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A Review Energy Efficiency in Massive MIMO-Based 5G Networks System

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ABSTRACT: The new upcoming technology of the fifth generation wireless mobile network is advertised as lightning speed internet, everywhere, for everything, for everyone in the nearest future. There are a lot of efforts and research carrying on many aspects, e.g. millimetre wave (mmW) radio transmission, massive multiple input and multiple output (Massive-MIMO) new antenna technology, the promising technique of SDN architecture, Internet of Thing (IoT) and many more. In this brief survey, we highlight some of the most recent developments towards the 5G mobile network.

Keywords. 5G, millimetre wave, Internet of Thing, massive MIMO,

I. INTRODUCTION

The fifth generation network (5G) is coming sooner than we expect, some say by 2020 which is expected to have a speed exceeding the 1Gbit/s. There has been a great interest in the research of the 5G future technology, so 700 million euro from the public fund has been committed only for this research over seven years. Many aspects could play an important role in forming the 5G network, in they concentrated on five elements: millimetre wave (mmW), massive multiple input and multiple output (massive -MIMO), device-centric architectures, smarter devices, and native support for machine-to-machine (M2M). The authors in emphasized five things as a challenge for 5G: Heterogeneous Networks (HetNets), Software Defined Cellular Networks (SDN), M-MIMO and 3D MIMO, M2M Communications and other technologies. Inthe authors talked about four generic elements which could form the 5G era: Big Data Analytics (Big Data), Cloud Computing (Cloud), Internet of Things (IoT), and SDN. In the authors discussed in detail about many aspects related to the upcoming 5G network: Engineering Requirements for 5G and the design issues, mmW, M-MIMO, Cloud-Based Networking, SDN, Energy Efficiency, spectrum regulation and standardization for 5G and many more. A qualitative comparison of the existing cell association and power control schemes is provided to our thesis for interference management in 5G networks [1]. A detailed survey is included regarding current research projects being conducted in different countries by research groups and institutions that are working on 5G technologies [2]. Wireless communication systems suffer from fading and signal attenuation due to the mobility factor associated with it [3,7]. The channel estimation is studied for low delay spread and high delay spread channels [4]. The MIMO-OFDM system is the combination of the MIMO technique and OFDM technique, which is enhancing the capacity, improve the link reliability high data rate transmission for future broadband wireless communication and also use for avoid Inter Symbol Interference (ISI) [5,6]. Some of the related aspects to the new 5G mobile networks.

II. MOBILE NETWORKS EVOLUTION

It seems that telecommunication technology advances every decade or so, as 1G started around 1980, 2G by 1992, 3G by 2001, 4G or Long-Term Evolution (LTE) by 2011 and the new 5G network expectantly by 2020 [8]. 4G nowadays supports 1 Gbits/s for low mobility and 100 Mbit/s for high mobility. For the new upcoming 5G they estimate 10 Gbits/s for low mobility and 1Gbit/s for high mobility. The latency in 4G is 15 ms while in 5G it is expected to be 1 ms or so. So how could all of that happen. The answer lies in the new architecture of the 5G network.

III. 5G NETWORK ARCHITECTURE

The architecture of the new network will be changed, many aspects will try to utilize and get the most out of the existing technology and add new ones to form much faster network capable to deliver the rich content of the multimedia (HD-4K [High Definition] streaming/none streaming video and Hi–Res [High Resolution] images) and the data flood produced from mobile phones and social media apps. One proposed idea is software-defined network architecture.

The 5G mobile network needs to deal with some of the challenges facing the 4G network nowadays such as high energy consumption, spectrum crisis, bad interconnectivity, poor coverage, flexibility, and poor Quality of Service. The impact of antenna array architectures on mmw communication systems in practical outdoor environments [9]. Four typical planar antenna array architectures are investigated and simulation results demonstrate the advantages of the circular antenna array, which has a flat gain fluctuation and is robust to beam misalignment. In addition, in order to maintain the effective coverage and connectivity of mmw systems that are vulnerable to frequent blockages,

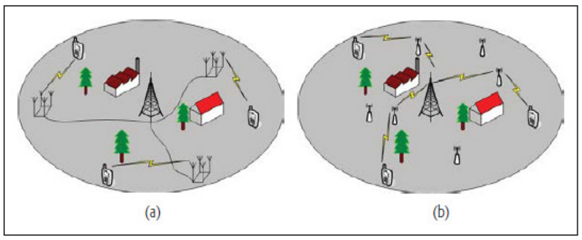

Fig. 1. MMW cellular networks with technology improving Coverage.

Despite the fact that the mmw antenna array can achieve higher gains than a microwave communication system with the same array area, mmw communications with shorter wavelengths experiences more severe attenuation within the same communication distance. Most energy is consumed by free-space loss during signal transmissions. Thus, to improve the energy efficiency of mmw communication systems, the mmw APs should be deployed with high density to reduce the distance between the AP and the user terminal.

The edge-caching-enabled commercial system in 5G networks, provided some typical game models, and discussed some applications of game theory. In particular, we first analyze the interests of multiple parties and give some typical game models to illustrate their interactions. To comply with future trends in 5G networks, [10] we have provided some applications of game theory. From these works, we have seen the effectiveness of applying game theory in the proposed edge caching systems, such as reducing downloading latency, preventing cheating, and decreasing buyers' costs. Finally, we propose some research directions, including the competitive seller's problem, multi-dimensional incentive design, and hierarchical game model. This article has provided some insights on game theory in designing incentive mechanisms for the commercialization of future edge caching systems.

We first discussed the initial intelligence emerging in nearly all aspects of 5G cellular networks, including radio resource management [11], mobility management, general management and orchestration, and service provisioning management. Following such intelligence, we argued it is still essential to bring more AI functionalities to 5G cellular networks by envisioning several prospective opportunities and listing some potential challenges. Finally, we provided a use case on how to obtain greener 5G cellular networks and demonstrated the thrilling effectiveness of AI. We could boldly argue that AI empowered 5G cellular networks will successfully enter the central stage of a digitalized world.

	4G	5G	AI modules				Intelligent 5G
			Sensing	Mining	Prediction	Reasoning	
Services	MBB	eMBB/mMTC/URLLC					Service-aware
RRM	Granted	Granted or grant-free Flexible bandwidth Flexible symbol length	✓	✓	×	✓	UE-specific on-demand
MM	Unified	On-demand	✓	×	✓	✓	Location tracking/awareness
MANO	Simple	Operator-tailored	✓	✓	✓	✓	Enhanced self-organizing and trouble-shooting capability
SPM	Unified	End-to-end NS	×	✓	✓	✓	Network slice auto-instantiation

Fig. 2. Evolution toward intelligent 5G.

Network is preferable but in densely populated regions to provide better service to all the users small cell is the logical network type to be used due to its higher area throughput, approximately four and half times higher than heterogeneous network according to our simulation results. Moreover for a given coverage area, [12] small cell network requires a higher number of BSs, since it has a fixed hexagonal geometry, therefore capital expenditure (CAPEX) requirement is also higher. Femto cells used in heterogeneous network in contrast have a random distribution therefore it can be placed only at strategic points in highly populated areas, minimizing the BSs requirement for optimum coverage, thereby reducing the overall CAPEX. In future, our work will be carried out for various transmission modes and will also try to find out the effect of mobility on different MIMO modes and scheduler schemes under different network architecture.

Increase in systems data rates & performance is achieved by proper system design of MIMO system. The capacity hikes linearly [13] by using MIMO system at high SNR, i.e. as TxN and/or RxN of the MIMO system increases their capacity increases. We have presented the Shannon capacity formula. Different multi-antenna systems are studied thoroughly.

The introduction of cognitive radio in 1999 there have been many high-level discussions on proposed capabilities of cognitive radios. In this paper we have tried to formalize some of the architecture behind these ideas and the applications for which they are most suited, and give some insight into the differences between reasoning and learning. Certainly there is a great deal of future work in the field of cognitive radio, and in particular applications of machine learning to cognitive radio. The architecture described here is flexible enough to address many different applications provided they can be expressed in predicates, actions, and objective functions. The real work will be mapping potential applications to predicate calculus.

Broadband wireless technologies represent a pressing need in current society. The interest of this paper has focused on its accurate modeling of WiMAX contention-based access under nonsaturated conditions and its performance analysis based on queuing theory, [14] investigating the impact of different parameters on the mean total packet delay. The analytical results are in close agreement with the simulation results obtained in different conditions. The study conducted here allows for performance optimization (i.e., maximization of a capacity parameter), which could adaptively be performed, depending on the system and traffic load conditions. Future investigations could be focused by considering WiMAX multimode transmissions, cases with more packets serviced per block, and the possible extension of this paper to the CDMA-based BW-REQ schemes adopted by IEEE 802.16-2009 and IEEE 802.16m- 2011, wherein a feedback signal is used to give immediate notice when a BW-REQ is correctly received.

In this paper, we have shown that a new upward cross layer design based error resilient video streaming method, OAER, over mobile WiMAX, works fine to cope with the unreliable subchannels without the cost of modifications of protocols and scheduling functions in access nodes and video clients. This upward cross-layer design over mobile WiMAX is firstly introduced in our knowledge [15] The OAER system performs a localized error resilient coding to the specific MB regions at mobile streaming server according to observed signal strength of first-hop OFDMA subchannels and the MB allocation to subchannels. In this manner, mobile streaming video transferred from mobile server can be more robust and more efficient in video quality than typical error resilience technique. This OFDMA channel aware streaming system can be used in the fields of mobile streaming system such as remote mobile robot system, environment monitoring system, and mobile broadcasting systems.

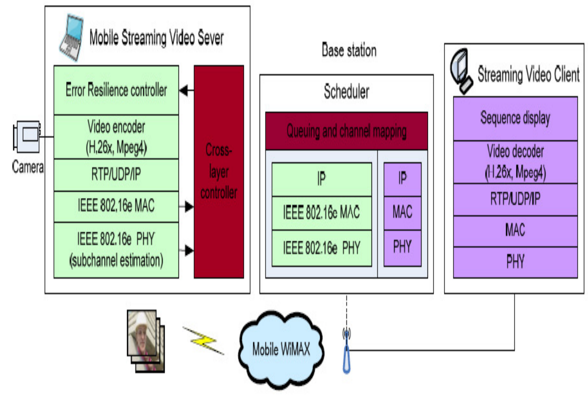

Fig. 3. System blocks of nodes providing services for error resilient streaming video service over mobile WiMAX.

A detailed introduction to the IEEE 802.16 MAC and PHY-layer protocol is presented. The MAC-frame structure is illustrated and the basic control elements are described. The basic PHY-layer chain modules of the IEEE 802.16 transmitter and receiver are outlined as well [16]. Based on the PHY-layer the MAC-layer capacity is calculated. The MAC-layer configuration is analyzed in the context of throughput and overhead. Performance on the MAC-layer of the IEEE 802.16 WMAN standard has been simulated. The point to multipoint mode is well suited for higher number of subscriber stations. MAC PDU length of 1024 bytes, the efficiency of the MAC layer is for 100 subscriber station around 75%. The data MAC PDU length is the parameter that highly influences on the MAC-layer performance. Obviously longer PDUs mean less MAC overhead. Another way of reducing the MAC-overhead is usage of a higher modulation/coding. Especially for the PMP mode, transmitting the broadcast message with higher number of bytes per symbols gives more space to the data MAC PDUs transmission. Introducing some changes to the IEEE 802.16 standard, for example defining more space saving.

Inter-cell interference management in a dense multi cell environment is essential to improve the overall network performance. Controlling the number of transmission streams, i.e. the transmission rank in a distributed manner is a relatively simple, yet effective, interference management technique. Coordination of the transmission rank among interfering cells is therefore necessary, especially considering the IRC receiver that can potentially suppress a number of dominant interfering streams. A practical inter-cell rank coordination mechanism considering the dominant interference ratio is introduced [17] in this paper.

The proposed scheme uses tools from random matrix theory to estimate the post IRC SINR, which is then used to calculate the desired self and interferer rank. A Xn link based protocol is then suggested to coordinate the transmission with the dominant interferer. The proposal further includes a priority information field to incorporate the different 5G service classes, namely eMBB, URLLC and mMTC; and a conflict resolution mechanism to address potentially conflicting Rank requests. Monte-Carlo based performance evaluation demonstrates up to 65% outage TP gain with the proposed coordination scheme over non-coordinated transmission.

IV. CONCLUSION

As we make progress toward the 5G of wireless networks, the bit-per-joule energy efficiency (EE) becomes an important design criterion for sustainable evolution. In this regard, one of the key enablers for 5G is massive multiple-input multiple-output (MIMO) technology, where the BSs are equipped with an excess of antennas to achieve multiple orders of spectral and energy efficiency gains over current LTE networks. Here, we review and present a comprehensive discussion on techniques that further boost the EE gains offered by massive MIMO (MM). We begin with an overview of MM technology and explain how realistic power consumption models should be developed for MM systems. We then review prominent EE-maximization techniques for MM systems and identify a few limitations in the state-of-the-art. Next, we investigate EE-maximization in "hybrid MM systems," where MM operates alongside two other promising 5G technologies: millimeter wave and heterogenous networks. Multiple opportunities open up for achieving larger EE gains than with conventional MM systems because massive MIMO benefits mutually from the co-existence with these 5G technologies. However, such a co-existence also introduces several new design constraints, making EE-maximization non-trivial. A critical analysis of the state-of-the-art EE-maximization techniques for hybrid MM systems allows us to identify several open research problems which, if addressed, will immensely help operators in planning for energy-efficient 5G deployments.

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