Pilot Contamination in TDD Massive MIMO: A Survey

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***Abstract*— A Future Generation Wireless Networks Have Rapidly Grown That's Demand More Power Efficiency and Spectral Efficiency. With This Demand In The Current Scenario, Massive MIMO Have Capable Technology. A Massive MIMO Can Support A Large Number Of The Antennas On Each Base Station. But One Major Problem Will Be Introduced When Massive MIMO Consider With TDD Protocol Which Is Called Pilot Contamination. When The Number Of Antennas Is Increased, Interference Will Occur. To Avoid The Interference, Each User Should Be Assigned With An Orthogonal Pilot Sequence. Practically Pilot Sequences Are Limited in Number and Therefore as the Number of Users Increases, It's Not Capable for Each User to Have a Different Pilot Sequence. So, The Same Pilot Sequences Are Reused In Different Cells Which Caused Inter-Cell Interference. This Phenomenon Is known As 'Pilot Contamination". In This Survey We Reviewed Various Mitigation Scheme To Overcome Pilot Contamination. We Compared Their Advantages And Limitations. We cover Major Aspects on PC like Source of PC, Impact of PC, Different Decontamination Methods and Discussed Its Uncluttered Issues..**

***Keywords*— 5G, Massive MIMO, Time Division Duplexing, Pilot Contamination, Soft Pilot Reuse**

I. INTRODUCTION

In Current Network, Various Technologies Were Made To Get Maximum Data Rates To Gain High Spectral Efficiency, More Spectrums. New Technologies like MIMO, Heterogeneous Networks ,And Carrier Aggregation (CA) Are Feature to Meet over Come Demand of Increased Capacity [1]. So Current Network Scenario May Be difficult to Solve of High Data Traffic Demand in Coming Next Era Of 5G.

MIMO (Multiple Input Multiple Output) Allow To Transmit Data Between Base Station And User Terminal. Single User MIMO Was Used In LTE To Get Much Higher Spectral Efficiency In Both Time Division And Frequency Division Multiplexing Mode. Later LTE Advance Introduce Multiuser MIMO Technology With Maximum 8x8 MIMO Which Is Better In Provide More Cell Coverage, Reliability Then Single User MIMO[2]. But With Increasing Demand Of Higher Data Rates, There Are Need More Advance MIMO Version To Improve Spectral Efficiency In Current Emerging Time Technologies Like Machine-To-Machine Communication (M2M), Internet Of Things.

Massive MIMO is Propitious Technology In On-Going and up Coming Generation of Wireless Communication. An Illustration of Massive MIMO Shown In Fig.1, Where BS Connected With More Antennas. A Different Study Are Being been Carried out to Research Challenges and Limitations through When Massive MIMO Are Used with Time Division Duplexing. The Use of Pilot Signal in Assessing Channel State Information (CSI) In TDD Scheme Acquaint with the Problem of Pilot Contamination in a Multi-Cell Massive MIMO. In Multi-Cell Systems, Pilots Have To Be Reused To Some Degree From Cell To Cell, Which Contaminates Channel Estimates In The Home Cell With Channels From Other Cells. This Phenomenon, Called Pilot Contamination. Study From Literature [18]–[21] Has Shown That Pilot Contamination Can Reduce In Massive MIMO System. As A Result, Several Methods Have Been Anticipated To Ease The Effect Of Pilot Impurity In Massive MIMO Systems.

The Rest Of The Paper Is Structured As Follows. In Section 2, Illustration utility Of Massive MIMO. Section 3 Defines TDD Or FDD. In Section 4 Brief Discuss About Pilot Contamination. In Section 5 Show Source Of Pilot Contamination. In Section 6 Mention Impact Of PC In Section 7 Gives A Review Of Proposed Methods For Mitigation Of Pilot Contamination. In Section 8 Discuss Of Open Issue and Section 9 Concludes This Paper.

II. THE UTILITY OF MASSIVE MIMO

Massive MIMO Can Aid In Various Prospects Which Is Given As Follow:

•Spectral Efficiency: The Large Number Of Service Antennas In Massive MIMO Systems And Multiplexing To Many Users To A Single User Provides The Increased Spectral-Efficiency [3].

•When Spatial Multiplexing Used, Capacity of Massive MIMO Increase 10 Times [4].

•Energy Efficiency: The High Antenna Arrays Are Help To Increased Energy Efficiency In Which Radiated Energy Can Be Concentrated On UE [3].

•Multiplexing Gain: Antagonistic Spatial Multiplexing Used In Massive MIMO Makes It Theoretically Possible To Increase The Capacity 10 Times More

•Increased Robustness And Reliability: A Large Number Of Antennas Allows For More Diversity Gains That The Propagation Channel Can Provide. When The Number Of Antennas Increases Without Bound, Data Rate And Reliability Is Increased [5].

•Reduce Cost: Due To The Reduction In Energy Consumption, The Large Array Of Antennas Allows For Use Of Low-Cost RF Amplifiers [5].

However, Some Limitations Have Been Identified Like Hardware Impairment and Pilot Contamination Problem [6]. Although Various Implementation Of Massive MIMO Make Like Pilot Sequence Design, Channel Estimation, Theoretical Limits In Massive MIMO.

III. TDD OR FDD SCHEME

TDD is more efficient than FDD because TDD requires estimation, which can be done in one direction and used in both directions; while FDD requires estimation and feedback for forward and reverse directions, respectively [11]. So we consider TDD Scheme in This paper to examine the sources of pilot contamination.

In a massive MIMO TDD system, the pilot signals which are used to estimate the channels can be contaminated as a result of the reuse of non-orthogonal pilot signals in a multi-cell system [9]. This phenomenon causes the inter-cell interference that is proportional to the number of BS antennas [10], which in turn reduces the achievable rates in the network and affect the spectrum efficiency.

The number of pilot symbols for CSI estimation is considered in [7], the minimum number of UL pilot symbols equal to the number of UTs, while in [8], the optimal number of pilot symbols can be larger than the number of antennas if pilot and data power are required to be equal. In the majority of studies carried out on pilot contamination, it is assumed that the same size of pilot signals is used in all cells.

IV. PILOT CONTAMINATION

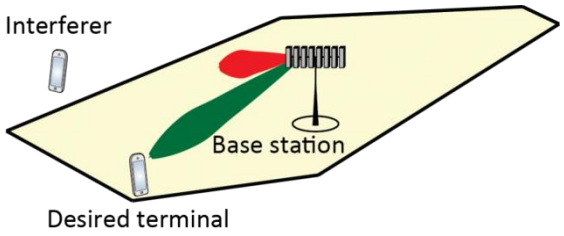

FIG 2. PILOT CONTAMINATION

Fig.2 Shows The Pilot Contamination Problem In Massive MIMO System On Channel Estimation.

In Multi-Cell Systems, Pilots Have To Be Reused To Some Degree From Cell To Cell, Which Contaminates Channel Estimates In The Home Cell With Channels From Other Cells. This Phenomenon, Called Pilot Contamination. It Does Not Remove Even When The Number Of BS Antennas Increases. PC Decreases The Achievable Rates In Massive MIMO System.

In Practical Scenario, Massive MIMO Must Have Accurate CSI At Every BS By Channel Reciprocity Or Feedback Schemes. To Gain The Benefit Of Massive MIMO In Practice, Every BS Needs Perfect Estimation Of The Channel State Information (CSI), Either Through Feedback Or Channel Reciprocity Schemes [3].

1). Source of Pilot Contamination

1) Non-Orthogonal Pilot Schemes: when the same frequency is shared by all cells in a multi-cell system, the intracell interference is considered negligible since the pilots are assumed to be mutually orthogonal. The pilot signals are affected by inter-cell interference When the frequency reuse factor is used, leading to pilot contamination from adjacent cells brought into the system. Each BS correlates its received pilot signals with its own orthogonal pilot signals while all terminals in the other cells contribute to the pilot contamination [12].

2). Hardware Impairment: Various Study has taken on the effect of Hardware Impairment.in [13], they declare that the hardware components in RF are prone to hardware impairments such as quantization error, phase noise, and amplifier non-linearity. Then after study of [14] shows how hardware impairment leads to a mismatch between the generated signal and the intended transmitted signal. It disturbs the correctness of the channel estimation and it causes pilot contamination.

2). Effect of Pilot Contamination

To evaluate the effect of pilot contamination we assume that all transmissions and receivers are coordinate with unchanging array user terminal at the base station [10]. The impact of receiver noise and intracell interference has become extinct when BS

antenna increases without limit and the remaining encounter of the inter-cell interference from transmissions which are accompanying with reuse of the similar pilot sequence [12].

In [3], it was shown that system performance is ominously tainted by pilot contamination when the inter-cell interference factor increases. As pilot contamination surges with the upturn of interference factor and considering the similar typical transferred power from the UTs, there is a significant reduction in the spectral efficiency and energy efficiency.

V. LITERATURE SURVEY ON MITIGATION SCHEMES OF PILOT CONTAMINATION

(A) Soft Pilot Reuse

This technique increases the quality of service (QoS) in massive MIMO systems due to pilot contamination. To enhance the quality of service (QoS) they proposed combination method of soft pilot reusing and Multi-Cell Block Diagonalization Precoding .to mitigate pilot contamination of LS-MIMO systems, a cell-edge pilot set is functional for the cell-edge users in nearby cells, while cell-center users reuse the same center pilot set in all cells.in addition by extending block diagonalization (BD) precoding to a multi-cell situation is considered for mitigate the ICI and for improving QoS for edge user. This performance of combining of SPR and MBD schemes can enhance both achievable UL and DL rate of edge users [15].

(B). Smart Pilot Assignment

It defines the problem of pilot contamination due to inter-cell interface .they take the problem to the targeted cell which is surrounded by other adjacent cells .this scheme aims to maximize minimum uplink SINR of all users in the target cell. First BS evaluate the inter-cell interference of every pilot order caused by the users with the similar pilot sequence in other end-to-end cells by exploiting the large-scale features of fading channels. Later, the channel potentials from different users in the target cell to the BS can be identified, which normally dissimilar from one user to another. This Scheme allocates the pilot sequence with the minimum inter-cell interference to the user having the poorest channel quality in a consecutive way until all users have been allocated by their equivalent pilot sequences [16]

(C). Weighted Graph Coloring

In [17], they enlighten the problem of pilot contamination because of unavailable reuse of pilots in nearby cells so they suggested weighted graph coloring based pilot decontamination scheme to diminish pilot contamination. Firstly the pilot assignment issue is formulated as a combinational optimization problem to maximize users coverage uplink achievable rate then based on limited co-operation amongst cells edge weighted interference graph (EWIG) is built to illustrate potential pc amongst users, whereby each weighted edge shows pc strength introduced between connected users when they are assigned with the same pilot. They denote each color as a pilot and each vertex as a user in EWIG, The purposed WGC-PD scheme greedily assigns different pilots to connected users with a large weight with the insufficient pilot resource. This scheme is able to mitigate pilot contamination with significantly reduced complicity under a constraint of the insufficient pilot resource.

(D). Precoding Schemes:

In [18], a precoding matrix at one BS is designed to overcome square error of its own users it also interference to the users of other cells. This is providing a better result than single cell ZF precoding.

In [19] and [20] mention this scheme on multi-cell cooperation to overcome pilot contamination. But information exchange requires the number of an antenna at BS so this scheme only feasible with a small network of MIMO.

(E). Angle of Arrival

As presented in [21], under realistic channel models, some users with orthogonal or non-orthogonal pilot sequences may have no intervention with each other. In [21], it is given away that users with conjointly non-overlapping AOA barely pollute each other even if they use the similar pilot sequence. This scheme accomplishes a major reduction in inter-cell interference and an analogous increase in uplink and downlink SINRs.

VI. ISSUES

There is much work still going on 5G with use of FDD or TDD but as we know TDD is more favorable because of operating on same carrier frequency [22]. Most obstacles they need to look at it is summarised below:

1). Achievable rate: Achievable rates are defined by use of SINR, also, compare the rate with establishing the rate and derived rates for practical models.

2). TDD mode is more promising but [23], the communication channel choosing factors like physical channel, antennas, mixers, filters, which is not suitable for all devices.

3). Estimation of proposed Schemes:

This is based on cost and complexity must be considered to pilot decontamination. Some scheme looks good based on theoretical but they have to consider between model accuracy and complexity.

VII. CONCLUSION

In this paper, a Survey of Pilot Contamination in TDD massive MIMO is taken. We explain the potential of Massive MIMO and also explain the suitable mode for massive MIMO which is TDD. We have to Explore about pilot contamination in TDD massive MIMO and its source & impacts. Numbers of Schemes are surveyed to mitigate pilot contamination by various authors by published work. in All This Scheme Assume That Users Suffer From the Same PC But In Reality, PC Varies With Among Users Except soft pilot reuse so it is more suitable than other schemes. We have also discussed on issues pilot contamination in TDD massive MIMO.

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