Active Plant Wall for Green Indoor Climate Based on Cloud and Internet of Things

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Abstract

An indoor climate is closely related to human health, well-being, and comfort. Thus, indoor climate monitoring and management are prevalent in many places, from public offices to residential houses. Our previous research has shown that an active plant wall system can effectively reduce the concentrations of particulate matter and volatile organic compounds and to stabilize the carbon dioxide concentration in an indoor environment. However, regular plant care is restricted by geography and can be costly in terms of time and money, which poses a significant challenge to the widespread deployment of plant walls. In this article, we propose a remote monitoring and control system that is specific to the plant walls. The system utilizes the Internet of Things technology and the Azure public cloud platform to automate the management procedure, improve the scalability, enhance user experiences of plant walls, and contribute to a green indoor climate.

Reference

This paper has been submitted to the IEEE Access journal and under review process.

Utility-based Downlink Pilot Assignment in Cell-Free Massive MIMO

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Abstract

We propose a strategy for orthogonal downlink pilot assignment in cell-free massive MIMO (multiple-input multiple-output) that exploits knowledge of the channel state information, the channel hardening degree at each user, and the mobility conditions for the users. These elements, properly combined together, are used to define a user pilot utility metric, which measures the user's real need of a downlink pilot for efficient data decoding. The proposed strategy consists in assigning orthogonal downlink pilots only to the users having a pilot utility metric exceeding a predetermined threshold. Instead, users that are not assigned with an orthogonal downlink pilot decode the data by using the statistical channel state information. The utility-based approach guarantees higher downlink net sum throughput, better support both for high-speed users and shorter coherent intervals than prior art approaches.

Reference

Published in the 22nd International ITG Workshop on Smart Antennas (WSA 2018), 14-16 March 2018. https://arxiv.org/abs/1803.08828

Distributed Power Control in Downlink Cellular Massive MIMO

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Abstract

This paper compares centralized and distributed methods to solve the power minimization problem with quality-of-service (QoS) constraints in the downlink (DL) of Massive multiple-input multiple-output (MIMO) systems. In particular, we study the computational complexity, number of parameters that need to be exchanged between base stations (BSs), and the convergence of iterative implementations. Although a distributed implementation based on dual decomposition (which only requires local statistical channel knowledge at each BS) typically converges to the global optimum after a few iterations, many parameters need to be exchanged to reach convergence.

Techniques for System Information Broadcast in Cell-Free Massive MIMO

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Abstract

We consider transmission of system information in a cell-free massive MIMO system, when neither the receiving terminal nor the transmitting access points have any channel state information. We analyze the system performance in terms of outage rate and coverage probability and use space-time block codes to increase these performance metrics. We propose a heuristic method for pilot/data power optimization that can be applied without any channel state information. We also analyze the problem of grouping the access points, which is needed when the single-antenna access points jointly transmit a space-time block code.

Reference

Submitted to IEEE Transactions on Communications.

How Much Will Tiny IoT Nodes Profit from Massive Base Station Arrays?

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Abstract

In this paper we study the benefits that Internet-of-Things (IoT) devices will have from connecting to a massive multiple-input-multiple-output (MIMO) base station. In particular, we study how many users that could be simultaneously spatially multiplexed and how much the range can be increased by deploying massive base station arrays. We also investigate how the devices can scale down their uplink power as the number of antennas grows with retained rates.

We consider the uplink and utilize upper and lower bounds on known achievable rate expressions to study the effects of the massive arrays. We conduct a case study where we use simulations in the settings of existing IoT systems to draw realistic conclusions.

We find that the gains which ultra narrowband systems get from utilizing massive MIMO are limited by the bandwidth and therefore those systems will not be able to spatially multiplex any significant number of users. We also conclude that the power scaling is highly dependent on the nominal signal-to-noise ratio (SNR) in the single-antenna case.

Reference

Submitted to 26th European Signal Processing Conference (EUSIPCO 2018).

Uplink Spectral Efficiency of Massive MIMO with Spatially Correlated Rician Fading

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Abstract

This paper considers the uplink (UL) of a multi-cell Massive MIMO (multiple-input multiple-output) system with spatially correlated Rician fading channels. The channel model is composed of a deterministic line-of-sight (LoS) path and a stochastic non-line-of-sight (NLoS) component describing a spatially correlated multipath environment. We derive the statistical properties of the minimum mean squared error (MMSE) and least-square (LS) channel estimates for this model. Using these estimates for maximum ratio (MR) combining, rigorous closed-form UL spectral efficiency (SE) expressions are derived. Numerical results show that the SE is higher when using the MMSE estimator than the LS estimator, and the performance gap increases with the number of antennas. Moreover, Rician fading provides higher achievable SEs compared to Rayleigh fading since the LoS path improves the sum SE.

Reference

Submitted to 19th IEEE International Workshop on Signal Processing Advances in Wireless Communications (SPAWC 2018).

Energy-efficient Resource Allocation for NOMA-assisted Mobile Edge Computing

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Abstract

Mobile edge computing (MEC) has been envisioned as a promising technology for enhancing the computation capacities and prolonging the lifespan of mobile devices, by enabling mobile devices to offload computation-intensive tasks to servers in close proximity. MEC introduces a new scenario for wireless communication, as computations are performed directly at the receiving side of the wireless links. Our objective is to evaluate the importance of spectrum efficiency enhancing techniques in this new scenario.

Specifically, we consider non-orthogonal multiple access (NOMA), one of the promising technologies to increase the spectral efficiency and system capacity of mobile networks, and formulate a joint radio-and-computational resource allocation problem to minimize the energy consumption of computation offloading for a multicarrier NOMA-assisted MEC system. Three different resources should be appropriately allocated, including the subcarriers, power and computational resources. The formulated resource allocation problem belongs to mixed integer nonlinear programming (MILNP) and is NP hard. We decompose the problem to the steps of NOMA clustering and subcarrier allocation, computational resource allocation and power allocation, among them the power allocation problem is solved optimally. Extensive simulations are performed, which fully validate the superiority of the proposed scheme over its OMA counterpart, especially in scenarios with strict delay limits, where both the transmission and the computational resources become scarce.

Reference

Will be submitted to IEEE Internet of Things Journal.

Batches Sparse Codes for Uplink of Industrial Internet of Things

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Abstract

The Industrial Internet of Things (IIoTs) enable industrial devices interacting with each other through networks and revolutionize industrial automation. In industrial automation applications, a large number of sensors located around industrial devices collect information generated during manufacturing. In order to avoid human safety accidents and precisely control the activities of the industrial devices, the collected information is required to be processed timely. The direction of data transmissions from sensors to processing centers is often called uplink transmission. During the uplink transmissions, data may lose due to unstable links from sensors to relays, among relays, and from relays to processing centers. Here the uplink model with multiple distributed processing centers is studied.

Schemes based on batches sparse (BATS) codes are proposed for the uplink transmissions to improve the transmission reliability. BATS codes are enhanced rateless sparse random linear network coding (RLNC) schemes. Compared with the RLNC, BATS codes have less coding overhead and lower decoding complexity, and require a smaller buffer size at intermediate nodes. The expected rank and the recovery probability of the information from sensors at processing centers are derived and analysed, respectively. Comparison results show that by using the proposed BATS-based schemes, improved transmission reliability can be achieved compared to the XOR-based network coding (NC) scheme. Finally, according to the analysis and the numerical results, the relationships among the expected rank, the recovery probability and the coding parameters, e.g., the degree and the batch size, are discussed. Because of the rateless property of BATS codes, the coding parameters of the BATS-based schemes can be changed flexibly with different channel conditions and network topologies. Therefore, the schemes based on BATS codes are quite suitable for the uplink transmissions in industrial environments with time-varying channel and network parameters and limited storage resources at relays.

Index Terms:IIoTs, uplink transmissions, BATS codes, distributed processing centers

Hide and Seek in a Social Network

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Abstract

In investigating covert organizations, many social network analysis tools are not sufficient since they fail to consider agents who take precaution and try to evade detection. In this work two methods are proposed to both model this hiding behavior and to recover the hidden agents.

Interest in analyzing covert organizations such as terrorist networks is rising. Many techniques exist for social network analysis (SNA), but most make oversimplified or naive assumptions. In particular we must assume that we are looking for individuals that are actively trying to evade such investigations. This work is about how individuals can elude detection by SNA methods and what countermeasures can be used to find such hidden individuals. For the first task a heuristic is proposed that manages to decrease degree, closeness, betweenness and eigenvector centralities for a chosen target node in the network, all while maintaining the target node's social influence. We used two influence models, linear threshold and independent cascade.

Thresholds of Braided Convolutional Codes on the AWGN Channel

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Abstract

It is established in [1] that belief propagation (BP) thresholds of turbo-like codes (TCs) improve with the introduction of spatial coupling (SC). The SC-TCs considered as examples in [1] are serially concatenated codes (SCCs), parallel concatenated codes (PCCs) and braided convolutional codes (BCCs). Exact density evolution (DE) equations are derived and used in analyzing the asymptotic behavior of these codes on the binary erasure channel (BEC) and the occurrence of threshold saturation is demonstrated numerically as well as proved analytically [1].

In [2], it is demonstrated that a close prediction of BP thresholds of randomly punctured low-density parity-check code (LDPC) ensembles on the binary-input additive white Gaussian noise channel (BIAWGNC) is possible if the BP threshold of the unpunctured code ensemble on the BEC and the desired rate are known. It is a remarkable fact that the thresholds on the BI-AWGNC are closely predictable with a simple expression for randomly punctured LDPCs, as density evolution (DE) and EXIT chart analysis techniques are often employed to compute the threshold of such codes on the BI-AWGNC. These techniques require a Monte Carlo (MC) simulation set-up and are computationally quite expensive.

For this poster presentation, we are going to present the thresholds of BCCs on the AWGN channel [3]. The decoding thresholds are estimated by MC-DE techniques and compared with approximate thresholds from an erasure channel prediction [2]. The results show that, with spatial coupling, the predicted thresholds are very accurate and quickly approach capacity if the coupling memory is increased. For uncoupled ensembles with random puncturing, the prediction can be improved with help of the AWGN threshold of the unpunctured ensemble.

References

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[3] M. U. Farooq, S. Moloudi, M. Lentmaier, “Thresholds of Braided Convolutional codes on the AWGN Channel,” accepted for publication in Proc. ISIT 2018.

Position Estimation of User Equipment in Urban Scenarios Based on 5G Testbed Data Using Machine Learning

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Abstract

Positioning is recognized as one important feature for the fifth generation (5G) cellular networks due to the massive number of commercial use cases that would benefit from access to position information. Radio based positioning has always been a challenging task in urban environments where buildings block and reflect the signal, causing multipath propagation and non-line-of-sight (NLOS) signal conditions. One approach to handle NLOS is a data driven approach, where a training data set with positioned measurements are used to train a model between measurements and positions, which is used for positioning

The work is based on positioned measurement data from a 5G testbed with an antenna with beams in both horizontal and vertical layers. The measurements are beam reference signal received power (BRSRP) from the beams, and the angle of departure from the set of beams with the highest received signal strength. For modelling of the relation between measurements and positions, we have considered two non-linear models – neural networks and random forest.

Our tests show that the data must be separated into line-of-sight (LOS) and NLOS data before the training of the machine learning (ML) algorithms to achieve good localization performance under both LOS and NLOS conditions. Therefore, a generalized likelihood ratio test to classify if a data segment originating from LOS or NLOS conditions, have been developed. The absolute error from the algorithms is less than 5% when comparing with an intuitive NLOS detection approach, i.e. by studying the map and where there are buildings blocking the signal.

The ML algorithms were able to position the user equipment in NLOS region with a horizontal positioning error of less than 10 meters in 95 percentage of the test cases. The results also show that studying beams in different layers is essential for positioning with high accuracy during NLOS conditions.

Genetic-Algorithm Based Beam Refinement for Initial Access in Millimeter-Wave Mobile Networks

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Abstract

Initial access (IA) is identified as a key challenge for the upcoming 5G mobile communication system operating at high carrier frequencies, and several techniques are currently being proposed. In this paper, we extend our previously proposed efficient genetic algorithm (GA)-based beam refinement scheme to include beamforming at both the transmitter and the receiver, and compare the performance with alternative approaches in the millimeter wave multi-user multiple-input-multiple-output (MUMIMO) networks. Taking the millimeter wave communications characteristics and various metrics into account, we investigate the effect of different parameters such as the number of transmit antennas/users/per user receive antennas, beamforming resolutions as well as hardware impairments on the system performance employing different beam refinement algorithms. As shown, our proposed GA based approach performs well in delay-constrained networks with multi-antenna users. Compared to the considered state-of-the-art schemes, our method reaches the highest service outage-constrained end-to-end throughput with considerably less implementation complexity. Moreover, taking the users' mobility into account, our GA-based approach can remarkably reduce the beam refinement delay at low/moderate speeds when the spatial correlation is taken into account. Finally, we compare the cases of collaborative users and non-collaborative users and evaluate their difference in system performance.

Reference

Hao Guo, Behrooz Makki, and Tommy Svensson. " Genetic-Algorithm Based Beam Refinement for Initial Access in Millimeter-Wave Mobile Networks." Wireless Communications and Mobile Computing 2018, to appear.

On the Effect of Polarization for Reliable Massive MIMO Communication

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Abstract

Massive MIMO is an important technology when developing future wireless systems. In a massive MIMO system, base stations are deployed with a large number of antennas and thereby spatial diversity can be exploited in order to increase reliability. Then the small-scale fading decreases and the channel starts to behave deterministically. This is called channel hardening. Here, reliability in massive MIMO systems, when also exploiting polarization diversity, is investigated.

We analyze channel measurements of a 128-port cylindrical array and nine closely-spaced users in an indoor auditorium. The array consists of 64 dual-polarized patch antennas and the users have omni-directional antennas with vertical polarization. User antennas are tilted 45 degrees and follow some small movements.

The measurements show a considerable impact of polarization on reliability in a massive MIMO system. We demonstrate what to expect in terms of variations of channel gain over the base station array, as well as the standard deviation of channel gain for each base station antenna in the array. We analyze the variations between the two polarizations and how they complement each other. We observe that for most users, one polarization outperforms the other. This shows the importance of having both polarizations present in the array in order to have reliable communication. The channel gain for 64 antennas over frequency and time is also analyzed when using one polarization or both polarizations. Channel hardening, in terms of decrease of standard deviation of the experienced channel gain, is evaluated when increasing the number of base station antennas. This is done for each one of the polarizations or a combination of both, the latter being the scenario where the channel hardened the most. Based on these results, the conclusion is that polarization diversity is an important factor to consider when aiming for increased reliability in a massive MIMO system.

Reference

These results have been submitted and are under review for SPAWC 2018.

4th Generation District Heating – LoRaWAN Implementation and field testing

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Abstract

Smart grid is a successful combination of ICT and energy systems, leading the way for achieving near-perfect load balancing. Thermal energy is, particularly, like electricity where diversity and number of systems connected to the networks, intermittence of energy sources, coupling of different energy grids, storage challenges, and complexity of integration with green-energy sources are similar. Key takeaways in utilizing ICT technology for energy systems are robust & reactive control system, malleable production facility, and modernized system operation. To maintain a responsive system, quality of data transmission of control plane is the prime factor. Data must have higher precision, increased frequency of sampling, reduced data errors, and lighter encoding. Nevertheless, data quality is inherently depended on the underlying transmission medium. 4DH is an active research Centre which collaborates with European industries, universities, and the public. 4DH investigates and promotes the potential of 4th Generation District Heating (4GDH). Analyzing data quality and packet loss rate in LoRaTM channel under 4th Generation district heating is the primary motive of the work. Output from analysis aids in formulation of robust adaptive computer algorithm. As real-time load balancing is the key for integration of green energy sources, reduced packet loss enables better data resolution, and responsive control system. Primary activities include designing, prototyping, field testing, and regular monitoring of things in constrained environment. Successful implementation involved enabling a LoRaWAN WSN using micropython chipsets to connect with a cloud server, provided efficient battery management and light-weight CBOR encoding mechanism are used. From observed results, datasets are evenly spaced out at higher spreading factor (SF), whereas, chunky graph is presented at lower SFs. It can be attributed to the fact that at high SFs wider bandwidth and more air-time is available for the packet.

Reference

Modelling the effect of the transmitted information quality on the management of 4th Generation district heating P. Haurant, L. Toutain, B. Bourges, B. Lacarrière

A Backscatter Architecture that Achieves a Long Communication Range

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Abstract

Backscatter communication enables wireless transmissions at a power consumption orders of magnitude lower than traditional radios. A backscatter transmitter modulates ambient wireless signals by selectively reflecting or absorbing them, which consumes less than 1 μW of power. This makes backscatter communication attractive for ultra-low power IoT applications. Early limitations in backscatter communication such as data rate and communication range have been overcome and the research community has recently made significant progress in reflecting standards compatible signals in order to integrate with commodity receivers such as WiFi, Bluetooth or IEEE 802.15.4. The backscatter reflections are inherently weak, hence separating them from the strong carrier requires complex techniques which increases both cost and complexity. The readers also suffer from poor sensitivity due to leakage of the carrier signal into the receive path reducing range.

We achieve a significan improvement across key metrics like range and power consumption in comparison to the state of the art. Our architecture is based on the following design elements: (i) generate narrow-band backscatter transmissions that improve receiver sensitivity, (ii) mitigate self-interference by keeping carrier signal and backscattered signal apart in frequency, and (iii) decouple carrier generation from the reader and using devices such as WiFi routers and sensor nodes as a source of the carrier signal. Our architecture's range scales with the carrier strength, and proximity to the carrier source and achieves a maximum range of 3.4 km when the tag is located at 1 m distance from a 28 dBm carrier source while consuming 70 μW at the tag. When the tag is equidistant from the carrier source and the receiver, we can communicate up to 75 m, a significant improvement over existing backscatter and RFID readers.

Reference

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Optimization vs. Reinforcement Learning for Wirelessly Powered Sensor Networks

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Abstract

We consider a sensing application where the sensor nodes are wirelessly powered by an energy beacon. We focus on the problem of jointly optimizing the energy allocation of the energy beacon to different sensors and the data transmission powers of the sensors in order to minimize the field reconstruction error at the sink. In contrast to the standard ideal linear energy harvesting (EH) model, we consider practical non-linear EH models. We investigate this problem under two different frameworks: i) an optimization approach where the energy beacon knows the utility function of the nodes, channel state information and the energy harvesting characteristics of the devices; hence optimal power allocation strategies can be designed using an optimization problem and ii) a learning approach where the energy beacon decides on its strategies adaptively with battery level information and feedback on the utility function. Our results illustrate that deep reinforcement learning approach can obtain the same error levels with the optimization approach and provides a promising alternative to the optimization framework.

Reference

This work has been submitted to “2018 SPAWC- Special Session: Wireless Information and Power Transmission: RF, Signal and System Design” as an invited paper.

On out-of-band Emissions of Quantized Precoding in Massive MU-MIMO-OFDM

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Abstract

We analyze out-of-band (OOB) emissions in the massive multi-user (MU) multiple-input multiple-output (MIMO) downlink. We focus on systems in which the base station (BS) is equipped with low-resolution digital-to-analog converters (DACs) and orthogonal frequency-division multiplexing (OFDM) is used to communicate to the user equipments (UEs) over frequency-selective channels. We demonstrate that analog filtering in combination with simple frequency-domain digital predistortion (DPD) at the BS enables a significant reduction of OOB emissions, but degrades the signal-to-interference-noise-and-distortion ratio (SINDR) at the UEs and increases the peak-to-average power ratio (PAR) at the BS. We use Bussgang's theorem to characterize the tradeoffs between OOB emissions, SINDR, and PAR, and to study the impact of analog filters and DPD on the error-rate performance of the massive MU-MIMO-OFDM downlink. Our results show that by carefully tuning the parameters of the analog filters, one can achieve a significant reduction in OOB emissions with only a moderate degradation of error-rate performance and PAR.

Reference

Presented at the 51st Asilomar Conference on Signals, Systems, and Computers, 2017.