results.** Spectral efficiency needs synchronization and sufficient backhaul capacity with a thorough value of 100 percent in the MIMO cells that is safe from out of cluster interference. These MIMO cells with frequency can be fully reused [6, 16]. The addition of transmitters and antennas will further improve the strength of signals and the limitations of efficient interference mitigation can be overcome. The cases where the channel matrix has low rank needs more power to separate the users which has low outdoor to indoor penetration loss and vice versa. Here the unity factor loss of a zero-forcing precoding a function of the CSI signal index which calculates the frequency. Using four antennas, this experiment is performed by the three users who are at the distance of 50 cm from the total distance of 250m and the loses are observed from 10-20dB. With 16 antenna elements, the average loss is 0 with the simultaneous array gain of 6 dB.

6.5. **Advantages.** The benefits for JT CoMP areusing massive MIMO interference is localized at the left. In the right, interference gets suppressed and robust. Integrated 5G mobile network approach with mass use of components will enhance the indoor coverage, low-cost high-speed backhaul and reduction of the prediction errors. Finally, the throughput and backhaul traffic is accomplished. The triple-sectored cell have 20 MHz, 2×2 MIMO LTE macro-site scenario and a visionary 5G HetNet using 100 MHz frequency with 10 micro cells per sector, JT CoMP, is compared with a 16-element MIMO antenna array having equal number of antennas [12]. The small cell traffic is averaged at the nearest macrocell using the HetNet. The Next Generation Mobile Networks (NGMNA) Alliance is used for backhaul estimation. If more subsectors are formed using a GoB, inter-site ratio in [6] would be small and vice versa. The 16×16 enlarged MIMO with the backhaul gets halved. Ccompared to LTE, the over-the-air traffic can be scaled multiplicatively by using micro cells ($10\times$), JT CoMP ($3\times$), more antennas ($8\times$), and more spectrum ($5\times$) . However the major disadvantage of using the clustering approach of micro cells, JT CoMP and massive MIMO cells, is the 1000 times more traffic compared to a macrocell LTE.

7. Department of ECE

This paper presents a holistic survey to improve spectral efficiency of future 5G network which could be a combination of present and future technology such as massive MIMO, JT CoMP and Micro cell. The basic constraint of proposed 5G network such as interference and spectral issues are reviewed critically. Theoretically, it has been shown that interference can be reduced as well as spectral efficiency can be improved by using the suggested approach in this paper.

References

[1] J. G. Andrews, S. Buzzi, W. Choi, S. V. Hanly, A. Lozano, A. C. Soong, J. C. Zhang: *What will 5g be?*, IEEE Journal on selected areas in communications, **32**(6) (2014), 1065–1082.

[2] R. Apelfröjd, M. Sternad, D. Aronsson: *Measurement-based evaluation of robust linear precoding for downlink comp*, IEEE International Conference on Communications, ICC, June 10-15, Ottawa, Canada, 2012.

[3] P. Baracca, F. Boccardi, V. Braun: *A dynamic joint clustering scheduling algorithm for downlink comp systems with limited csi*, 2012 international symposium on wireless communication systems (ISWCS), IEEE, 2012, 830–834.

[4] Z. Gao, L. Dai, D. Mi, Z. Wang, M. A. Imran, M. Z. Shakir: *Mmwave massive-mimo-based wireless backhaul for the 5g ultra-dense network*, IEEE wireless communications, **22**(5) (2015), 13–21.

[5] R. Irmer, H. Droste, P. Marsch, M. Grieger, G. Fettweis, S. Brueck, H. P. Mayer, L. Thiele, V. Jungnickel: *Coordinated multipoint: Concepts, performance, and field trial results*, IEEE Communications Magazine, **49**(2) (2011), 102–111.

[6] V. Jungnickel, K. Manolakis, S. Jaeckel, M. Lossow, P. Farkas, M. Schlosser, V. Braun: *Backhaul requirements for inter-site cooperation in heterogeneous lte-advanced networks*, 2013 IEEE International Conference on Communications Workshops (ICC), IEEE, 2013, 905–910.

[7] V. Jungnickel, K. Manolakis, W. Zirwas, B. Panzner, V. Braun, M. Lossow, M. Sternad, R. Apelfröjd, T. Svensson: *The role of small cells, coordinated multipoint, and massive mimo in 5g*, IEEE communications magazine, **52**(5) (2014), 44–51.

[8] A. Kumar, S. Saha: *A decision confidence based multiuser mimo cooperative spectrum sensing in crns*, Physical Communication **39**, (2020), 100995.

[9] A. Kumar, S. Saha, K. Tiwari: *A double threshold-based cooperative spectrum sensing with novel hard-soft combining over fading channels*, IEEE Wireless Communications Letters, **8**(4) (2019), 1154–1158.

[10] E. G. Larsson, O. Edfors, F. Tufvesson, T. L. Marzetta: *Massive mimo for next generation wireless systems*, IEEE communications magazine, **52**(2) (2014), 186–195.

[11] D. Lee, H. Seo, B. Clerckx, E. Hardouin, D. Mazzarese, S. Nagata, K. Sayana: *Coordinated multipoint transmission and reception in lte-advanced: deployment scenarios and operational challenges*, IEEE Communications Magazine, **50**(2) (2012), 148–155.

[12] J. Lee, Y. Kim, H. Lee, B. L. Ng, D. Mazzarese, J. Liu, W. Xiao, Y. Zhou : *Coordinated multipoint transmission and reception in lte-advanced systems*, IEEE Communications Magazine, **50**(11) (2012), 44–50.

[13] M. Lossow, S. Jaeckel, V. Jungnickel, V. Braun: *Efficient mac protocol for jt comp in small cells*, 2013 IEEE International Conference on Communications Workshops (ICC), IEEE, 2013, 1166–1171.

[14] C.-X. Wang, F. Haider, X. Gao, X.-H. You, Y. Yang, D. Yuan, H. M. Aggoune, H. Haas, S. Fletcher, E. Hepsaydir: *Cellular architecture and key technologies for 5g wireless communication networks*, IEEE communications magazine, **52**(2) (2014), 122–130.

[15] T. Wild: *A rake-finger based efficient channel state information feedback compression scheme for the mimo ofdm fdd downlink*, 2010 IEEE 71st Vehicular Technology Conference, IEEE, 2010, 1–5.

[16] W. Zirwas, W. Mennerich, A. Khan: *Main enablers for advanced interference mitigation*, Transactions on Emerging Telecommunications Technologies, **24**(1) (2013), 18–31.

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