Analysis of User Clustering for Resource Allocation in IRS-enabled MU-SISO Systems

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Abstract

The evolution and diversification of communication requirements in the recent years have necessitated the development of new quality of service (QoS) requirements for the next-generation communication systems. One of the most promising key enabling technologies for the next generation communication systems is intelligent reflecting surfaces (IRSs) owing to its low-power operation and revolutionary channel controlling capabilities. This article provides a brief introduction to the requirements of the next generation systems and the focus of IRSs in the current research space. This is followed by a brief discussion of the effects of different clustering metrics on the performance of an IRS-aided system with multiple single-antenna users at different rate thresholds. Finally, the insights are summarized, and future directions are provided in the conclusion.

Ⅰ. Introduction

The adoption and proliferation of IoT devices have increased exponentially in the recent years. The global IoT market share is expected to grow to 8131 Billion by 2030 with a compound annual growth rate of 38% [1]. This growth signifies a paradigm shift from traditional human-to-human communications to machine-type communications that bring forward new QoS requirements. These QoS requirements were envisioned in the development of 5G communication systems but the developing landscape of IoT devices is expected to far exceed the limitations of the 5G infrastructure [2]. These factors motivated the inclusion of these requirements in the next generation of communication systems.

These next-generation systems are expected to greatly increase the performance and versatility of traditional, human-to-human communications while also supporting the heterogenous requirements of machine-type communications. Key parameters defined in 5G such as latency, peak data rate, mobility, connection density etc., have to undergo orders of magnitude of improvement while new performance indicators such as signal bandwidth and positioning accuracy etc., will ensure the support of new application paradigms.

These types of improvements have to be enabled with the help of disruptive technological improvements that can help support the development of such high performance and heterogeneous systems. Among the promising technological advancements expected to accelerate the development of next-generation systems is IRSs. IRSs are low-powered and usually passive controllable reflecting surfaces. Their unique ability to provide low energy control over the reflection of impinging waves even allows them to be integrated in the current communication infrastructure. This flexibility of IRSs and their ability to control the channel has attracted a large amount of research in this area including use cases such as interference cancellation[3], sum-rate maximization[4], coverage maximization[5], secure communications[6], etc.

Ⅱ. User Clustering in IRS aided MU-SISO

One of the most interesting and attractive advantages of IRSs is their ability to decrease the outage probability within a system. This is done by using the IRS to influence the channel between the transmitter and receivers employing various techniques. The effectiveness of the IRS in different configurations and operating scenarios has been well documented in various articles.

This article focuses on the performance of different user clustering techniques in an IRS-aided multi-user single input single output (MU-SISO) system using OFDM. The base station consists of a single antenna and multiple single-antenna users are served by the base station while being assisted by a reflect-only, passive IRS.

A total of 100 users are served using the base station in a 8000 x 8000 m^2 area with the base station at the origin (0,0) and the IRS at (0,2000). The users within the area are classified using 4 metrics including their distance from the base station, location within the area, link budget, and the last clustering scheme assigns random clusters to the users in order to have a baseline for comparison.

Each of the cluster is assigned an equal number of elements and the rate requirements of all the users are kept uniform. These rate requirements are then varied across simulations to get an idea of the outage

probability at various application scenarios having different rate requirements.

It can be seen in fig. 1 that at low rate requirements the outage is significant only in scenarios having no IRS in the system. This is expected as the introduction of even an unoptimized IRS should provide positive gains. As the rate threshold increases, the performance fluctuates depending on the scenarios, however distance and location based clustering show promising performance in most scenarios.

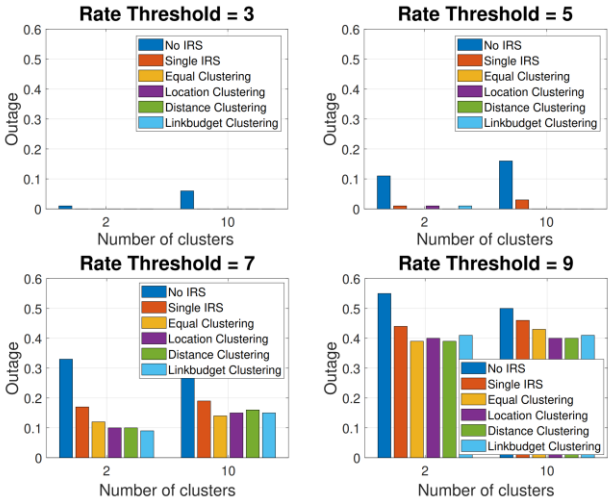

Fig 1. Effect of clustering type on outage vs no. of clusters

Ⅲ. Conclusion

This article provides a brief introduction to the demands of next-generation networks and the motivation for the development of disruptive technologies in the communications landscape. IRSs have been described as one of the key enablers of next generation communication systems, and a simulation-based analysis has been provided of the effects of user clustering on the performance of an IRS-enabled single base station MU-SISO system. This analysis can be expanded by considering heterogeneous QoS requirements, IRS placement and unequal element allocation for a more comprehensive analysis.

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