
Popular Science Summary

Do you remember a time when you were watching a standard definition (SD) YouTube video or streaming a song on your laptop or PC and the player suddenly stopped? Nowadays you want to watch streaming videos on your laptop or mobile phone in a high-definition (1080p) format and in the future you may even want to stream 4K 3D videos and watch them in your Smart-TV or mobile phone. Mobile services are expected to be fast, reliable and cheap. Apart from this, the number of connected devices is growing exponentially, and three times more devices are expected to be connected in the next 5 years. Consequently, scientists and engineers are working towards developing and installing increasingly sophisticated systems to meet today's and tomorrow's user demands.

When it comes to cellular communications, there are several ideas on how to improve the network performance. Two of them are to have base stations with a lot of cooperating antennas and to use higher frequency bandwidths, only available at higher frequencies, in the millimeter wave region. These two concepts seem complicated, and they are! Nevertheless, these novel technologies are two main candidates to be integrated in future fifth-generation (5G) mobile systems, expected to be rolled-out in 2020.

When using multiple antennas in a base station (or even in a mobile device), it is desirable to avoid different behavior of the circuits in the system over time caused by temperature, humidity and other environmental factors. This is even more important when many antennas are used, as slight changes in the circuit responses may destroy the performance advantage of using these cooperating antennas. Everything gets even more complicated in higher frequencies, since the environmental effect is stronger. But Maths are really strong, and since all the data in our devices is in fact processed mathematically in a digital form, can't we do something to compensate for this physical (i.e. analog) effects in the mathematical (i.e. digital) domain?. The answer is yes, we can, and this mathematical compensation process is called calibration.

For the calibration procedure (or algorithm) to work, it is necessary to know how the many antennas interrelate to one another, for the different frequencies in the frequency band of interest. Hence, some antenna factory characterization must be done beforehand. Since this characterization gets more and more complex with an increasing number of antennas, and the antenna properties may still vary after installation, it is necessary to find more efficient methods of charac-

terization (in particular, efficient estimators of massive MIMO arrays coupling matrix). This Master thesis addresses these two problems associated with environmental changes effects in mm-wave massive MIMO systems and characterization of massive MIMO arrays.