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Evolution Towards 5G Multi-tier Cellular Wireless Networks Higher Data Rates Transmission in MIMO Systems

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ABSTRACT: The evolving fifth generation (5G) cellular wireless networks are envisioned to overcome the fundamental challenges of existing cellular networks, higher data rates, excellent end to- end performance and user-coverage in hot-spots and crowded areas with lower latency, energy consumption and cost per information transfer. To address these challenges, 5G systems will adopt a multi-tier architecture consisting of macrocells, different types of licensed small cells, relays, and device-to-device (D2D) networks to serve users with different quality-of-service (QoS) requirements in a spectrum and energy-efficient manner. Starting with the visions and requirements of 5G multi-tier networks, this thesis outlines the challenges of interference management (power control, cell association) in these networks with shared spectrum access (when the different network tiers share the same licensed spectrum In this context, a qualitative comparison of the existing cell association and power control schemes is provided to our thesis for interference management in 5G networks.

Keywords: Fifth generation**,** quality-of-service, MC-CDMA, device-to-device, DS-CDMA, MIMO.

I. INTRODUCTION

In recent years, Human-centric as well as connected machine-centric networks will need to be enabled. Enable any mobile application and service to connect to anything at anytime connectivity between connected people and connected machines Existing wireless systems will not be able to deal with thousand fold increase in mobile broadband data.5G: the next generation of ubiquitous ultra-broadband network Massive capacity and massive connectivity 2 Increasingly diverse set of services, applications, and users with extremely diverging requirements 1000 times higher mobile data volume per unit area (1000_ challenge) 10-100 times higher number of connecting devices and user data rate (e.g., peak data rate of 10 Gbps for low mobility and peak data rate of 1 Gbps for high mobility) Less than 1 ms latency to support real-time control applications Max 10 ms switching time between different radio access technologies (RATs) Communication scenarios in the range of 350 - 500 km/hr(compared to 250 km/hr in 4G networks)10 times longer battery life MC-CDMA has become increasingly popular as a promising wireless access technique in wideband communication systems mainly due to its high spectral efficiency, robustness against frequency selective fading and flexibility to support various integrated applications [9, 13]. In MC-CDMA the information symbols of individual users are spread in the frequency domain over a number of orthogonal sub carriers using pseudo-noise (PN) sequences. Most of the MC-CDMA receivers proposed designed previously is to be optimal or suboptimal under the Gaussian noise assumption. However when the radio bandwidth becomes wider in order to meet the demands for higher data rates, the transmission performance may be seriously degraded by impulsive noise which is caused by vehicle ignitions, power lines, electrical equipment etc. In many physical channels like in urban, indoor radio and underwater acoustic channels the ambient noise is known through experimental measurements to be decidedly Non-Gaussian due to the impulsive nature of man-made electromagnetic interference and natural noise as well. Linear and Nonlinear receivers for DS-CDMA system has been investigated in [1,2]. Native support for Machine-type communication low latency and real-time operation May require radical changes at both the node and architecture Levels into the network through the use of reliable, fast and low latency backhaul connections which will be a major technical issue for upcoming multi-tier 5G networks.

In the remaining of this article, we will focus on the review of existing power control and cell association strategies to demonstrate their limitations for interference management in 5G multi-tier prioritized cellular networks (i.e., where users in different tiers have different priorities depending on the location, application requirements and so on). Design guidelines will then be provided to overcome these limitations.

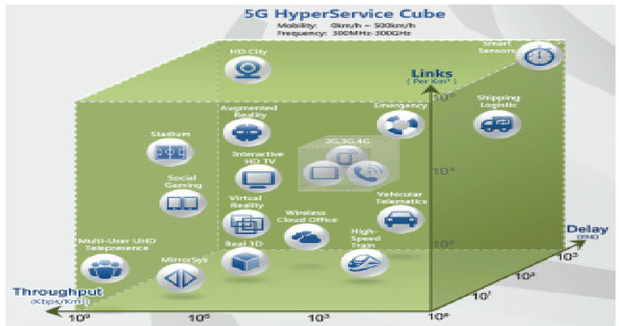

Fig. 1. A technology vision1 5G.

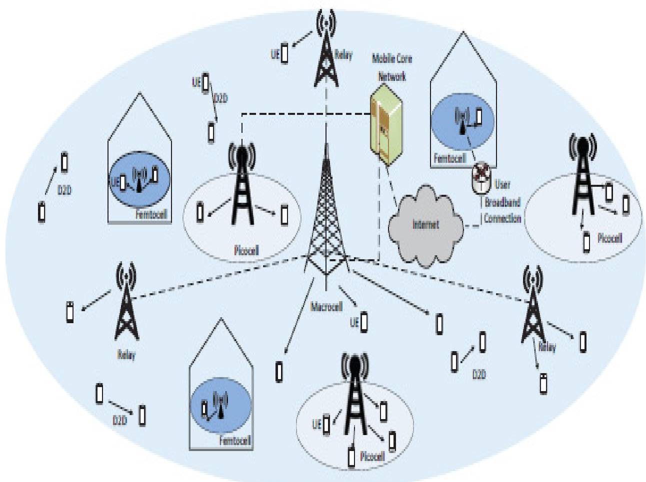

Fig. 2. Multi-tier cellular network architecture.

The effects of impulsive noise for both MCM systems and single-carrier modulation (SCM) system have previously been analyzed in [8] where the BER of orthogonal frequency-division multiplexing (OFDM) QAM based systems has been derived by varying impulse power and probability. Robust detection of DS-CDMA and OFDM based signals under similar channel conditions has been studied and various nonlinear detection techniques have been investigated in [3,6,15,16]. The BER performance of MC-CDMA in the presence of impulsive noise and frequency-selective multipath fading has been investigated in [12,7]. However it was inconclusive that MC-CDMA systems are more robust to impulsive noise than the equivalent DS-CDMA as the performance was demonstrated in the presence of frequency-selective fading thus it was not evident that the gain obtained was due to robustness to impulsive noise or frequency selectivity. We will compare the performance of MC-CDMA and MC-DS-CDMA in mixture impulsive noise model which is widely used to model impulsive noise environments [1,3,15]. The theoretical analysis and simulation results evidently illustrate the conventional MC-CDMA is more sensitive to impulsive noise than DS-CDMA and OFDM. However it is not true that MC-CDMA structure fails in the presence of impulsive noise. Furthermore we propose a modified MC-CDMA structure called MC-SI-CDMA with sub carrier interleaving which outperforms DS-CDMA and OFDM in impulsive noise. Interference has become a real problem because of the limited available bandwidth resources.

As telecommunication systems rapidly growing so that the interference among such systems is becoming increasingly serious, especially in industrial environments. Measurement of interfering signals is the main initial step for realizing coexistence of these systems. Numerous works have studied the impact of impulsive interference into multiple modulation schemes but they have not performed real measurements [1]. The main objective in this thesis is to develop three different measurement setups to test the performance of multiple modulation schemes under certain interference. Two types of noise models are generally used to describe noise interference. These models include the Gaussian noise and the Non-Gaussian noise (impulsive noise). Actual wireless systems are designed to work under certain signal to noise ratio, considering this noise as Additive White Gaussian Noise (AWGN). However impulsive interferences have different statistical properties than AWGN and so that their effects can be different into the communication system. The man-made environments are much more impulsive that can drastically degrade the performance of the systems to operate effectively against background noise. So that there is really requirement to combat against the interfering noise and to improve the quality of communication system also requires to parameterize the interference noises in a statically way. For high quality communications required a low BER and it is not always obtained in some cases due to impulsive noise. But we cannot fight against only the impulsive noise in order to get a realistic noise model it should be a combination of the both noises Gaussian and Non-Gaussian where Middleton's class A model is the one that fits better with most of Non-Gaussian noises [2]. The main parameter of the Gaussian model is the average noise power across the channel. The Gaussian probability density function and a constant power spectral density characterize in this model. on the other hand impulsive noise is completely random and has an unpredictable power and cannot know when it is going to occur. The only way to get statistical information about it is doing measurements in a specific place and characterizing it [3].Gaussian noise is defined as noise with some particular statistical properties. This noise has a probability density function as a normal distribution also known as Gaussian distribution. That means the power of the noise is Gaussian distributed for an specific case of this noise and the noise we are going to work with is Additive White Gaussian noise which besides of the values of the noise in two different times are statistically independent and uncorrelated which makes it appear in broadband [4]. Impulsive noise is non-stationary and is compounded by irregular pulses of short duration and signifier energy spikes with random amplitude in spectral content so this is why impulsive noise is considered the main cause of burst error occurrence in data transmission causing a temporary loss of signal. Therefore this is essential to know the statistical nature of impulse noise in order to be able to evaluate its impact on a communication system. These pulses are made by two main causes ambient electromagnetic interferences (storms) and natural electromagnetic interference or errors on telecommunications systems by man-made. Impulsive noise is a sequence of pulses characterized by three parameters and those are pulse amplitude, time-duration of the pulse and the time between consecutive pulses.

II. DEVICE-TO-DEVICE (D2D) COMMUNICATION

D2D communication (already being studied in 3GPP as a 4G add-on) should be natively supported in 5G as another cell-tier. Permits transmitter-receiver pairs coexisting in close proximity to establish direct peer-to-peer connections without the use of BSs (social networking, peer-to-peer content sharing, public safety communications) Enables short-range, low-power links to coexist with cellular links (improves spectral efficiency, decreases power consumptions of UEs, improves total network throughput)4Dense spectrum reuse, irregular interference topology Spectrum overlay or spectrum underlay.

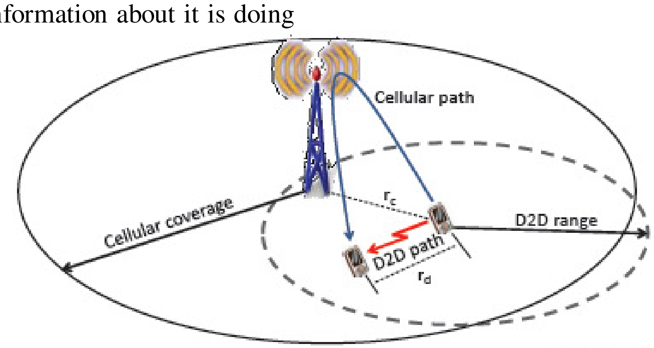

Fig. 3. Device-to-device (D2D) communication.

Multiple access/interference management and advanced waveform technologies combined with advances in coding and modulation algorithms (for massive IoT connectivity) Miniaturized multi-antenna technologies and significantly advanced baseband and RF architecture (e.g., for massive MIMO computations)Advanced RF domain processing, single-frequency full-duplex radio technologies Device technologies to support a vast range of capabilities Backhaul design for ultra dense networking Virtualized and cloud-based radio access infrastructure. Open challenges are highlighted and guidelines are provided to schemes in order to overcome these and make them suitable for the emerging 5G systems. The multi carrier code division multiple access (MC-CDMA) systems and analyze the performance by examining the MC-CDMA system model in time domain. We have discovered that conventional Walsh-code based MC-CDMA is less robust as compared in presence of impulsive noise than the direct sequence DS-CDMA and the multi carrier modulation based (MCM) systems. It is cleared that the performance of MC-CDMA depends strongly on the selection of the utilized spreading codes and modified MC-CDMA structure is called as MC-SI-CDMA and it is investigated in impulsive noise that employs sub carrier interleaving (SI) to reduce the cross correlation between the time domain MC-CDMA waveforms and the impulsive noise. From Computer simulation results it is cleared that to support our analysis the proposed MC-SI-CDMA system in impulsive noise can gives a performance improvement of 2.5 dB at a bit error rate (BER) level of 10^{-3} and it is compared with the DS-CDMA system.

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III. SIMULATION RESULT

Evolution Towards 5G Multi-tier Cellular Wireless Networks Higher Data Rates Transmission in MIMO Systems outage ratio for HPUEs performance of the MC-CDMA system, the theoretical performance and computer simulation results are presented. TPC, TPC-GR, Prioritized TPC, Prioritized TPC,GR QAM modulation is employed for all investigated systems. For MC- CDMA and PSK 16 systems, MMSE for MC-CDMA based systems, the parameters of TPC,TPC-GR, Prioritized TPC, Prioritized TPC,GR performance versus signal-to-noise ratio (SNR) db/N0, where db is the energy transmitted per information bit and N0 is the one-sided noise power spectral density. For comparison purposes, both theoretical performance and simulation results of the linear receivers for MC-CDMA in impulsive noise are plotted. It can be seen that the computer simulation results match the theoretical analysis perfectly. Evolution Towards 5G Multi-tier Cellular Wireless Networks Higher Data Rates Transmission in MIMO Systems. In addition to setting their transmit power for tracking their objectives, the LPUEs limit their transmit power to keep interference caused to HPUEs below a given threshold. HPUEs can notify the nearby LPUEs when the interference exceeds the given threshold. A two-tier system (high-priority cell tier and low-priority celltier) with same target SIR for all users25 HPUEs per high-priority cell and 4 LPUEs per low-priority cell, each user is associated with only one BS of its corresponding tier. 3 LPUEs employ either TPC, TPC-GR, prioritized TPC, or prioritized TPC-GR, and HPUEs use TPC (i.e., rigidly track their target-SIRs).

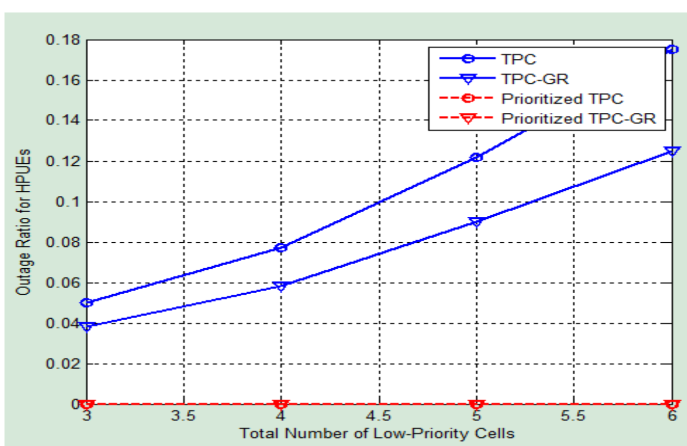

Fig. 4. Performance of TPC, TPC-GR, Prioritized TPC, Prioritized TPC,GR and total number of low –Priority Cell.

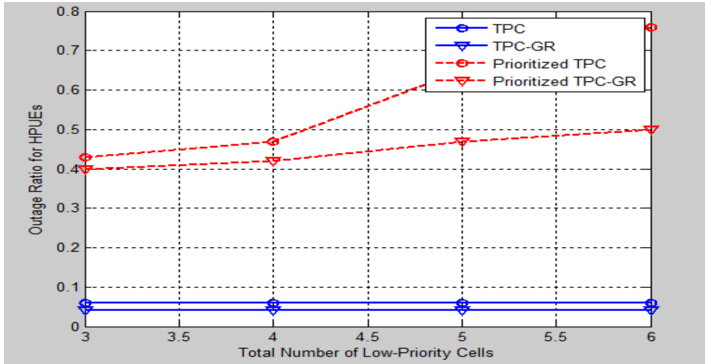

Fig. 5. Performance Prioritized power control.

Although outage ratio for HPUEs are improved by TPC-GR, as compared to TPC, protection of HPUEs is not guaranteed. Prioritized TPC and TPC-GR guarantee protection of HPUEs at the cost of increased outage ratio for LPUEs. Also, with prioritized OPC for LPUEs and TPC for HPUEs, protection of HPUEs is guaranteed at the cost of decreased throughput for LPUEs (compared to non-prioritized OPC).

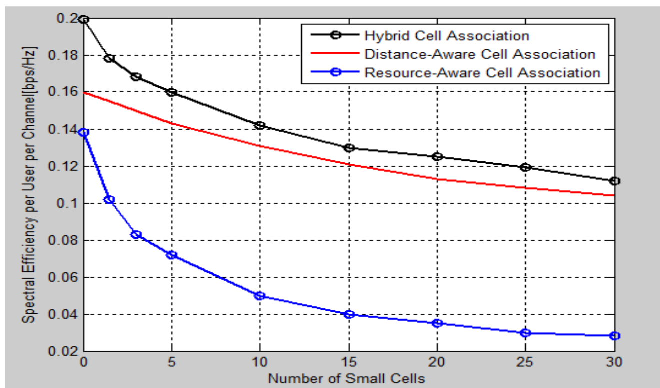

Fig. 6. Hybrid cell association scheme.

Combine resource-aware and distance-aware criteria A user selects a cell with the maximum of product of distance-based channel gain and pi. If pi = 0 (i.e., high or innate traffic load), a user will not select cell i even if it is the closest cell and vice versa. Hybrid scheme achieves a balance between traffic load balancing and throughput maximization. Quantitative comparison among resource-aware, distance-aware, and hybrid cell association schemes: two-tier macrocell-small cell network, downlink transmission, round-robin scheduling.

IV. CONCLUSION

Evolution Towards 5G Multi-tier Cellular Wireless Networks Higher Data Rates Transmission in MIMO Systems We considered the effect of Performance gain due to cognitive spectrum access Outage probability (of small cell users) vs. spectrum sensing threshold for cognitive techniques and different values pc (= percentage of SBSs operating in the closed access mode) Outage due to SINR violation and outage due to unavailability of channel for opportunistic spectrum access for small cell users vs. spectrum sensing threshold for different cognitive techniques and different values pc effect of channel allocation at the macro tier Two channel assignment techniques for the MBSs in in a two-tier network with cognitive SBSs: random channel assignment (RCA) and sequential channel assignment (SCA) RCA: each MBS randomly and uniformly chooses one channel for each of its associated users the available channels have a specific order and each MBS assigns the channels to its associated users in a sequential manner.RCA deteriorates the opportunistic spectrum access performance for cognitive SBSs. SCA minimizes the number of unique channels used by the coexisting MBSs (hence maximizes the opportunistic spectrum access performance for cognitive SBSs).

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