A Review on Random Access Protocol for Pilot Provisioning in Crowded LTE Network

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Abstract

The Massive Multiple input multiple output (MIMO) technology has a boundless potential to accomplish the fast-growing data traffic in wireless network. Massive MIMO attains excellent spectral efficiency by spatial multiplexing of many tens of User equipment (UE). These gains are only realized by practicing if several UE’s can connect effectively to the wireless network than today. As the no. of UE’s continuously intensifying, while each & every UE irregularly accesses the network, there by random-access protocol plays vital role in sharing the restricted no. of pilots among the connected UE’s. In this paper, we give review over traditional techniques for pilot allocation in MIMO based network and random access protocol techniques used for pilot allocation in over- crowded Long term evolution (LTE) network.

Keywords: MIMO, Random Access Protocol, Pilot Allocation, LTE, Wireless Network, 4G, Massive MIMO.

INTRODUCTION

Future of mobile network is facing immense numbers of linked user equipment’s or UEs that mutually request for immense data volumes [1]. As the allotted cellular frequency resources are limited, hence, magnifying improvements are required in the spectral efficiency. The Massive MIMO i.e. multiple-input multiple-output network, projected in [2], can fetch such astonishing enhancements [3]. The elementary idea is
to arrange base stations abbreviated as Base station (BS) with hundreds of antennas and use them for multiplexing tens of UE’s with equal time-frequency resource. Crowded MIMO is principally for time division duplex (TDD) systems, where channel mutuality can be subjugated for accessible pilot-based channel assessment. The attainable Uplink (UL) and Downlink (DL) data outputs have been examined broadly in recent years; for example, in [2] – [7]. On contrary, the network access functionality has acknowledged little devotion in crowded MIMO [8], in spite of the circumstance that the enormous numbers of UE’s with intermittent action need scalable and efficient solutions. Random access has a vital role in crowded MIMO network.

In the unique crowded MIMO perception [2], all UE’s inside a cell use devoted orthogonal pilot arrangements, while the essential re-use of pilot’s crossways cells leads to contamination of pilot lying under inter-cell. In future, massive situations, the no. of UE’s exists in a cell is also much higher than the no. of pilot sequences, hence this work was achieved partially in the outline of the DFF133500273 i.e. Danish Council for their Sovereign Research work, ELLIIT, the ICT-671660 i.e. Horizon 2020 project FANTASTIC-5G, CENIIT and the EU FP7 project MAMMOET i.e. ICT- 619086. The authors would like to admit the contributions given by their colleagues in MAMMOET and FANTASTIC-5G. pilots cannot be pre-related with UE’s but need to be resourcefully deallocated and allocated to follow according to their recurrent activity. [8] and [9] papers examine situations where the UE’s transmit data packages arbitrarily designated pilot sequences, with the menace for intra cell pilot contamination/collisions. The paper [15] by E. Bjornson proposed a novel random access protocol which resolves pilot contamination & collisions in crowded MIMO network before the data transmission initiates. A Random-Access Protocol in LTE network is to put our protocol into framework, in this paper firstly protocol used on the Physical Random Access Channel (PRACH) is being reviewed in LTE network which is concise in Fig. 1.

In Step 1, the retrieving UE picks arbitrarily a preamble from a set of pre-defined preambles. This preamble permits the BS to gain synchronization. It does not transfer a specific reserved data or information and hence has a role as a pilot sequence. As multiple UE’s pick preambles in an awkward way, a collision may happen if two or more UE’s choose the same preamble. Though, at this stage the base station only senses if a particular preamble is live or not [10]. In Step 2, the base station transmits a random-access reply to each activated preamble correspondingly, which helps to know various physical parameters likewise timing advance and assign a resource to the UE or UE’s that triggered the preamble. In Step 3, each UE that has acknowledged a reply to its transmitted preamble, sends a Radio Resource Control (RRC) Connection request in order to gain resources for succeeding data transmission. If more than one UE triggered with that preamble, then all UE’s use the same resources to direct their RRC connection invitation in Step 3 and this collision is noticed by the base station. Step 4 is termed by contention resolution and comprises of one or multiple steps that are envisioned to avoid collision.
This is a complex process that can root significant delays. In paper presented by E. Bjornson [15] proposed Strongest user collision resolution (SUCR), which re-defined random access for beyond LTE systems (5G) in other words crowded LTE networks by manipulating the channel hardening parameter according to crowded MIMO channels. The SUCR protocol comprises of four main steps, as demonstrated in Fig. 2. There is also an initial Step 0, in which the base station transmits a synchronization signal broadly from which each UE can assess its average channel gain to the base station. In Step 1, a UE arbitrarily chooses a pilot order from a pre-defined set of pilots. This looks alike the selection of preambles in LTE network, as the collision of two or more UE’s that choses the same pilot sequence that cannot be detected in Step 1. The base station notices which pilot sequences that were used and evaluates the channel that each pilot has broadcasted over. If a collision has happened this turn out to be an evaluation of the super position of the several UE channels. In Step 2, the base station transmits downlink pilot signals that are pre-coded using the channel evaluations. These permits each UE to approximate the summation of gains of respective channels of the UE’s that have chosen the same pilot and equate it with its own channel gain attained in Step 0. Each UE can hence perceive if there’s been a collision in Step 1 in a scattered way. This proceeds from the traditional method in which collisions are perceived in a central way at the base station and aired to the UE’s. Depending upon the detection in Step 2, the UE’s can solve out contentions already in Step 3 by implying the local conclusion rule that only the UE having strongest channel gain is permitted to re-transmit its pilot.

This is a main benefit over physical random access channel (PRACH) in LTE network, where all UE’s re-send their preambles in Step 3. hence forth, in the SUCR procedure the possibility of effective transmission in Step 3 have been increased. Step 3 in our protocol be similar to the Radio resource control (RRC) connection request, the UE notifies about its uniqueness and requests resources to send payload data. Step 4 allowances these resources or initializes a contention resolution, if a collision is noticed in Step 3. The new SUCR protocol implemented on uncorrelated Rayleigh fading channels.

![Figure 1 The PRACH Protocol of the LTE System.](image-url)
LITERATURE REVIEW

In 2011, Jubin Jose et.al. [7] presented pilot contamination and precoding in multi-cell TDD Systems. This paper deliberates a multiple antenna system in a multi-cell with pre-coding used at the base stations for downlink transmission. For pre-coding at the BS, channel state information (CSI) is vital at the BS. A widespread method for evaluating this CSI in TDD systems is uplink exercise by employing the reciprocity of the wireless medium. This paper statistically exemplifies the influence of uplink training on the performance of multiple antenna systems in multi-cell network. When non-orthogonal training arrangements are used for uplink training, the paper demonstrates that the pre-coding matrix used by the BS in one cell turn out to be tainted by the channel between that BS and the users in other cells in an unwanted way. This paper examines this essential problem of pilot corruption in multi-cell systems. Additionally, it progresses a novel multi-cell minimum mean square error (MMSE) based pre-coding method that mitigate this delinquent. Furthermore, to being a linear pre-coding technique, this pre-coding technique has a modest closed form expression that outcome from a spontaneous optimized problem formulation. Mathematical outcomes show substantial performance gains equated with certain popular single cell pre-coding approaches.

In 2014, Emil Bjornson et.al. [12] delivers information about no. of users and pilots should be allocated to achieve maximal spectral efficiency in massive MIMO. Massive MIMO is a capable technique to upsurge the spectral efficiency (SE) of cellular networks, by arranging antenna arrays with hundreds or thousands of active elements at the BS and executing coherent transceiver processing. A public rule of thumb is that these schemes should have a magnitude order of more antennas M than arranged user’s K as the user’s channels are expected to be close orthogonal when M=K > 10. Though, it has not been demonstrated that this rule of thumb really maximizes the SE. This paper examines how the optimum no. of scheduled user’s K be contingent on M and other system parameters. New SE expressions have been
deliberated to empower effective system level examination with power controller random reuse of pilot and arbitrary user sites. The value of K in the large M regime is resultant in closed form, while simulations are used to demonstrate what ensues at finite M, indifferent interference situations, with diverse pilot re-use parameters, and for different processing arrangements. Up to half of the coherence block should be devoted to pilots and the optimum M=K is less than 10 in many cases of realistic significance. Remarkably K be contingent strongly on the processing system and henceforth it is biased to equate different systems using the same K.

In 2016, Elisabeth de Carvalho et.al. [13] presented random access for massive MIMO systems with intra-cell pilot contamination. In massive MIMO network where the base stations having hundreds of antennas is an influencive way to accomplish extraordinary spectral efficiency in future wireless networks. In the traditional massive MIMO setting, the stations are presumed to be fully loaded and a foremost damage to the performance derives from the inter cell pilot corruption i.e. interference from stations of neighbouring cells by using the same pilots as in the home-based cell. Though, when the stations are active occasionally, it is feasible to avoid inter cell corruption by pre-distribution of pilots, while same cell stations use arbitrary access to choose the allocated pilot arrangements. This primes to the problem of intra cell pilot corruption. This paper proposed an outline for random access in crowded MIMO networks and derives novel uplink sum rate terms that take intra cell pilot collisions.

In conclusion of this research work a communication situation with massive MIMO and recurrent terminal activity have been considered. In such a situation, it is impossible to assign orthogonal pilots with in stations and cell to apply arbitrary access to a small mutual pilot set. On the contrary, the pilot sets assigned to the neighbouring sets are orthogonal. This gives arise to process that is freed from the common inter cell pilot corruption and instead leads to intra cell pilot corruption that happens as a consequence of a collision of a random-access protocol. This paper has provided performance expressions as well as optimization gears that are predominantly vital for a system where the activity of the stations and the no. of pilots have to follow certain arithmetical rules.

In 2016, Emil Bjornson et.al. [14] introduced a random-access protocol for pilot allocation in crowded massive MIMO systems. The Massive MIMO technology has a boundless potential to achieve the hasty growth of wireless data traffic. Massive MIMO accomplish marvellous spectral efficiency by spatial multiplexing of tens of user equipment’s. These gains are only accomplished in practice if many more UE’s can connect effectively to the network than today. As the no. of UE’s increases, while each UE irregularly accesses the network, the random-access functionality turn out to be vital to share the inadequate no. of pilots among the UE’s. In this paper, random-access issue in the crowded MIMO setting and progress a redefined protocol termed as strongest user collision resolution abbreviated by SUCR. An retrieving UE asks for a devoted pilot by sending an vulnerable random-access pilot, with a risk that other UE’s may send the same pilot. The satisfactory propagation of Massive MIMO channels is applied to allow distributed collision recognition at each UE, thus defining the strength of the competitor’s signals and determining to recurrence the pilot if the
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UE perceives that its signal is strongest at the receiver. The SUCR protocol determines the massive majority of all pilot collisions in crowded situations and endures to acknowledge UE’s proficiently in overloaded crowded network too.

CONCLUSION

The pilot sequences are precious resources in Massive MIMO since they enable the BS to separate the UEs in the spatial domain. In most practical cases, the number of UEs that resides in a cell is much larger than the number of available pilots, thus the pilots need to be temporally allocated only to the UEs that have data to transmitter receive. The proposed SUCR random access protocol provides an efficient way for UEs to request pilots for data transmission in beyond-LTE Massive MIMO systems. The protocol exploits the favourable propagation properties to enable distributed collision detection and resolution at the UE’s, where the contender with the strongest signals gain is the one being admitted. The numerical results demonstrate that the SUCR protocol can resolve around 90% of all collisions and that it is robust to inter-cell interference and channel distribution. The protocol does not break down in overloaded situations, where more UEs request pilots than there are RA resources, but continues to admit a subset of the accessing UE’s.

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