

Survey Paper on Massive MIMO System based on Beamforming Technology for mmWave Communication

Bhawana Pal¹ and Prof. Uday Panwar²

¹M. Tech. Scholar, Department of Electronics & Communication Engineering, S.I.R.T., Bhopal, India

²Professor, Department of Electronics & Communication Engineering, S.I.R.T., Bhopal, India

Abstract—Multipath propagation, mobility of transmitter, receiver and local scattering cause the signal to spread in frequency, time and angle, resulting in ISI in the received signal. Possible potential gain in spectral efficiency is challenged by the receiver's ability to accurately detect the symbol in the presence of ISI. Even though OFDM mitigates the problem of time dispersion, still it is necessary to effectively remove the amplitude/phase shift caused by channel and to solve this problem, channel estimation based equalization in the receiver, beam forming (BF) in the transmitter and relay in channel can be invoked. Among the various equalization methods for OFDM and Massive MIMO, minimum mean square error (MMSE) is considered to be a good solution for data recovery in spite of its complexity. MMSE can effectively utilize the diversity of the frequency selective channel and reduce the ISI.

The MMSE equalization alone is not an efficient way of reduction of ISI, as the equalization is not carried out with the knowledge of channel impairments. To strengthen the effect of equalization for reducing ISI, channel estimation is used to estimate the amplitude/phase shift caused by the wireless channel impairments

Index Terms— Massive MIMO, MMSE, Beam Forming, ISI.

I. INTRODUCTION

The interest for remote throughput has developed exponentially in the previous hardly any years, with the expansion in various remote gadgets and number of new versatile clients. The throughput is the result of Bandwidth (Hz) and Spectral productivity (bits/s/Hz) [1]. To expand the throughput, either Bandwidth or Spectral productivity must be expanded. Since expanding the Bandwidth is an expensive factor, the ghastly productivity must be mulled over. It very well may be expanded by utilizing numerous radio wires at the transmitter and recipient. Numerous Input Multiple Output (MIMO) reception apparatuses improve both correspondence unwavering quality just as the limit of correspondence (by transmitting various information in various receiving wires). For the most part MIMO frameworks are separated into two classes: Point-to-Point MIMO and Multi User - MIMO (MU- MIMO) [2], [3]. In Point-to-Point MIMO, both the transmitter and collector are furnished with numerous radio wires. The presentation increase can be accomplished by utilizing the systems, for example, beamforming and spatial multiplexing of a few information streams. Then again, in MU-MIMO, the remote channel is spatially shared among the clients. The clients in the cell transmit and get information without joint encoding and joint discovery among them. The Base Station (BS) discusses all the

while with every one of the clients, by misusing the distinction in spatial marks at the BS radio wire exhibit. MIMO frameworks are consolidated in a few new age remote gauges like LTE - Advanced, Wireless LAN and so forth. The principle challenge in MU-MIMO framework is the obstruction between the co-channel clients. Subsequently, complex recipient strategy must be utilized, to diminish the co-channel impedance. In [4], it is demonstrated that by utilizing an unending number of reception apparatuses at the BS in examination with the quantity of clients in the phone, the irregular channel vectors among clients and the BS become pair-wise symmetrical. By presenting more reception apparatuses at the BS, the impacts of uncorrelated commotion and intra cell obstruction vanish and little scale blurring is arrived at the midpoint of out. Henceforth, basic coordinated channel preparing at BS is ideal. MU-MIMO framework with several radio wire at the BS which serves many single reception apparatus client terminals all the while at same recurrence and time is known as Massive MIMO framework or huge receiving wire exhibit MU-MIMO framework [5],[6]. One of the structures proposed for 5G remote correspondence is the enormous MIMO framework in which BS is furnished with countless radio wires and serves different single receiving wire client terminals as appeared in Fig 1.

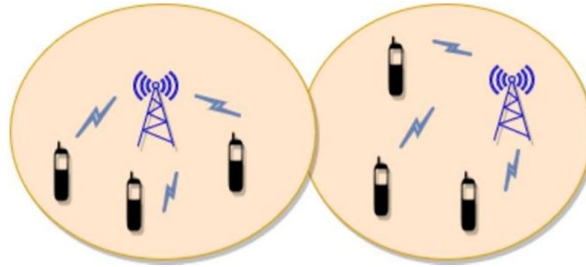


Figure 1: Multi-cell Massive MIMO System

A. Advantages of Massive MIMO System

High vitality productivity: If the channel is assessed from the uplink pilots, at that point every client's transmitted force can be decreased relatively to $1/\sqrt{M}$ considering M is huge. On the off chance that ideal Channel State Information (CSI) is accessible at the BS, at that point the transmitted force is diminished relatively to $1/M$ [7]. In the downlink case, the BS can impart signs just in the ways where the client terminals are found. By utilizing the Massive MIMO, the emanated force can be diminished accomplishing high vitality effectiveness.

Simple signal processing: Using an extreme number of BS radio wires contrasted with clients lead to the pair-wise symmetry of channel vectors. Henceforth, with basic straight preparing strategies both the impacts of bury client impedance and clamor can be disposed of.

Sharp digital beamforming: With a receiving wire exhibit, by and large simple beamforming is utilized for guiding by changing the periods of RF signals. Be that as it may, on account of Massive MIMO, beamforming is computerized in light of direct precoding. Computerized beamforming is performed by tuning the stages and amplitudes of the transmitted signals in baseband. Without guiding genuine shafts into the channels, signals include in stage at the proposed clients and out of stage at different clients. With the expansion in various receiving wires, the sign quality at the planned clients gets higher and gives low impedance from different clients. Advanced beamforming in gigantic MIMO gives an increasingly adaptable and forceful method for spatial multiplexing. Another preferred position of computerized beamforming is that it doesn't require exhibit alignment since correspondence is utilized.

Channel solidifying: The channel passages become practically deterministic in the event of Massive MIMO, in this way nearly killing the impacts of little scale blurring. This will fundamentally diminish the channel estimation mistakes.

Reduction of Latency: Fading is the most significant factor which impacts the dormancy. Additional blurring will prompts more dormancy. As a result of the nearness of Channel solidifying in Massive MIMO, the impacts of blurring will be nearly disposed of and the dormancy will be diminished altogether.

Robustness: Robustness of remote correspondences can be expanded by utilizing different reception apparatuses. Huge MIMO have overabundance degrees of opportunity which can be utilized to drop the sign

from purposeful jammers.

Array gain: Array gain brings about a shut circle interface spending improvement corresponding to the quantity of BS radio wires.

Good Quality of Service (QoS): Massive MIMO gives the arrangement of consistently great QoS to all terminals in a cell as a result of the obstruction concealment capacity offered by the spatial goals of the cluster. Run of the mill gauge power control calculations accomplish max-min decency among the terminals.

Autonomous activity of BS's: The activity of BS's is improved on the grounds that there is no necessity of sharing Channel State Information (CSI) with different cells and no prerequisite of exact time synchronization.

II. CHALLENGES

Propagation Model: In most of the Massive MIMO related works, the assumption that made was: as the BS antennas grow the user channels are uncorrelated and the channel vectors become pair-wise orthogonal. But in real time propagation environment, antenna correlation comes into the picture. If the antennas are highly correlated, then the channel vectors cannot become pair-wise orthogonal by increasing the number of antennas. This means that users location is an important factor in Massive MIMO systems.

Modulation: For the construction of a BS with a large number of antennas, cheap power efficient RF amplifiers are needed.

Channel Reciprocity: TDD operation depends on channel reciprocity. There seems to be a reasonable consensus that the propagation channel itself is basically reciprocal unless the propagation is suffering from materials with strange magnetic properties. Between the uplink and the downlink, there is a hardware chain in the base station and terminal transceivers may not be reciprocal.

Channel Estimation: To perform detection at the receiver side, we need perfect CSI at the receiver side. Due to the mobility of users in MU case, channel matrix changes with time. In high mobility case, accurate and time acquisition of CSI is very difficult. FDD Massive MIMO induces training overhead and TDD Massive MIMO relies on channel reciprocity and training may occupy a large fraction of the coherence interval.

Low-cost Hardware: Large number of RF chains, Analog-to-Digital converters, Digital-to-Analog converters are needed.

Coupling between antenna arrays: At the BS side, several antennas are packed in a small space. This causes mutual coupling in between the antenna arrays. Mutual coupling degrades the performance of Massive MIMO due to power loss and results in lower capacity and less number of degrees of freedom. When designing a Massive MIMO system, the effect of mutual coupling has to be taken into account [8], [9].

Mobility: If the mobility of the terminal is very high, then the coherence interval between the channel becomes very less. Therefore, it accommodates very less number of pilots. • **Pilot Contamination:** Pilot contamination is a challenging problem for multicell massive MIMO is to be resolved. In multicell system, users from neighboring cells may use non-orthogonal pilots that result in pilot contamination. This causes inter-cell interference problem which further grows with the increase in a number of BS antennas.

III. Literature Review

Rifat Hasan et al. [1], the next major step in mobile communications technology beyond the current LTE-A is 5G wireless technologies. With the rapid progression of 5G, massive MIMO innovation has turned out to be one of the most significant advances in 5G networks by facilitating beamforming technology. In this paper, we have simulated and analyzed the statistical propagation channel model for 5G massive MIMO millimeter-wave (mmWave) cellular communication in the ultra-wideband unlicensed spectrum of 60 GHz. This investigation is based on IR (impulse response) channel model named NYUSIM which is a geometrical based channel modeling tool developed by NYU Wireless. We have used the drop based mode to determine the propagation channel coefficients. We investigated the network performance by considering the directional, omnidirectional power delay profiles (PDPs) and path loss. Analyzing the propagation channel is fundamental to define the actions of the channel response of the wireless stream link in the specific environment to reach the 5G expectations.

R. Hasan et al. [2], in recent years, an increasing interest in the millimeter wave (mmWave) communications plays a vital solution for the growing demands of the data and speed. As a vast unused spectrum, mmWave is expected to handle a key role in the access network of the fifth generation (5G) mobile technologies. Despite its ability to provide higher transmission rate and spread spectrum capability, mmWave suffers from several major drawbacks such as high attenuation and sensitivity due to its weather dependency which causes the modeling of an mmWave channel to be very challenging. In this research, we investigate a statistical analysis of an outdoor channel in 73 GHz for access network of an urban micro cell. A well-known mmWave channel modeling simulator NYUSIM is used for both LOS and NLOS scenarios. Simulation scenarios consider some crucial network parameters such as angle of arrival, angle of departure, power delay profiles, and path loss to characterize an mmWave channel in the 73 GHz E band. These investigations may be utilized to demonstrate the potential of 73 GHz mmWave band and its suitability for the 5G outdoor networks.

R. Hasan et al. [3], millimeter wave (mmWave) is perceived as an essential innovation so as to meet the rapid increment of wireless mobile traffic request utilizing its massive bandwidth. However, channel modeling is still difficult for its high weather dependency and antenna positioning for line-of-sight (LOS) communication. Co-polarization and cross polarization(X-pol) are two main incidents of radiation pattern direction for transmitting wave; where the desired direction of transmitting wave indicates co-pol and orthogonal propagation of the desired direction represents X-pol. This paper presents an extensive analysis of polarization impact on a statistical channel modeling for two definite front-runners of mmWave bands (28 GHz & 73 GHz) by a novel simulator NYUSIM. We simulate a realistic urban microcell scenario using the 3-D statistical spatial channel model (SSCM) that is adopted by time cluster and spatial beam approach. Simulation results present 3-D channel characteristics (AoA, AoD, and path loss) and various power delay profiles (directional, omnidirectional, and small scale) for Co-pol and X-pol in 28 GHz and 73 GHz.

M. Khatun H et al. [4], this paper presents a large scale fading channel model at the 60 GHz band. This model is based on the measurement campaign that our team conducted at Boise Airport and Boise State University. The close-in reference path loss and floating-intercept path loss models with both statistical and stochastic approaches are investigated for these environments. The measurements were collected at several different locations in line-of-sight (LOS) and non-line-of-sight (NLOS) scenarios using high gain directional antenna. The path loss exponent and shadowing factor are determined based on the measurement results and compared with recent work at this frequency. Both the stochastic gradient descent algorithm and the statistical least-square technique are used to analyze the floating-intercept path loss model. The results show that the path loss exponents in the outdoor scenarios are higher than the indoor environment due the RF noise caused by the sunny and dry climate in the Boise area. Finally, a good agreement is found between the measurement results and the prior work results in presented in the literature.

Supraja Eduru et al. [5], in massive Multiple Input Multiple Output (MIMO) systems, spatial correlation is one of the factors, which significantly affects the bit error rate (BER) performance. Therefore, in this paper, linear detection is employed with different decomposition techniques to improve the performance. It is observed that there is 10 dB degradation in channel gain for 10% increment in correlation coefficient. At a BER of 10^{-3} , with Zero Forcing (ZF) using Singular Value Decomposition (SVD), the channel gain is doubled by doubling the order of the MIMO system when compared to Cholesky and QR decomposition. Further, the BER remains unchanged for Minimum Mean Square Error (MMSE) detection irrespective of the type of decomposition techniques used. However, it is also observed that for 32×32 MIMO system, at a BER of 10^{-3} , MMSE provides nearly 10 dB to 15 dB channel gain when compared to ZF.

T. Abbas F. et al. [6], this paper examines the physical layer security issue of psychological decipher and-forward hand-off systems over Nakagami-m blurring channels. We consider the handing-off correspondence between one auxiliary client (SU) source and one SU goal by utilizing a pioneering transfer choice from numerous SU transfers and sharing the authorized range of different essential clients (PUs) in the underlay arrange. While the transmission between the SUs forces impedance on every PU, the handed-off transmission is caught by one SU meddler. Without the busybody's channel state data, the hand-off determination depends on the biggest channel addition of transfer to-goal connect, which is thought to be obsolete because of input delay. We infer the definite likelihood of non-zero mystery limit and the precise mystery blackout likelihood (SOP) in the shut structure. Besides, we determine the asymptotic SOP in two distinct cases, and unequivocally

demonstrate the impacts of framework parameters on the mystery decent variety request and the mystery assorted variety gain, individually. Both asymptotic investigation and reenactment results demonstrate that the mystery execution can be improved by expanding either the quantity of transfers or the Nakagami parameter of the authentic hand-off channels, while the mystery decent variety addition disintegrates as the quantity of the PUs increments.

S. Sun G. R. et al. [7], in future functional organizations of gigantic multi-input multi-yield (MIMO) frameworks, the quantity of radio-recurrence (RF) chains at the base stations (BSs) might be a lot littler than the quantity of BS receiving wires to lessen the general use. In this correspondence, we propose a novel structure for joint information and counterfeit commotion (A) precoding in a multiuser enormous MIMO framework with predetermined number of RF chains, which improves the remote security execution. With defective channel state data (CSI), we logically determine an attainable lower bound on the ergodic mystery rate of any versatile terminal (MT) for both simple and half breed precoding plans. The shut structure lower bound is utilized to decide ideal power part among information and AN expands the mystery rate through basic 1-D search. Diagnostic and numerical outcomes together uncover that the proposed cross breed precoder, albeit experiencing diminished mystery rate contrasted and the hypothetical full-dimensional precoder, is free of the high computational multifaceted nature of enormous scale framework reversal and invalid space counts and to a great extent decreases the equipment cost.

H. Q. Ngo et al. [8], a Cell-Free Massive MIMO (different info numerous yield) framework involves countless disseminated passageways (APs), which all the while serve an a lot more modest number of clients over a similar time/recurrence assets dependent on legitimately estimated channel attributes. The APs and clients have just a single reception apparatus each. The APs gain channel state data through time-division duplex activity and the gathering of uplink pilot sign transmitted by the clients. The APs perform multiplexing/de-multiplexing through conjugate beamforming on the downlink and coordinated separating on the uplink. Shut structure articulations for individual client uplink and downlink throughputs lead to max-min power control calculations. Max-min power control guarantees consistently great administration all through the region of inclusion. A pilot task calculation mitigates the impacts of pilot sullyng, yet power control is unquestionably progressively significant in such manner. Cell-Free Massive MIMO has significantly improved execution regarding an ordinary little cell conspire, whereby every client is served by a devoted AP, as far as both 95%-likely per-client throughput and resistance to shadow blurring spatial connection. Under uncorrelated shadow blurring conditions, the phone free plan gives almost fivefold improvement in 95%-likely per-client throughput over the little cell plot, and ten times improvement when shadow blurring is related.

Huang A. Burr et al. [9], in this paper, we consider the uplink of sans cell huge MIMO frameworks, where countless conveyed single reception apparatus passageways (APs) serve an a lot more modest number of clients at the same time by means of restricted backhaul. Just because, we explore the presentation of register and-forward (C&F) in such a ultra- thick system with a reasonable channel model (counting blurring, path-loss and shadowing). By using the normal for path-loss, a low unpredictability coefficient determination calculation for C&F is proposed. We likewise give a covetous AP determination technique for message recuperation. Moreover, we contrast the presentation of C&F with some other promising straight systems for conveyed monstrous MIMO, for example, little cells (SC) and most extreme proportion consolidating (MRC). Numerical outcomes uncover that C&F lessens the backhaul load, yet additionally fundamentally expands the framework throughput for the symmetric situation.

IV. METHODOLOGY

Beamforming can be classified as fixed beamforming, switched beamforming, delay and sum beamforming, beam space beamforming and adaptive beamforming.

Fixed Beamforming:- In fixed BF the interference is not completely suppressed and also it does not perform amplitude weighting of the received signal which can be realized by adopting either an analog approach (e.g. switched beam, delay and sum) or a digital approach (e.g. beam space BF) where the system can be usually realized at a reasonable cost.

Switched Beamforming:- In switched beam antennas the performance of the system can be improved by multiple fixed beams which generate a finite number of radiation patterns, thus making one RF signal available

for each possible beam as shown in Fig. 2. The patterns are synthesized using an RF network that combines the signals received by the N antennas in order to form the different beams targeted towards certain directions. The RF network (Butler matrix) is realized adopting analog phase shifters. An RF switch selects the signal with the highest SINR from the set of available outputs, which will be further processed by the Low Noise Amplifier.

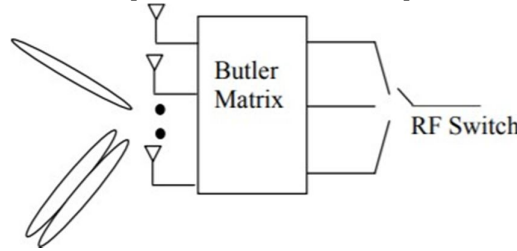


Fig. 2: Switched Beamforming

Delay and sum beamforming

The most ancient form of spatial filtering that adopts an analog approach is the delay and sum BF, where delays are used instead of phase shifters as shown in Fig. 3. For narrowband signals this scheme is substantially equivalent to switched beam but the delay and sum technique can also be applied to broadband signals. Depending on the delays, the antenna array isolates the signal for certain directions but the interference is not specifically taken into account because this scheme does not perform any amplitude weighting.

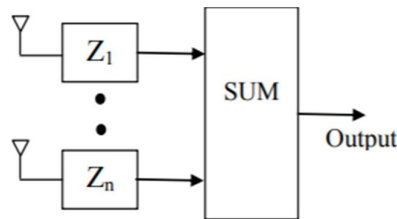


Fig.3: Delay and sum Beamforming

Maximum Likelihood Sequence Estimator (MLSE):- The optimal equalizer with highest probability correctly detects the transmitted sequence which is the maximum likelihood sequence estimator (MLSE). It minimizes the sequence error probability, i.e. the data symbol vector error probability, which is equivalent to maximizing the conditional probability.

The ORC equalizer cancels all ISI but can lead to considerable noise enhancement. The MMSE technique minimizes the expected mean squared error between the transmitted symbol and the symbol detected at the equalizer output, thereby providing better balance between ISI mitigation and noise enhancement as shown in Fig. 4.

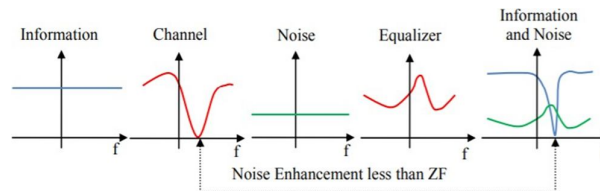


Fig. 4: Noise Enhancement in MMSE

V. CONCLUSION

The communication over wireless channel has three fundamental distinctions from the wireline communication. The first is the large-scale and small scale fading, second is the interference between the transmitter and receiver and the third is the user mobility in the network. The presence of fading, interference and mobility makes the

design of wireless communication system challenging. The conventional design focusing on the reliability of the connection needs to mitigate the fading and multipath effects. Modern wireless system design focusing on the spectral efficiency gains from the rich multipath environment by means of utilizing bandwidth and spatial diversity through multicarrier modulation and MIMO communication. However, possible potential gain in spectral efficiency is challenged by the receiver's ability to accurately detect the symbol.

If ISI arises within a system, the receiver output becomes erroneous at the decision device. This is an unfavorable result that should be reduced to the most minimal amount possible. Error rates from ISI are minimized through the use of equalization techniques. The performance of the equalizer depends on the quality of the channel estimate. The channel frequency response is typically not known at the receiver in advance and changes over time for a time varying channel. Therefore, it is necessary to perform channel estimation at the receiver prior to equalization.

REFERENCES

- [1] Rifat Hasan, Md Munjure Mowla and Nabila Hoque, "Performance Estimation of Massive MIMO Drop- based Propagation Channel Model for mmWave Communication", IEEE Region 10 Symposium (TENSymp), IEEE 2020.
- [2] R. Hasan M. M. Mowla M. A. Rashid M. K. Hosain and I. Ahmad "A Statistical Analysis of Channel Modeling for 5G mmWave Communications" 2019 International Conference on Electrical Computer and Communication Engineering (ECCE) pp. 1-62019.
- [3] R. Hasan M. M. Mowla and M. Khatun "The Impact of Linear Polarization on Channel Modeling in 5G Cellular Communications: A Statistical Approach" 2019 5th International Conference on Advances in Electrical Engineering (ICAEE) pp. 329-3342019.
- [4] M. Khatun H. Mehrpouyan and D. Matolak "60-GHz Millimeter-Wave Path loss Measurements in Boise Airport" 2018 IEEE Global Conference on Signal and Information Processing (GlobalSIP) pp. 1276-1280 2018.
- [5] Supraja Eduru and Nakkeeran Rangaswamy, "BER Analysis of Massive MIMO Systems under Correlated Rayleigh Fading Channel", 9th ICCCNT IEEE 2018, IISC, Bengaluru, India.
- [6] T. Abbas F. Qamar I. Ahmed K. Dimyati and M. B. Majed "Propagation channel characterization for 28 and 73 GHz millimeterwave 5G frequency band" 2017 IEEE 15th Student Conference on Research and Development (SCOREd) pp. 297-302 2017.
- [7] S. Sun G. R. MacCartney and T. S. Rappaport "A novel millimeterwave channel simulator and applications for 5G wireless communications" 2017 IEEE International Conference on Communications (ICC) pp. 1-7 2017.
- [8] H. Q. Ngo A. Ashikhmin H. Yang E. G. Larsson T. L. Marzetta "Cell-free massive MIMO versus small cells" IEEE Trans. Wireless Commun. vol. 16 no. 3 pp. 1834-1850 Mar. 2017.
- [9] Huang A. Burr "Compute-and-forward in cell-free massive MIMO: Great performance with low backhaul load" Proc. IEEE Int. Conf. Commun. (ICC) pp. 601-606 May 2017.
- [10] H. Al-Hraishawi, G. Amarasuriya, and R. F. Schaefer, "Secure communication in underlay cognitive massive MIMO systems with pilot contamination," in In Proc. IEEE Global Commun. Conf. (Globecom), pp. 1-7, Dec. 2017.
- [11] V. D. Nguyen et al., "Enhancing PHY security of cooperative cognitive radio multicast communications," IEEE Trans. Cognitive Communication And Networking, vol. 3, no. 4, pp. 599-613, Dec. 2017.
- [12] R. Zhao, Y. Yuan, L. Fan, and Y. C. He, "Secrecy performance analysis of cognitive decode-and- forward relay networks in Nakagami-m fading channels," IEEE Trans. Communication, vol. 65, no. 2, pp. 549-563, Feb. 2017.
- [13] W. Zhu, J. and. Xu and N. Wang, "Secure massive MIMO systems with limited RF chains," IEEE Trans. Veh. Technol., vol. 66, no. 6, pp. 5455-5460, Jun. 2017.
- [14] R. Zhang, X. Cheng, and L. Yang, "Cooperation via spectrum sharing for physical layer security in device- to-device communications under laying cellular networks," IEEE Trans. Wireless Communication, vol. 15, no. 8, pp. 5651-5663, Aug. 2016.
- [15] K. Tourki and M. O. Hasna, "A collaboration incentive exploiting the primary-secondary systems cross interference for PHY security enhancement," IEEE J. Sel. Topics Signal Process., vol. 10, no. 8, pp. 1346-1358, Dec 2016.