Major Project Synopsis Presentation
on

"Optimal Power Allocation and Channel Estimation in NOMA based Wireless Systems"

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Presented on: 10/10/2019

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Introduction

- **NOMA: Non Orthogonal Multiple Access**.
- **NOMA Types: Power Domain and Code Domain**
- **OFDMA: Orthogonal Frequency Division Multiple Access**

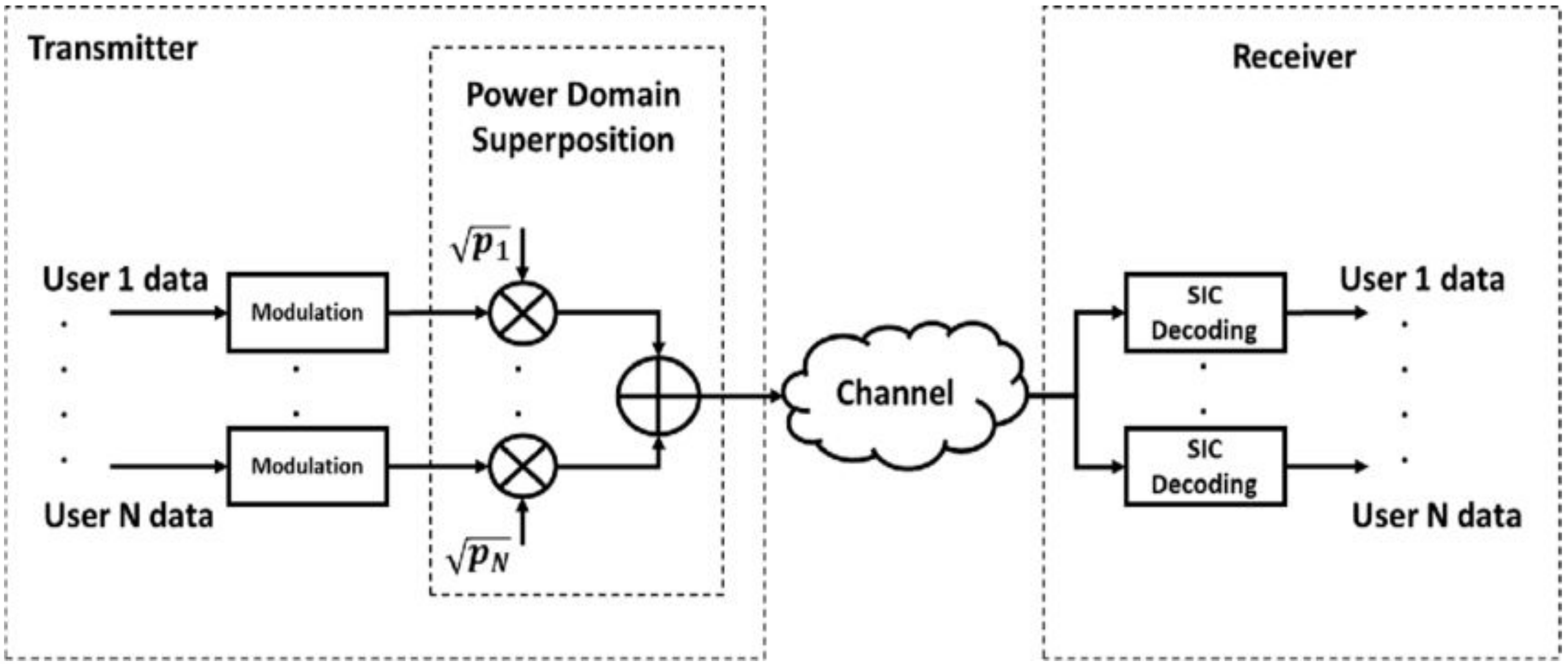
Literature Survey

- In general, NOMA schemes can be classified into two types: power-domain multiplexing and code-domain multiplexing. In power-domain multiplexing, different users are allocated different power coefficients according to their channel conditions in order to achieve a high system performance.

- In particular, multiple users' information signals are superimposed at the transmitter side. At the receiver side, successive interference cancellation (SIC) is applied for decoding the signals one by one until the desired user's signal is obtained [1], providing a good trade-off between the throughput of the system and the user fairness. In code-domain multiplexing, different users are allocated different codes and multiplexed over the same time frequency resources, such as multiuser shared access (MUSA) [2], sparse code multiple access (SCMA) [3], and low-density spreading (LDS) [4].

- In addition to power-domain multiplexing and code-domain multiplexing, there are other NOMA schemes such as pattern division multiple access (PDMA) [5] and bit division multiplexing (BDM) [6]. Although code-domain multiplexing has the potential to enhance spectral efficiency, it requires a high transmission bandwidth and is not easily applicable to the current systems. On the other hand, power-domain multiplexing has a simple implementation as considerable changes are not required on the existing networks. Also, it does not require additional bandwidth in order to improve spectral efficiency [7].
- In [9], they utilized a model free Reinforcement-Learning (RL) framework to perform power allocation which is based on two part algorithm (Actor-Critic). This predicts power allocation coefficients in the power domain NOMA. Energy Efficiency (EE) of the system is optimized through continuous iteration.

NOMA Block Diagram



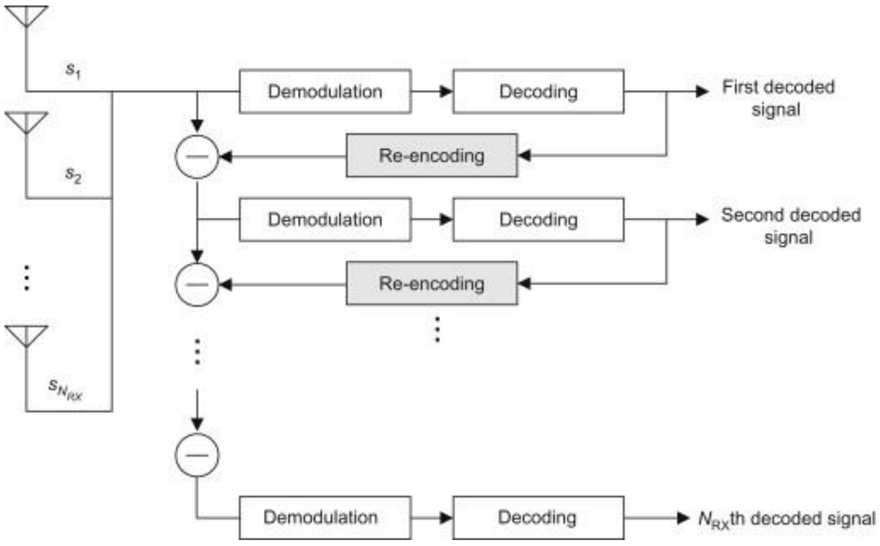
$$\boldsymbol{y} = \sum_{k=1}^{K} \sqrt{P_k}\boldsymbol{h}_k x_k + \boldsymbol{n},$$

NOMA: System Model

Transmitter:

$$\boldsymbol{y} = \sum_{k=1}^{K} \sqrt{P_k}\boldsymbol{h}_k x_k + \boldsymbol{n},$$

Receiver: Successive Interference Cancellation



NOMA: Channel Estimation

- Most wireless systems use pilot-based training signals to perform channel estimation.

$$\mathbf{z}_i = h_i \mathbf{t} + \tilde{\mathbf{n}}_i$$

- Based on the channel condition, power is allocated to different users.
- In this project, we will try to solve both the channel estimation and power allocation in one go.
- For a two user (U1 & U2) SISO downlink NOMA system, where U1 has strong channel conditions while U2 has a bad channel.

Consider a linear estimator of h_i with a general form as

$$\hat{h}_i = \mathbf{v}_i^{\dagger} \mathbf{z_i} \tag{3}$$

- $\mathbf{v}_i$ n unknown vector to be designed

NOMA : Channel Estimation

- At U1, the system needs to decode the signal containing information for U2 by performing SIC before detecting its own signal

$$y_1^2 = \hat{h}_1\sqrt{\alpha_2 P}s_2 + (h_1 - \hat{h}_1)\sum_{i=1}^{2}\sqrt{\alpha_i P}s_i + \hat{h}_1\sqrt{\alpha_1 P}s_1 + n_1$$

$$y_1^1 = \hat{h}_1\sqrt{\alpha_1 P}s_1 + (h_1 - \hat{h}_1)\sum_{i=1}^{2}\sqrt{\alpha_i P}s_i + n_1$$

- The signal to interference and noise ratio (SINR) is given by:

$$\bar{\gamma}_1^2 = \frac{\mathbb{E}\{|\hat{h}_1|^2\}\alpha_2 P}{\mathbb{E}\{|h_1 - \hat{h}_1|^2\}P + \mathbb{E}\{|\hat{h}_1|^2\}\alpha_1 P + \mathbb{E}\{|n_1|^2\}}$$

NOMA : Channel Estimation

- At U2, the system can directly detect its own signal since it has the highest power allocated and treat rest of the power levels as interference.

$$y_2^2 = \hat{h}_2\sqrt{\alpha_2 P}s_2 + (h_2 - \hat{h}_2)\sum_{i=1}^{2}\sqrt{\alpha_i P}s_i + \hat{h}_2\sqrt{\alpha_1 P}s_1 + n_2$$

- The signal to interference and noise ratio (SINR) is given by:

$$\bar{\gamma}_2^2 = \frac{\mathbb{E}\{|\hat{h}_2|^2\}\alpha_2 P}{\mathbb{E}\{|h_2 - \hat{h}_2|^2\}P + \mathbb{E}\{|\hat{h}_2|^2\}\alpha_1 P + \mathbb{E}\{|n_2|^2\}}$$

NOMA: Power Allocation

- The problem of power allocation and channel estimation is handled simultaneously.
- The objective is to maximize the SINR at strong user while maintaining the SINR at a weak user above a certain threshold
- This objective is formulated as a non-convex optimization problem, given by:

$$\max_{\{0\leq\alpha_1\leq1\},\{\mathbf{v}_i\}} \bar{\gamma}_1^1 \quad \text{s.t.} \quad \min_{i\in\mathcal{M}}\{\bar{\gamma}_i^2\} \geq \gamma_0, \forall i \in \mathcal{M}.$$

Software Requirement

- MATLAB (ver. R2018b) is a high-performance language for technical computing. It integrates computation, visualization, and programming in easy to use environment with a mathematical approach.

Problem Statement and Methodology

Problem Statement: Orthogonal Multiple Access (OMA) requires higher bandwidth and also lead to lack user fairness in allocating resources i.e., a strong user may be allocated good channel while weak user may get bad channel.

Methodology: NOMA utilises the available spectrum efficiently serving multiple users at the same time using the same resources.

- We therefore propose to use NOMA as the multiple access technology.
- However, power to each user must be efficiently allocated based on the Channel State Information (CSI) of the respective user
- We therefore study algorithms for estimating the channel conditions and allocate power accordingly.

Applications and Advantages

Advantages:

- High Spectral Efficiency
- Massive Connectivity
- Improved User Fairness
- Low latency

Applications:

- 5G Wireless Systems using NOMA and Massive MIMO for increased data rates and better spectral efficiency (and system capacity as well).
- Narrow-band IoT Systems using NOMA for better system capacity in handling more devices.

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THANK YOU