International Journal of Multidisciplinary Research and Growth Evaluation

International Journal of Multidisciplinary Research and Growth Evaluation
ISSN: 2582-7138
Received: 11-12-2020; Accepted: 16-01-2021
www.allmultidisciplinaryjournal.com
Volume 2; Issue 1; January-February 2021; Page No. 235-247

A survey on antennae adaptive Downtilt for long term evolution (LTE)

Egbon Osarhiemen
[1] Department of Electrical/Electronic Engineering, University of Lagos, Nigeria

Corresponding Author: **Egbon Osarhiemen**

Abstract
This work carried out a survey on Antennae Adaptive Downtilt for Long Term Evolution(LTE), towards realisation and actualising of Antennae Vectorization, this paper highlighted various contribution made by different authors, The Long Term Evolution (LTE) is one of communication standards for next-generation mobile phones, which has evolved the high-speed data communication standard HSDPA for the mainstream 3G (third generation) mobile phone system W-CDMA and beyond. A survey explained the workings of a scheduling algorithm that help enhance the capacity of an LTE system which is based on dynamically adapted Proportional Fair (PF). A new scheme was implemented to boost energy efficiency in the user equipment while retaining an overall packet wait around the latency level also for real time applications in the downlink of LTE networks, a novel algorithm of scheduling is proposed and implemented in some of the paper reviewed. Some of the proposed algorithm reduced the number of packets that has been dropped due to congestion as well as the number of lost packets due to bad channel quality, and thus enhancing the system performance. LTE Downlink 2x2 MIMO Channel B indoor model with SFBC: Design and BER analysis. The BER and SFBC were analyzed using Matlab based 2x2 MIMO orthogonal frequency division multiplexing (MIMO-OFDM) with space frequency block coding (SFBC). Benefiting from Active Antenna Systems (AAS), many active antenna technologies such as 3D beamforming and vertical sectorization could be easily implemented. Vertical sectorization can be realized by multiple antenna elements, by which two separate beams with their distinct antenna parameters are arranged to serve vertically split inner and outer cells. In our work, performance with various electrical tilt angles have been analysed and also observe the optimization space of the overlap between two vertical sectors and the gain in terms of cell capacity. In all other authors worked on how Antennae Adaptive Downtilt for Long Term Evolution(LTE) can help improve performance.

Keywords: Adaptive Downtilt, Long Term Evolution(LTE), Antennae, Sectorization, Vectorization

Introduction

The Long Term Evolution (LTE) is one of communication standards for next-generation mobile phones, which has evolved the high-speed data communication standard HSDPA for the mainstream 3G (third generation) mobile phone system W-CDMA at present.

The LTE specifications have been standardized by 3G (W-CDMA) Standardization Organization 3GPP (3rd Generation Partnership Project).

Globally, the cellular industry has converged on 3GPP Long Term Evolution (LTE), including LTE-Advanced, as the common air interface. An industry that was previously fragmented among multiple air interfaces—Global System for Mobile Communication (GSM), Universal Mobile Telecommunications System (UMTS)/High Speed Packet Access (HSPA), Code Division Multiple Access 2000 (CDMA2000), Worldwide Interoperability for Microwave Access (WiMAX)—now has one standard, resulting in huge economies of scale for infrastructure and user equipment. 5G will become an extension of this communications platform.

In local area networks, Wi-Fi has also achieved remarkable success. With ongoing developments to more tightly integrate Wi-Fi operation with LTE, as well as extending LTE operation into unlicensed bands, the industry is about to realize the vision of one global, harmonized network. Mobile broadband satisfies an inherent human and business need: to do more without being tied to a physical location. Two technology vectors have collided and reached critical mass: handheld computing and fast wireless connections. This computing and communications platform encourages the innovation that has produced millions of applications. Until now, human interaction has driven wireless demand, but communicating machines will be a third vector that expands demand to an even higher level. What types of things communicate and how they do so will vary far more than human communication. Predicting whether, over the next decade, the Internet of Things (IoT) contributes to demand by a factor of ten or a hundred is impossible. IoT's massive impact, however, is inevitable as shown in figure 1.

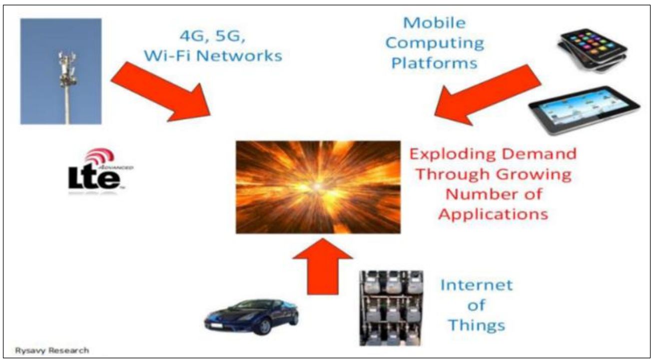

Fig 1: Exploding Demand from Critical Mass of Multiple Factors

Review of related work

This section highlight works as it relates to enhancing Long term evolution network via adaptive downlink towards realising vertical vectorization scheme.

A survey shows that in reference [4] which proposed a scheduling algorithm that help enhance the capacity of an LTE system of which is based on dynamically adapted Proportional Fair (PF). This was done by improving the throughput performance of the well-known PF scheduling algorithm in a dynamic way. The algorithm tends to distribute the resources fairly among different users, therefore enabling fairness while at the same time trying to maximize system capacity performances within the cell. They introduced a new adaptive parameter for the metric equation which was solely responsible for improving the average cell throughput with slightly lower fairness level than that of the conventional PF scheduling algorithm. The algorithm dynamically adapts its performance according to the channel conditions between the UE and the eNB which directly affect the UE instantaneous throughput to significantly improve the throughput performance [4].

A new scheme was implemented in [4] to boost energy efficiency in the user equipment while retaining an overall packet wait around the latency level. The mechanism utilized packet delay, traffic rate and queue threshold in eNodeB, adjusted DRX inactivity timer to optimize energy consumption and maintained average packet delay around a given threshold. He used packet coalescing technique which let eNodeB delay packet transmission to the UEs in DRX mode until their corresponding downlink queues reached a certain threshold. The algorithm, DRX inactivity timer dynamically adapted to traffic rate and queue threshold, in this way when there were no downlink data packets for UE (low traffic rate), inactivity timer would be decreased to reduce energy consumption, and when traffic rate was high, inactivity timer would be increased to reduce packet delay. This improved the operation of previously developed Adaptive Coalesced DRX mechanism.

For real time applications in the downlink of LTE networks, a novel algorithm of scheduling is proposed and implemented in [4]. The proposed algorithm reduces the number of packets that has been dropped due to congestion as well as the number of lost packets due to bad channel quality, and thus enhancing the system performance. It also prioritizes the user with the highest packet loss rate by taking into account the packet loss rate of each user and maintaining the metric of fairness within normal levels as the number of users increases. In taking advantage of the Adaptive Modulation and Coding Scheme (AMC), the system capacity, throughput and modulation order were increased. The algorithm maintains almost a constant fairness value of 0.95 regardless of the number of users, while improving the systems throughput which is unlike many of other proposed algorithm that provide a compromise between fairness and throughput.

While in [5] the quest to minimize computational overhead posed by the optimal resource allocation scheme which attempts to multiplex the available bandwidth in order to maximize Quality of service (QoS), proposed a hybrid offline-online resource allocation strategy which effectively allocates all the available resources among flows such that their QoS requirements are satisfied. The objective of the offline phase was to maintain system load within a given threshold value in each scheduling interval (or TTI). The online resource allocation scheme ran on top of the offline policy and conducted the physical mapping of one or more RBs to a set of selected flows at any given TTI. Also, tunes the offline decisions to maximally utilize available resources at any given time, if required [5].

Under a study that presented an efficient packet scheduling algorithm designed on the basis of the proportional fair criterion for use in multiple-CC systems for downlink transmission [4, 5] an algorithm was proposed which included a focus on providing simultaneous transmission support for both real-time (RT) and non-RT traffic. The algorithm when applied with sufficiently efficient designs can provide adequate utilization of spectrum resources for the purposes of transmissions, while also improving energy efficiency to some extent. The proposed algorithm was able to achieve significant improvements in system throughput, mean delay, and fairness performance compared with baseline algorithm also ensured a certain level of fairness among all the users.

The work in [6] aimed at improving QoS provision for different traffic types while maintaining a reasonable tradeoff between system throughput and user fairness, proposed an Adaptive Time Domain Scheduling Algorithm (ATDSA) for Long Term Evolution Advanced (LTE-A) downlink (DL) transmission. The ATDSA uses Hebbian learning process to allocate the radio resources dynamically based on the QoS feedback. The Hebbian learning process learns the environment in terms of the activity rate of a parameter and takes decisions based on comparison of current and previous occurrence of that activity. In each TTI, the proportion of resource reserved for RT traffic is adaptively adjusted based on the Hebbian learning process. Their simulation results showes that the ATDSA reduces average delay, delay viability and PDR of RT traffic and supports minimum throughput guarantee to NRT streaming video traffic [6].

The work in [7], proposed a scheduling algorithm that was based on Quality of Service QoS utility function (PF - A) algorithm, which involved the introduction of a parameter to improve priority mechanism to overcome weaknesses such as delay and packet loss in modern wireless communication. Through the simulated result it was observed that the algorithm could meet the VoIP business, through the function to solve packet loss rate and time delay problem. Lastly, it could be noted that the algorithm was at the expense of the other properties, like part of the equity [7].

In their paper the reference in [5], presented a performance comparison between Best Channel Quality Indicator BCQI, and Round Robin RR Scheduler, in terms of scheduling schemes for LTE networks. Also, a new packet scheduler which adapted dynamically between the two-packet scheduling BCQT and RR scheduler was proposed. The resulted throughput and fairness suggested that the scheme proposed gave compromise fairness between BCQI and RR, in resource distribution, maintaining the system capacity at high level. The proposed scheme achieved a lesser fairness than RR scheduler, though had higher fairness than BCQI [8].

(Nadim, Zurina, Mohamed, & Shamala, 2018) proposed an effective Delay–based and QoS–Aware Scheduling (DQAS) scheme with a low complexity overhead to efficiently solve the resource allocation issue in downlink LTE channel Medium Access Control (MAC) layer. The ultimate aim of DQAS is to minimize delay for Real-Time (RT) traffic while still offering a good level of QoS. An algorithm called Efficient Delay Control (EDC) that weighs each flow priority in terms of delay was developed to effectively analyze the queue buffer of each user flow.

Work in [10] presented two random neural network (RNN) based context-aware decisions making frameworks to improve adaptive modulation and coding (AMC) in long-term evolution (LTE) downlink systems. The first framework, AMC was modelled as a traditional classification problem aimed to maximize the probability of correct classification while second framework intention to optimize the throughput as opposed to simply maximizing the probability of the correct classification, whose model gave rise to development of a hybrid cognitive engine (CE) architecture by integrating an RNN based learning algorithm with genetic algorithm (GA) based reasoning. The critical analysis of the first framework revealed that RNN based CE can achieve comparable results with faster adaptation, even in severe environment changes without the need of retraining compared to ANN. The analysis of the second approach demonstrated RNNs faster adaptation as compared to ANN and showed upto 253% gain in user throughput [10].

In another work in Ref [12]. Which presented a paper on LTE Downlink 2x2 MIMO Channel B indoor model with SFBC: Design and BER analysis. The BER and SFBC were analyzed using Matlab based 2x2 MIMO orthogonal frequency division multiplexing (MIMO-OFDM) with space frequency block coding (SFBC). The performance of the BER depends on the SNR applied to the channel model. Based on the simulations, it was found out that MIMO channel models with more number of antennas are best and well suited for long term evolution networks by the improved characteristics. The 2x2 was compared with the 2x1 and the 1x1 mode of operation and it established that the 2x2 works better and efficiently. The advantage of the above approach is that MIMO reduces the effects of inter symbol interference and inter carrier interference [12].

While in reference [13] presented a paper on minimum memory vectorization of wavelet lifting. This paper presented a novel method of minimum memory discrete wavelet transform utilizing SIMD instructions. The proposed method for the research is the diagonal approach which was compared with the vertical and the horizontal approach. The vertical and diagonal vectorization methods were implemented using SSE intrinsics and inline assembly (no auto-vectorization of GCC was used). In both cases, aligned memory access instructions was used to access the coefficients. The diagonal approach is basically useful for memory limited systems and can start iteration of vectorized loop immediately when a new pair of coefficients are available. The diagonal approach also does not require buffering in contrast to the vertical approach. The proposed method was compared to two other approaches – the naive implementation and similar vectorisation introduced. The achieved speedup goes asymptotically to 3.1× on the Intel Core2 Duo CPU and 3.1× on the AMD Athlon 64 X2 CPU. This speedup was achieved for CDF 9/7 wavelet using SSE instruction set [13].

The authors in reference [14] presented a paper on the Adaptive Cell Admission Control with Bandwidth Reservation for downlink LTE Networks. In this paper, a novel Call Admission Control scheme was proposed as an improvement of Reservation based scheme. This approach uses different traffic loads to admit new users and employs a threshold Quality of Service provisioning approach to increase the efficient bandwidth utilization. The basic concept of this scheme is that user traffic has different adaptive threshold QoS requirement. Thus, CAC criteria is adapted using the available bandwidth to increase the number of admitted calls and adaptive QoS. One of the advantages of this approach is that it solves problems of some network resources being left unutilized and performs better than the reservation based scheme as it reduces call blocking problems and call dropping probability ratio with increased throughput [14].

In ref [15] Kumar et al presented a paper on a hybrid offline-online approach to Adaptive Downlink Resource Allocation over LTE. The approach aims at enabling LTE service providers to efficiently achieve good quality of service while incurring low overall scheduling overheads. It integrates online and offline techniques in order to allocate resource blocks to real time flows. The objective of the offline phase is to maintain system load within a given threshold value in each scheduling interval. The online resource allocation scheme runs on top of the offline policy and conducts the physical mapping of one or more RBs to a set of selected flows at any given TTI. The advantage of this approach is that it flows at better packet rate and average throughput for real time flows as compared to other schedulers to tune offline decisions to maximally utilize available resources. Spectral efficiency also increases with increased number of flows and gives better multiuser diversity gain with increasing number of flows.

Guo proposed an Adaptive SU/MU-MIMO scheduling schemes for LTE – A downlink transmission. Code grouping technique was used for user pairing and PMI selection in the MU-MIMO. The method is set to address a classical linear optimization problem therefore proposed a low complex suboptimal algorithm to adaptively switch between SU and MU MIMO nodes for each Resource Block (RB) to maximize throughput. The proposed algorithm can meet requirement for LTE Advanced and improve cell throughput with no extra feedback overhead and can be extended to Multi stream systems.

Gao and Cui presented a paper in reference [16] on Adaptive Coordinated Scheduling, Beamforming Scheme for downlink LTE – Advanced System with non-ideal Backhaul. Coordinated Multipoint Scheduling (COMP) decisions require necessary Channel State Information sharing via the backhaul links which leads to high latency of the Non Ideal Backhaul (NIB) may lead to severe delayed or lost CSI which results in improper COMP decision and serious performance decrease of COMP system. To address this, an adaptive

Coordinated Scheduling/ Coordinated Beamforming (CS/CB) for downlink is proposed. This was done by classifying User Requirement (UE) on the basis of Reference Signal, Received Power. Then the semi-state coordinated resource allocation method is provided based on user classification. The proposed method works well in satisfying the QoS demand of UEs under high backhaul latency [16].

Tara and Alagha presented a paper in ref [17]. on the downlink fairness – aware adaptive resource allocation approach for LTE networks. The approach utilizes two methods which are the Adaptive Slot Allocation and Reservation based Slot Allocation. The proposed algorithm proposes an Adaptive Slot Allocation with multiple types of SDF where the UEs are classified and prioritized according to their active Service Data Flow characteristics. RSA depends on the application and physical data rates for the SDFs in order to determine how many slots should be allocated to them. The advantage of the approach is that it achieves good capacity gains for all types of SDFs [17].

Adesh and Renuka presented a paper in [18] on adaptive downlink scheduling in LTE networks based on queue monitoring. In each TTI, the resource scheduler in eNodeB assigns the radio resources to the active users who are competing for resources. In case the eNodeB has sufficient amount resources to satisfy the demand of the users, then there is no problem in resource else there is. The main focus is to reduce packet loss from the user queue at eNodeB during congestion in a network. This paper proposes three different methods for allocating resources to the competing users based on the FD priority metric: rotation-based priority set scheduler, switch based priority set scheduler and adaptive priority set scheduler.

The proposed method enhances throughput and fairness among users and packet delivery fraction and reduces transmission time of packets [18].

Abd-Elnaby et al presented a paper on capacity enhancement based on dynamically adapted PF scheduling algorithm for LTE downlink system. The proposed algorithm aims to achieve a significant increase in the total throughput with a slight reduction in the fairness performance compared to conventional PF algorithm. The algorithm aims to improve performance of the LTE system by improving the throughput of the PF scheduling algorithm in a dynamic way. This distributes resources fairly among different users therefore enabling fairness and maximizing system capacity performance. The advantage of the system is that it is efficient in terms of throughput and fairness and also gives compromised performance between that of the best CQI scheduling algorithm characterized by high throughput but poor fairness performance and conventional PF scheduling with high fairness and low throughput [19].

Here an original leaky-wave antenna which exhibits the interesting property of hosting two quasi-orthogonal leaky modes which can be simultaneously tuned. In this way, two independent radiation beams transporting a channel each one, can be synthesized from a single antenna. Each channel can be thus shaped to a different defined angular position and with a specified controlled beam width, providing effective low-cost vertical sectorization. The working principles are illustrated with a practical design operating at 2GHz with 10MHz bandwidth, for increased transmission rate applications in 3GPP Long Term Evolution (LTE).

The Long Term Evolution interface designed by the Third Generation Partnership Project (3GPP) seeks for higher peak data rates and more users per cell as well as lower control plane latency than currently employed 3G technologies [1]. It also hopes of simple, cost effective operation, being the RF front-end chain a key design aspect to this purpose. Radio technology is based on Orthogonal Frequency Division Multiple Access (OFDMA) and it applies sophisticated scheduling and multiple antenna methods. The role of the antenna system performance is thus determinant, and as a result increasing interest is being given to novel multiple antenna schemes [2-9], to increase the Signal to Interference plus Noise Ratio (SINR) and the throughput performance.

Intelligent/smart antennas [2, 3] (based on electronically reconfigurable arrays, either in switched beam mode or in adaptive phased array mode), space-time coding [4], vertical sectorization [6, 7], or multiple antenna [3, 8-10] techniques have been proposed to increase the capacity gain in 3GPP LTE. As mentioned, LTE aims for simpler and lower-cost solutions. However, multiple antenna techniques require a dramatic increase in the amount of RF hardware, being this issue particularly unattractive for cellular base stations cost.

The work present a contribution for vertical sectorization schemes, as illustrated in Fig.2 for a 3X2 case [7]. Sector capacity performance strongly depends on the optimization of the antenna parameters, and in the used network deployments and antenna techniques (e.g. SISO, MISO and MIMO SM & STTD), being the effective radiation pattern one of the decisive aspects [3].

LTE Low-Cost Vertical Sectorization Through a Leaky-Wave Antenna describes a novel antenna which can produce two independently tuned scanned beams by using a single common radiating aperture. Thus this topology simplifies the manufacture and deployment, and reduces the volume and associated costs, if compared to array/multiple antenna techniques

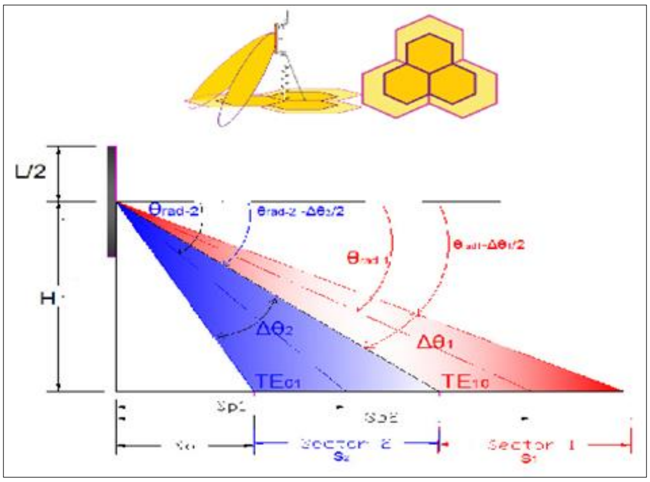

Fig 2a: 3x2 Vertical sectorization from [7] b) Scheme with geometrical parameters to synthesize two elevation-scanned radiation lobes [20]

2.2 Resource allocation for vertical sectorization in lte-advanced systems

Resource Allocation for Vertical Sectorization in LTE-Advanced Systems is another related area is Massive multiple input multiple output (MIMO) technology has been discussed widely in the past few years. Three-dimensional MIMO (3D MIMO) can be seen as a promising technique to realize massive MIMO to enhance the performance of LTE-Advanced systems. Vertical sectorization can be introduced by means of adjusting the downtilt of transmitting antennas. Thus, the radio wave from a base station (BS) to a group of user equipments (UE) can be divided into two beams which point at two different areas within a cell. Intra-sector interference is inevitable since the resources are overlapped, the influence of intra-sector interference can enhanced resource allocation scheme for vertical sectorization.

Compared with the conventional 2D MIMO scenarios, cell average throughput of the whole system can be improved by vertical sectorization. System level simulation is performed to evaluate the performance of the proposed scheme. In addition, the impacts of down tilt parameters and inter-site distance (ISD) on spectral efficiency and cell coverage are presented

Long Term Evolution (LTE), proposed by the Third Generation Partnership Project (3GPP), is aimed at achieving enhanced performance in terms of cell throughput and system overhead. As is generally known, LTE-Advanced is addressed to achieve higher data rates and better UEs' Quality of Service (QoS) than LTE [1, 2]. Based on Orthogonal Frequency Division Multiple Access (OFDMA), capacity of wireless systems can be significantly increased by using multiantenna methods. As one of the key techniques in LTE Advanced systems, massive MIMO has been widely discussed currently and 3DMIMO can be seen as an effective method to approach large-scale MIMO [3-6]. Compared with the conventional 2D antenna, 3D antenna is comprised of many element units. Each element is deployed at different heights in an individual 3D antenna. Thus, difference of elements in vertical domain should not be neglected.

Benefiting from Active Antenna Systems (AAS), many active antenna technologies such as 3D beamforming and vertical sectorization could be easily implemented. Vertical sectorization can be realized by multiple antenna elements, by which two separate beams with their distinct antenna parameters are arranged to serve vertically split inner and outer cells. In our work, performance with various electrical tilt angles have been simulated to observe the optimization space of the overlap between two vertical sectors and the gain in terms of cell capacity.

One of the major advantages of introducing vertical sectorization into LTE-Advanced systems is to improve cell capacity. In [7], capacity gain brought by electrical downtilt in standard 3-sector in Figure 2, BS (Base Station) configuration could be up to 48.4% for 1500m intersite distance for 3G WCDMA systems. In [8], 45.7% capacity improvement was observed for 3-sector BS with 1732m intersite distance by optimizing antenna parameters for LTE systems. In [9], performance of vertical sectorization with Near Electrical Tilt (NET) and Remote Electrical Tilt (RET) is evaluated for different network deployment scenarios by means of 3D system level simulation.

By applying the separate antenna elements into transmitter, each BS can dominate twice as many frequency resources as before.

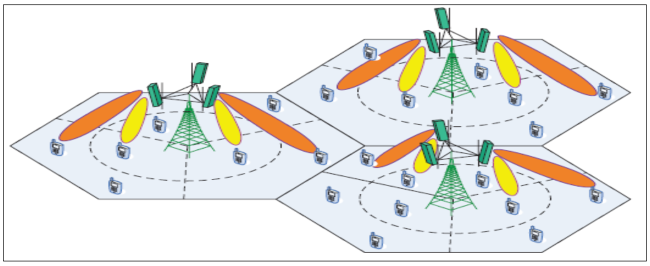

Fig 3: Vertical sectorization and 3 × 2 sector layout.

The number of physical resource blocks (PRBs) is doubled for vertical sectorization networks. Severe intracell interference will occur to reduce the signal to interference and noise ratio (SINR) of UEs and degrade performance of the whole networks when the resources are scheduled to different groups of UEs at the same time. Coverage is improve on as shown in Figure 4 Figure 5.

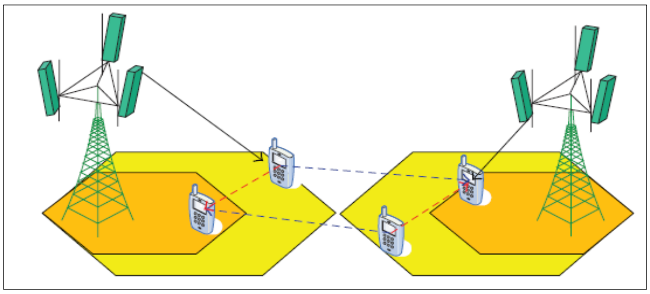

Fig 4: Vertical sectorization.

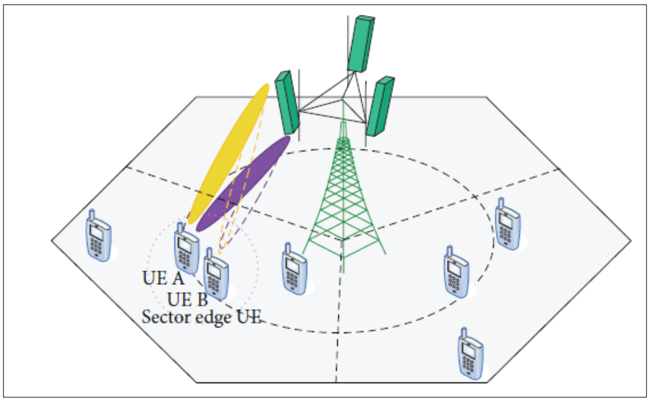

Fig 5: Resource allocation scheme [21].

LTE is bringing with it a usage of the term "cell" that is more common among the Europeans than that used in the Americas; namely, "cell" references the sector rather than the base station. Where it has been common in the U.S. to refer to a "3-sectored cell," it is becoming more appropriate not to use the term "sector", but to refer to the 3 "cells" associated with a single base station or Node-B. (One may also have other than three cells associated with a single base station, four or six, for example.), this work used the words “cell” and “sector” interchangeably, and try to be clear in referring to base stations as a fixed site, such as a tower or rooftop, where multiple antennas are located., the inference on all of this is on cell coverage as in Figure 6 and Figure 7.

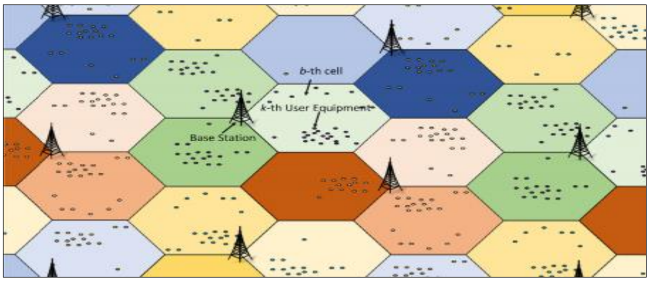

Fig 6: Cell Coverage

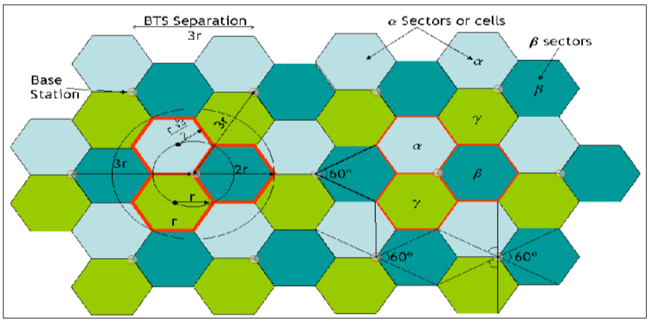

Fig 7: Illustration of the terminology of base stations and cells.

The previous vocabulary will be increasingly strained as the industry deploys remote antennas further from the base station, so we will refer to the area covered by common control signals (PCFICH, PDCCH, PHICH) as a cell.
This work further refine their vocabulary by pointing out that a radome can contain multiple antennas, typically in columns (though that is not the case with some active array antennas). These columns share a common RF connector with the same RF signal. So a radome might consist of pair of cross polarized antennas one at -45 degrees, the other at 45 degrees polarization (from the vertical) and each with a distinct, RF connector that is fed with a distinct RF signal having a separate Reference Signals (RS) while serving the same cell (sector). This is distinct from some references 18/135 that consider multiple antennas within a single radome to be part of one antenna.

2.3 Active antenna arrays

Mimo and Smart Antenna for 3G and 4G Wireless System, is general approach to DSP controlled smart antennas that permits both the typical horizontal beamforming but also vertical beamforming, is made possible by active antenna arrays as shown in Figure 7. This scheme permits amplitude and phase variation to be applied to vertically stacked antenna elements, such as the 16 elements shown below. In contrast to standard passive base station antennas, where a coaxial cable distribution network divides and feeds power to each element, individual transceivers, composed of radio modems, amplifiers, and filters are located directly next to the radiating antenna elements.

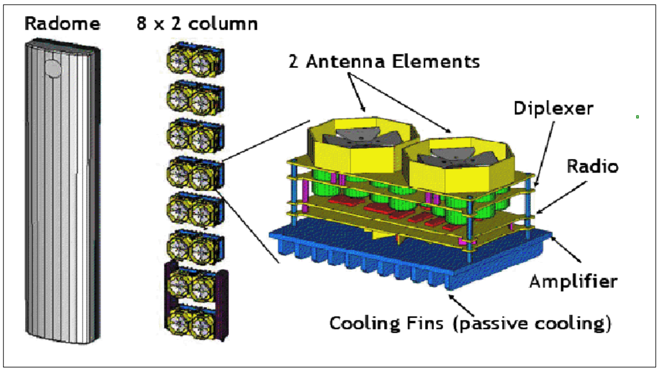

Fig 7: Active antenna array concept with a column array (left) and single antenna module (right).

This technology has the added benefit of eliminating power losses in the RF feeder cables, much like Remote Radio Heads. With the radios integrated directly into the radome housing, and with replacement of a small number of large amplifiers with many small amplifiers, the heat is spread over the larger antenna structure as opposed to the smaller RRH or amplifier shelf, permitting larger total RF transmit powers without the use of fans or other active cooling. Alternatively, the use of many lower power amplifiers, operating at cooler temperatures, can increase the reliability of the radio system. By integrating the remote radio head functionality into the antenna, the aesthetics of the site can be improved, wind load reduced, and potentially, some leasing costs avoided. See Figure 8.

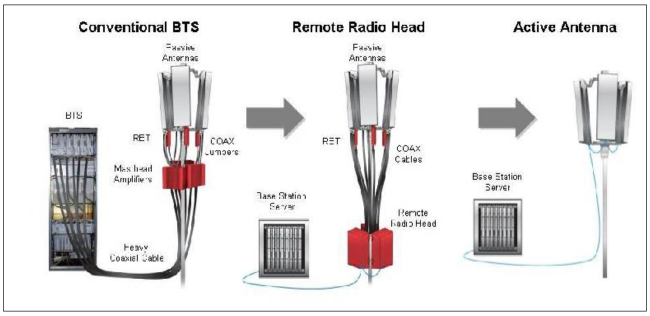

Fig 8: Radio Integration Trend.

Research and development activities on active antenna systems for cellular applications have been conducted by various organizations over the last decade, Figure 2.9 presents an active antenna used in a 900 MHz field trial. 14, 15 and recently field trials have been completed.16

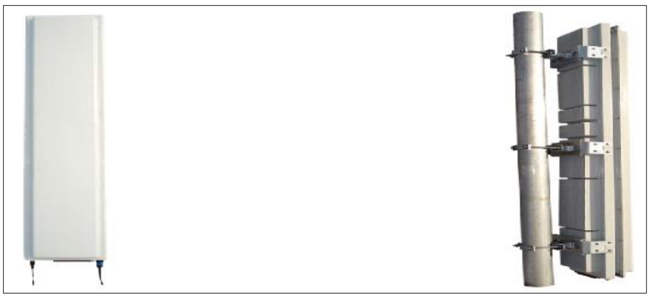

Fig 9: 900 MHz Active Antenna.

Another critical benefit of an AAS is the unique ability to electronically tilt elevation beams by having independent base band control of the phase and amplitude on each element. This supports multi-mode systems where different carriers in the same frequency band, with different air interfaces, may require different orientations. For example, legacy GSM/GPRS/EDGE or UMTS carriers may provide adequate coverage, but when a newly introduced LTE carrier is used for hot spot coverage or is used to span a more sparsely deployed area, LTE may be down-tilted differently than the legacy carriers. With a two-column active array, the LTE carrier may also be directed toward different azimuths directions than are the legacy carriers. The electronic tilt capability also allows for the separate beam tilting and optimization of the TX and RX paths and of the vertical sectorization of a cell (see Figure 2.10). Vertical sectorization of an LTE sector has been shown in simulation to provide significant capacity benefits.17

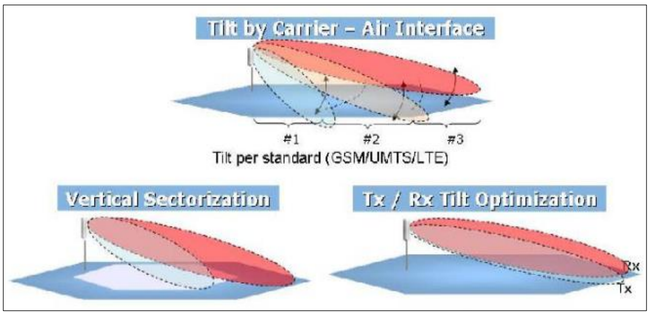

Fig 10: Electronic tilt applications.

The distributed and redundant architecture of the AAS, where each antenna element has its own transceiver, provides reliability benefits as the failure of one micro-radio does not cause the catastrophic failure of the sector. Of course, some loss of both EIRP and received signal level is experienced, but this may be tolerable for a period of time while the AAS awaits repair. Since the system is intelligent, and can sense a transceiver failure, the amplitude and phases on the remaining elements can be adjusted to compensate for the elevation beam distortion and the reduction of EIRP on the horizon (see Figure 11).

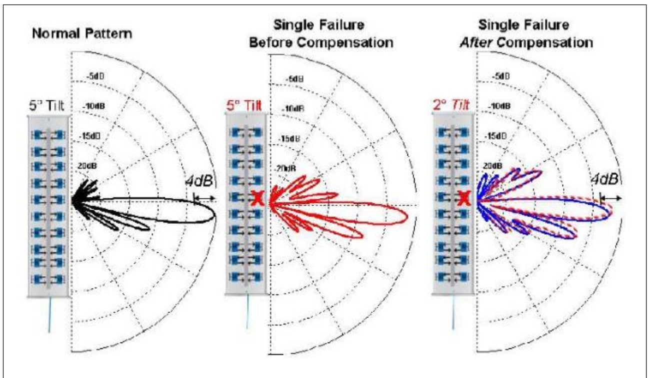

Fig 11: Elevation beam distortion and the reduction of EIRP on the horizon

2.4 Design of non-uniform antenna arrays for improved near-field multi-focusing

An extended method for Near-Field Multi-focusing on antenna arrays, including the optimization of the locations for the elements of the array, is proposed. Multi-focusing is gaining attention in recent years due to the growth of applications such as Internet of Things, or 5G, where a wireless link between a number of sensors and devices must be established, and energy or interference must be managed efficiently. Multi-focusing requirements may be addressed by optimizing the feeding weights that must be applied to the elements of an array, but the proposed methodology also optimizes their locations, increasing the degrees of freedom by allowing a non-uniform structure for the array, leading to more efficient structures or better compliance with the specifications. Some experiments are presented to validate the method, showing that it is able to determine the weights and mesh of the array to fulfill the requirements, both obtaining an arbitrary distribution of elements or following a predefined geometric model.

Near-Field (NF) techniques [1-4] are gaining increasing relevance in recent years due to the growth of applications such as Internet of Things (IoT) or 5G mobile telephony that require establishing wireless links between sensors and devices typically located at short distances, in most cases into the Near-Field region of their antennas. Morever, efficient energy management is requested to avoid wasting energy in locations where no devices are present, as provided by techniques such as Wireless Power Transfer (WPT) or Wireless Power and Information Transfer (WPIT) [5, 6]. Near-Field Focusing (NFF) has been shown to be extremely useful to achieve these objectives, as it is able to concentrate most of the radiated energy at an assigned position, the so-called focal point, where the device to be linked is located. However, conventional approaches to NFF are limited to only one focal point, while new applications usually involve multiple devices simultaneously. Near-Field Multi-focusing (NF-MF) on antenna arrays is a novel technique for concentrating the radiated field in certain assigned positions of the NF region of the antenna [7, 8]. This technique arises as an alternative to traditional methods for NF focusing on one position, such as the Conjugate-Phase (CP) [9], which has been proven to be useful in applications such as RFID [1], medical systems [10] or weapon detection [11]. In the conventional CP approach, the phase of the weights applied at each element of an antenna array is modified to compensate the different distances to the focal point, so that all their individual contributions arrive in-phase at that focal point. It has been shown to be an excellent choice to solve one-spot problems, but it is not useful when multiple devices or sensors are involved. Other techniques have been proposed to overcome these limitations. They are related to the use of multiple-feed reflect arrays [12], leaky wave lenses [13-15], artificial neural networks [16], optimization approaches [7, 17-19], or time-reversal techniques [8, 18, 19]. Among them, optimization approaches have been proven to be a flexible and powerful methodology, able to deal with general NFF problems, and also being the basis for the NF-MF

framework. It allows focusing on multiple points simultaneously, assigning nulls or minimizing focal-shift effects in the peak positions [20] or spureous peaks caused by the shape of the radiated field in the rest of NF positions [17].
The NF-MF method [7] consists of the resolution of a Least Squares problem, based on the definition of a proper cost function where a range of allowed field levels is established for each location of the NF region. This function is minimized using the iterative Levenberg-Marquardt algorithm (LM) [18] as an optimization method, given its success in the resolution of nonlinear problems [7].
The definition of bounds or a mask for the radiated field in the cost function allows handling different types of requirements besides NF multi-focusing, such as specification of nulls or focusing at arbitrary volumes or regions. Moreover, the flexibility of the method is also noted in the type of variables to obtain in the synthesis process, since either magnitudes and phases of the weights applied at each element of the array (magnitude-phase optimization, MP), or only their phases (phase-only synthesis, PO) can be configured.
On the other hand, there is a growing interest in designing non-uniform arrays, since the degrees of freedom achieved by considering the locations of the elements of the array may improve the antenna capabilities without increasing its cost or complexity [22, 23]. Thus, a complete framework including location synthesis is proposed in this paper, allowing flexibility in the array unknowns: the previous MP and PO cases can be extended for location optimization, providing a complete Magnitude-Phase-Position or Phase-Position synthesis. Although the computational cost is increased with respect to the synthesis of uniform arrays (since the number of variables to obtain is higher), demanding specifications can still be handled. In addition, different meshes can be designed, providing more flexibility in the array structure. Linear distributions are disregarded since NF-MF requires asymmetrical 3D specifications, but the location of the elements can be follow a planar or non-uniform distribution, even acquiring three dimensional functions.
For example, using digital signal processing (DSP) techniques, smart antennas are able to estimate the direction of arrival (DoA) for a connected device and shape the radiating patterns accordingly. To better understand how these techniques work, we need to take a closer look at some of the technologies that make them possible:

- Principles of phased antenna arrays
- Beam steering using switched beam antennas
- Beamforming with adaptive array antennas
- Precoding and Eigen beamforming systems

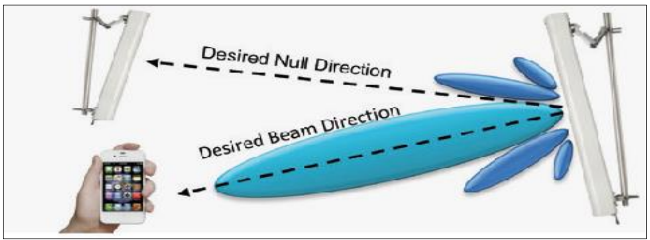

Fig 12: Phased array antennas

A phased array antenna applies phase control in figure 13 (or time delay) at each radiating element, so its beam can be scanned to different angles in space. Here is how it's constructed.

2.5.1 Antenna array patterns

A typical base station panel antenna consists of a number of radiating antenna elements (AE). Some examples can be seen in Figure 14

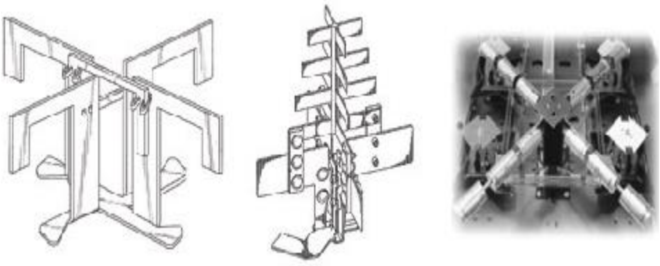

Fig 14: Andrew patented antenna elements examples

There are different types of AEs, with wire and aperture elements being the most common. Examples of wire AEs include dipole and monopole elements, while aperture AEs include slot elements. Some designs incorporate combinations of both types and can also be built over printed circuit boards or micro strip patches. Every AE has a radiation pattern, usually referred to as an **element pattern,** whose characteristics are determined by the design of the element.
When multiple AEs are mounted in a line along a shared reflector, the result is a panel antenna with linear arrays (Figure 15).

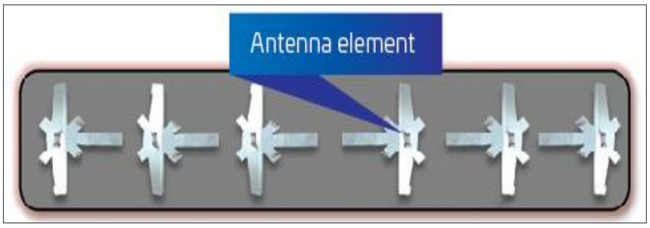

Fig 15: Base station panel antenna

While each AE in a linear array has its own radiation pattern, the RF effect of the entire array depends on the spacing, phase shifts and amplitude variation between its elements. Together, these three variables are used to describe the array factor pattern. By combining the array factor pattern and the element pattern, we can determine the overall far-field radiation pattern of the panel antenna.
The RF signal phases and amplitudes feeding the AEs can be controlled in order to shape the array factor pattern. This eventually directs and shapes the final beam see figure 16

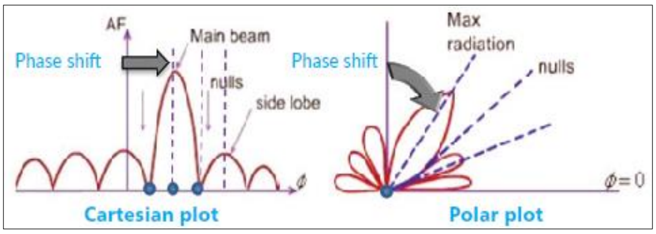

Fig 16: Adaptive array antennas (AAA)

Planar arrays

We have seen how beamforming techniques rely on the alteration of the RF signal phases and amplitudes that are fed across the internal antenna radiating elements. For linear array antennas, vertical beam steering (e-tilting) is a direct application of this concept. However, to enable horizontal and vertical beam steering, a two-dimensional rectangular array is needed. This is known as a planar array, a key component of today's adaptive array antennas (AAA).

Adaptive array antennas consist of columns of a planar array that work together to form a steerable beam that is shaped for improved side lobes.

Adaptive beamforming uses digital signal processing technology to identify the RF signal's direction of arrival (DoA) to a User Equipment (UE)—and generate a directional beam towards it.

Vertical sectorization in self-organizing LTE-advanced networks

Cellular radio networks continuously evolve to respond the exponential growth in data traffic volume in mobile communications. Active antenna technology contributes to this evolution by introducing vertical sectorization, which splits the horizontal sector into two subsectors with respect to the elevation plane and doubles the number of cells that can be deployed. However, in order to guarantee a reliable and near-optimal operation of vertical sectorization in a system that applies universal frequency reuse, such as LTE-advanced, co-channel interference mitigation is essentially needed. In this article we propose a decentralized self-optimization method that can be used to mitigate the undesirable inter-cell interference by self-tuning the electrical antenna downtilt toward the optimal antenna elevation angle. The performance evaluations for the proposed self-optimization method are carried out for both coordinated and uncoordinated subsector transmission scenarios within the LTE-advanced framework using a dynamic LTE-advanced compliant system level SON simulator. Based on the extensive performance evaluations carried out for a realistic urban scenario, it is found that self-optimization improves the vertical sectorization performance 25 % in terms of virtual load.

Furthermore, the performance gain reaches up to 30 % when vertical vectorization is provided with dynamic point selection and muting feature. Therefore, the article concludes that in LTE-advanced networks vertical sectorization can largely benefit from the antenna self-optimization and outperform the traditional horizontal sectorization approach with low algorithmic complexity.

Long Term Evolution (LTE) is a new cellular radio technology designed by the Third Generation Partnership Project (3GPP) [1]. The underlying radio technology is based on orthogonal frequency division multiple access which enables more flexible utilization of the radio spectrum, sophisticated scheduling methods, and multi-antenna techniques. The work conducted by 3GPP on the evolution of the third and fourth generation (3G and 4G) mobile systems has achieved substantial advancements in terms of service provisioning and cost reduction. As a consequence of this work, LTE admits higher peak data rates and can serve more user equipments (UEs) than previous generation technologies. Furthermore, the new network architecture of LTE, which is called Service Architecture Evolution (SAE), enables cost-effective and simplified operation with lower control plane latency. Subsequently, Long Term Evolution-Advanced (LTE-A) has been emerging as the continual improvement for the LTE radio technology and architecture standards. LTE-A standards (3GPP Release 10 and 11) fulfill the requirements set by ITU for IMT- Advanced with minimal additional complexity to the LTE air interface and SAE. Carrier aggregation, new types of relay nodes, multiple-input multiple-output (MIMO) enhancements up to eight layers (e.g., 8x8 downlink MIMO), and coordinated multipoint (CoMP) transmission and reception have been introduced as the major enhancement leaps [2, 3].

Active antenna technology will reduce coaxial cable and line losses between radio units and antenna, RF components such as power amplifiers and transceivers, which are conventionally part of the base station, are moved next to the antenna in remote radio heads or physically merged to the antenna in integrated antenna systems [23]. However, to provide intelligent beam pattern forming such as vertical sectorization and array diagram compensation [17], RF components should be integrated with each radiating element of the antenna [14, 23].

The integration of RF components and radiating elements enables the amplitude and phase control of the signals fed into to each radiating element; and three dimensional beamforming and further (horizontal or vertical) sectorization thereof.

Vertical sectorization, which splits the horizontal sector into two or more subsectors in the elevation plane [24], is a novel active antenna technique applicable in the cellular networks. As a result of vertical sectorization, antenna directivity can be used not only for expanding coverage but also for extending the capacity as depicted in Fig. 1. Inner and outer vertical subsectors, i.e., subsectors, are created by electronic adaptation of the phase delays and amplitude weights of the signals emitted from the vertically aligned radiating elements. In such system, antenna parameters can be reconfigured more rapidly and accurately compared to legacy antenna technologies that are tuned mechanically or manually.

In performance evaluations of [15, 16] it was observed that sectorization in vertical plane improves the best-effort throughput around 60 % in urban and sub-urban 3-by-2 cochannel site deployments where the first digit refers to the number of horizontal sectors and the second digits refers to the number of vertical subsectors. On the other hand, the received signal quality in downlink degrades notably as reported in both [15, 16] due to a large ICI presence (SON) technology has been of vital importance promising large expenditure reductions for LTE networks. By means of SON, the major processes of network operation and maintenance are automated and distributed over the radio access network minimizing the human intervention. Self optimization is one of the important SON functions that improves the coverage and capacity [4-8] and lowers the cost per bit thereof [9, 10]. Since the traffic is estimated to grow exponentially during the current decade [11, 12], LTE-A continues to evolve further with the advancements in self-optimization, for instance, by means of dynamic deployment of active antennas [13].

In [4], we have reported that substantial capacity improvements can be achieved via the self-optimization of adaptive antenna parameters. Yet, active antenna system (AAS) further advances the electronic elevation beam control and enables vertical sectorization [14] where horizontal sector is divided into two or more vertical subsectors.

However, to optimize vertical sectorization in cochannel deployments, the excessive inter-cell interference (ICI) between subsectors [15-19] have to be minimized.

Using very narrow vertical beam patterns and extensive electrical downtilt (EDT) is not practically feasible due to the physical limitations in beam pattern design. Narrowing the beam pattern will increase the side lobe level (SLL) and decrease the antenna gain [17]. CoMP [3, 20, 21] could be an attractive LTE-A technology to mitigate ICI since the subsectors are controlled by the same base station. Thus, seamless co-operation in scheduling and transmission is possible without any restriction of underlying backhaul. On the other hand, in order to effectively mitigate the load imbalance between inner and outer subsectors; and to find a reasonable setting that maximizes the received signal quality in a subsector [18], EDT optimization is required, regardless of a CoMP scheme as will be discussed in details in Sect. 4.

Previously we have reported gains from vertical sectorization and noted the potential problems of the initial technology concept [15]. The performance evaluation for this advanced concept is carried out by modeling a dynamic system level SON simulator in details within the framework of 3GPP LTE-A [22]. The main goal of the work is to investigate whether self-optimized vertical.

Fig 16: Vertical sectorization is comprimised of beams that are formed electronically by controlling the phase delays and amplitude weights of the signals emitted from the vertically aligned radiating elements.

Beam shapes can be adjusted using suitable electronical downtilt

Beam shapes can be adjusted using suitable electronical downtilt and half power beamwidth parameters between the subsectors. Furthermore, in an earlier study [15] we noted that the gain in terms of user satisfaction largely depends on the load-balancing between subsectors. Therefore, the dynamic adaptation of antenna elevation parameters is of utmost importance not only to mitigate ICI but also to optimize the effective coverage of subsectors. However, due to the fact that the increasing SLL can limit the electrical downtilting capability [17], complementary signal enhancement and interference mitigation techniques, such as coordinated scheduling [3, 20, 21], can be beneficial to fully exploit vertical sectorization in co-channel deployments. To enable the dynamic adaption of antenna elevation parameters in LTE-A networks, the framework on LTE-A self-optimization [10] is assumed in our studies. LTE-A self-optimization allows (local) eNB or (distributed or centralized) network management system to auto-tune various radio network parameters, such as antenna tilt (e.g., [4, 5]), handover offset (e.g., [6]) and random access channel parameters (e.g., [7, 8]), with the aid of base station and terminal performance measurements. Since the mechanical adaptation is not required in active antenna systems, operational cost and maintenance efforts can be substantially reduced. Thus, the self-optimization of antenna parameters, especially antenna elevation optimization, has become more attractive from the operator’s point of view [20, 21].

Virtual load and user satisfaction ratio are chosen as the major KPIs to compare the impact of different optimization means and scenarios. As shown in Fig. 6, which assumes 3 km/h mobility, EDT optimization improves the vertical sectorization gain around 25 and 15 % in terms of virtual load and user satisfaction respectively. Furthermore, the simulation results show that EDT optimization converges rapidly, which facilitates the use of vertical sectorization under dynamically changing conditions, such as time varying traffic load and distribution. This can be particularly seen when the red and green lines, for which a coordinated scheduling scheme, is implemented, are compared [22, 23].

Evolution of adaptive antennas for LTE systems

Long term evolution (LTE) is a 4G wireless broadband technology developed by Third Generation Partnership Project (3GPP), an industry trade group. There is an increasing interest in technologies that will be define the next generation (5G) telecommunication standard. Some of these technologies are already making their way into standards such as 3GPP LTE. 3GPP has been centered on enhancing LTE radio standards to improve capacity and performance. In order to increase both the capacity and employed bit rate of the down link LTE system, an adaptive array of 64-element has been proposed by the 3GPP in Release-13. In this paper, the capacity improvement and the saving power of the LTE system due to using of adaptive antenna array are studied in different channel scenarios. Simulation results showed that the system developed is more transmit power efficient as well as capacity improvement to a remarkable degree when the adaptive antenna is used compared to the conventional antenna system. Finally, a mathematical model of the improved capacity over a non-adaptive antenna is used case has been obtained and simulated.

2.8 Long term evolution

Long Term Evolution; as defined by the 3rd Generation Partnership Project; is supposed to be the next generation and will be the basis on which future mobile telecommunications systems will be built. Engineers named the technology "Long Term Evolution" because it represents the next step in a progression from, a standard, to, the technologies that based upon. LTE was required to deliver a peak data rate of in the downlink and in the uplink. This requirement was exceeded in the eventual system, which delivers peak data rates of and 75 Mbps respectively [1]. Supports deployment on different frequency bandwidths. The current specification outlines the following bandwidth blocks: and [1]. Frequency bandwidth blocks are essentially the amount of space a network operator dedicates to a network. Depending on the type of being deployed, these bandwidths have slightly different meaning in terms of capacity.

In, various antenna technologies, such as antenna array beamforming, are used to provide better [2] by a factor of the number of transmit/receive antennas. Moreover, this technology, i.e., adaptive antennas; will enhance and improve the quality of the link between the user equipment and the base station [3]. In addition, adaptive antennas can fulfill the requirements of higher spectrum efficiency, better coverage and higher data rate [4]. Beamforming can also be used to provide better performance in low and fading conditions.

Beamforming, in general, is a signal processing technique used to control the direction of the beam pattern of the array by applying a specific weight complex values for each element. These weights are updated based on some chosen beamforming criterion in which the phases and amplitudes are adjusted to optimize the received signal. This causes the output of the antenna arrays to form transmission or reception of the signals in a particular direction and minimizes the output in other directions [5]. defines many downlink, transmission modes, that employ beamforming, Whilst the system has been studied extensively using single antenna transmission, there is little research and work 2 reported on the supported adaptive antenna beamforming. In [7], author have studied the adaptive antennas and the results show an improvement in of 1.8 to achieve an error of 10-3 bit per second (bps) when Stanford University Interim channel models are used. The performance of the system can be more improved by increasing the number of antennas at receiver side. Authors in [8] have investigated the self-optimization of coverage and capacity in networks using adaptive antenna systems. In addition, they study the self-optimization algorithms of both the uplink and down link transmission powers by means of simulations in scope of the coverage and capacity optimization and interference reduction. The work in [2] shows the employment of transmit and receive diversity to improve the by a factor of the number of transmit/receive antennas. In another study [9], the Dominant Eigen Transmission ( ) power algorithm has been used to further improve the performance of the system. This algorithm maximize the and the Bit-Error Rate at the side.

In this paper, we investigate the implementation of the beamforming algorithms, e.g. Zero Forcing, in the system that supported in Release 13. This improvement of Bit Error Rate, capacity and saving power when adaptive antenna array is employed have been studied in an Additive White Gaussian Noise channel with different values and with the existence of co-channel interfered signals. In addition, free space and shadowing models have also been considered in this study. The main purpose of this paper is to show the huge improvements of performance when adaptive antenna array is employed.

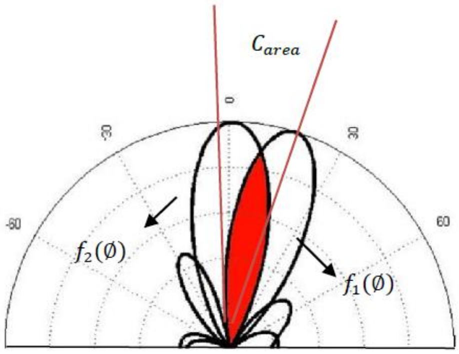

Fig 17: The common area between the beams.

2.10 Meta analysis table

A Meta-Analysis table was developed was use to combine the results of multiple scientific studies of most of the literatures reviewed. studies addressing the same question, with each individual paper studied and reporting measurements that are expected to show the strength and weaknesses of the papers., we use meta-analysis to contrast results from different studies and identify the strengths and patterns among studied results.

Table 1: Meta Analysis 1

SN	Authors	Title of work	Strength	Weakness
1.	Monikandan et al., (2019)	LTE Downlink 2x2 MIMO Channel B indoor model with SFBC: Design and BER analysis	It reduces the effects of inter symbol interference and inter carrier interference. It also works efficiently	The modulation methods will be more affected by errors caused by noise when they transmit more bits per symbol
2.	David Barina and Pavel Zemcik	Minimum memory vectorization of wavelet lifting	The approach does not require buffering and is basically useful for memory limited systems. It can start iteration of vectorized loop immediately. Useful in platform with SIMD instructions	Limited to only 1D wavelet transform i.e. SIMD. Also, it works only for fewer architectures.
3.	Mamman et al., (2017)	Adaptive Cell Admission Control with Bandwidth Reservation for downlink LTE Networks	This approach solves problems of some network resources being left unutilized. It reduces call blocking problems and call dropping probability ratio with increased throughput	Energy efficiency was not addressed.
4.	Kumar et al., (2018)	A hybrid offline-online approach to Adaptive Downlink Resource Allocation over LTE	It flows at better packet rate and average throughput for real time flows.	Efficiency is reduced with reduced number of flows…
5.	Guo et al., (2016)	Adaptive SU/MU-MIMO scheduling schemes for LTE – A downlink transmission	The proposed algorithm can meet requirement for LTE Advanced and improve cell throughput with no extra feedback overhead	No consideration for the feedbacks
6.	Gao and Cui (2014)	Adaptive Coordinated Scheduling, Beamforming Scheme for downlink LTE – Advanced System with non-ideal Backhaul	The proposed method works well in satisfying the QoS demand of UEs under high backhaul latency	The proposed CS/CB scheme has small loss in the cell average UE through-put for the reason that macro cell adopts a muting strategy.
7.	Tara and Alagha	Downlink fairness – aware adaptive resource allocation approach for	It achieves good capacity gains for all types of SDFs.	No evidence of previous review

	(2011)	LTE networks		
8.	Adesh and Renuka (2018)	Adaptive downlink scheduling in LTE networks based on queue monitoring	It enhances throughput and fairness among users and packet delivery fraction	There is high delay when there is lesser number of data bits per frame.
9.	Abd-Elnaby et al., (2018)	capacity enhancement based on dynamically adapted PF scheduling algorithm for LTE downlink system	The system is efficient in terms of throughput.	Slight degradation in fairness level as compared to conventional algorithm.

Table 2: Meta Analysis 2

S/N	Author(s)	Work title	Strength (s)	Limitation (s)
1	(Mohammed, Mohamad, & El-Sayed, 2018)	Capacity Enhancement Based on Dynamically Adapted PF Scheduling Algorithm for LTE Downlink System	Enhancement of overall system capacity, providing fairness in the distribution of the resource, improving average cell throughput.	The Best-CQI of the system is still lower than desirable meaning that the fairness is still reduced.
2	(Bahram, 2019)	Energy Efficient Discontinuous Reception Strategy in LTE and Beyond Using an Adaptive Packet Queuing Technique.	Develop a Reception Strategy in LTE and Beyond	Check for the disadvantage of DRX in the delay bcos of the que at the threshold.
3	(Kareem, 2017)	A proposed algorithm for scheduling and resource allocation For the downlink of LTE networks	The Packet Loss Rate (PLR) performance of the algorithm is significantly lower than the PF algorithm that led to an improved throughput.	The algorithm may not perform to a state expected if the any assumption was not satisfied like the ignored encapsulation overhead.
4	(Satish, Rajesh, & Arnab, 2019)	A Hybrid Offline-Online Approach to Adaptive Downlink Resource Allocation Over LTE	The system was able deliver higher overall QoS to real-time multimedia applications that are sensitive to delay.	Resource allocation and management disadvantage and offline – online lte resource scheduler
5	(Yao-Liang, 2016)	A Novel Algorithm for Efficient Downlink Packet Scheduling for Multiple-Component-Carrier Cellular Systems	The efficiency of the design help to improve energy efficiency.	Adaptivity wasn't incorporated into the algorithm to help adjust the η and t_{th} in the scheduling process
6	(Hashim, Santosh, & Manish, 2019)	Intelligent Radio Resource Scheduling for LTE-Advanced using Wavelet Neural Network	Use of WNN mechanism provides advantage of improved prediction capabilities and advantage of reduced processing time and reduced complexity with better results	For WNN biggest drawbacks is the difficulty of the choice of mother wavelet function
7	(Rehana, Chen, & Chai, 2011)	Adaptive Time Domain Scheduling Algorithm for OFDMA Based LTE Advanced Networks	Algorithm maintains a good trade-off between system overall throughput and fairness among users	
8	(Ahsan, Hadi, & Ali, 2016)	Random neural network based cognitive engines for adaptive modulation and coding in LTE downlink system.	RNN based CE efficiently exploits the channel quality information feedback delay to improve system throughput giving better experience to Cell-edge and cell-centre.	Training of RNN is a very tough task.

Conclusion
The paper took time to review all work done on various authors on Antennae Adaptive Downtilt for Long Term Evolution(LTE), the paper did carry out analysis on real time applications in the downlink of LTE networks, a novel algorithm of scheduling is proposed and implemented in some of the papers were reviewed. Some of the proposed algorithm reduced the number of packets that has been dropped due to congestion as well as the number of lost packets due to bad channel quality, and thus enhancing the system performance. LTE Downlink 2x2 MIMO Channel B indoor model with SFBC: Design and BER analysis. The BER and SFBC were analyzed using Matlab based 2x2 MIMO orthogonal frequency division multiplexing (MIMO-OFDM) with space frequency block coding (SFBC). Benefiting from Active Antenna Systems (AAS), many active antenna technologies such as 3D beamforming and vertical sectorization could be easily implemented. Most of the authors worked on how Antennae Adaptive Downtilt for Long Term Evolution(LTE) can help improve performance.

References

1. International Telecommunication Union, ICT Facts and Figures, International Telecommunication Union, Geneva, 2017.
2. ITU; UNESCO. The state of broadband: broadband catalyzing sustainable development, Broadband Commission for Sustainable Development, 2017.
3. Dahlma E, Parkvall S, Skold J, Beming P. 3G Evolution: HSPA and LTE for Mobile Broadband, 1st ed., London: Elsevier, 2017.
4. Citation Hät16 \l 1033. Mohammed Abd-Elnaby, Mohamad Elhadad, El-Sayed El-Rabaie. Capacity Enhancement Based On Dynamically Adapted Pf Scheduling Algorithm For Lte Downlink System, The International Arab Journal of Information Technology. 2016-2018; 15(5):795.
5. Satish Kumar, Rajesh Devaraj, Arnab Sarkar. A Hybrid Offline-Online Approach to Adaptive Downlink Resource Allocation Over LTE IEEE/CAA Journal of

Automatica Sinica 1, 2016.
6. Rehana Kausar, Chen Y, Chai KK. Adaptive Time Domain Scheduling Algorithm for OFDMA Based LTE Advanced Networks, 2017.
7. Duy-Huy Nguyen SAMOVAR. A new Channel- and QoS-Aware Scheduling Scheme for Real-time Services in LTE Network International Journal of Applied Information Systems (IJAIS) ISSN: 2249-0868 Foundation of Computer Science FCS, New York, USA. 2016; 11:4.
8. Tara Ali-Yahiya, Khaldoun Alagha. Downlink fairness-aware adaptive resource allocation approach for LTE networks, International journal of network management, Published online in Wiley Online Library,, 2011, 269-283. (wileyonlinelibrary.com) DOI: 10.1002/nem.795
9. Nadim Madi KM, Zurina Mohd Hanapi, Mohamed Othman, Shamala K Subramaniam. Delay-based and QoS-aware packet scheduling for RT and NRT multimedia services in LTE downlink systems, 2018.
10. Ahsan Adeel, Hadi Larijani, Ali Ahmadinia. Random Neural Network based Cognitive Engines for Adaptive Modulation and Coding in LTE Downlink Systems School of Engineering & Built Environment, Glasgow Caledonian University, UK Computer Science and Information Systems Department, California State University San Marcos, U, 2016.
11. Prasanna Venkatesan GKD. LTE Downlink 2x2MIMO in Channel-B Indoor Model with SFBC: Design and BER Analysis, Proceedings of International Conference on Recent Trends in Computing, Communication & Networking Technologies (ICRTCCNT), HYPERLINK, 2018.
12. David Barina, Zemcik, Pavel. Minimum Memory Vectorisation of Wavelet Lifting web of science, published: 2013 in lecture notes in computer SCIENCE DOI: 10.1007/978-3-319-02895-8_9
13. Tomoki Murakami, Riichi Kudo, Koichi Ishihara, Masato Mizoguchi, Naoki Honma. (Experimental Results of Network-Assisted Interference Suppression Scheme Using Adaptive Beam-Tilt Switching, Hindawi International Journal of Antennas and Propagation, 2017.
14. Maharazu Mamman, Zurina Mohd Hanapi, Azizol Abdullah, Abdullah Muhammed. An Adaptive Call Admission Control With Bandwidth Reservation for Downlink LTE Networks Hanapi IEEE/CAA journal of automatica SINICA 1A, 2003.
Satish Kumar, Rajesh Devaraj, Student Member, IEEE, and Arnab Sarkar, Member, IEEE
15. Wei Guo, Jiancun Fan, Geoffrey Ye Li, Qinye Yin, Xiaolong Zhu. Adaptive SU/MU-MIMO scheduling schemes for LTE-A downlink transmission, doi: 10.1049/iet-com.2016.0456, 2017, www.ietdl.org, IET Communications
16. Tara Ali-Yahiya, Khaldoun Alagha. Downlink fairness-aware adaptive resource allocation approach for LTE networks, international journal of network management, 2011, Published online in Wiley Online Library (wileyonlinelibrary.com) DOI: 10.1002/nem.795
17. Adesh ND, Renuka A. Adaptive downlink packet scheduling in LTE networks based on queue monitoring Springer Science + Business Media, LLC, part of Springer Nature, Wireless Networks, 2018.
18. Capacity Enhancement Based on Dynamically Adapted PF Scheduling Algorithm for LTE Downlink System, Mohammed Abd-Elnaby, Mohamad Elhadad, and El-Sayed El-Rabaie, The International Arab Journal of Information Technology. 2018; 15(5):795.
19. James Agajo, Jonathan Kolo G, Obiora-Dimson IC, Okeke Benjamin Chukwuejekwu, Lazarus Uzoechi O. Remote Monitoring and Automated Diagnosis via Interactive Sofware Interface Using Wireless Communication Network Telemedicine, ATBU Journal of Science, Technology and Education, Volume 4 number 1, Abubakar Tafawa Balewa University, 2016.
20. Lukman Adewale Ajao, James Agajo, Jonathan Gana Kolo, Mutiu Adesina Adegboye, Yakubu Yusuf. Learning of Embedded System Design, Simulation and Implementation: A Technical Approach, American Journal of Embedded Systems and Applications, Science Publishing Group USA. 2016; 3(3):35-42.
21. James Agajo, Okeke BC, Nnadi N Ifeyinwa CO. Remote Monitoring and Data Acquisition Model of Agro-Climatological Parameter for Agriculture using Wireless Sensor Network, IEEE Based African Journal of Computing & ICT. 2015; 8(4):153-166, available online at pp21027 https://static.secure.website/wscfus/5655211/2203102/v8n4p16-2015-ajocict.pdf
22. James Agajo, Nuhu B, Faith N, Okeke BC, Lazarus OU. Zigbee Based Wireless Patient Temperature And Pulse Monitoring System, Journal of Wireless Sensor Networks, JWSN. 2016; 3:1. DOI-0015, pp43-54,, available online at http://www.wsnmagazine.com/journal/index.php/journal/article/view/44/38