3G-5G Spectrum Bundling: Strategies for Rapid Technology Adoption for the 5G Communication Standard

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***Abstract*— The increasing demand for bandwidth and the need for higher data rate for both voice and data transmission has made it mandatory for a review of the current communication technologies and standards. The 5G telecommunication standard expected to be deployed in 2020 offers a number of capacity and bandwidth enhancements over the current 3G and 4G standards however, the challenges associated with the frequency spectrum being proposed for the 5G network will place a limit on the cell sizes and thus a rollout will require a massive investment in infrastructure. This paper proposes a bundling of the 5G spectrum with the existing 3G spectrum so as to enable operators share BTS cell site resources between both the existing 3G networks and the 5G network. The key advantages of this approach include a minimal requirement of CAPEX and OPEX required to deploy the 5G technology, a quicker return on investment for the operators and an improved user experience due to a reduction in the number of dropped calls as a result of the availability of both the 3G and the 5G spectrum.**

***Index Terms*—3G, 5G, Colocation, Infrastructure sharing, spectrum bundling.**

I. INTRODUCTION

THE capacity enhancement and data transfer speeds being promised by the 5G communication standard will remain inaccessible to the users if the operators cannot identify profitable business models upon which investment decisions for the 5G rollout can be made. Operators in both the developed and developing countries have either the 3G or the 4G communication Technology rolled out and a migration to the 5G communication standard must provide sufficient proof of profitability to justify such an investment. 5G offers increased capacity at much higher data speeds compared to the 3G and 4G standards but at the expense of increased infrastructure count and cost. The pathloss associated with the 5G communication standards and frequency is much higher than the pathloss associated with the 3G standard hence the cell sizes are much smaller compared to the 3G cells. This results in increased number of cells, increased infrastructure and increased CAPEX and OPEX cost especially for operators in developing countries where the cell sites are powered largely by diesel generators.

This paper proposes a bundling of the 5G and the existing 3G communication technologies such that operators can deploy the 5G infrastructure together with the 3G infrastructure. This will enable an inter-standard handover between the 3G and the 5G when the user goes out of the 5G coverage. The operators can also deploy the 5G transceiver at the BTS cell sites of the closest operator especially in urban areas which already has a high number of cell sites from different operators. The 5G standard can be dedicated to high speed data transfers in densely populated urban areas due to the high bandwidth capacity of the network. While it can be used minimally for voice traffic especially where it overlaps with the 3G networks for ease of handover. Collocation strategies can also be used to enable operators install 5G equipment at the cells of other operators thus minimizing the costs associated with site acquisition while maximizing the coverage of the 5G network. These strategies will enable operators deploy the 5G networks in a cost effective manner. It will increase the traffic capacities of their networks and improve consumer experience.

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II. 3G SPECIFICATIONS AND GLOBAL COVERAGE

A. 3G Global Coverage

The migration of communication traffic from voice to data centric loads placed a demand of the communication networks to be provide higher capacities to the users. The led to the migration from the 2G to the 3G communication standards. The 3G networks are the WCDMA, HSPA, EV-DO and TD-SCDMA network technologies. These technologies have been able to increase the theoretical maximum download speed from about 0.4 Mb/s to over 40 Mb/s all in one decade. 4G technologies prominent among which is the LTE standards have taken the maximum download speeds from 100 Mb/s (LTE) to 300 Mb/s (LTE Category 6).

3G networks are currently deployed by almost 700 operators across over 200 countries. The 3G network covers over 70% of the global population. In developed economies, 3G coverage surpassed 95% of the population in 2011 in developed economies while it covered two thirds of population in developing economies in 2014. 3G networks currently cover 97% of the population in the European Union. [1]. New research data from GSMA Intelligence predicts that more than four out of five people (greater than 80%) worldwide will have access to 3G networks by 2020 (up from 70% today), while 4G networks will cover over

60% of the global population by this point (up from 25% today). [1].

III. 5G COMMUNICATION STANDARD

The evolution of the mobile telecommunication standards is driven largely by the increasing demand for bandwidth by the multimedia applications of the users, the increased bandwidth and data rate demands of these applications have led to a massive increase in the volume of data from about 3 Exabyte in 2010 to an estimated 190 Exabyte being expected in 2018. This increase is projected to exceed 500 Exabyte by 2020. This increase in data rate demand led to the development of the 5G communication standard which is capable of accommodating the high volume of data, provide support for more users and an estimated 1000x increase in data rates. 5G is also anticipated to be able to support a huge number of devices reaching tens or even hundreds of billions by the time it is fully deployed. It is expected to support device to device communication and the Internet of Things in addition to personal communications [2][3][4][5][6][7][8][9][10]

The 5G standard is expected to meet the following benchmarks [11]

1. Data rates of tens of megabits per second for tens of thousands of users
2. 1 Gb per second simultaneously to many workers on the same office floor
3. Several hundreds of thousands of simultaneous connections for massive wireless sensor network
4. Spectral efficiency significantly enhanced compared to 4G
5. Coverage improved
6. Signaling efficiency enhanced
7. Latency reduced significantly compared to LTE.

5G cellular systems will encompass frequencies from around 500 MHz all the way to around 100 GHz. The U.S. Federal Communications Commission (FCC) also approved the spectrum for 5G to include the 28 Gigahertz, 37 GHz and 39 GHz bands [12] [13]

A. Challenges with 5G Deployment

The key challenges associated with 5G deployment especially for frequencies beyond the 6GHz frequency are due to the path loss issues and the impact of the propagation environment on the signals. The results of atmospheric attenuation at frequencies ranging from 0 to 400GHz shows that the rain attenuation for the 5G spectrum is much higher than that of the 3G spectrum. Thus 5G cells will be much smaller in diameter compared to the 2G, 3G or 4G cells. However, the atmospheric absorption at 28 GHz and 38 GHz (0.06 dB/km and 0.08 dB/km, respectively), as well as in the 70-90 GHz, 120-170 GHz and 200-280 GHz bands are negligible and suitable for use in indoor environments [13]

The challenges with 5G deployment include

1. Increased number of infrastructure requirement
2. Increased path loss in outdoor propagation environments
3. Increased number of handover requirement for mobile calls
4. Increased penetration loss as the signal comes across walls
5. Increased scattering by walls, grasses, rain and foliage.

In view of these limitations with the 5G standard, it is cannot be used effectively for outdoor and long range communication. However, the high capacity of the network makes it very suitable for indoor propagation.

For 5G to be deployed outdoors, it must be used together with the existing 2G, 3G and 4G networks in the heterogeneous network configuration. This paper proposes a spectrum bundling scheme for the development of these heterogeneous networks upon which a successful and profitable 5G network rollout can be implemented

IV. SPECTRUM BUNDLING STRATEGIES

The mobile communications technology comprises of the blocks shown in fig 1 and the operators deploy the service in small sized cells as shown in fig 2.

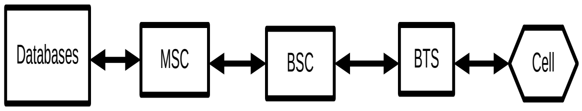

Fig 1; Mobile communication technology block diagram

The cell structure used is the hexagonal configurations with the ideal structure shown in fig 2

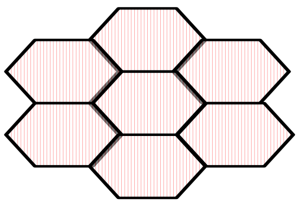

Fig 2: Hexagonal cell structure.

The cells are further grouped into clusters with the number of cells in a cluster determining the frequency reuse number utilized by the operator in the network planning.
The spectrum bundling strategies include

A. Bundling 3G and 5G Networks

The 3G shelter provides coverage to the cell and the range of the cell is determined using the appropriate channel characterization models

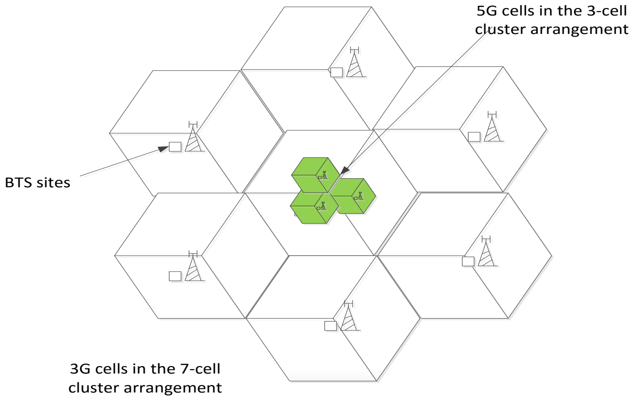

Fig 3: 3G standard with a 7-cell cluster with a 5G standard with a 3-cluster overlay.

The diagram in fig 3 shows the network layout of a 3G system and a 5G system. The 5G system is overlaid on the 3G system such that the BTS of both the 3G and the 5G can be integrated into one system and installed at the 3G BTS shelter. Both the 3G and the 5G system will share the same cell site infrastructure.

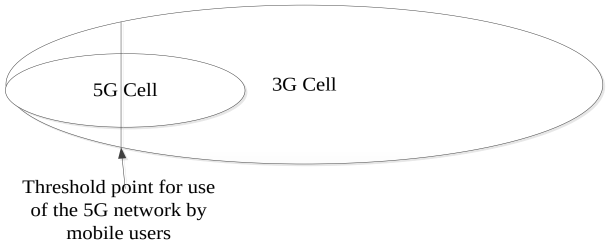

Fig 4: 3G and 5G cell overlay

The diagram in fig 4 shows the cell structure for both the 3G and the 5G standards overlaid on each other when sharing the same BTS cell site. Due to the small size of the 5G cells, the system can implement a handover between the 3G and the 5G standard whenever the user exists from the 5G coverage. However, to minimize the frequency of this handover, the system can be designed such that the mobility of the users are factored in before channel can be allocated. This is so that calls from users to the left of the 5G threshold will be assigned to the 5G network provided they are either stationary of their mobility is very minimal while call from users to the right of the threshold point are assigned to the 3G network and only when the 3G has no capacity will calls from users in that location be assigned to the 5G network. The 5G networks are installed in on cell sites located at the center of the urban areas or business district. This is based on the assumption that those locations are office locations and the user mobility in such locations will be very minimal and not vehicular and the need for data transmission will be at a maximum in these areas. The 5G networks can thus be maximized for the data transmission and also for voice especially in areas to the left of the threshold point as shown in fig 6.

B. Inter-band Handover between 3G and 5G

In the event that a user on the 5G network has to move beyond the threshold point, the BSC initiates an inter-band handover where the call is transferred from the 5G spectrum to the 3G spectrum. The use of the threshold minimizes the processing overhead on the BSC as the call becomes a candidate for hand over only when it exceeds the threshold point. The bundling of the 3G and 5G makes it possible for the BSC to manage the frequency allocations of both the 3G and the 5G spectrum.

C. Colocation of 5G Repeaters at the nearest BTS Cell Tower of other Operators

Urban areas are mostly served by multiple operators with overlapping cells. This configuration is prevalent where there is no centralized network planning. Under this scenario, the possibility of BTS cell sites of different operators existing at ranges closer than the 3G cell range becomes very high. The diagram of multiple cells overlapping an urban area is shown in fig 7(a)

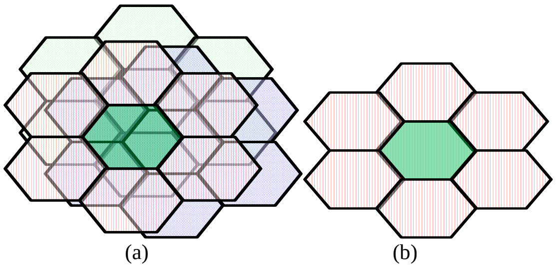

Fig 5: Hexagonal cell structure for cell with three operator networks.

Comparing fig 5(a), with the diagram for a single operator per cell in 5(b), the shaded area can be served by one transceiver station but with the presence of other operators, we can see from the diagram in 5(a) that there is the possibility of at least 3 BTS covering the same cell area. With this configuration, 5G repeaters can be installed at the BTS sites of other operators such that these repeaters serve as range extenders and are not interfaced with the other operators BTS/BSC.

V. DISCUSSION

The capacity enhancements that 5G technology can provide will go a long way in meeting the bandwidth and technology demands of both the software, user applications and new technology especially the internet of things. However, this system needs to able to be able to cater for voice traffic transmissions and for it to be able to do this, the operator must be willing to deploy the technology. The characteristics of the 5G frequency spectrum with respect to the pathloss and attenuation effects and the impact of the surrounding materials both manmade and natural places a limit on the range the technology can cover and also a limitation on its deployment for voice traffic which is the most significant communication traffic load. Operators must identify novel strategies with which they can profitable roll out the 5G technology for the benefit of the users. The strategies discussed in this work which include the bundling of both the 3G and the 5G spectrum will enable operators deploy both technologies using the same site infrastructure. It will also enable operators use the 5G for voice traffic as well as for data traffic especially for users with minimal mobility or those that are stationary during the call. The use

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of 5G repeaters installed on nearby BTS of other operators will also serve as a means of extending the coverage of the networks thus providing more users with access to more frequency spectrum.

VI. CONCLUSION

The strategies proposed in this paper provide a cost effective approach which operators can employ to facilitate a profitable deployment of the 5G communication technology. The strategies will provide operators a high amount of spectrum to deploy mobile communication services to users. Users will also experience high and better call quality and rates as the increase in the available bandwidth will minimize the rate of dropped calls thus providing the users with a more satisfying experience and increasing the revenue accruable to the operators. It will increase the return on the mobile communication infrastructure investment and also improve the capacity utilization of these infrastructures.

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