Adaptive Beamforming for Next Generation Cellular System

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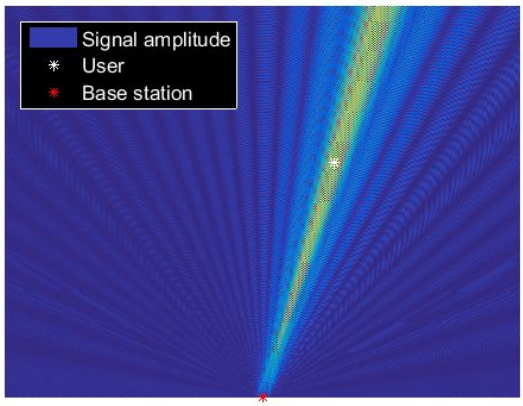
This article is based on the master's thesis "Adaptive Beamforming for Next Generaton Cellular System". The idea of multiple smart antennas that cooperate to improve network performance has been known for a while. This idea is to be realized and applied in the next generation of telecommunications systems as it will be a part of the 5G network. In this work, a scalable simulation tool using parts from the current 4G/LTE network has been built for the purpose of comparing beamforming algorithms.

Every cellphone has wireless technology today and our way to communicate with each other has rapidly changed over the past few years. As more and more devices are connected to the Internet and we're using applications that require more data, such as streaming, higher data rates are needed to support the everyday use. With the next generation of 4G/LTE, also known as 5G, beamforming will be used more extensively to improve throughput in a cellular system. The general idea of beamforming is that it directs the beam or beams from multiple base station antennas to one or more users. This increases the received signal strength at the user and it comes with another benefit as the information targeted to one user may not be seen by the others if the channel conditions are adequate. Thus resources can be reused between users to increase system capacity.



One way to view beamforming is to imagine yourself driving on the highway and your lane is the wireless channel. By using beamforming all users of the highway will have their lanes for themselves which results in a traffic where you can go as fast as you like and still make it in time. If the channel deteriorates, in case of for example "roadwork", interference may occur in terms of other drivers that might intrude on your lane and thus the throughput will be reduced. To overcome the congestion one can make more lanes, which is similar to increasing the number of base station antennas, and in case one lane worsens you can choose another one without an existing user driving on it. Another way would be to have several users share the same lane (resource), but give them enough space so they won't interfere. In that case it is also possible to group users with the same conditions so that people with similar amount of "roadwork" or noise share resources. This way, no one with higher capacity gets stuck behind someone slower.

The simulation tool has been built as a graphical user interface where the user intuitively can play around with a wide range of parameters such as; number of base station antennas, number of users, wireless channel conditions and modulation levels. Two types of beamforming algorithms have been compared; maximum ratio transmission (MRT) that maximizes the signal strength at the users and zero-forcing (ZF) that minimizes the interference between users. MRT was shown to be a much faster algorithm time-wise while ZF has a better performance in systems servicing many users. The results of the simulation tool can be used as an aid when developing 5G or as an educational tool for people who want to learn more about 4G/LTE and beamforming.