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MASSIVE MIMO OPTIMIZATION USING SELF-OPTIMIZING NETWORKS

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ABSTRACT

Massive multiple-input and multiple-output (MIMO), which refers to the practice of employing a large number of antennas at a base station to achieve better spectral efficiency using the same time and frequency resources, has received extensive interest as a potential solution for a next-generation cellular system. Presented herein are techniques to optimize a MIMO antenna configuration in order to reduce power consumption (and therefore operation cost) in a next-generation cellular network, paving the way to an energy-efficient wireless network.

DETAILED DESCRIPTION

One promising technology for achieving higher data rates in a next-generation cellular network is massive multiple-input and multiple-output (MIMO). There are many well-documented publications available explaining the benefits and energy efficiency challenges of massive MIMO in future networks (see, e.g., Larsson, E. G. (2017). Massive MIMO for 5G: Overview and the road ahead. *2017 51st Annual Conference on Information Sciences and Systems (CISS)*; Ge, X., Yang, J., Gharavi, H., & Sun, Y. (2017). Energy Efficiency Challenges of 5G Small Cell Networks. *IEEE Communications Magazine, 55*(5), 184-191; Huawei and DOCOMO Conduct World's First 5G Large Scale Field Trial in the 4.5 GHz Band - Huawei press center. (2016, November 16).).

However, the benefits of massive MIMO can be costly, as increasing the number of antennas at a base station will also increase power consumption and signal processing requirements. When massive MIMO has been deployed in a cell, in some situations (e.g. late at night or in particular regions where the traffic demand is low), keeping all of the antennas in a powered-on state may waste a large amount of power. Considering the ultra-densification of small cells in next-generation cellular systems, a method to optimize MIMO configurations would add a competitive advantage in energy saving, thus reducing operational cost.

The embodiments presented herein address the challenges of managing a massive MIMO base station by dynamically adjusting the MIMO configurations. MIMO antenna matrix configurations may include 2 x 2, 8 x 8, 16 x 16, 32 x 32, 64 x 64, 128 x 128, 256 x 256, and the like. The configuration of a MIMO antenna transceiver matrix can be adjusted using a self-optimizing network that analyzes metrics known as key performance indicators (KPIs). Current self-optimizing network technology can be leveraged and enhanced for 5G networks. For example, a self-optimizing network may use KPI data to determine the traffic load of the cell and, based on the load, fine-tune the MIMO matrix without impacting user experience. During low-load conditions, MIMO antennas are deactivated as long as an acceptable level of throughput can be maintained. During high-load conditions, MIMO antennas may be reactivated to maintain throughput. For example, during non-peak hours, a MIMO antenna matrix can be scaled down, and during day time or peak hours, the MIMO antenna matrix can be scaled back up.

A self-optimizing network will generate actions based on KPIs reported by a cell, and send the actions to an operations support system for execution. Once the action is executed, the self-optimizing network may monitor the cell's performance, and based on the results, the actions will either be reverted (e.g., to a previous configuration) in the case of a degradation of performance, or the action will be committed, and the new MIMO settings will serve as a latest baseline. Cell KPIs, such as number of users, total calls, call drops, downlink throughput, uplink throughput, and the like, will be used by a self-optimizing network to determine whether a current MIMO antenna matrix configuration requires any re-configuration and/or optimization (e.g., by increasing or decreasing the number of MIMO antennas that are active). Based on the exposure of the parameters of various radio access network vendors, corresponding MIMO parameters may be configured by a self-optimizing network.

Embodiments presented herein use a self-optimizing network to analyze cell KPIs and adjust a MIMO antenna matrix accordingly, as depicted in Figure 1.

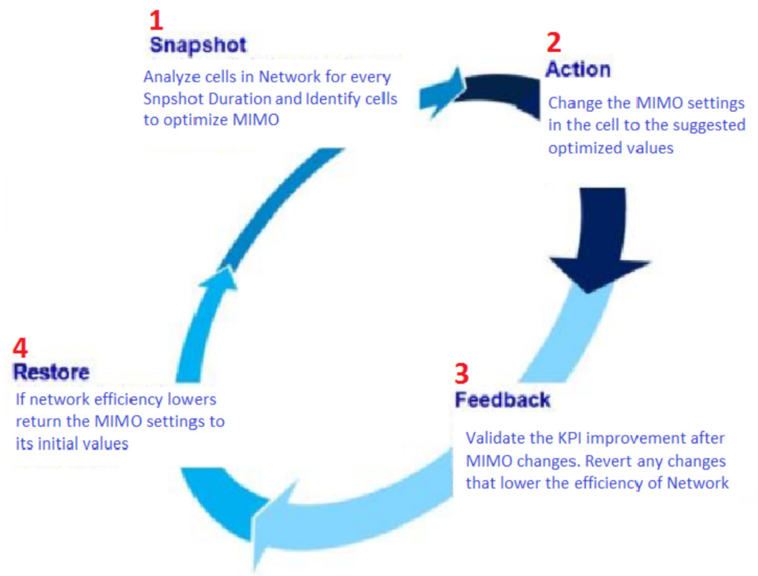

Figure 1

A self-optimizing network may process and analyze KPIs, such as the number of users, downlink/uplink throughput, and the like, to determine if the current MIMO configuration is optimized for the current traffic load. If the MIMO configuration is not optimized, then the self-optimizing network will take action on the cell by tuning the MIMO settings to either increase or decrease the number of active MIMO antennas. Once the appropriate tuning action is executed, the self-optimizing network analyzes feedback using the latest KPIs to decide if the tuning action has improved or degraded the network's efficiency; if degraded, the tuning action may be reverted.

In one use-case example, a MIMO configuration is scaled down. In this example, Cell A has a current MIMO configuration of 256 x 256 antennas. The KPIs for Cell A indicate that the traffic load is below a configured threshold (i.e., Cell A is experiencing a low-load condition), so a self-optimizing network would scale down Cell A. The self-optimizing network may adjust the configuration by turning off some antennas, reducing Cell A to a 128 x 128 MIMO antenna matrix. The self-organizing network will then analyze the feedback from Cell A to determine if there is any degradation in cell performance. This procedure may be repeated until Cell A has an optimal MIMO matrix configuration.

In another use-case example, a MIMO configuration is scaled up. In this example, Cell B has a current MIMO configuration of 64 x 64 antennas. The KPIs for Cell B indicate that the traffic load is above a configured threshold (i.e., Cell B is experiencing a high load condition), so a self-optimizing network will scale up Cell B. The self-optimizing network will adjust the configuration by turning on additional antennas, bringing Cell B up to a 128 x 128 MIMO antenna matrix. The self-organizing network will then analyze the feedback from Cell B to determine if there is any improvement in cell performance. This procedure may be repeated until Cell B has an optimal MIMO matrix configuration. Figure 2 depicts an example of a MIMO matrix configuration changing over the course of a day as the self-optimizing network adjusts to changing traffic loads.

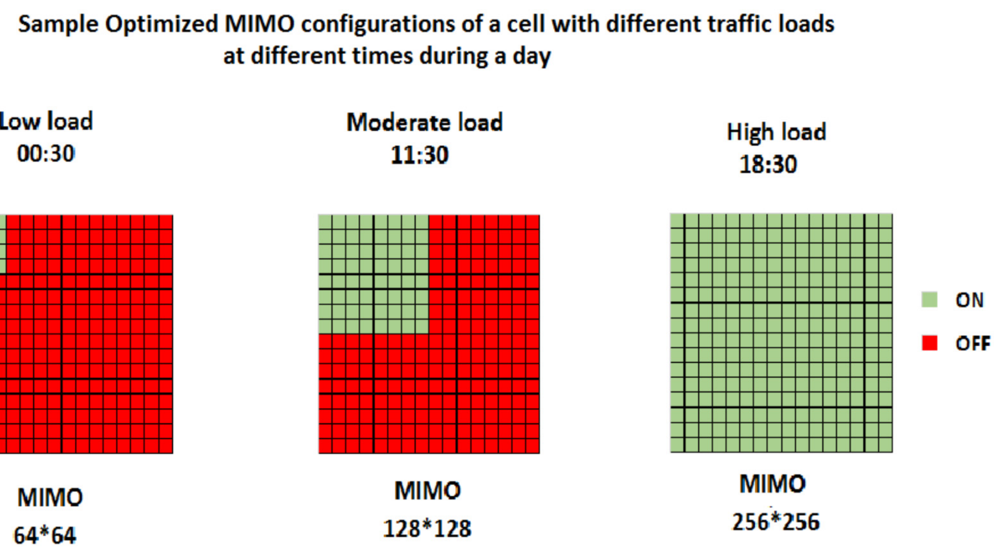

Figure 2

By fine-tuning a MIMO antenna matrix based on the current traffic load, the power consumption of a base station is reduced, thus paving the way to an energy efficient wireless network. Furthermore, the operational expenses of a cellular network may be reduced by reducing the amount of power usage of each cell. Since the process may be automated using a self-optimizing network, there is little or no manual intervention required. Additionally, by avoiding interference, better throughput may be achieved.