MIMO FOR Cutting Edge Remote for Massive Frameworks

[1]Deepa B, [2] Sunil S G, [3]Naeem N

Guest Faculties
Computer Science Department
Amuv Torvi

Abstract— **Multi-client Multiple-Input Multiple-Output (MIMO) offers huge favorable circumstances over conventional point-to-point MIMO: it works with shoddy single-radio wire terminals, a rich scrambling condition isn't required, and asset portion is improved on the grounds that each dynamic terminal uses the majority of the time-recurrence containers. Be that as it may, multi-client MIMO, as initially imagined with generally parallel quantities of administration reception apparatuses and terminals and recurrence division duplex activity, isn't a versatile innovation.**
Monstrous MIMO (otherwise called "Vast Scale Antenna Systems", "Extensive M IMO", "Hyper MIMO", "Full-Dimension MIMO" and "ARGOS") makes a clean break with mutt lease hone using an expansive abundance of administration receiving wires over dynamic terminals and time division duplex task. Additional receiving wires help by centering vitality into ever-littler areas of room to get enormous changes throughput and emanated vitality productivity. Different advantages of huge MIMO incorporate the broad utilization of in costly low-control components, diminished inactivity, rearrangements of the media access s control (MAC) layer, and robustness to purposeful sticking. The expected throughput rely upon the spread condition giving asymptotically orthogonal channels to the terminals, yet so far experiments have not uncovered any confinements in such manner. While huge MIMO renders numerous customary research issues unimportant, it reveals altogether new issues that ur-delicately require consideration: the test of influencing some minimal effort to low accuracy parts that work viably together, securing and synchronization for recently joined terminals, the abuse of additional degrees of opportunity gave by the abundance of administration receiving wires, lessening inside power utilization to accomplish add up to vitality proficiency diminishments, and finding new sending situations. This paper shows an overview of the enormous MIMO idea and of contemporary research on the point

I. INTRODUCTION

1 Background: Multi-Client MIMO Developing
MIMO, Various Info Numerous Yield, innovation depends on different receiving wires to simultaneously transmit numerous surges of information in remote correspondence frameworks. At the point when MIMO is utilized to speak with a few terminals in the meantime, we talk about multiuser MIMO. Here, we simply say MU-MIMO for short.

2 MU-MIMO in cell frameworks expedites upgrades four fronts:

•Increased information rate, in light of the fact that the more receiving wires, the more free information streams can be conveyed and the more terminals can be served all the while;

•Enhanced dependability, in light of the fact that the more reception apparatuses the more unmistakable ways that the radio flag can spread over;

•Improved vitality productivity , on the grounds that the base station can center its radiated vitality into the spatial bearings where it realizes that the terminals are found; and

•Reduced impedance on the grounds that the base station can intentionally abstain from transmitting into directions where spreading obstruction would be hurtful.

All enhancements can't be accomplished all the while, and there are necessities on the propagation conditions, yet the four above shots are the general advantages. MU-MIMO innovation for remote correspondences in its customary frame is developing, and fused into re-penny and advancing remote broadband measures like 4G LTE and LTE-Progressed (LTE-A). The more reception apparatuses the base station (or terminals) are outfitted with, the better execution in all the over four regards—in any event for task in time division duplexing (TDD) mode. How-ever, the quantity of radio wires utilized today is unassuming. The most present day standard, LTE-Progressed, takes into consideration up to 8 radio wire ports at the base station and hardware being constructed today has many less reception apparatuses than that.

2 Going Substantial: Enormous MIMO

Gigantic MIMO is a rising innovation, that scales up MIMO by conceivably requests of magnitude contrasted with current best in class. In this paper, we follow up on our prior exposition [1], with an attention on the advancements over the most recent three years: most especially, vitality effectiveness, misuse of abundance degrees of flexibility, TDD calibration, systems to battle pilot defilement, and completely new channel estimations.

With huge MIMO, we consider frameworks that utilization receiving wire clusters with a couple of hundred reception apparatuses, all the while serving a large number of terminals in a similar time-recurrence asset. The fundamental start behind gigantic MIMO is to receive every one of the rewards of conventional MIMO, yet on a significantly more noteworthy scale. By and large, gigantic MIMO is an empowering agent for the advancement of future broadband (settled and portable) systems which will be vitality productive, secure, and vigorous, and will utilize the range effectively. In that capacity, it is an empowering agent for the future computerized society foundation that will interface the Web of individuals, Web of things, with mists and other system framework. A wide range of setups and arrangement situations for the real reception apparatus exhibits utilized by

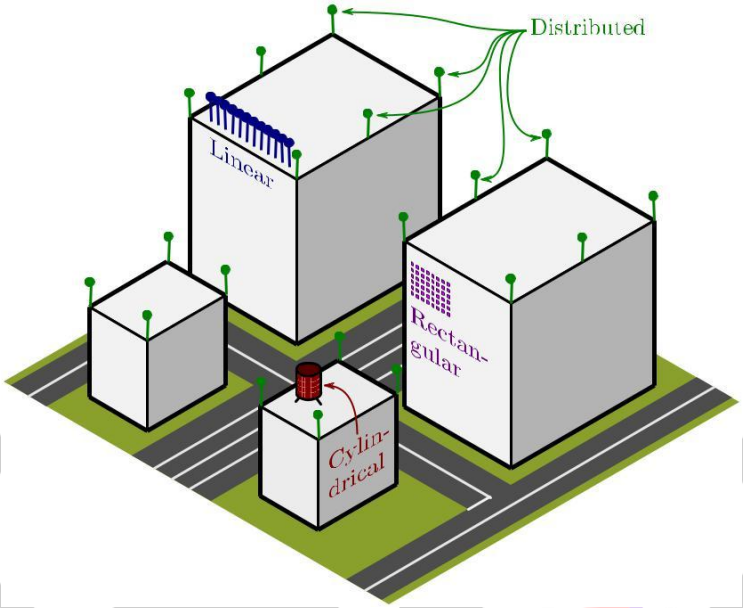

Figure 1: Some conceivable radio wire setups and arrangement scenar ios for a monstrous MIMO base station.

A gigantic MIMO framework can be imagined, see Fig. 1. Every reception apparatus unit would be little, and dynamic, ideally encouraged by means of an optical or electric computerized transport.

Enormous MIMO depends on spatial multiplexing that thus depends on the base station having adequate channel information, both on the uplink and the downlink. On the uplink, this is anything but difficult to achieve by having the terminals send pilots, in view of which the base station evaluates the channel reactions to every one of the terminals. The downlink is more troublesome. In regular MIMO frameworks, similar to the LTE standard, the base station conveys pilot waveforms in light of which the terminals assess the channel reactions, quantize the so-acquired gauges and sustain them back to the base station. This won't be practical in monstrous MIMO frameworks, at any rate not while working in a high-portability condition, for two reasons. To start with, ideal downlink pilots ought to be commonly orthogonal between the recieving wires. This implies the measure of time-recurrence assets required for downlink pilots scales as the quantity of radio wires, so a huge MIMO framework would require up to a hundred times more such assets than an ordinary framework. Second, the quantity of channel reactions that every terminal must gauge is likewise corresponding to the quantity of base station reception apparatuses. Subsequently, the uplink assets expected to illuminate the base station about the channel reactions would be up to a hundred times bigger than in customary frameworks. By and large, the arrangement is to work in TDD mode, and depend on correspondence between the uplink and downlink channels—al however FDD task might be conceivable in specific cases [2]. While the ideas of huge MIMO have been generally hypothetical up until now, and specifically invigorated much research in irregular lattice hypothesis and related arithmetic, essential testbeds are getting to be accessible [3] and beginning channel estimations have been performed [4, 5].

3 The Capability of Enormous MIMO

Enormous MIMO innovation depends on stage intelligible however computationally exceptionally basic process-ing of signs from every one of the receiving wires at the base station. Some particular advantages of a monstrous MU-MIMO framework are:

•Massive MIMO can build the limit 10 times or increasingly and at the same time, enhance the transmitted vitality effectiveness in the request of 100 times.

The limit increment comes about because of the forceful spatial multiplexing utilized as a part of enormous MIMO. The essential rule that makes the sensational increment in vitality proficiency conceivable is that with vast number of receiving wires, vitality can be engaged with outrageous sharpness into little areas in space, see Fig. 2. The fundamental material science is reasonable superposition of wave fronts. By suitably forming the signs conveyed by the reception apparatuses, the base station can ensure that all wave fronts all in all transmitted by all radio wires include usefully at the areas of the planned terminals, yet dangerously (arbitrarily) wherever else. Impedance between terminals can be stifled considerably facilitate by utilizing, e.g., zero-compelling (ZF). This, nonetheless, may come at the cost of more transmitted power, as showed in Fig. 2.

All the more quantitatively, Fig. 3 (from [6]) portrays the major tradeoff between the vitality proficiency as far as the aggregate number of bits (entirety rate) transmitted per Joule per terminal getting administration of vitality spent, and ghostly productivity as far as aggregate number of bits (whole rate) transmitted per unit of radio range devoured. The figure outlines the connection for the uplink, from the terminals to the base station (the downlink execution is comparable). The figure demonstrates the tradeoff for three cases:

– A reference framework with one single reception apparatus serving a solitary terminal (purple),

– A framework with 100 reception apparatuses serving a solitary terminal utilizing regular beamforming (green)

– A monstrous MIMO framework with 100 reception apparatuses at the same time serving various (around 40 here) terminals (red, utilizing most extreme proportion joining; and blue, utilizing zero-compelling).

The engaging quality of greatest proportion consolidating (MRC) contrasted and ZF isn't just its computational straightforwardness—augmentation of the got motions by the conjugate channel reactions, yet in addition that it can be performed in an appropriated design, freely at each radio wire unit. While ZF likewise works genuinely well for a regular or respectably measured MIMO framework, MRC for the most part does not. The purpose behind why MRC works so well for enormous MIMO is that the channel reactions related with various terminals have a tendency to be about orthogonal when the quantity of base station reception apparatuses is vast—see Segment 4.3.

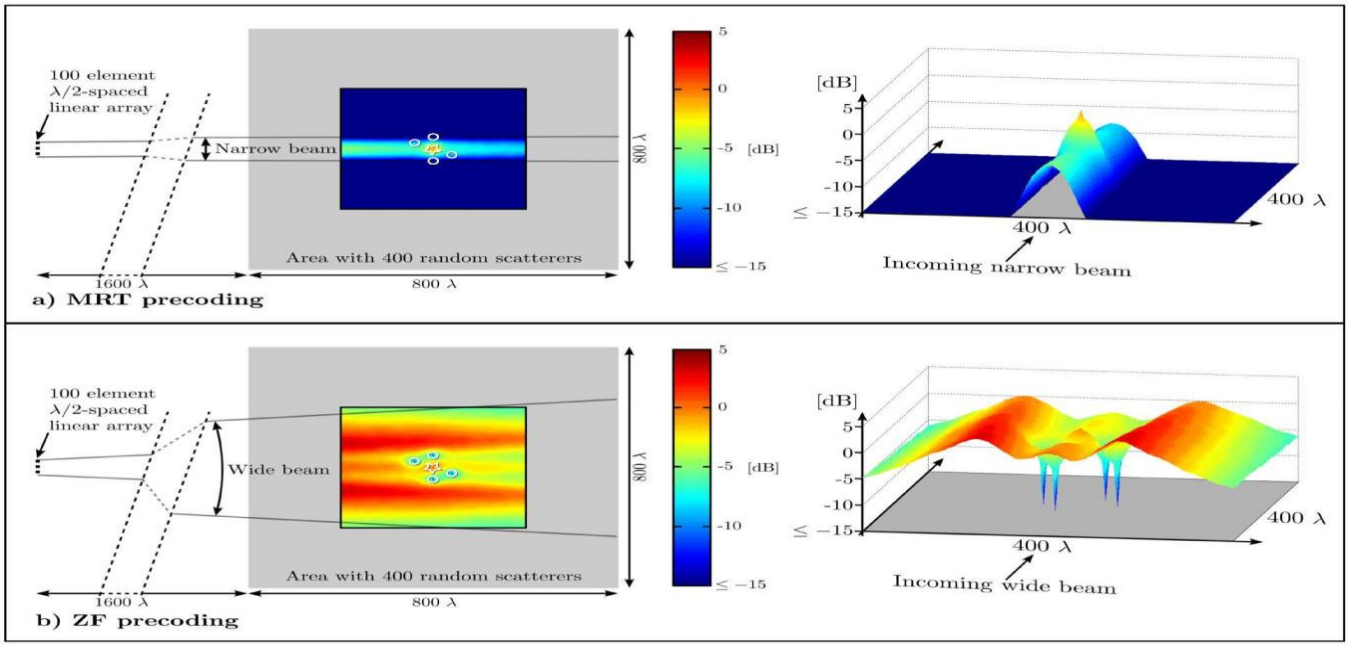

Figure 2: Relative field quality around an objective terminal in a scramble ing condition of size 800λ×800λ, when the base station is put 1600λ to one side. Normal field qualities are ascertained more than 1000 0 irregular situations of 400 scatterers, when two diverse direct precoders are utilized: a) MRT precoders and b) ZF precoders. Left: pseudo-shading plots of normal field qualities, with target u ser positions at the inside (⋆), and four different clients close-by (◦). Right: normal field qualities as surface plots, permitting a substitute perspective of the spatial centering.

The expectation in Fig. 3 depends on a data theoretic examination that takes into air conditioning tally intracell obstruction, and additionally the transfer speed and vitality cost of utilizing pilots to get divert state data in a high-versatility condition [6]. With the MRC re-ceiver, we work in the about commotion constrained administration of data hypothesis. This implies furnishing every terminal with a rate of around 1 bit for each intricate measurement (1 bps/Hz). In a huge MIMO framework, when utilizing MRC and while working in the "green" administration,

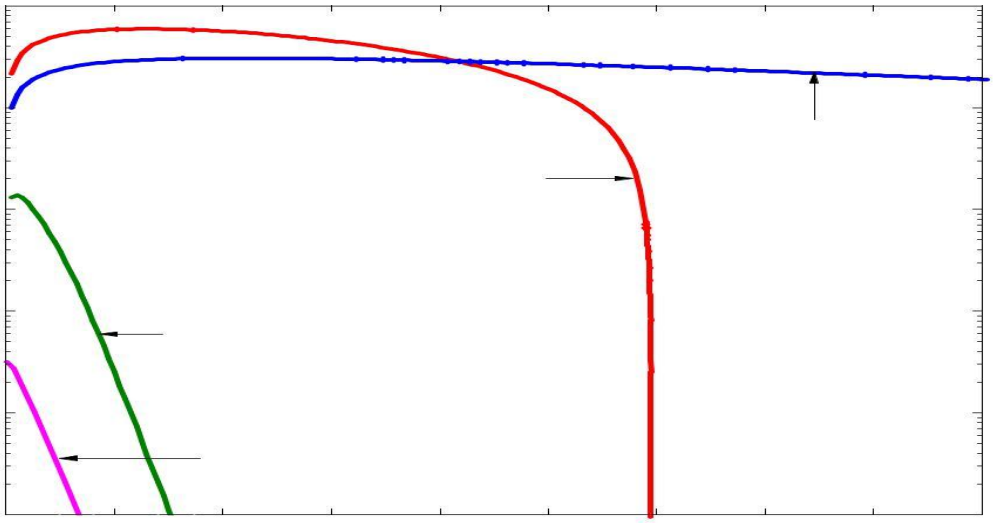

Figure 3: A large portion of the power—double the power (from [6]): Enhancing uplink unearthly productivity 10 times and at the same time expanding the emanated control proficiency 1 00 times with enormous MIMO innovation, using greatly straightforward flag handling—taking into account the vitality and transfer speed expenses of getting channel state data.

That is, downsizing the power however much as could reasonably be expected without genuinely influencing the general phantom productivity, multiuser obstruction and impacts from equipment defects have a tendency to be overpowered by the warm commotion. The reason that the general ghastly proficiency still can be 10 times higher than in regular MIMO is that a huge number of terminals are served at the same time, in a similar time-recurrence asset. While working in the 1 bit/measurement/terminal administration, there is likewise some proof that intersymbol impedance can be dealt with as extra warm commotion [7], consequently offering a method for arranging with OFDM as a methods for combating intersymbol obstruction.

To comprehend the size of the limit picks up that huge MIMO offers, consider an ar-beam comprising of 6400 omnidirectional radio wires (add up to frame factor 6400 × (λ/2)2 ≈ 40 m2), transmitting with an aggregate energy of 120 Watts (that is, every receiving wire emanating around 20 mW) over a 20 MHz transfer speed in the PCS band (1900 MHz). The cluster serves one thousand (1000) settled terminals haphazardly circulated in a disk of sweep 6 km focused on the exhibit, every terminal having a 8 dB pick up radio wire. The stature of the reception apparatus cluster is 30 m, and the tallness of the terminals is 5 m. Utilizing the Hata-COST231 show we find that the way misfortune is 127 dB at 1 km extend and the range-rot type is 3.52. There is likewise log-ordinary shadow blurring with 8 dB standard deviation. The beneficiaries have a 9 dB clamor figure. One-fourth of the time is spent on transmission of up interface pilots for TDD channel estimation, and it is accepted that the channel is generously consistent over interims of 164 ms keeping in mind the end goal to gauge the channel picks up with adequate accuracy. Downlink information is transmitted by means of most extreme proportion transmission (MRT) beam forming joined with control, where the 5% of the terminals having the most exceedingly awful channels are rejected from ser-bad habit. We utilize a limit bring down bound from [8] that is stretched out to suit moderate blurring, close/far impacts and power control and which represents collector commotion, channel estimation mistakes, the overhead of pilot transmission, and the blemishes of MRT beam forming. We utilize ideal max-min control which gives an equivalent flag to-impedance and-clamor proportion on every one of the 950 terminals and consequently measure up to throughput. Numerical averaging over irregular terminal areas and over the shadow blurring demonstrates that 95% of the terminals will get a throughput of 21.2 Mb/s/terminal. In general, the cluster in this illustration will offer the 1000 terminals an aggregate downlink throughput of 20 Gb/s, bringing about a whole otherworldly productivity of 1000 bits/s/Hz. This would be sufficient, for instance, to give 20 Mbit/s broadband support of every one of a thousand homes. The maximum min control gives break even with benefit at the same time to 950 terminals. Different kinds of energy control joined with time-division multiplexing could oblige heterogeneous activity requests of a bigger arrangement of terminals.

The MRC recipient (for the uplink) and its partner MRT precoding (for the downlink) are otherwise called coordinated sifting (MF) in the writing.

• Massive MIMO can be worked with economical, low-control parts.
Monstrous MIMO is a diversion changing innovation both with respect to hypothesis, frameworks and execution. With huge MIMO, costly, ultra-straight 50 Watt speakers utilized as a part of traditional frameworks are supplanted by many minimal effort enhancers with yield control in the milli-Watt run. The differentiation to traditional cluster outlines, which utilize couple of radio wires encouraged from high-control speakers, is critical. A few expe nsive and cumbersome things, for example, substantial coaxial links, can be disposed of through and through. (The average coaxial links utilized for tower-mounted base stations today are in excess of four centimeters in width!)

Monstrous MIMO lessens the limitations on precision and linearity of every individual amplifier and RF chain. All what makes a difference is their consolidated action. As it were, enormous MIMO depends on the law of extensive numbers to ensure that clamor, blurring and equipment imperfections normal out when signals from countless are consolidated noticeable all around together. A similar property that makes huge MIMO flexible against blurring likewise makes the innovation to a great degree vigorous to disappointment of one or a couple of the receiving wire units.

A huge MIMO framework has a huge excess of degrees of flexibility. For instance, with 200 reception apparatuses serving 20 terminals, 180 degrees of flexibility are unused. These degrees of opportunity can be utilized for equipment inviting sign forming. Specifically, every reception apparatus can transmit signals with little crest to-normal proportion [9] or even consistent envelope [10] at an exceptionally humble punishment as far as expanded aggregate transmitted power. Such (close consistent)

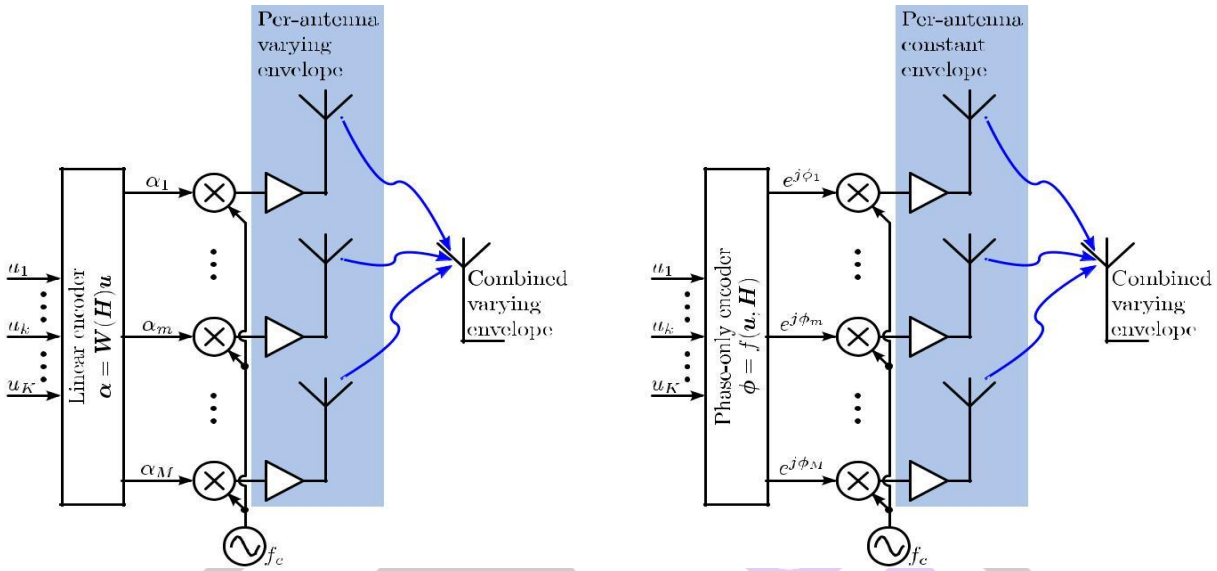

Figure 4: Customary MIMO beam forming, stood out from per-reception apparatus steady envelope transmission in huge MIMO. Left: ordinary beam forming, where the flag produced by every receiving wire has a huge dynamic range. Right: per-receiving wire consistent envelope transmission, where every radio wire conveys a flag with steady envelope.

envelope flagging encourages the utilization of to a great degree shoddy and power-productive RF amplifiers. The systems in [9,10] must not be mistaken for convemotional beam forming techniques or equivalent size weight beam forming methods. This qualification is clarified in Fig. 4. With (close) consistent envelope multiuser preceding, no pillars are shaped, and the signs radiated by every radio wire are not framed by weighing of an image. Or maybe, a wave field is made, with the end goal that when this wave field is test d at the spots where the terminals

4 Limiting Components of Enormous MIMO

4.1Channel Correspondence

TDD activity depends on channel correspondence. There seems, by all accounts, to be a sensible agreement that the proliferation channel itself is basically complementary, unless the engendering is influenced by mama terials with peculiar attractive properties. Be that as it may, the equipment chains in the base station and terminal handsets may not be proportional between the uplink and the downlink. Adjustment of the equipment ties does not appear to constitute a difficult issue and there are alignment based arrangements that have just been tried to some degree practically speaking [3, 12]. In particular, [3] treats correspondence adjustment for a 64-reception apparatus framework in some detail and claims an effective test execution.

Note that alignment of the terminal uplink and downlink chains isn't required so as to get the full beam forming additions of gigantic MIMO: if the base station hardware is legitimately adjusted then the exhibit will undoubtedly transmit a sound bar to the terminal. (There will in any case be some confuse inside the beneficiary chain of the terminal however this can be taken care of by transmitting pilots through the shaft to the terminal; the overhead for these supplementary pilots is little.) Total adjustment inside the cluster isn't required. Rather, as proposed in [3], one of the radio wires can be dealt with as a source of perspective and signs can be exchanged between the reference reception apparatus and every one of alternate receiving wires to infer a remuneration factor for that reception apparatus. It might be conceivable completely to do without correspondence adjustment inside the exhibit; for instance if the most extreme stage distinction between the up-interface anchor and the connection chain were under 60 degrees then rational bar framing would in any case happen (at any rate with MRT beam forming) though with a conceivable 3 dB lessening in pick up.

4.2 Pilot Defilement

In a perfect world each terminal in an Enormous MIMO framework is appointed an orthogonal uplink pilot sequence. However the most extreme number of orthogonal pilot arrangements that can exist is upper-limited by the length of the intelligence interim isolated by the channel delay-spread. In [13], for an average working situation, the greatest number of orthogonal pilot arrangements in a one millisecond intelligibility interim is assessed to be around 200. It is anything but difficult to debilitate the accessible supply of orthogonal pilot groupings in a multi-cell framework.

The impact of re-utilizing pilots starting with one cell then onto the next, and the related negative results, is named "pilot sullying". All the more particularly, when the benefit cluster corresponds its received pilot motion with the pilot grouping related with a specific terminal it really obtains a channel assess that is sullied by a straight blend of channels to alternate terminals that offer a similar pilot succession. Downlink beam forming in view of the contaminated divert assess brings about impedance that is coordinated to those terminals that offer a similar pilot arrangement. Comparative impedance is related with uplink transmissions of information. This coordinated impedance develops with the quantity of administration reception apparatuses at an indistinguishable rate from the coveted flag [13]. Indeed, even halfway associated pilot groupings result in coordinated obstruction.

Pilot defilement as a fundamental marvel isn't generally particular to enormous MIMO, however its impact on gigantic MIMO seems, by all accounts, to be substantially more significant than in traditional MIMO [13, 14]. In [13] it was contended that pilot sullying constitutes an extreme cutoff on execution, when the quantity of reception apparatuses is expanded without bound, in any event with collectors that depend on pilot-based channel estimation. While this contention has been challenged as of late [15], at any rate under some particular presumptions on the power control utilized, it shows up likely that pilot defilement must be managed somehow. This should be possible in a few ways:

•The designation of pilot waveforms can be upgraded. One probability is to utilize a less forceful recurrence re-utilize factor for the pilots (yet not really for the payload information)— say 3 or 7. This pushes commonly sullying cells more remote separated. It is additionally possible to organize the utilization of pilots or adaptively apportion pilot successions to the diverse terminals in the system [16]. Presently, the ideal technique is obscure.

•Clever channel estimation calculations [15], or even visually impaired systems that go around the utilization of pilots by and large [17], may relieve or dispense with the impacts of pilot contamination. The most encouraging course is by all accounts dazzle procedures that together gauge the channels and the payload information.

•New precoding strategies that consider the system structure, for example, pilot Pollution precoding [18], can use helpful transmission over an assortment of cells outside of the beam forming task to invalidate, in any event halfway, the coordinated impedance that outcomes from pilot sullying. Dissimilar to facilitated beam forming over numerous cells which requires evaluations of the genuine channels between the terminals and the administration varieties of the debasing cells, pilot tainting precoding requires just the relating moderate blurring coefficients. Down to earth pilot-defilement precoding re-mains to be created.

4.3Radio Engendering and Orthogonality of Channel Reactions

Enormous MIMO (and particularly MRC/MRT preparing) depends to an expansive degree on a property of the radio condition called great engendering. Basically expressed, positive proliferation implies that the spread channel reactions from the base station to various terminals are adequately extraordinary. To consider the conduct of enormous MIM O frameworks, channel estimations must be performed utilizing reasonable reception apparatus exhibits. This is so in light of the fact that the channel conducts utilizing extensive clusters contrasts from that normally experienced utilizing regular littler exhibits.

Figure 5: Enormous MIMO receiving wire exhibits utilized for the estimations.

Most essential contrasts are that (I) there may be huge scale blurring over the exhibit and (ii) the little scale flag insights may likewise change over the cluster. Obviously, this is additionally valid for physically littler exhibits with directional receiving wire components pointing in different ways.

Fig. 5 indicates photos of the two enormous MIMO exhibits utilized for the estimations revealed in this paper. To one side is a smaller round monstrous MIMO exhibit with 128 receiving wire ports. This cluster comprises of 16 double spellbound fix radio wire components organized around, with 4 such circles stacked over each other. Other than having the benefit of being minimized, this exhibit additionally gives the likelihood to determine scatterers at various rises, however it experiences more terrible determination in azimuth because of its constrained gap. To the privilege is a physically extensive direct (virtual) exhibit, where a solitary omnidirectional reception apparatus component is moved to 128 unique positions in a generally static condition to imitate a genuine cluster with similar measurements.

One method for evaluating how unique the channel reactions to various terminals are, is to take a gander at the spread between the littlest and biggest solitary estimations of the network that contains the channel reactions.

Fig. 6 represents this for a case with 4 client terminals and a base station having 4, 32 and 128 receiving wire ports, individually, configured either as a physically substantial single-captivated straight exhibit or a smaller double spellbound roundabout cluster. All the more particularly, the figure demonstrates the combined thickness work (CDF) of the difference between the littlest and the biggest solitary incentive for the distinctive estimated (narrowband) recurrence focuses in the different cases. As a source of perspective we likewise demonstrate reproduced comes about for perfect free, indistinguishably appropriated (i.e.) channel lattices, frequently utilized as a part of hypothetical examinations. The estimations were performed outside at the Lund College grounds zone. The middle recurrence was 2.6 GHz a the estimation transfer speed 50 MHz. When utilizing the barrel shaped exhibit, the RUSK Lund channel sounder was utilized, while a system analyzer was utilized for the manufactured straight cluster estimations. The principal comes about because of the battle were presented in [4].

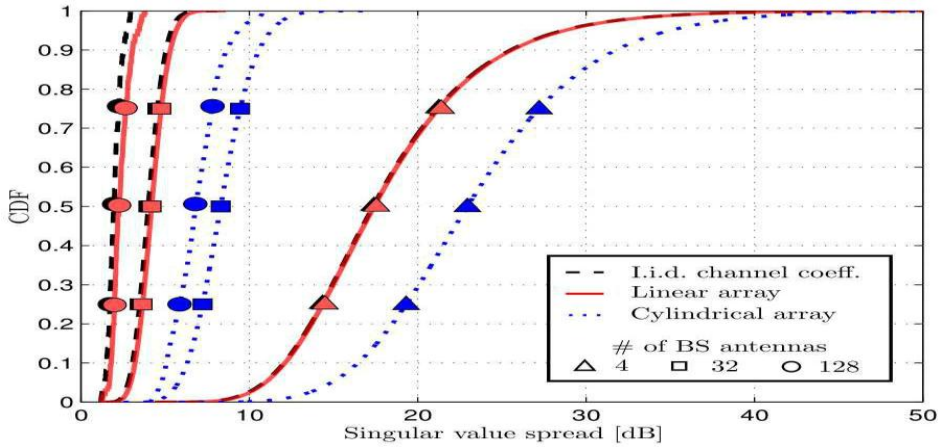

Figure 6: CDF of the solitary esteem spread for MIMO frameworks with 4 terminals and three unique

Quantities of BS radio wires: 4, 32, and 128. The hypothetical i.e. channel is appeared as a source of perspective, while the other two cases are estimated channels with straight and barrel shaped cluster structures at the BS. Note: The bend for the straight exhibit harmonizes with that of the i.e. channel for 4 BS. Separately. This number is a measure of the blurring edge, the extra power that must be utilized as a part of request to serve all clients with a sensible got flag control. With the huge straight cluster, the spread is under 3 dB. Likewise, take note of that none of the bends has any significant tail. This implies the likelihood of seeing a particular esteem spread bigger than 3 dB, anyplace finished the deliberate data transfer capacity, is basically irrelevant.

To additionally represent the impact of various number of a tenna components at the base station and the receiving wire setup, we plot in Fig. 7 the aggregate rate f or 4 firmly divided clients (under 2 meters between every client at a separation of around 40 m from the base station) in a non viewable pathway (NLOS) situation when utilizing MRT as pre-coding. The transmit control is standardized so that on the normal, the obstruction free flag to-commotion proportion at the terminals is 10 dB.

As can be found in Fig. 7, the total rate approaches that of the hypothetical impedance free case as the quantity of reception apparatuses at the base station increments. The shaded territories in red (for the direct exhibit) and blue (for the roundabout cluster) demonstrate the 90 percent certainty levels of the total rates for the diverse narrowband recurrence acknowledge. As previously

CONCLUSIONS

In this paper we have featured the vast capability of monstrous MIMO frameworks as a key enabling innovation for future past 4G cell frameworks. The innovation offers colossal advantages as far as vitality productivity, phantom effectiveness, burglarize ustness and dependability. It takes into consideration the utilization of minimal effort equipment both at the base station and additionally at the portable unit side. At the base station the utilization of costly and effective, yet control wasteful, equipment is supplanted by enormous utilization of parallel minimal effort, low-control units that work reasonably together. There are still difficulties ahead to understand the maximum capacity of the innovation, e.g., with regards to computational multifaceted nature, acknowledgment of

disseminated handling calculations, and synchronization of the reception apparatus units. This gives scientists both in the scholarly world and industry a goldmine of completely new research issues to handle.

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