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Resource Allocation in 5G and Beyond Networks for mu-MIMO Systems

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Resume

I was born in 1999 in Patras, Greece. In 2017 I graduated from my public high school and started studying as an undergraduate student in the Department of Computer Engineering and Informatics at the University of Patras. As a 3rd year student, I joined the LDST team and work since 2020 as a researcher. My interests consist of 5G Networks, Resource Allocation and Game Theory.

I am currently working on my thesis project which is about Game Theory and how it can aid Resource Allocation for 5G networks.

Information About Our Team

- Our website: http://telematics.upatras.gr/telematics/

- The Lab of Distributed Systems and Telematics is one of the Labs of the Department of Computer Engineering & Informatics of University of Patras. The LDST exhibits substantial research activity in the following areas:

- Mobile Networks
- Next Generation Networks
- Cross-layer Design and Mechanisms
- Network Simulations
- LPWAN

Outline

- Introduction
- Resource Allocation in Mu-MIMO
- Presentation of Transmission and Precoding Techniques
- Comparison
- Conclusions
- Future Work

Introduction (1/2)

- Radio Resource Allocation (RRA) uses a frequency reuse to increase spectrum efficiency. The utilization plays a significant role since the spectrum is a widely shared and scarce resource.

- Resource Allocation (RA) as a discipline of its own encompasses a variety of techniques. MIMO and beamforming integrate RA.

- MIMO provides practical solutions and techniques to send and receive more than one data signal simultaneously at the same radio. There is a separation that prevents them from interfering with each other.

- MIMO multiplies the network capacity by using the horizontal and vertical polarity of a radio wave. Scaling is challenging and mu-MIMO can help by providing many benefits.

Introduction (2/2)

- MIMO can increase the capacity of the communication system while also improving its reliability.

- During the last years,various techniques are developing for many heterogeneous and diverse MIMO scenarios furthering that way the applications possible and the research made.

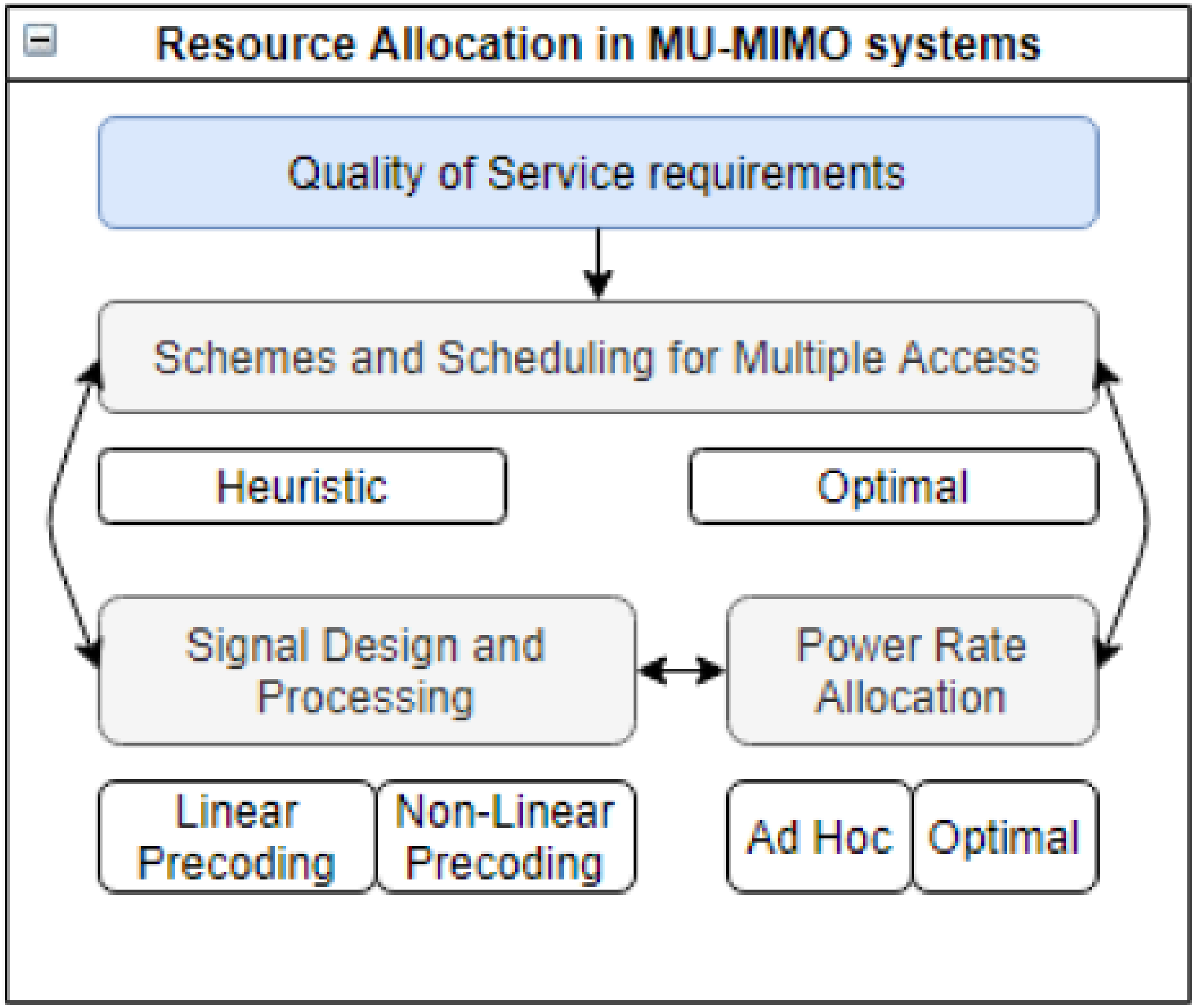
- In this paper, an overview of different methodologies used for RA is presented. Moreover, the algorithms are compared. We aim to provide guidelines for efficient design of RA algorithms, point out practical challenges, and comment and compare the processing techniques of mu-MIMO's state of the art.

Resource Allocation (1/2)

- Mu-MIMO systems come without propagation limitations like channel rank loss or antenna correlation.

- Massive MIMO or largescale MIMO employs a few hundred antennas at the Base Station that are responsible for sending simultaneously data streams to many users.

- RA management in wireless communications includes various network functions, such as power control, transmission rate control, call admission control, scheduling, handover, transmitter assignment, and bandwidth reservation.



Resource Allocation in MU-MIMO systems
Quality of Service requirements
Schemes and Scheduling for Multiple Access
Heuristic
Optimal
Signal Design and Processing
Power Rate Allocation
Linear Precoding
Non-Linear Precoding
Ad Hoc
Optimal

Resource Allocation (2/2)

- In order to maintain the QoS and potential interference that may occur to the users, various components are used.

- Mu-MIMO allows the same data channels to distribute messages for different users. Serving with the same transmission ensures increased capacity and better utilization of resources.

- Each antenna receives both direct and indirect components. The direct ones are intended for this antenna and the indirect ones are not.

Transmission

- Mu-MIMO transmissions are organized into two types, partial and full bandwidth.
- Mu-MIMO aims to accommodate as many users as possible per resource.
- That is the reason why RA techniques are thoroughly examined at the basic resource unit, e.g., time-slot, code, frequency-time resource block, or single carrier.

Precoding

- The term indicates the rotation and scaling of the set of beams having their spatial properties and power adjusted towards one particular purpose.
- Precoding can be either linear or non-linear.
- In mu-MIMO wireless technology, the term beamforming indicates the signal steering needed to achieve SDMA using beams.

Comparison

The algorithms mentioned bellow are analyzed and compared:

- Zero Forcing (ZF)
- Energy Efficiency Optimization
- Transmit Spatial Diversity (TSD)
- Spatial Multiplexing (SM)
- Space Division Multiple Access (SDMA)
- Power Allocation
- Fully adaptive RA scheme
- Maximum Radio Transmission (MRT)
- Minimum Mean Square Error (MMSE)

Work	Algorithm	Techniques	Results
[11]	ZF	Design prefilters to remove multi-user interference	Good throughput, EE quite low
[12]	EE optimization	Obtain an asymptotic EE expression utilizing smatrix theory	Target QoS
[13]	TSD	Assign each subcarrier to one user.	Best EE Bad throughput
[13]	SM	Spatial Multiplexing	Good throughput EE quite low
[13]	SDMA	Subcarrier assigned to multiple users concurrently	Improved throughput for low power consumption
[14]	Power allocation	Global optimization ranges depending on the user's high or low SINR.	Total EE increases significantly
[15]	Fully-adaptive RA scheme	Joint EE-SE performance	EE performance exceeds semi-adaptive and non-adaptive RA schemes
[16]	MRT	Beamforming	Low Complexity Processing
[17]	MMSE	Combination of ZF and MRT	Good throughput, EE quite low

*EE: Energy Efficiency

TSD algorithm analysis

I. The first subcarrier is assigned to the channel with maximum gain. We set $Y = (a, b)$. Furthermore, the pair (a^*, b^*) represents the data modulated onto the nth subcarrier. We set $m^n(a, b)$ as the maximum number of bits that can potentially be transmitted to a_{th} user using nth subcarrier.

II. Calculate $m^n(a, b)$ and T_{a*}.

III. Ensure that the user T_{a*} meets the minimum bit rate constraint stating that the data rate designated for a_{th} user should equal R_a bits per OFDM symbol.

IV. The algorithm keeps backtracking to step 1 until all the users meet the minimum bit rate constraint and therefore all the subcarriers have been allocated to subchannels.

Conclusion

The paper aims to:

- Compare algorithms and techniques.
- Provide useful information about how resource allocation works in mu-MIMO systems and how that can significantly improve in order to increase the system's performance.

Thank you!

Questions?

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