TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

Public summary of PhD-thesis of Laurens A. Bronckers
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Better mobile connections possible by including human factor and agility in antennas and their characterization

In current mobile communication systems, mobile devices utilize fixed frequency bands. When a device can get a better connection on another frequency band, it is possible to switch to that band, allowing for some degree of flexibility. Unfortunately, the mobile frequency spectrum is rapidly filling up, leading to new challenges. This calls for the ability to adapt with *smart* mobile communications for the electronics and antennas in mobile devices. This thesis presents such solutions that can easily be adopted by producers of mobile devices.

A fundamental problem in modern mobile communications is the limited efficiency that the compact antennas used for mobile applications can achieve. This is due to the trade-off between antenna size, bandwidth and efficiency. By creating a frequency-reconfigurable antenna (that can change its operating frequency) the efficiency can be enhanced, resulting in longer battery life and better performance.

The design complexity of such systems has prevented wide-spread industry adoption: efficiency is extremely challenging to measure, so it is hard to verify a design and compare it to previous designs. Since both design and measurement techniques are critical aspects, I investigated both issues in this context of smart frequency-reconfigurable antennas.

I introduce a new design that employs multiple tuning components, whereas previous designs used a maximum of two. I overcome the increased design complexity by computing the losses from a circuit-simulation approach instead of calculating the extremely involving behavior of the electromagnetic fields. This allows to find optimal settings for nearly any antenna geometry. Since I included a highly-integrated, fully functional prototype in this part of my work, the technology is ready for adoption by industry. This should be the next step towards truly smart communication systems.

Traditional methods to verify the performance of mobile antennas include characterization in anechoic chambers (an environment without reflections), however, I chose to characterize them in a reverberation chamber (a fully reflective environment). Taking into account the physical and properties of such chambers allowed me to measure the impact of a human phantom on the antenna efficiency. The resulting technique is practical, easy to set-up and relatively fast. This allows manufacturers of mobile devices to improve their designs accordingly to improve battery life decrease radiation exposure to the user.

Title of PhD-thesis: Design and Measurement Techniques for Next-Generation Integrated Antennas. Supervisors: Anne Roc'h (TU/e), Bart Smolders (TU/e). Other main parties involved: NXP Semiconductors, Nijmegen; National Institute of Standards and Technology (NIST), Colorado, United States.